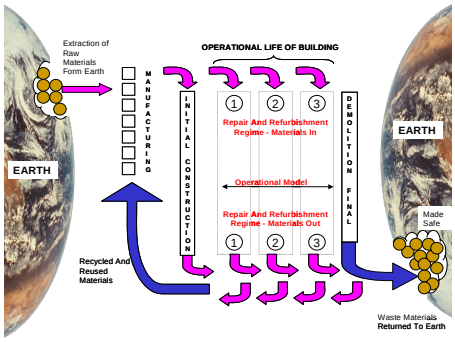
FINAL REPORT

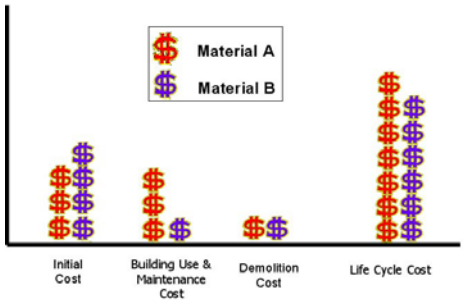
LIFE CYCLE ASSESSMENT (LCA) AND LIFE CYCLE COSTING (LCC) STUDY OF BUILDING MATERIALS AND COMPONENTS

(AGREEMENT NO. CB20020024)

FOR

THE HONG KONG HOUSING AUTHORITY





JULY 2005

BEC REF : C1169

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EXECUTIVE SUMMARY

BACKGROUND TO THE STUDY

In June 2002, Hong Kong Housing Authority (HA) commissioned a study on the combined *Life Cycle Assessment* (LCA)[1] and *Life Cycle Costing* (LCC)[2] of building materials and components. The purpose of the study is to develop, in HA's context and from a whole life point of view, an *integrated decision support tool* to help inform the procurement of environmentally conscious and cost effective alternatives. The outcomes of the study are:

- an in-house database and technical guidelines of HA's major building materials, taking into consideration LCA and LCC; and
- a procurement strategy and specifications for more environmentally friendly materials which are technically and economically viable.

Development of the tool was driven by HA's *Environmental Procurement Policies*, which seek to optimise resource and cost effectiveness in providing public housing, and the *Construction Industry Review Committee* January 2001 report (recommendation 90), which encourages major clients to take the lead in life cycle costing. The Business Environment Council leads the study with a core team of experts including Davis Langdon & Seah Management Ltd, Hong Kong University and DHV Buildings and the Environment.

APPROACH TO THE STUDY

The client brief stipulates that work be conducted in three stages:

- *Stage 1* – to devise, in the local context, a method to combine LCA and LCC indices of the various building materials and engineering provisions used by HA;
- *Stage 2* – to develop an LCA and LCC database model of the materials and components in a typical New Harmony 1 (Option 2) block (6/00 revision to 1/00 Edition) [3], rank the materials (in terms of consumption volume, environmental impact and money spent), and propose 'better'[4] alternatives for the top ten selected materials (focusing on architectural components) ; and
- *Stage 3* – to prepare technical specifications for the identified alternatives, develop a maintenance strategy for the database and technical guidelines, and recommend best maintenance practices to optimise LCC.

[1] *Life Cycle Assessment* (LCA) is an environmental evaluation tool in which all impacts arising from the manufacture, use and disposal of a product or service are quantified. These impacts include all extractions from (i.e. resources) and all emissions to (i.e. pollution) the environment throughout the whole life cycle. LCA allows the potential impacts posed to the environment and human health from different design alternatives to be assessed.

[2] *Life Cycle Costing* (LCC) is an economic evaluation tool in which all costs arising from creating, owning, operating, maintaining, and disposing of a project are quantified. LCC is particularly suited to the evaluation of alternative designs that satisfy a required performance level but have different investment, operating, maintenance, or repair costs and possibly life spans. LCC allows the trade off between capital and operating costs for different design alternatives to be compared.

[3] This provides the "model" building upon which the study scope is based. In line with current HA policies the model premises is assumed to be fully rental throughout its life cycle.

[4] 'better' means of no lesser technical performance which are locally available, but less environmental and affordable economic impact

THE FINAL REPORT

This report provides an account of the works undertaken in this assignment (Stage 1 to 3, inclusive) as detailed above and summarises findings of the study. The report is structured as follows :

- *Section 1 : Introduction*. An overview of HA's business divisions, with specific reference to their needs for a LCC/LCA decision making tool. Concise explanations of LCA and LCC practice, highlighting basic concepts, definitions, terminologies and general principles, with a view of developing a model suitable for HA are also given.
- *Section 2*: *The HKHA LCA/LCC Model Developed.* Detailed explanations of the overall approach and methodologies adopted for the LCA/LCC model developed. Highlights the architecture and functionality of the model and its sub-components (ie the quantum, cost and environmental impact and life cycle models). Also describes the sources and treatment of environmental, cost, quantum and operational data and formulation of functional units.
- *Section 3: Building Material Ranking* presents the methodologies and results of the ranking of building materials on the basis of cost, quantity, environmental impact and whole life profile. This section also provides a comparison with the findings of the HKHA EPP Report (May 2001) and a brief commentary of the overall results.
- *Sections 4: Alternatives Selection.* Explains the method used in identifying possible alternatives and highlights works undertaken to reach at the final set of alternatives examined. Following this is a detailed review of the alternatives proposed as well as their whole life profile when compared with the base building design.
- *Section 5: Recommended Way Forward for the LCA/LCC Decisions Making Tool.* Provides suggestion recommendations on the management and maintenance of the LCA/LCC Model as well as suggested responsibilities and organisational structures for the future operation of the model.
- *Section 6 : Findings and Conclusions.* Overall findings and conclusions from the assignment are provided along with a general review of the study.[5]

The findings from the study are summarised in the following sections.

REVIEW OF INTERNATIONAL PRACTICES AND TOOLS

The review of international practices and tools is described in *Section 1* and revealed limited adoption of LCA for buildings. This is attributed to: their long and unknown life expectancy (causing imprecise predictions for energy use, etc); their local and site specific impacts (seldom considered in LCA); their composition of many components (requiring much data); and their variable life cycle impacts (during construction, use and demolition).

Over 30 methods were however reviewed in terms of their applicability to this study. Whilst most exhibited commonalities (such as their construction, use and demolition life stages), none were considered appropriate for direct adoption. Key concerns were the lack of transparency and flexibility needed for the analysis of a unique building type: most are general and generic in their detail, limited to pre-set construction techniques and materials (e.g. for pitched roofs timber framed dwellings), and restricted to pre-selected outputs.

[5] The findings of the study was presented to HKHA's Building Committee on 16 December 2004. A copy of the information paper and presentation material used is provided in Appendix R for reference.

The review also included environmental data sets, of which there are no comprehensive sources for the Hong Kong region, to be adopted and adjusted for the HA model. This addressed various factors (accuracy, completeness, variability, representivity, repeatability, etc) and resulted in the selection of the SimaPro suite and its databases[6].

Finally, the environmental impact categories adopted by the HA LCA model (ten in number) were also identified during the review stage. These are: *acid rain* (kg SO_2 eq); *climate change* (tonnes CO_2 eq); e*nergy* (Megajoules, MJ); *photochemical smog* (kg C_2H_2 eq); *ozone depletion* (kg CFC-11 eq); *resource depletion* (kg SB); *toxicity to humans* (kg. 1,4-DB); *toxicity to ecosystems* (kg. 1,4-DB); *waste* (kg Waste); and *water consumption* (litre).

Findings from the review was applied in the HA LCA/LCC model described below.

THE HA LCA AND LCC DATABASE MODEL

The methodology for the LCA and LCC database model developed is described in *Section 2* of this report. The model consists of:

- The *Quantum Model*, which contains the type and quantity of every material used throughout the building's life (i.e. construction, operation, maintenance, repair, refurbishment, and demolition);
- the *LCA model*, which assigns an environmental impact to every material used throughout the building's life; and
- the *LCC model*, which assigns a cost of every material used throughout the building's life, in the context of its whole life costs.

The Quantum Model

The *Quantum Model* identifies the mass (kg) of each material used throughout the three key stages of the buildings life – construction, use and demolition. These quantities are used with the LCC and LCA models to establish the cost and environmental impacts of each material at each stage (including construction, building use and demolition) and, ultimately, of the whole building across all stages.

The *Quantum Model* groups the materials into *Functional Units* [7] so that they can be investigated in context. As such, data in the *Quantum Model* can be visualised in simple terms as follows (for illustration only):

"Type 1" Window	Mass
Aluminium	xx kg
Glass	yy kg

[6] The *processed data* from these sources will form the basis of the HA LCA/LCC Model, not the raw databases and SimaPro. Therefore these raw databases and SimaPro do not form part of the HA deliverable and their licensing by HA will not therefore be required.

[7] A functional unit is a group of materials which together constitute a component or system within the building, for example a cooking bench or a letter box. The model as developed for the New Harmony 1 block comprises 154 functional units from foundations through to building services installations.

Information included in the *Quantum Model* is illustrated in *Figure A.* It should be noted that:

- since no NH1 (Option 2) blocks were occupied at the time of this study, data on material use during occupation (e.g. for repair, maintenance, refurbishment, etc) is taken from similar block types (mainly existing Harmony 1 blocks and, for older premises, Trident and other cruciform shaped buildings);
- similarly, since no NH1 (Option 2) blocks have yet been demolished, data on material quantities is taken from similar blocks (construction data is available from several tenders);
- since a standard bill of quantities is not provided by HA for building services, data is instead being obtained from nominated sub-contractor tenders for NH1 (Option 2) blocks;
- material wastage is addressed through reference to data from the Architectural Services Department.

Figure A: The Quantum Model

STAGE 1: CONSTRUCTION

Material quantities (from *Bill of Quantities*, *Specifications*, etc) in:

Temporary works;
Foundations;
Superstructure;
Service Installations; and
Fixtures/Finishes; etc

STAGE 2: BUILDING USE

Material quantities from repair and maintenance (R&M) over 50 years (accounting for "*Churn Rates"** , etc) in:

Day-to-day R&M;
Planned R&M and;
Emergency R&M, etc

AND, energy consumption in public and private areas (from the *Operational Energy Model*)

STAGE 3: DEMOLITION

Includes the material quantified in the *Construction* and *Use* stages, and also accounts for:

the extent of material recovery;
quantities disposed of at public fill;
quantities disposed of landfill;
temporary works for demolition; etc

Changes in the type and quantity of individual materials and functional units in the *Quantum Model* allow the cost and environmental impacts of alternatives to be compared using the LCC and LCA models.

Associated with the *Quantum Model* is the *Operational Energy Model (OEM)* [8] , which quantifies energy use (in kWh) in public and private areas. Energy data from the *OEM* can be used by the LCA and LCC models to gauge the cost and environmental impacts of changes, helping to compare, for example, the increased cost and embodied energy of thermal insulation with the associated cost and energy savings throughout the building's lifetime.

* Churn rate is an estimated allowance to cover the rate at which typically occupants within a building will change. This information is both necessary and important as part of the overall establishment of the rate of refurbishment and renewal within the premises. In terms of the whole life profile, this would have obvious cost implications from the associated refurbishment and maintenance works.

The LCA Model

LCA addresses the "cradle to grave" environmental impacts of a material or product over its whole life span, starting from raw material extraction, transport to factory and

[8] The *Operational Energy Model* is based upon the DOE3 computer modelling tool and published data from the Electrical and Mechanical Services Department, actual utility bills and HA data. Where alternative materials that are known not to affect operational energy are to be considered (e.g. changing one tile for another) the *Operational Energy Model* need not be rerun since the base data will remain valid.

processing, through its manufacture and transport to point of use, and its use and ultimate disposal. The LCA of each material for this study follows the principles set out in the ISO14040 series of standards.

As mentioned previously, there are at present no comprehensive data sets of environmental information relating to product manufacture, use and disposal for the Hong Kong region. As a consequence, international data has been sourced and analysed to provide a basis for the HA LCA model. Preparation of the environmental data associated with each individual material for use in the HA model, illustrated in *Figure B*, consists of the following steps:

- **regionalisation** – the adjustment of overseas "cradle to factory gate" environmental data to ensure their applicability in the local context. This takes into account factors such as the type, source and extraction of raw materials, the energy mix and method of power generation used in the processing, the production processes themselves, and transportation modes and distances, etc[9];
- **characterization** – the classification of the many different impacts associated with a substance into the ten selected impact categories, using common units to provide more manageable and informative environmental information: *acid rain*; *climate change*; e*nergy*; *photochemical smog*; *ozone depletion*; *resource depletion*; *toxicity to humans and ecosystems*; *waste* and *water consumption* (m^3);
- **normalisation** – the comparison of regionalised and characterised data to a notional regional average to allow different environmental impacts to be compared and investigated under a common basis (nominal *Hong Kong Eco-Points (HKEP)*, representing the environmental impacts associated with the average Hong Kong person[10],, have been adopted for this study; and
- **weighting** – assigning the relative importance of each category to arrive at a single environmental indicator. This weighting process has been based upon the consensus achieved from a series of weighting workshops conducted for the study in December 2002 to solicit the views of delegates from HA, other government departments, tenant and community groups, contractors, suppliers and other building professionals. The workshops also provided information for the comparison of environmental impacts with costs.

The LCA model applies weighted *Hong Kong Eco-Points* for each material to the quantities in the *Quantum Model* to establish the impacts, at each stage of the building's life, of each material and functional unit (or indeed of the building as a whole). Materials / Functional Units can be changed to alternative quantities or types for comparison.

Since environmental data is not yet available for the Hong Kong region, and the factors affecting this data (e.g. production processes, etc) tend to change slowly with time, it is recommended that data in the LCA model is updated once every five years.

[9] The regionalisation process has for example included a detailed study of the transport modes and distances of materials used in the model NH1 (Option 2) block with reference to information from *Material Approval Forms*, etc. Two workshops have also been held at which selected HA suppliers have provided information on the origins and production processes associated with their materials and products.

[10] ie 1Eco-point sets to be equivalent to the typical impacts caused by a HK citizen in a year.

The LCC Model

LCC addresses the financial implications of an asset over its whole life span, starting from the capital expenditure in creating the building, through its operation and maintenance, and finally its end of life demolition. *Figure B* overleaf illustrates the key costs included in the HA model to provide the necessary context and aid interpretation.

Figure B: The HA LCA and LCC Models

INITIAL IMPACTS

Impacts (in terms of HKEP) of all Materials / Functional Units used in construction (from Quantum Model)

IMPACTS IN USE

Environmental Impacts (in terms of HKEP) of all Materials / Functional Units used for replacement during the building's operation and maintenance (from the Quantum Model)

PLUS, the Environmental Impacts (in terms of HKEP) arising from energy consumption in public and private areas (from the Operational Energy Model)

END OF LIFE IMPACTS

Environmental Impacts (in terms of HKEP) of all Materials / Functional Units recovered, sent to public fill or landfill (from the Quantum Model)

INITIAL COSTS

Material / Functional Unit costs, plus; Site Formation, Foundations, Main & Direct Contracts; Professional Fees; Connection Charges; etc

COSTS IN USE

Material replacement costs, plus; Repair, Maintenance, Refurbishment, Building Mgt / Cleansing costs; etc PLUS, the costs arising from energy consumption in public and private areas (from the Operational Energy Model)

END OF LIFE COSTS

the value of materials recovered; and the demolition contract cost (includes all associated costs such as materials removal, transportation, the cost of public filling; the cost of landfill disposal; etc)*

LIFE CYCLE IMPACT (Hong Kong Eco-Points)

LCA of any material, functional unit, or the building as a whole at any or all stages of building life:

- Can track the environmental impact of any single change (e.g. Type 1 to Type 2 window)
- Can compare the impacts of such a change to the associated costs from the LCC Model

LIFE CYCLE COST ($$$)

LCC of any material, functional unit, or the building as a whole at any or all stages of building life:

- Can track the cost of any single change (e.g. Type 1 to Type 2 window)
- Can compare the costs of such a change to the associated impacts from the LCA model

***** Currently, it is impractical to itemise costs such as materials removal, transportation and landfill charges associated with building demolition within the LCC model. However, the model is designed in such a way to allow incorporation of these cost data into the LCC database, once such information becomes available or practical for use in future.

It should be noted that:

- although there is no universal standard for LCC, most nations adopt similar guidelines. The approach for this study is aligned with that being developed for the *Environment, Transport and Works Bureau* by DLSM;
- the HA model excludes income from building use (since the building studied is a rental premises) and land values (since the model is not site specific and HA has traditionally been allocated land by government) [11];
- since no NH1 (Option 2) blocks were occupied or demolished at the time of this study, data on costs during building use and demolition is taken from similar block types. Construction data for NH1 (Option 2) blocks is however available (from several tenders).

In terms of the materials, the LCC cost model applies unit prices (i.e. per kg) to the *Quantum Model* to establish the purchase costs, at each stage of the building's life, of each material and functional unit (or indeed of the building as a whole). Materials / Functional Units can be changed to alternative quantities or types for comparison.

Costs will be presented in terms of costs at current levels (i.e. the cost of performing all works at the base date, ignoring value of money adjustments and inflation), and future costs discounted back to the Net Present Value (NPV, to establish how much money is really required to construct and maintain the building over its whole life). Such adjustments are made at the end the LCC process to allow the checking and comparison of results. Since costs (e.g. of construction and maintenance contracts, materials, utilities, etc) change often, the cost database should be frequently updated (every quarter).

Generation of Life Cycle Environmental and Cost Data

Using the approaches described above, the Quantum Model, LCA Model and LCC Model can provide data on the type, quantity, cost and environmental impacts (either as individual impact categories such as acid rain, climate change, etc, or as combined *Hong Kong Eco-Points*) for each and every material used in the building. This information can be accessible in terms of each individual material or as appropriate functional units (e.g. precast elements, windows, etc), at each or all three stages of the building's life. Conceptually, the data in the model can be visualised as follows (for illustration only).

	Construction			**Building Use**			**De-Construction**		
Type 1 Window	**Mass**	**Cost**	**Impact**	**Mass**	**Cost**	**Impact**	**Mass**	**Cost**	**Impact**
Aluminium	kg	$	EP	kg	$	EP	kg	$	EP
Glass	kg	$	EP	kg	$	EP	kg	$	EP
Etc									

[11] All aspects of revenue generated from the occupation of the building as well as the residual value of the site upon demolition should be accounted for in a complete LCC evaluation. Notwithstanding this normal complete approach, in the case of HKHA's rental premises, the revenue streams would not normally be included within the scope of the LCC calculation. This is because for these buildings, the asset ultimately remains with HA and this approach is also in line with usual government practice when dealing with private sector buildings.

LCA/LCC COMPUTER SOFTWARE DEVELOPED

In practice, based upon the methodologies and approaches described above, a purpose designed computer programme was developed for processing the information and to yield results from the LCA and LCC models.[12] As illustrated in *Figure C* overleaf, the computer software can be thought of as four separate but interrelated sub-models, with each sub-model reflecting different functionality, data and data flows within the model. A brief description of the functionality and evaluation principles of each module is given in the following sections.

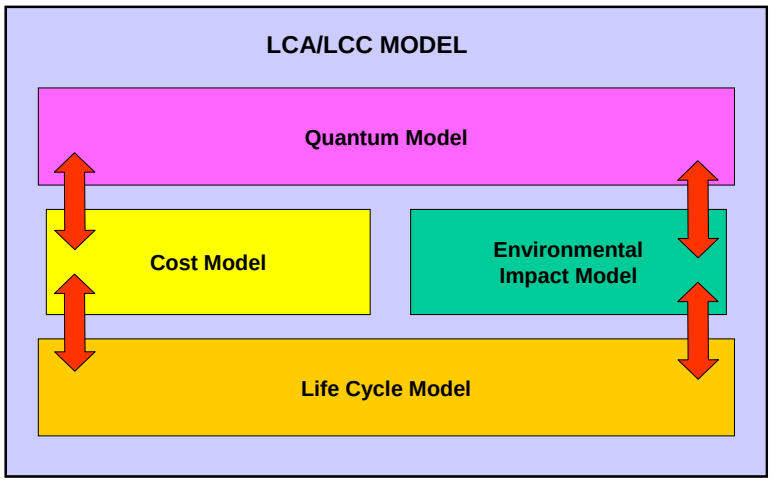


Figure C : Modular Structure of the LCA/LCC Computer Model.

Quantum Model

Arguably this is the most important sub-model since the quantum of the materials contained in each of the functional units drives the overall model.

Initial Impact: Generates initial quantities of materials. Retrieves the quantities from the quantum database for a specified material (in kg) and multiplies them by the functional unit data. The generated quantities are then multiplied by the environmental impact data to give overall results. The generated total quantities for a particular functional unit are then multiplied by the environmental impact data for the associated materials to give *Hong Kong Eco-Points* for the initial stage.

Repair & Maintenance: Takes results from the initial impact module for a particular functional unit and multiplies them by the input replacement factors and the inputted maintenance factors to generate annual results.

Operation : Operational energy data are sourced from utility bills and the Operational Energy Model's computerised simulation[13] and is used to calculate :

- Power consumption of the building in kWh
- Gas consumption of the building in m^3
- Water consumption of the building in m^3

[12] For full operation and maintenance details of the LCA/LCC software, refer to the *Life Cycle Console Software User/Maintenance Manual*

[13] Eight possible building orientations are included in the computerised simulation.

End of Life : Contains algorithms to calculate demolition and removal impact of the building. Through this process, the model establishes the quantum of the waste material at end of life as well as the recycled content of each material.

Cost Model

All the cost information entered into the model is processed in this sub-model and contains algorithms to:

- Calculate the capital cost for each functional unit and for the quantum of each functional unit in the building
- Generate a whole life profile
- Calculate annual cost impacts of repair and maintenance

In order to simplify data processing, "all-in"[14] rates / kg are used in the model.

Environmental Impact Model

For the sake of simplicity, consistency, security and to minimise processing time, the environmental impact data contained in the database is only in a normalised format. All previous process calculations are carried out outside the model.

The model contains algorithms for calculating *Hong Kong Eco-Points*. Simply, this involves taking weighting factors and applying them to the normalised data for each of the ten environmental impacts.

Sets of default weighting factors have been established and are contained in the database, for each of the environmental impacts. These weightings are based upon local, regional and global views and were obtained during the stakeholder workshops described in *Section 2*.

Life Cycle Model

Given known quantities of the functional units that make up the building, the model calculates the environmental impact of the building over its whole life. It merges embodied and operational environmental impact values into a total environmental value for each functional unit to create a whole life annual profile based upon the *Hong Kong Eco-Points* generated.

The model also contains algorithms for calculating the whole life cost of the building. Taking into account of the building's lifetime, the whole life costs are represented in the same format.

THE COMBINED LCA/LCC DECISION MAKING TOOL

In the LCA/LCC software, the types and quantities of materials and/or functional units in the Quantum Model, and their costs in the LCC model, can be changed to investigate the resultant cost and environmental impacts of alternative materials/systems for comparison.

The methodology to investigate/reconcile the LCA and LCC assessments is illustrated in *Figure D* and forms an integral part of the software report output. The methodology expresses proposed specification changes as a percentage of the overall building costs and the normalised environmental impacts. In this way one can compare the significance of a

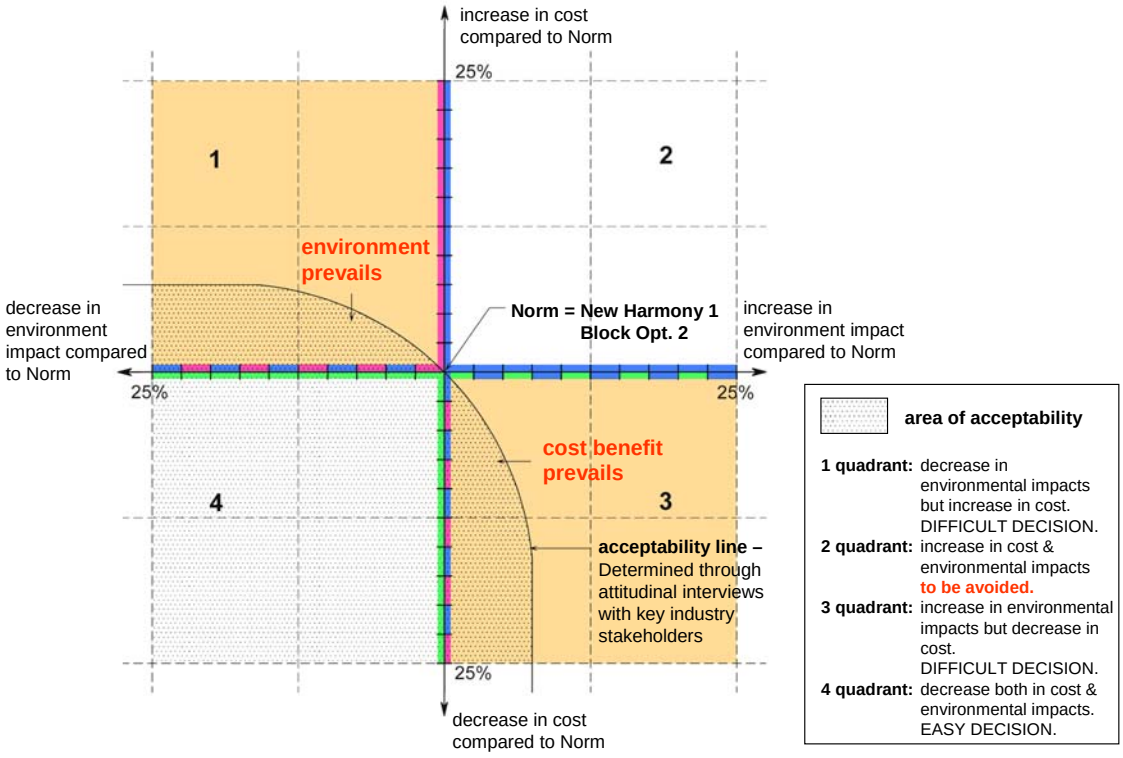
[14] "All-in" rates are those rates which incorporate an allowance for labour, plant, materials, overheads, profit and preliminaries.

proposed specification change in terms of its percentage environmental deterioration or improvement to the percentage change in cost.

The acceptability curves have been established by undertaking attitudinal interviews with key industry stakeholders in a series of workshops as discussed in *Section 2*. These acceptability curves represent the boundaries of what the workshop participants, considered to be acceptable. Once percentage change figures are generated, a simple decision making framework can then be put into practice where for example it is suggested that all alternatives that fall between the respective acceptability curves and the X (environmental impact) and Y (cost) axes in Quadrant 1, Quadrant 3 as well as those fall into Quadrant 4 are deemed to be satisfactory.

Currently the LCA/LCC model generates the base impact of the New Harmony 1 block design and therefore represents the centre point of the "cross-hair" chart (refer to illustration in *Figure D*). As alternative options are run the overall answer changes. These changes are represented as a revised numerical outcome. In order that the relative changes in environmental and cost impact can be measured, the difference between the base results and the revised outcome are expressed as a percentage difference and plotted on the "cross hairs". This percentage therefore shows how much more or less impact the alternative has when compared back against the base design. The newly plotted point represents therefore the impact of the revised design in the context of the complete building. In other words, the further this point is away from the centre of the cross hairs, the greater the percentage impact, either positive or negative, the proposed change has had. All alternatives which fall within the acceptability curve illustrated below is deemed to be a satisfactory option.

Figure D Combining LCA Environmental Impacts with LCC Price Mechanisms: The Decision Making Tool



BUILDING MATERIAL RANKINGS

Based upon application of the computerised LCA/LCC software developed, the whole life top ten rankings of the functional units used in the New Harmony 1 (Option 2) block in terms of cost and environmental impact are :

Table A : Top Ten LCA and LCC Ranking Functional Units in a New Harmony 1 (Option 2) Block

	Life Cycle Cost Impact	**Life Cycle Environmental Impact**
1	RC Slabs – Fairfaced	Precast Facades – Type 1
2	RC Walls – Fairfaced	RC Walls – Fairfaced
3	Wall Finishes – Internal Flat Areas	Precast Facades – Type 2
4	Floor Finishes – Kitchens and Bathrooms	RC Slabs - Fairfaced
5	Piles	RC Water Tanks
6	Small Power Installation – Flats	Aluminium Windows – Bedrooms
7	Panel Walls – Internal	RC Walls – Generally
8	Fresh Water System - Distribution	Aluminium Windows – Living Area
9	Lighting Installation – Flats	Piles
10	Internal Waterproofing	Mains & Distribution

On the whole architectural items, whilst significant, are generally less dominant than the structure and building services items in cost terms. Similarly, structural elements dominate in environmental terms since their impact is driven largely by the substantial mass of the material they contain.

The top ten ranking of the functional units based upon their predicted usage throughout whole life of the New Harmony 1 (Option 2) block in terms of a combined cost and environmental impact[15] are :

1. Precast Facades – Type 1
2. RC Walls – Fairfaced
3. RC Slabs – Fairfaced
4. Precast Facade – Type 2
5. Wall Finishes – Internal Flat Areas
6. Piles
7. Small Power Installation – Flats
8. Floor Finishes – Kitchen and Bathrooms
9. Aluminium Windows – Bedrooms
10. Aluminium Windows – Living Area

Again these results highlight the dominance of structure and building services items in the context of the complete building.

[15] The combined LCA/LCC ranking of the functional units is based upon summing LCA and LCC ratios (to the whole building) as given by the formula below :

$$\text{Combined LCA/LCC indices} = \left\{ \frac{\text{LCA of functional unit}}{\text{LCA of whole building}} + \frac{\text{LCC of functional unit}}{\text{LCC of whole building}} \right\} / 2 \times 100\%$$

There is no weighting of the LCC and LCA at this stage because this would lead to distortions and misrepresentation of the results, therefore this method is simply used to establish a numerical ranking. The decision making tool should be used to establish the trade-off between competing environmental and economic considerations.

PROPOSED ALTERNATIVE MATERIALS/DESIGNS

Since the focus of this study is architectural materials, the top ten ranking architectural functional units on a combined whole life basis were extracted and alternatives were identified [16]. With application of the LCA/LCC model, the life cycle environmental and economical benefits of these alternatives were evaluated (refer to Section *4.3* for detailed LCA/LCC evaluations and illustrations) and these are summarised in *Table B* overleaf, with practical considerations for adopting these proposed alternative designs/products.

Based on adoption of all proposed alternatives which fall within the acceptance curve in *Table B*, a predicted combined reduction of life cycle environmental impacts of 0.26 % (in the context of the whole building) could be produced, and coupled with this would be a potential life cycle cost saving of 0.98 % (in the context of the whole building).[17] Alternatively, based upon purely financial considerations, it could be possible to achieve a 1.33 % economic benefit but this would have an increased adverse environmental impact of 0.90 % (again in terms of the entire building over its life cycle).[18] Similarly from a purely environmental point of view the best case would be a 1.03 % reduction with a 0.30 % increase in whole life cost[19].

[16] Due to the nature of the building and the degree of refinement which has already been carried out on the design (from the original design version of the Harmony 1 block range) over the last 10 years, the scope for improvement is limited. This is not to say that the building is perfect, but that the opportunities for making enhancements without diminishing the functionality and quality of the building are very limited. Therefore, the alternatives proposed are more cosmetic in nature rather than radical revisions.

[17] This is based upon adoption of Alternatives 4, 5, 6, 7, 8, 9 and 11, listed in *Table B*.

[18] This is based upon adoption of Alternatives 4, 5, 6, 7, 8, 10 and 11, listed in *Table B*.

[19] This is based upon adoption of Alternatives 1, 4, 5, 6, 7, 8, 9 and 11, listed in *Table B.*

Table B Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
1. Aluminium Windows – Bedrooms	UPVC Window	0.78 %	- 1.28 %	N	Widespread adoption of UPVC windows by HKHA should result in cost reduction for this alternative and with short term (5 years) global trend for aluminium cost escalation, financial burden may be further lowered. ***This is considered as a "dubious" alternative since although there is environmental benefits to be gained through its adoption, life cycle expenditures would cost more than the original design. The shape of the acceptance curve (subject to constant review) would be the critical factor in deciding its adoption.***
2. Internal Precast Panel Walls	Within flat wall systems to comprise of gypsum board (12.7mm thick) on either side of a metal framework. For inter-flat partitions, use a double layer system with central void filled with insulation material.	-0.25 %	-0.16 %	N	Potential economical benefits for gypsum dry wall system if volume of demand increases – up to 30% reduction (in capital cost) for private sector. Other benefit include better (smoother) finishing, potential installation of building services items, enhanced safety and better on site storage. Potential environmental benefit by refining panel thickness to accurately match required function. ***This is considered as a non viable alternative since neither environmental or cost saving benefits could be gained through the adoption of this alternative.***
3. Cooking Unit/Bench (Prefabricated concrete with stainless steel cladding)	Timber framed plastic laminated plywood faced unit with a stainless steel covering on the counter top.	- 0.25 %	- 0.80 %	N	Perceived benefits not achieved but offer a better quality product with enhanced durability. ***This is considered as a non viable alternative since neither environmental or cost saving benefits could be gained through the adoption of this alternative.***
4. Floor Washing Pipework [1](Galvanised steel pipe with UPVC lining)	Standard PVC pipes (similar to products used for fire services and flushing systems)	0.00 %	0.02 %	Y	Reduce dependence of HKHA on a unique piping system for floor washing. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***
5. Flat Entrance Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating and plywood facing)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied	0.01 %	0.18 %	Y	Alternative design is of at least equal performance to origin and should lead to reduced replacement rates. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***

[1] This alternative was investigated (though not ranked amongst the top 10 architectural materials with the most LCA, LCC impacts) because it was particular interest to HA.

Table B Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
6. Kitchen Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating, plywood facing and Georgian wired glass window)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied.	0.02 %	0.06 %	Y	Insignificant financial benefit in adopting doorset systems – should consider separate doors and frames since current rate of churn means little advantage for using exceptionally durable systems. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***
7. Floor Finishes – Kitchen and Bathroom (cold applied waterproofing system overlaid with 40 mm thick screed, with homogenous tiles bedded on mortar backing).	Reduce overall thickness of screed to 25 mm.	0.05 %	0.41 %	Y	Based upon HKHA's current repair and maintenance cycle and quality control measures, performance deterioration should not be an issue. Significant cost and environmental benefits are attributable to reduction in recurring maintenance works with noticeable savings in terms of screed consumption. ***There are both life cycle environmental and cost benefits to be gained through the adoption of this design modification. However, it is considered as a "dubious" alternative since there are concerns regarding its practical application for HA projects and further investigative works which is beyond the scope of this study would be required..***
8. Floor Finishes – Corridors and Lobbies (40mm thick screed with homogenous tiles bedded on mortar backing)	Reduce screed thickness to 25 mm	0.02 %	0.11 %	Y	Based upon HKHA's current repair and maintenance cycle and quality control measures, performance deterioration should not be an issue. ***There are both life cycle environmental and cost benefits to be gained through the adoption of this design modification. However, it is considered as a "dubious" alternative since there are concerns regarding its practical application for HA projects and further investigative works which is beyond the scope of this study would be required..***
9. Bathroom Doorsets (for larger flats : 46.3 mm hollow cored timber doorsets with plastic laminate plywood facing and for smaller flats : plastic folding partition)	Plastic folding door for all flats	0.10 %	-0.01 %	Y	Although the alternative design currently has a slightly higher whole life cost, with increased demand from HKHA projects, cost reductions should yield. Although, there is a difference in terms of appearance – the alternative does not compromise functionality of the original doorset. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***

Table B Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
10. Fresh Water Pipework [2](Galvanised steel pipe with UPVC lining)	Copper piping	-1.05 %	0.34 %	N	With reference to the acceptance curve, although there is whole life cycle cost savings, this alternative should not be acceptable on the basis additional life cycle environmental burden. Alternatives were still investigated because they were of HD's particular interest. ***This is considered as a "dubious" alternative since although there is potential life cycle cost savings to be gained through its adoption, life cycle environmental impacts would be more adverse in comparison to the original design. The shape of the acceptance curve (subject to constant review) would be the critical factor in deciding its adoption.***
11. Lift Lobby Wall Finishes (tiles)	Acrylic Paint	0.05%	0.21%	Y	This proposal appears to offer benefits in both cost and environment, although the question of durability and overall quality of completed building would require careful consideration. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***

[2] This alternative was investigated (though not ranked amongst the top 10 architectural materials with the most LCA, LCC impacts) because it was particular interest to HA.

RECOMMENDED WAY FORWARD FOR HKHA LCA/LCC MODEL

In order to maintain integrity of the model and ensure that the information and data contained are current, it is recommended the following updating regime is adopted :

Model Component	Updating Frequency
1. Repair and Operational Cost Data	Annually or every time term contract rates are reviewed
2. Quantum Data	
• Initial	as design changes
• Repair & Maintenance	After 5 – 10 years of use
• Operation	After 5 – 10 years of use
3. Environmental Impact Data	Every 5 years

It is proposed that the following parties be responsible for the above updating/maintenance process :

Task	Responsible Party
1. Maintaining Cost Data	*CQS* for initial building cost (builder's works) *CBSE* for initial building cost (B.S. works) *EMD* for repair & maintenance cost
2. New Quantities – Initial	CQS for builder's works CBSE for B.S. works
3. New Quantities – R+M	SMS/TNS
4. New Quantities – Operational	Externally sourced [1]
5. New Environmental Impact Data	Externally sourced

In summary, therefore this study has provided the methodology and framework within which HKHA can develop and examine alternative materials and design options. However, the current limitation to a single block type, which has yet to be fully developed, renders the model of only limited value at present. In view of this, it is recommended that HKHA look to expand the model database to cover more buildings within their portfolio so that more assessments and comparisons can be considered.

[1] As previously explained, operational data required for updating the LCA/LCC databases needs to sourced from market surveys and consumption records in tenant areas from utility companies and HA's building services section does not have the resources to obtain such information. However, the EMD may be able to provide operational data for the public areas.

1. INTRODUCTION

1.1 OBJECTIVES OF THE ASSIGNMENT

The Hong Kong Housing Authority's (HA) published *Environmental Procurement Policies* (EPP) seek to minimise the use of natural resources and achieve cost effectiveness in the production and provision of public housing. In order to pursue these goals, key recommendations in the EPP include:

- the identification of the significant environmental impacts of materials in use; and
- the purchase of materials which have lower environmental impact, if both technically acceptable and cost effective throughout their whole life span.

In response to these recommendations, the Business Environment Council (BEC) was commissioned in June 2002 to undertake a combined Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) study of building materials and components (including their subsystems as appropriate) to pursue more environment friendly and economically viable alternatives. BEC is assisted in this study by a core team of experts from Davis Langdon & Seah Management Ltd (DLSM), Hong Kong University Department of Architecture (HKU), and DHV Buildings and the Environment (DHV). Further expert assistance in this study has been provided by WSP Asia Ltd (WSP).

The main goal of the study has been to develop, in HA's context, an integrated decision support tool that will aid the selection and procurement of building products and components in an environmentally responsible and cost efficient manner from a whole life cycle point of view[1]. The stated outcomes of this assignment are as follows:

- An in-house database and technical product guidelines of major building materials used by HA, taking into consideration Life Cycle Assessment and Life Cycle Costing; and
- Recommended procurement strategy and specification of more environmentally friendly building material alternatives, which are technically and economically viable.

The definitions of *Life Cycle Assessment* and *Life Cycle Costing* being adopted for the purposes of this assignment are as follows:

- *Life Cycle Assessment* (LCA) is an environmental evaluation tool in which all impacts arising from the manufacture, use and disposal of a product or service are quantified. These impacts include all extractions from (i.e. resources) and all emissions to (i.e. pollution) the environment throughout the whole life cycle. LCA allows the potential impacts posed to the environment and human health from different design alternatives to be assessed and quantified.
- *Life Cycle Costing* (LCC) is an economic evaluation tool in which all costs arising from creating, owning, operating, maintaining, and disposing of an asset are quantified. LCC is particularly suited to the evaluation of alternative designs that equally satisfy a required performance level but have different investment, operating, maintenance, or repair cost profiles as well as life spans. LCC allows the trade off between capital and recurring costs for different design alternatives to be compared.

[1] In terms of exact scope for the study, whilst the LCC\LCA decision making developed would be capable of investigating of all aspects of the typical new Harmony 1 block, it was intended that model specifications will only created to address the top ten architectural materials/functional unit.

1.2 PROJECT DELIVERABLES FOR THE ASSIGNMENT

To achieve the objectives of the assignment, a three-stage approach has been adopted with the following actions and project deliverables:

1.2.1 Stage 1 – Devise the LCA/LCC Methodology

- Familiarisation with HA's business structure and understanding the needs of the various disciplines and the three business divisions (namely *Development & Construction Division*, *Estate Management Division* and *Allocation and Commercial Division)* in respect of the study.
- Devise a methodology to combine LCA indices and LCC price mechanisms with suitable weighting of the various building materials (including their sub-systems as appropriate) in HA's consumption. Review of Overseas LCA and LCC models for consideration and adjustment to *HA and local context***.** Liaison with the local construction industry, environmental experts, materials suppliers/manufacturers and other relevant parties within and outside HA to seek their views and feedback.

1.2.2 Stage 2 – Apply the LCA/LCC Tool and Identify Improvements

- Review and follow-up the environmental risk scores of the initial list of materials included in but not limited to the May 2001 EPP Report;
- Comprehensively review a typical standard HA domestic block, i.e. New Harmony 1 (Option 2) block (6/00 revision to 1/00 Edition)[2] and thoroughly scan through building materials/components (including structural, architectural and building services elements), and prioritise major items according to *consumption volume, environmental impact and money spent,* with reference to the combined LCA/LCC methodology developed;
- Prepare a LCA cum LCC database (compatible with HA's in-house web-based Environmental Information System, ENVIS) and technical product guidelines that give best practices for environmental assessment for the building materials studied;
- Apply the strategy to rank the building materials according to their relative merits in LCA/LCC context; and
- identify opportunities for enhancing the environmental friendliness and cost effectiveness of these materials, to propose "better" alternatives[3] for the *top 10* selected materials (focusing on architectural components) with the most significant consumption, environmental and economic impact.

1.2.3 Stage 3 – Devise the LCA/LCC Implementation Strategy

- Prepare technical specifications, in line with HA's existing Specification Library structure and format, for the identified material alternatives which are available in the local market and appropriate for HA's use;
- Propose a practical strategy to regularly maintain and update the database/technical guidelines outlined; and
- Recommend best maintenance practices for the optimisation of LCC.

[2] This provides the "model" building upon which the study scope is based. In line with current HA policies the model premises is assumed to be fully rental throughout its life cycle.

[3] 'better' means of no lesser technical performance which are locally available, but less environmental and affordable economic impact

1.3 PURPOSE AND STRUCTURE OF THE FINAL REPORT

The purpose of this report is to provide an account of the works undertaken in this assignment (Stage 1 to 3, inclusive) as detailed above. The remainder of this report is structured as follows :

- *Section 1 : Introduction*. An overview of HA's business divisions, with specific reference to their needs for a LCC/LCA decision making tool in light of initiatives currently adopted. Concise explanations of LCA and LCC practice, highlighting basic concepts, definitions, terminologies and general principles, and descriptions of the reviews undertaken of international tools, with a view of developing a model suitable for HA. Finally, an evaluation of the critical issues considered (in the HA context) in the development of the LCA/LCC model.
- *Section 2*: *The HKHA LCA/LCC Model Developed.* Detailed explanations of the overall approach and methodologies adopted for the LCA/LCC model developed, along with a description of the software database framework, highlighting the architecture and functionality of the overall model and its sub-components (i.e. the quantum, cost, environmental impact and life cycle models). An explanation of the major sources and treatment of data used in the model, including the formulation of *functional units*, regionalisation/characterization/normalization/weighting of environmental data, and the collection and a review of the cost, quantum and operational data used is also given. The integration of LCC and LCA as a decision making tool for the selection of better alterative building materials is briefly explained as well as an illustrative example of how to generate LCC and LCA indices from the raw data is also provided as an accompanying appendix. Finally a brief summary of the limitations and assumptions used in the development of the model are set out at the end of this section.
- *Section 3: Building Material Ranking* presents the methodologies and results of the ranking of building materials on the basis of cost, quantity, environmental impact and whole life profile. This section also provides a comparison with the findings of the HKHA EPP Report (May 2001) and a brief commentary of the overall results.
- *Sections 4: Alternatives Selection. E*xplains the method used in identifying possible alternatives and highlights works undertaken to reach at the final set of alternatives examined. Following this is a detailed review of the alternatives proposed as well as their whole life profile when compared with the base building design. The detailed technical specifications developed for the proposed alternatives are also explained in this section.
- *Section 5: Recommended Way Forward for the LCA/LCC Decisions Making Tool.* Provides suggestion recommendations on the management and maintenance of the LCA/LCC Model as well as suggested responsibilities and organisational structures for the future operation of the model. Details of the other documentation prepared under this study is also provided which includes the promotion of the tool within the HA and associated practice manuals. Potential applications of the LCA/LCC model and decision making tool developed are also highlighted.
- *Section 6 : Findings and Conclusions.* Overall findings and conclusions from the assignment are provided along with a general review of the study.

1.4 OVERVIEW OF HA ACTIVITIES AND NEED FOR GREEN PROCUREMENT

Operational and business activities involving building materials procurement within HA principally come under the responsibilities of the three business divisions, namely, the *Development & Construction Division*, *Allocation and Commercial Division* and the *Estate Management Division.*

1.4.1 Development and Construction Division – Development and Procurement Subdivision

The responsibilities of the *Development and Procurement Sub-Division* include planning, coordinating, implementing and controlling development programmes of new works projects within HA. These projects consist of rental housing, the home ownership scheme and providing technical advisory services for *Private Sector Participation Scheme* commercial and carpark projects. In addition, the sub-division is effectively the "think tank" of the *Development & Construction Division*, and is responsible for the establishment of strategies and standards for new projects, in line with HA policies set by the Director of Housing. In this respect, their core areas of activities include formulating and implementing building policies, strategies and standards, coordinating and monitoring the development of standard designs and implementing research programmes on building components and materials for new developments.

In terms of building materials procurement standards and strategies, the following sections provide input within the *Development & Construction Division*:

- *Architectural Section (Design & Standard)* – responsible for design and standards, research and development of materials specifications that are implemented by the projects sub-divisions for the construction of new HA developments. The responsibilities of the section also include the management of feedback for design and construction issues from new works and operational issues from the *Estate Management Division*, and accordingly devise appropriate remedial action and future strategic solutions if required. The *Architectural Section (Design & Standard)* also provides professional advice and technical support on architectural matters to other sections and divisions within HA on an ad hoc basis.
- *Structural Engineering Section* – services principally consist of materials testing, calibration and structural standard designs. The section also provides structural/technical support for legislative advice, establishment of standards and structural material research.
- *Building Services Section* – provides advice and technical support on building services, including legislation and ordinances, standards, material research, building services standard designs, development and maintenance.
- *Quantity Surveying Section, Construction Services* – responsible for standard bills of quantities for standard blocks, compilation of cost yardsticks and tender price indices, contract advisory services, capital budgets compilation and monitoring, and quantity surveying consultant management on New Works projects.

1.4.2 Estate Management Division

The principal responsibilities of the *Estate Management Division* include the development and implementation of maintenance policies, strategies and standards for rental premises and providing maintenance services to other divisions within HA. In light of introducing

alternative building materials, the *Estate Management Division* has a significant role to play in terms of ensuring the subsequent maintenance and improvement works regimes are both environmentally sound and cost effective.

1.4.3 Allocation and Commercial Division

The prime responsibilities of the *Allocation and Commercial Division* are to designate rental tenants to respective Housing Estates and thus with respect to this assignment, their role in the selection of building materials is limited although they provide valuable feedback on performance and other issues.

Currently, the *Allocation and Commercial Division* is responsible for the operations and implementation of two schemes that will have an impact on the overall life cycle costing of building materials, the *Tenants Purchase Scheme* (TPS) and the *Home Ownership Scheme* (HOS). The maintenances cost of these properties is borne by the owners subsequent to their sale and thus their LCC profile would be significantly different in comparison to rental premises. However, based upon HA's current policies, there are no plans to make any of these schemes available to the model building for this assignment, i.e. New Harmony 1 (Option 2) Block, and thus the *Allocation and Commercial Division* would only have a role to play in this respect when there is a relevant change in these directives.

One potential contribution of the *Allocation and Commercial Division* to the assignment is in the promotion of the final project outputs and education of the general public of HA's achievements and commitments in terms of selecting building materials which are both environment friendly and economically beneficial.

1.4.4 Current Environmental Initiatives for Building Materials Procurement

In line with the recommendations of the *Environmental Procurement Policy (EPP) Report (May 2001)*, a number of environmental initiatives for building products procurement have been adopted by the three Business Divisions and these are summarised below. [4]

Environmental procurement action plans and "green" building materials selection initiatives currently adopted by the *Development and Construction Division* include:

- *Materials and Products* – The use of prefabricated elements (e.g. facades, bay windows, bathrooms and kitchens), recycled materials (e.g. pulverised fuel ash as filling materials in concrete and recycled plastics for landscape furniture) and steel formwork (for columns and wall partitions) are either being implemented for existing projects or incorporated into the design of future works. In addition, a list of building products which is thought to be most environmentally and financially significant to the *Estate Management Division's* operations has been compiled. For each product, information related to their environmental impacts, expenditure, consumption volume and maintainability will be sourced and monitored.
- *Services and Processes* – Development of standard environmental contractual and specification requirements such as an Environmental Management Plan (EMP), and devising a '*Pay for the Environment*' scheme for contractors. The *Development and Construction Division* also intends to identify and categorise contractors and services that pose an environmental risk from a HA point of view.

[4] Information associated with these environmental initiatives was sourced from "*Environmental Procurement Policy Action Plan, 14 January* 2002" and "*Summary of Initiatives being Implemented in Trial or Pilot Projects (as at May 2002) – Revision 1* ".

- *Measurement of Performance* – The *Development and Construction Division* has developed a performance criteria and a scoring system for service providers and processes (in September 2003) who are able to register their performance standards with HA in order to aid future tendering opportunities.
- *Awareness and Training* – A list of staff who are responsible for materials procurement and performance monitoring of services providers/product suppliers has been identified and compiled. In addition to the provision of appropriate in house training to these staff members, partnering workshops with other stakeholders have been arranged to enhance awareness and share ideas with other parties that have a vested interest in material sourcing.

Currently, the *Estate Management Division* has devised environmental procurement action plans for different work types involving horticulture, cleansing, and security. However, action plans have not yet been developed for the maintenance of building materials during the operational life of HA properties for which there could be significant environmental and financial implications.

The *Allocation and Commercial Division* has environmental initiatives in areas ranging from the use of environment friendly paper in publications to awareness enhancement for appropriate staff members and external service providers (e.g. property management companies) through training sessions and partnering workshops. However, as explained in *Section 1.4.3*, in terms of building materials procurement, the *Allocation and Commercial Division's* activities do not have any direct influence and thus there are no supporting or related action plans in place.

1.4.5 The Need for a LCA/LCC Decision Making Tool

The existing environmental initiatives currently adopted by the three business divisions do not fully address the strategic directives implicated by the EPP which recommends the identification of significant environmental impacts associated with top priority building materials and the adoption of practical alternatives which are less impact and are more economical. With reference to *Section 1.4.4* above, the majority of the alternative building materials (and components) proposed in the *Development and Construction Division* trial projects have apparent environmental benefits for only one or a few impacts and often only, at one stage of their life span. The overall environmental impact of these alternative materials over their life cycle have not been fully appraised or evaluated.

Furthermore, HA's current environmental initiatives do not appear to fully address financial implications associated with the adoption of any alternative material.

In response to these gaps, HKHA initially requires an evaluation model that appraises the environmental performance and expenditure implications of building material selection, over a complete life cycle. Interpretation of the outputs from any model should identify be in the form of a decision making tool to assist specifiers in exercising their value judgement when company building material alternatives. The formulation of this integrated decision-making tool is in fact the ultimate goal of this assignment.

Other deliverables from the assignment which includes the compilation of a LCA and LCC database and development of technical product guidelines for alterative materials will further support and complement existing EPP action plans adopted by the *Development and Construction Division*.

1.5 LCA & LCC – BASIC PRINCIPLES AND INTERNATIONAL PRACTICES

1.5.1 The Principles of Life Cycle Assessment

1.5.1.1 An Introduction to Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique for assessing the environmental aspects and potential impacts associated with a material/product from a whole life cycle viewpoint by:

- collecting an inventory of relevant inputs and outputs of a product or system;
- evaluating the potential environmental impact of those relevant inputs and outputs; and
- interpreting the results of the inventory analysis and impact assessment in relation to the objectives of the study.

The ISO 14040 standardisation series provides guidance on LCA and its use. Various computer software tools are commercially available which allow the user to follow these standards more closely and perform life cycle assessments of products. In LCA studies, environmental effects are often not the only issue of interest, particularly if the determining systems are of industrial or research significance.

The objective of LCA is quite different from simpler approaches based on product criteria or characteristic comparison. Not only are the material components of the product itself being assessed, but also the production method, facilities and supporting systems required to produce and deliver the product to site along with the resources reaches, maintain, deconstruct, recycle or otherwise dispose of it are included.

The concept of LCA originated in the late 1960's when it became clear that the only sensible way to examine industrial systems was to examine their performance, starting with the extraction of raw materials from the earth and tracing all operations until the final disposal of these materials as waste back into the earth occurred (referred to as the cradle-to-grave approach). In principal, LCA[5] is a technique for assessing the environmental aspects and potential impacts associated with a product or material. These aspects and impacts are considered throughout its entire life span, from raw material extraction through production, use and eventual disposal. This "Cradle to Grave" principle is illustrated below taking the fundamental scenario that the raw material extraction and manufacturing takes place overseas whilst the product's use takes place locally (similar to many materials used in the Hong Kong construction industry). LCA is an important tool to help improve the life cycle environmental performance of products, therefore enhance decision-making and reinforce the suitable image of those who utilise it.

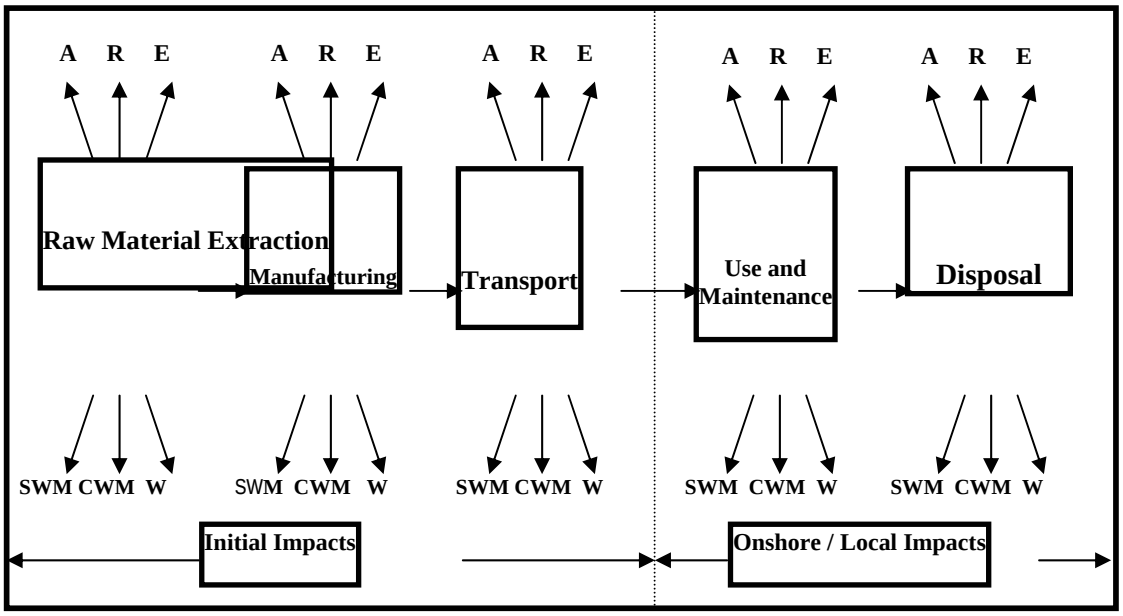
There are two reasons for this cradle to grave approach. Firstly, it is useful for identifying situations where environmental benefits occurring in one location are offset by problems generated elsewhere in the production process so there would be no real improvement overall. In these instances, individual component operations may initially appear to be cleaner and more efficient but in fact the pollution is simply being displaced from one geographic location to another. A current example is the proposal to introduce electric trolley buses to over congested cities: this would reduce the associated transportation pollution in these regions but displaces the pollution to the areas around the power stations

[5] LCA is to a large extent specified and defined by the Society of Environmental Toxicology and Chemistry, SETAC 1 (Fava et al, 1990) (Consoli et al, 1993), the Centre for Environmental Studies, CML (Heijungs et al, 1992), the Nordic Guidelines on Life Cycle Assessment (Lindfors et al, 1995) and ISO 14000 (ISO, 1997). A more recent compilation and introduction to the methodology can be found in Jensen, 1997.

needed to provide the additional fuel (electricity). The second reason is that traditionally engineers have concentrated their efforts towards making individual unit operations more efficient without looking at the way in which these unit operations were put together to form an overall production process. Sometimes, by rearranging the building blocks used in a process, overall systems can be made more efficient.

The first LCAs for buildings were made purely on the basis of the final energy consumption arising from building operations, which was directly linked to primary energy outcomes through primary energy coefficients. These coefficients came from national energy statistics or from input/output calculations. The primary energy in turn could be linked to emissions through emission coefficients for each type of energy. The results obtained were mainly emissions related (carbon dioxide) and resource related impacts were considered only as energy resources (primary energy).

Life Cycle Environmental Impacts Associated with Building Materials



Environmental Impacts: A – Global, Local and Indoor Air Pollution; **R** – Resource Consumption; **E** – Energy Consumption; **SWM** – Solid Waste Management, Reusability, Recyclability; **CWM** – Chemical Waste Management; **W –** Water Pollution

In the next step in the LCA development, embodied energy was taken into account in the overall assessment mainly through the need of primary energy to produce individual building materials. As a basis of calculation, the quantities of building materials had to be estimated and through mass flow material resources balancing, waste quantities could be estimated. The main weakness of this approach was the difficulty in finding data on embodied energy impact figures for different materials with clear indications of system limits and processes accounted. Today, most published environmental data available is given in this level of detail.

Generally impacts considered by LCA are those on resource use, human health and on the ecological consequences associated with the input and output flows. The LCA method is not the only approach to analyse impacts of materials and products from an environmental stand point, but it is probably the most comprehensive and hence authoritative.

LCA methods can be directly applied to the building sector – building products, single buildings and groups of buildings. However buildings are exceptional products and have

many characteristics that serve to complicate or frustrate the application of standard LCA methods. More specifically, buildings are difficult to assess because:

- The life expectancy of a building is both long and difficult to product with any degree certainly;
- Buildings are site specific and many of the impacts are local – something not normally considered in LCA;
- Buildings and their components/products are heterogeneous in their composition. Therefore large quantities of data is needed for all the associated products such components and materials to be evaluated;
- Manufacturing processes can vary greatly from one site to another; and
- The building life cycle includes specific phases - construction, use and demolition that have variable consequences on the environment.

Nevertheless, adoption of the general principles described below would allow the LCA of buildings and their components to be effectively performed and these have been applied to accomplish the objectives of this assignment.

1.5.1.2 LCA Approaches

Depending on the degree of quantitative data used in the LCA study, the approach adopted can be classified as qualitative, semi-quantitative and quantitative.

Using the *qualitative approach*, no attempt is made to quantify the various impacts across the life cycle of the product. The main life cycle steps, mass, energy and other flows (air, water, waste etc) are qualitatively described, the main impacts are identified and the results are presented in a matrix form. There is no single universally recognised methodology for the qualitative approach. The advantage of this approach is that all flows and impacts across the life cycle can be tracked and potential trade offs can be qualitatively recognised, however the importance of these flows are not identified making comparison of competing options difficult.

The *semi-quantitative approach* is similar to the qualitative approach with the exception that some steps are quantified. There are various different methods to this approach as there is no one universally accepted method. One such method is the matrix method as illustrated below. Each life cycle stage is ranked from 0 (high impact) to 4 (low impact) against each environmental concern selected on a subjective basis. All the cells are added up to give an overall product rating out of 100. This is a very basic quantification process and is not suitable for application in complicated studies.

A Semi-quantitative LCA Approach (The Matrix Method)

	Environmental concern				
Life Cycle Stage	**Materials Choice**	**Energy Use**	**Solid Residues**	**Liquid Residues**	**Gaseous Residues**
Pre-manufacture					
Product manufacture					
Product packaging and transportation					
Product use					
Refurbishment-recycling-disposal					

Finally, *quantitative approaches* identify and quantify the various flows within the life cycle of the product and are by far the most scientific of all the LCA methodologies due to the fact that they have the least degree of uncertainty and subjectivity. Quantitative LCA approaches are adopted for more complex studies such as building materials and components, and typically involve the following major steps:

- *Life Cycle Inventory* – Quantification of the mass and energy flows for each process included in the system; and
- *Life Cycle Impact Assessment* – Interpretation of these flows in terms of individual environmental impact.

In fact, the ISO 14040 series for LCA refers to the quantitative approach, as being the most suitable method.

1.5.2 LCA Methodologies

As described in the ISO 14040 series, a LCA methodology should consist of the following stages and principal elements:

- *Goal and Scope Definition:* Life Cycle Definition; Functional Unit; System Boundaries and Data; Quality Requirements; and Critical Review Process.
- *Inventory Analysis:* Data Collection; Refining System Boundaries; and Calculation Procedures.
- *Impact Assessment:* Category definition; Classification; Characterization; and Weighting.
- *Interpretation of Results:* Reconsider the initial definitions and assumptions; and interpret the results of the inventory and impact assessment phases in relation to the objectives of the study.

The term *Life Cycle Inventory Analysis* (LCI) is often used as a name for steps one and two of a LCA (i.e. Goal and Scope Definition to Inventory Analysis only). While the term *Life Cycle Impact Assessment* (LCIA) is often used as a name for steps one to three (i.e. inclusive of Impact Assessment). These basic definitions have a large influence on the steps in the assessment procedure. Meanwhile, the character of a LCA study is often iterative, as initial definitions may have to be changed, adapted and refined during the

conduct of the study. Disregarding or mistreating the first steps will lead to poor quality results. Definitions of standardised terms commonly used in LCA studies are provided below:

- *Functional Units.* The usefulness of a complete product is identified through its composite functional units, which can be expressed by various measures. These have to be clearly identified and measurable. The functional unit serves as a basis of comparison and as a basis for normalisation as well as reference for input and output flows associated with a product. The functional unit is strongly related to the "product in its application"; hence it can be simply defined as functionality. In comparative studies, evaluation of different products or design solutions are valid only when the products fulfil the same functional.
- *System Boundaries & Data Quality Requirements.* According to the goal and the scope of the study, boundaries identify the extent to which specific processes are included or excluded. The system boundaries define and structure the technical system under assessment. In defining the system boundaries, a balance must be struck between the practicality of the study and validity of the results. In a LCA study, an inventory of inflows and outflows must be performed over all processes that lie within the system boundaries. In addition, quality requirements for the gathered data should be defined and quality indicators established. Data quality requirements may address aspects such as time, geographical and technology-related coverage of the included information.
- *Critical Review Process.* A critical review process may serve to ensure the quality of the study. If appropriate, a reviewer or a review panel may be consulted in order to ensure that the methodology adopted is consistent with the ISO 14040 standard series, is scientifically and technically valid, uses data which is appropriate and reasonable in relation to the study goal, consists of interpretations which reflect limitations and the goal of the study, and allows the compilation of a final report which is transparent and consistent.

The underlying principles and techniques involved in each of the four key stages above are detailed in this report below.

1.5.2.1 Step One – Goal and Scope Definition

Successful application of the study requires a clear identification of the product, its life cycle, the choice of technical systems to be represented in the system, boundaries and statements of basic anticipations. Before starting with any data inventory for the investigated product, a set of definitions has to be made within the goal and scope definition document. These basic definitions are needed for users to understand the results of the study, to enable a clear structure of the analysis, and to clearly identify the object and the objective of the study.

The definition of the goal and scope includes Functional Units, System Boundaries, Data Quality Requirements, and a Critical Review Process. These basic definitions have to be carried out carefully, as the results obtained will only be valid for those identified and stated definitions. Interpretation of results in situations similar to, but varying from the preconditions of the study, may remain unsupported by the study life cycle definition. The entire life cycle of the product must be included in LCA from the outset, although boundary setting may later exclude specific life stages. This means that those systems required for generating, using and disposal of the product are all relevant to the study as a whole.

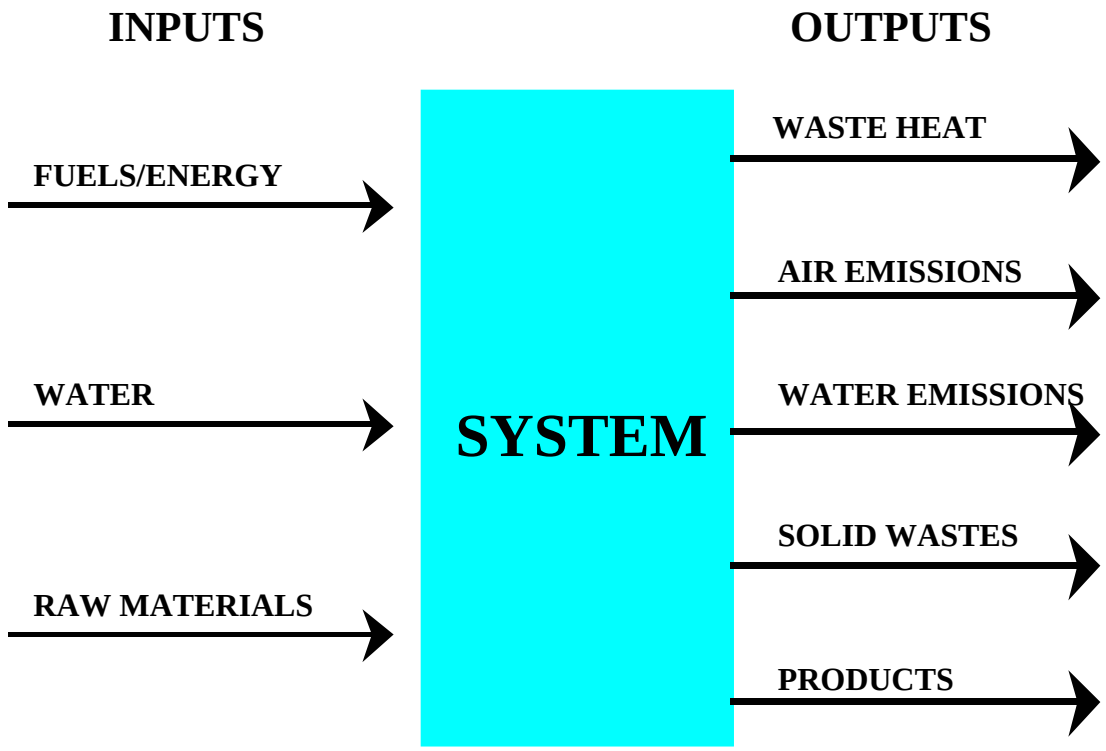
This 'cradle to grave' approach necessitates identification of the product life cycle as well as the processes participating in it. In the case of long-lived products, such as a building, the definition of the product's life cycle requires assumptions or estimates of the following:

- functional service life time;
- use and maintenance scenarios;
- repair and replacement of components;
- major refurbishment or renovation scenarios for the building; and
- demolition and recycling scenarios.

1.5.2.2 Step Two – Inventory Analysis

The fundamental idea underlying the calculation of environmental inventories is simple. Any group of industrial operations can be regarded as a system by enclosing them within a system boundary. The region surrounding this system boundary is known as the system environment. This system environment acts as a source of all the materials and fuels inputs to the system and as a sink for all outputs from the system. This concept is diagrammatically represented below, with the shaded box representing the system.

Schematic Illustration of Life Cycle System Inputs and Outputs



An environmental inventory for this system is therefore simply a list of all inputs that pass from the environment, across the system boundary into the system itself, and all of the outputs are those which pass from the system across the boundary and into the environment. When the inputs are all derived from raw materials in the earth and the final products are all waste materials returned to the earth, the inventory is referred to as a life-cycle inventory. It is important to note that in a true life-cycle system there are no usable products — only waste.

It is not part of the inventory analysis to make value judgements about the relative significance of the different inputs and outputs; instead the analysis aims to provide the quantitative data upon which judgements can subsequently be made. It will however be clear from the above description of an industrial system that the inputs to the system are the parameters involved in discussing conservation problems while the outputs are the parameters of interest in discussing pollution problems.

Inventory Analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product or system and the refining of the system boundaries. Typically, energy and material flow balancing is carried out at this stage of the LCA study. Data is reviewed to ensure it is valid for the specific system under study. In addition, system boundaries are refined, in consideration of the defined scope of the study. Finally data handling at this stage is restricted only to inputs and outputs that are significant to the ultimate goal of the study.

This refining process may involve the exclusion of life cycle stages or subsystems or material flows which are considered to be insignificance. It may also involve the inclusion of unusual unit processes in cases where they appear to generate significant impacts. Inventory data is to be related to reference flows for each unit process in order to quantify and normalise input and output to the studied functional unit. The data will then be aggregated in order to result in an input-output table for the studied product or service.

Depending on the goal and scope of the study, interpretations may be drawn directly from these data via:

- checklists that verify whether certain substances or emissions are to be found in the tables;
- criteria evaluation, where key data are assessed or specially promoted and interpreted; or
- an indicator approach, where data contributing to certain key aspects are used to represent a first estimation of the actual environmental impact, or they may constitute input to the following Impact Assessment step.

1.5.2.3 Step Three – Impact Assessment

The Impact Assessment step can be sub-divided into four sub-steps:

- *Category Definition* The aim is to provide guidance for selecting and defining the environmental categories addressed by the study. The selection should be comprehensive, consistent with the goal and scope of the study, and shall not avoid or disguise environmental issues or concerns.
- *Classification* The classification step is performed to assign inventory input and output data to the defined impact categories. It is a qualitative step based on scientific analysis or an understanding of the relevant environmental processes. Eventually all the relevant inventory data are assigned to potential environmental impacts, in so-called “impact categories”. Classification is regarded as the minimum step of Impact Assessment. In some cases, no further impact assessment is necessary prior to interpreting results.
- *Characterisation* For each impact category, the relative importance of the contributing substances can be modelled and quantified. This relative importance, or impact potential, is expressed relative to a norm or a reference substance. Essentially the impacts are converted to a proxy using an equivalency factor. The characterisation step

necessitates the ability to model the categories in terms of standardised indicators. The chosen indicator is used to represent the overall change or loading in the category. Equivalency factors do not yet exist for all impact categories. The result of the characterisation step is the expression of contributions to impact categories in terms of equivalent amounts of emitted reference substance for each impact category.

- *Weighting* For ease and clarity of decision-making, it is sometimes useful to further combine impact categories. This is accomplished by means of weighting – a process that ranks categories according to their relative importance to each other, and assigns numerical values to represent degrees of significance. Weighting often involves ethical or societal value judgments rather than scientific information. The weighting factors for this study was based upon the consensus achieved from a series of weighting workshops conducted to solicit the views of delegates from HA, other government departments, tenant and community groups, contractors, suppliers and other building professionals.

Many approaches are used for weighting impacts, including intuition. A difficulty arises due to the arbitrariness of the weighting numbers used, since changes in weights can swamp efforts to ensure precision in the values to be rated. Allocating a weighting factor beyond two significant figures is almost certainly unrealistic. This, in turn, indicates that there is little to be gained by determining the value of other data beyond two significant figures also.

Weighting is especially helpful when attempting to reduce LCA to a single "score" for a series of environmental impacts, so as to be able to then make overall comparisons between alternative building materials or designs. Without doubt this is of value to the user who has neither the time nor the interest to get involved in all the detailed calculations. However, within that very simplification process lies the weakness of weighting – namely that it can overly isolate the user from the reality represented by the detailed information available. For example, it is important for users to understand the potential for the emission of greenhouse gases during the in-use phase relative to other phases, and to comprehend the significance of transportation energy in relation to the location of a building. Obscuring such information through weighting to produce a single "LCA environmental performance indicator" may ultimately be a disservice to decision-makers.

In addition to the above, there is also a difference between *process related*, *cumulative* and *life cycle assessment* data. Only the combination of data, sets of hypotheses or allocations allows the establishment of life cycle related information for application in LCA modelling.

Process related assessment takes the form of industry inventories, taking into account the inputs and outputs inside the system limits of a plant or process. *Cumulative* assessments are based on a large number of assessments (inventories) of basic materials, energy related processes, transport and disposal processes and take into account all upstream and process related data. *Life cycle* related assessments are typically undertaken for complex products such as a building or its components, taking into account cumulated data and the probable future impacts including all downstream processes and transfer functions, based on scenario assumptions and space/time system limits.

1.5.2.4 Step Four – Interpretation of LCA Results

In earlier LCA studies, the final step of an LCA was called "improvement assessment". With varying intention in the application of LCA, from hot spot analysis in product development to comparative studies of alternative products, such improvement assessment

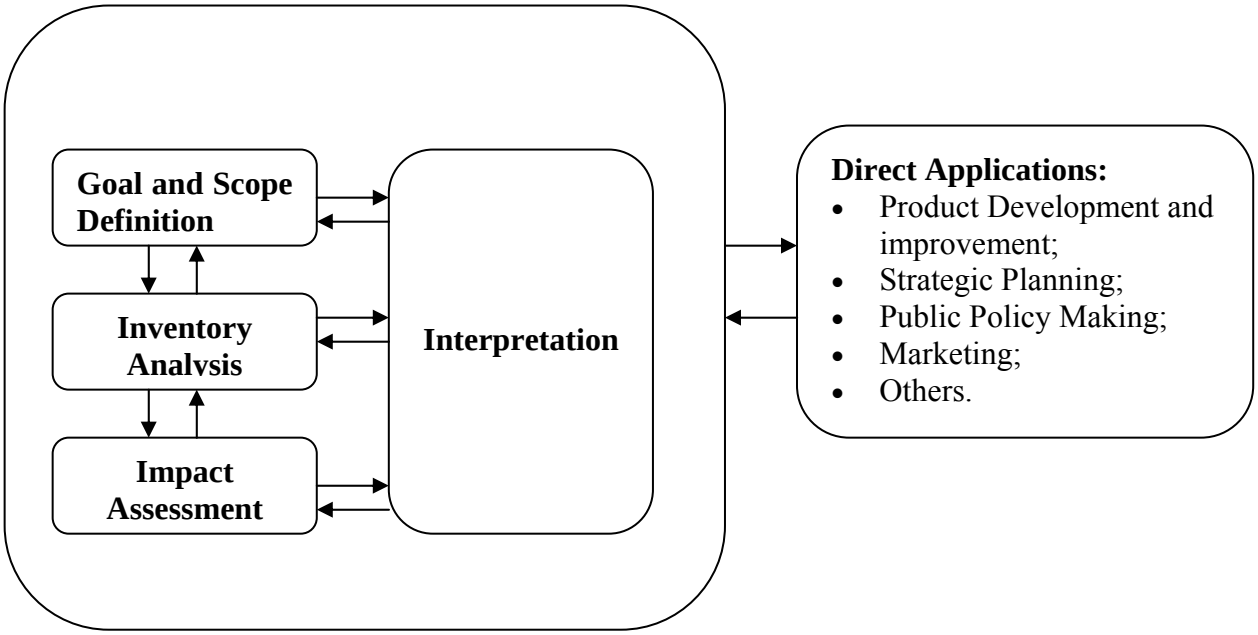
is often not relevant. Consequently, the step has been replaced by an "interpretation of results".

Interpretation of results incorporates the identification of significant environmental issues, the generated information, and an evaluation of the underlying study. Interpretation procedures should be evaluated for completeness, sensitivity and consistency. Finally, interpretation of results derived from LCA studies should reconsider definitions established during the goal and scope setting stage.

1.5.3 The ISO14040 Series

The simple Inventory—Interpretation—Improvement process of the Society of Environmental Toxicology and Chemistry (SETAC) 1990 conference has since been replaced (in 1997) by the international standard ISO 14040. The Life-Cycle Assessment framework as laid down in this standard is shown below.

Life Cycle Assessment Framework as laid down in ISO 14040:1997



The ISO 14040 series is a series of international standards that have been developed to aid the application of LCA and forms the basis of most LCA tools, models and computer software currently available. The series consists of five sections as listed below:

- ISO 14040: Principles and Framework
- ISO 14041: Goal and Scope Definition and Inventory Analysis.
- ISO 14042: Life Cycle Impact Assessment.
- ISO 14043: Life Cycle Interpretation.
- ISO/TR 14049: Examples of application of ISO 14041 to goal and scope definition and inventory analysis.[6]

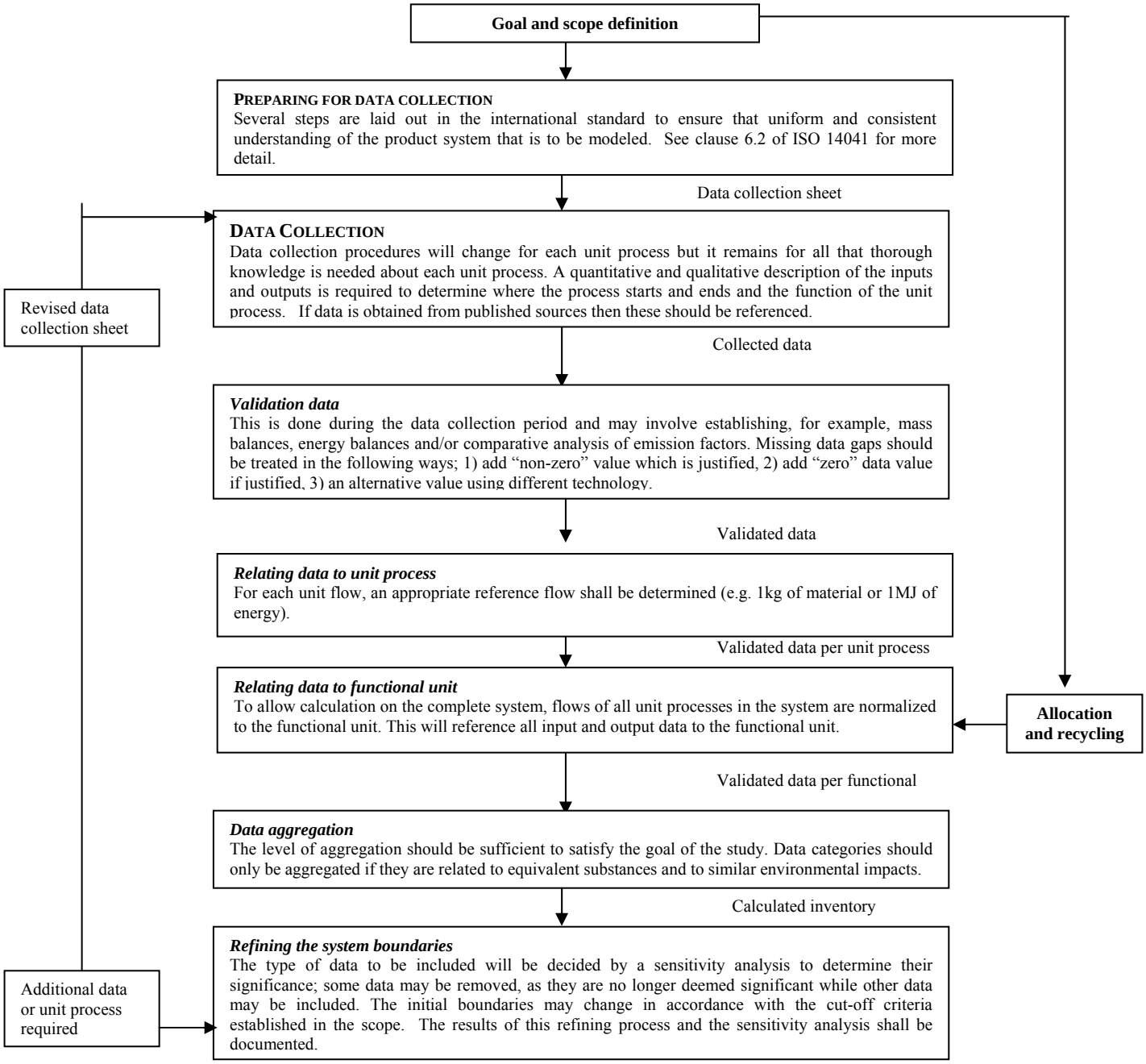
A concise summary of the objectives and applications of these ISO 14040 standards is given in the following sections.

[6] A description of the contents of this document has not been included in this report but can be referred to for a description of useful examples and source of information

1.5.3.1 ISO 14041: Life Cycle Assessment – Inventory Analysis Definitions

This part of a LCA study is associated with the data collection and calculation procedures. The operational steps are outlined in the figure below.

Simplified Procedures for Life Cycle Inventory Analysis



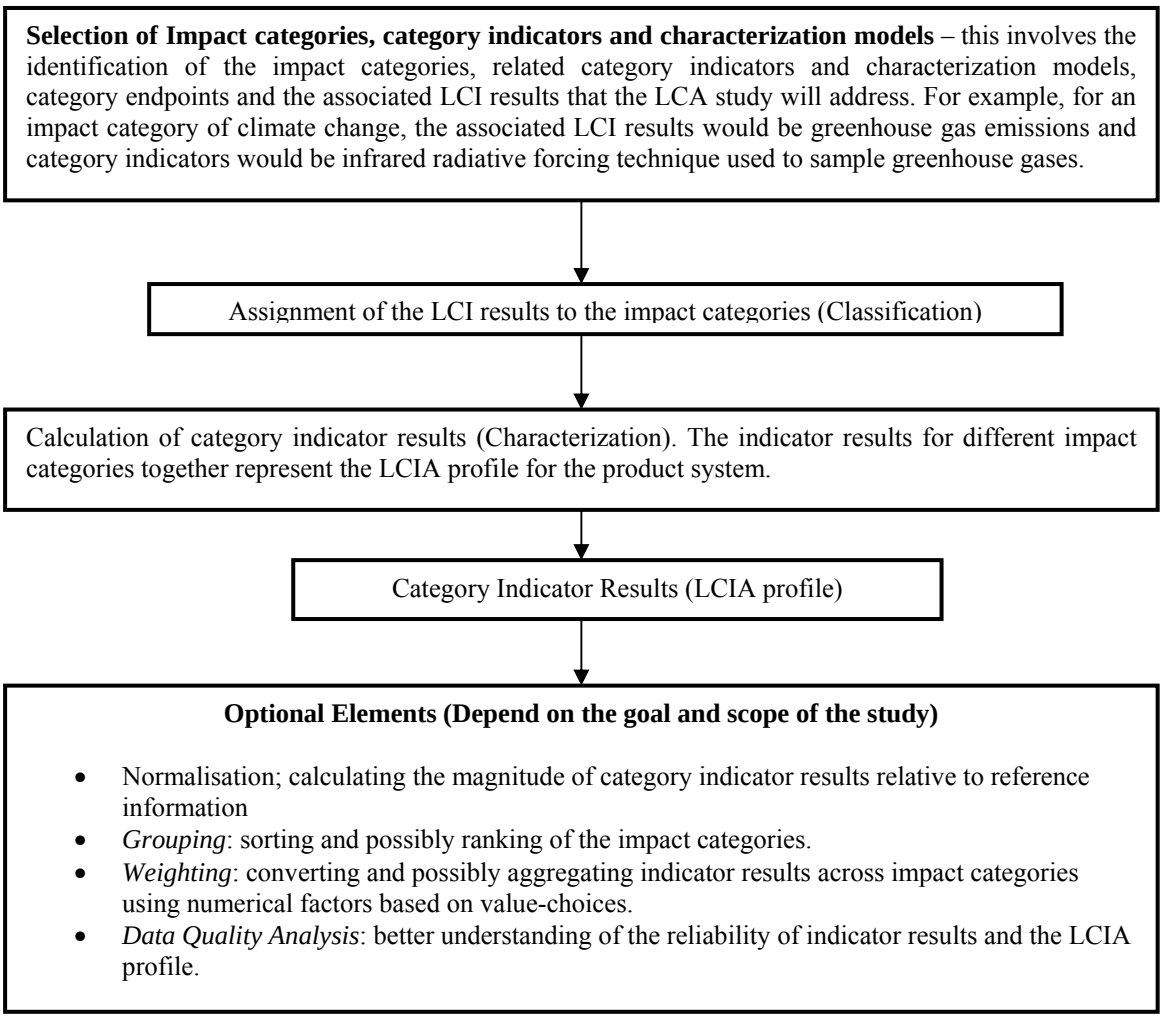
ISO 14041: Environmental Management – Life Cycle Assessment – Definitions – Inventory Analysis outlines the several components to an LCI analysis, product system, unit process, data categories and modelling product systems. A product system is a collection of unit processes that are connected by product flows (a flow diagram of the system). Dividing a product system into unit flows helps identify inputs and outputs, the unit flows are the internal workings of the product system. Collected data is sorted into data categories that help to quantify the inputs and outputs of a unit process. LCA studies are conducted by developing models that describe the key elements of the physical systems.

To conclude a LCI study, a report must be produced that fairly, completely and accurately documents the study findings to the intended audience. The ISO 14041 standard details the expected content of such a study report. Examples of a data collection sheet and different allocation procedures are given are in *Annexes A* and *B* of the ISO14041 standard respectively.

1.5.3.2 ISO 14042: Life Cycle Assessment – Life Cycle Impact Assessment

LCIA is defined as "the phase of an LCA aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system", using the core elements illustrated below.

Core Elements in a Life Cycle Impact Assessment Phase



ISO 14042: Environmental Management – Life Cycle Assessment – Life Cycle Impact Assessment provides an overview of the system-wide perspective of environmental and resource issues for one or more product system(s). LCIA is a relative approach based on a functional unit and is therefore different from techniques such as environmental performance evaluation and environmental impact and risk assessment.

The LCIA phase is composed of several mandatory elements that convert LCI data into indicator results. There are also optional elements for normalization, grouping or weighing of the indicator results and data quality analysis techniques. Detailed information on the

limitations of this technique are given in ISO 14042, however one significant limitation of LCIA is that it only covers the environmental issues that are identified in the goal and scope and is therefore not a complete assessment of all environmental issues of the product system under study.

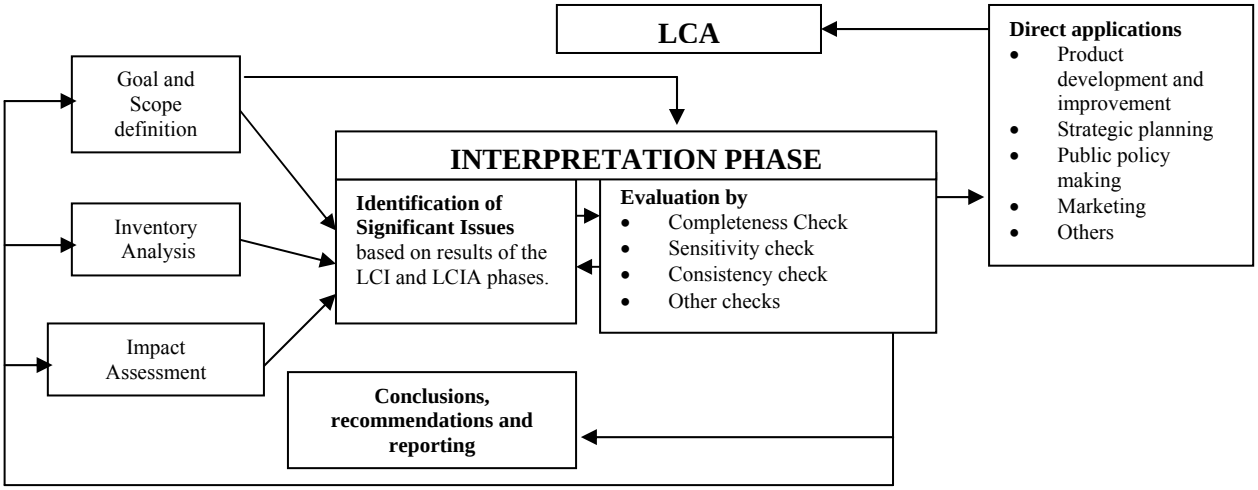
In summary, LCIA as part of an overall LCA can be used to:

- identify and prioritise product system improvement opportunities;
- characterise or benchmark a product system and its unit processes over time;
- compare product systems based on selected category indicators; and
- identify environmental issues for which other techniques can provide complementary environmental data and information useful to decision-makers.

1.5.3.3 ISO 14043: Life Cycle Assessment – Interpretation

The objectives of the life cycle interpretation phase are to analyse results, reach conclusions, explain limitations and provide recommendations for the study. These must all be reported in a transparent manner. The figure below illustrates the relationships between the interpretation phase and other phases of LCA.

Relationship of Interpretation Phase Elements with Other LCA Phases



ISO 14043: Environmental Management – Life Cycle Assessment – Life Cycle Interpretation does not provide guidance on why an issue is significant or not, there are a variety of specific tools, methods and approaches available which could be adopted to assign significance to an environmental issue. The evaluation stage is there to establish and ensure confidence in the reliability of the results and also to ensure that the correct issues have been classified as significant. During the evaluation phase, the completeness check ensures that all information and data is available and complete, the sensitivity check assesses the reliability of the final results and the consistency check determines whether or not the assumptions, methods and data are consistent with the goal and scope.

During the third and final phase, conclusions and recommendations are drawn for the intended audience of the LCA or LCI study. While drawing the conclusions it must be undertaken interactively with the other elements of the life cycle interpretation phase. Examples of the Life Cycle Interpretation are given in Annex A of the ISO 14043 standard.

Therefore, in principle, the life cycle interpretation phase identifies, qualifies, checks and evaluates information from the results of the LCI and/or LCIA of a product system. They

are then presented in a way that best describes the goal and scope of the study. By rationalising and focusing on the results, life cycle interpretation may also demonstrate links that exist between LCA and other environmental management techniques.

1.5.4 International LCA Models and Tools

1.5.4.1 International Trends in LCA for Buildings

LCA has recently gained an increasing share of interest in the field of construction industry sustainability. As an assessment method it has been around for the last twenty or so years but has been mainly used by other industries like the chemical and food processing industries where the end products are simpler and the expertise and operation of the industry have a scientific background that is sympathetic to LCA methodology. Indeed one of the best reference texts on the methodology guidelines still remains that produced by the *Society of Environmental Toxicology and Chemistry* (SETAC).

The construction industry has also been rather slow to adopt LCA for other reasons. The industry is very varied in the products it produces in terms of size, function and sophistication and the construction methods it employs are equally diverse, from simple timber and masonry construction through to the sophistication of steel tensile and geodesic systems with the latest fabric systems. It has therefore been difficult to establish a universal methodology to assess the environmental impacts that are a consequence of the industry's operation and moreover it has been difficult to collect reliable construction material data that is applicable to such a diverse modus operandi.

Nevertheless sufficient data has now been gathered to assess the environmental impacts caused by the manufacture, supply, operational life, repair and maintenance regime and the eventual safe disposal of most major construction materials. Many of the impacts however, do occur in the manufacturing stage and the measurement of these should definitely include the impacts attributable to transport to site, often via many secondary-manufacturing stages as this can be very significant for some building materials and components.

This data then enables whole buildings to be modelled in very much the same way as a bill of quantities is tabulated. The principle is the same as the quantity of all the materials that make up a building are measured and then converted into a figure that is the total mass of each material within the building. The inclusion of the building's consumption during its operational life; energy for lighting, cooling, heating etc.; repair and maintenance regimes together with the assessments of impacts caused by the safe disposal of the materials at the end of the buildings life enables a whole building life cycle to be modelled.

Great strides have also been made in accurately measuring all the 'outputs' (emissions to air, water and wastes) from manufacturing and other life cycle processes for each building material and component. As a consequence the level of detail of data that 'records' the material life cycle process now extends to hundreds of chemicals rather than just being limited to the energy consumed, the solid wastes produced and CO_2 emitted over the life cycle. This in turn has enabled materials to be assessed in terms of a whole range of environmental impacts; from climate change (global warming) and acidification to eco and human toxicity through to human toxicity which wasn't possible until relatively recently. As previously stated great strides have been made possible by the increasing sophistication and detail of the data available in addition having a database that accurately reflects the material-manufacturing locality is an essential prerequisite before any LCA can be contemplated.

The importance of carrying out real measurement is illustrated by the United Kingdom's *Constructional Steel Sector* (CSS) response in the early 1990's to a growing opinion amongst construction industry clients and professionals that steel's environmental credentials were perhaps rather questionable. The CSS commenced a study to investigate the accuracy of these emerging views, to which there were two main strands:

- Material embodied energy[7] values published widely for the first time showed steel to have relatively high values in comparison with alternative structural materials; typically hot rolled structural steel sections produced in the UK at approximately 25 giga-joules per tonne (GJ/tonne) while reinforced concrete is 1-4 GJ/tonne dependant on mix and the quantity of reinforcement.

- The concept that the greater the mass of the structure and in particular the floor structure the greater the capacity of the building to 'soak up' the daily internal heat gains was also prevalent at the time. The idea is that heat enters the structure during the day reducing internal temperatures as they rise to a peak during the afternoon. This heat is then purged at night by bringing the relatively cold outside air into contact with the structure thus reducing the overall cooling load and theoretically eliminating the need to air-condition most office spaces in the UK. Buildings with ever-greater mass, especially 'heavy weight' concrete offices were therefore considered to be more 'environmentally virtuous' than steel frame alternatives that were perceived to be far too 'light-weight' to significantly benefit from this effect, properly termed 'fabric energy storage'.

These two coincident arguments, which appeared to paint a disparaging environmental picture of constructional steel, prompted the steel sector to initiate a real programme of environmental research rather than bandy words in the press based on an incomplete understanding of the real underlying building and environmental physics.

The approach was to carry out a comparative environmental assessment that considered the full life cycle of two types of modern office building, a four storey science park type, the other a high rise, inner-city, head quarters type with an atrium. Steel and concrete versions of the same office buildings were modelled in terms of their embodied energy and operational[8] energy and when the work was carried out was the first time that modelling a complete life-cycle of an office building had been carried out. The results of the study[9] showed that there is little difference between the embodied and operational energy performance of both types of construction. This might be rather surprising in view of the prevailing opinion that steel's environmental characteristics were poor when the research commenced. The two reasons that emerge from these results are as follows :

- Really the embodied energy of the material is not relevant in terms of determining what is the most environmentally benign form of construction but what is, is the function that a material performs as a product in comparison with its alternative. In other words what we really want to compare is one 'functional unit' with another, i.e. one unit of steel structure with a similar unit of concrete structure. But in this case there are a

[7] Embodied energy is the energy consumed in the process of winning all raw materials, processing and manufacturing them to make a product and delivering it to the point of use and then its safe disposal after its use has finished. Included in this consumption is the energy consumed by all transport movements. This can be a significant proportion of the embodied energy of some construction products.

[8] Operational energy is the energy consumed in the running of the building and in offices includes, heating ventilating and cooling, lighting, small power consumption and all other energy consumption like catering, vertical transport, telecommunications, security, etc.

[9] A short report of the study is published by the Steel Construction Institute - "A Comparative Life –Cycle Assessment of Modern Office Buildings", AMATO, A., and EATON, K. J.

number of consequential or knock-on effects from the use of either steel or concrete, much larger foundations for a concrete frame and fire proofing for steel. Thus the most appropriate functional unit for this study was embodied energy per m^2 (gross area) of complete building and conceptually is very much like a cost comparison based on $\$/m^2$ of alternative constructional solutions. When comparing the results the reason that the steel and concrete alternatives are so similar is because steel is, in terms of mass, a more efficient structural material and therefore less mass is required to perform the same structural function.

- The expectation that the additional mass of the concrete alternatives would reduce the cooling requirement was essentially based on an incomplete understanding of the building physics involved. The reason is that over a diurnal range mass has no additional value after a thickness of 100 – 120 mm of dense structure is reached. In other words all that is required to effectively use 'fabric energy storage' (FES) is about 100mm of dense structure and thereafter any additional mass is superfluous and in fact slightly inhibits FES performance. Previously steel office buildings considered previously to have insufficient mass in fact turn out to have just about the correct amount of thermal mass.

The comparative study also examined CO_2, which perhaps, since 'Kyoto', is now considered a more important environmental parameter than energy. Here the results of the embodied models showed that the steel alternatives faired slightly better than the concrete as there is a significant quantity of CO_2 that is given off in the manufacture of cement that must be included as well as the CO_2 emitted by the energy production associated with its production. However what the study clearly showed is that the differences that actually exist between steel and concrete construction in terms of energy performance (embodied and operational) are so marginal as to be insignificant. In fact the study conclusively showed that designers will have more impact choosing energy efficient lighting and office equipment than worrying about the choice of whether the frame should be steel or concrete as far as UK commercial buildings are concerned. In a sense UK designers are now free to choose on other grounds, e.g. cost, speed of construction etc. These results subsequently, appear to be ratified by the recent release, from the BRE's *Centre for Sustainable Construction*, of their 'Envest' software.

1.5.4.2 Review of International LCA Models and Tools

As indicated above, international LCA tools and models are becoming more widespread in existence, if not in their adoption. Reviews of such tools have been completed to consider their nature, current applications, and relevance to this study. In addition to this desk-top research, meetings with team members in Europe have facilitated input in formulating the methodology for the combination of LCA/LCC impacts.

Overseas LCA tools most widely adopted for building materials can be categorised into seven general areas:

- *Detailed LCA Modelling Tool: Material / Product Level* – software tools that evaluate LCA impacts, such as embodied energy, of specific building products with inbuilt and customisable material and process database;
- *Detailed LCA Modelling Tool: Building / Component Level* – software tools which evaluate LCA impacts of elementary components and materials within building products, again with inbuilt and customisable material and process database;
- *LCA Design Tools* – devised to assist architects and designers in selecting environment friendly building products on component levels, using LCA as a basis. However, these tool usually include pre set material with limited flexibility and the results are often represented by a few indicator points, without due consideration of the complete LCA impacts of the building product under study;
- *LCA CAD Tools* – integrated tools that can evaluate material and component information from CAD drawings, with environmental impact and embodied energy prediction capabilities;
- *Building Assessment Schemes* – emphasis on overall environmental performance of building, LCA approach not always adopted, and quantitative information of building materials and products seldom apply, although could serve as preliminarily indicators of environmental issues which require detail investigation;
- *Green Product Guides and Checklists* – are qualitative guides for building materials and products and could serve as preliminarily indicators of environmental issues that require detail investigation.

Examples of tools from each area are listed in the Table below. The review of the unique properties of the seven types of tools includes: the approach adopted, type and level of details of data required, environmental issues considered, and environmental weightings assigned, if any. Key observations drawn from the review are that:

- although there are various building assessment methodologies that are already in use around the world, few come close to the quantitative accuracy of a full life cycle assessment both in environmental and cost terms;
- the databases, models and design tools reviewed predominantly include pre-set materials and functional units with limited flexibility (e.g. timber framed dwellings with pitched roofs) for change;
- given their propriety nature, database, model and design tool results are often restricted to pre-selected indicators, preventing users from exploring other factors that may be of concern, and are often without due consideration of the complete LCA impacts of the item under study;
- few models give a detailed reassessment of changes to design to the operational energy component of the buildings life cycle performance;
- those models reviewed[10], which have an LCC module attached, are general and generic in their detail, particularly in their adoption of cost information which soon becomes outdated unless regularly maintained;
- credit based methods like HK-BEAM and US LEED give a general assessment of environmental performance but do not pin-point the environmental 'hotspot' of a building or show the relative proportion of impacts throughout a building's life.

[10] BEES (USA), Ecotect (Australia), Ener-Rate (Australia), Legoe, OGIP (Switzerland), Team (France), Carnegie Melon (USA), NIRM (Japan), LISA (Australia), Granlung Energy Tool and Envest (UK)

Table 1.4a Worldwide LCA Models in More Widespread Use

MATERIAL/PRODUCT LCA MODELS Boustead (United Kingdom) Carnegie Melon (USA, embodied energy) GaBi (Germany, process engineering based KCL-ECO (Finland, for the paper industry) LCAiT (Sweden) NIRM (Japan, embodied energy) PEMS (United Kingdom) SimaPro 4.0 (Netherlands, used mainly by the European concrete industry) TEAM (France, LCA and cost modelling) **BUILDING/COMPONENT LCA MODELS** ATHENA (Canada) BEES (USA, BRE) BRI-LCA (Japan) EcoQuantum (Netherlands) ECOMethods (France) EQUER (France) Green Building Advisor (USA) LISA (Australia) Optimize (Canada, includes direct and indirect cost estimates) SBI (Denmark) SIA D0123 (Switzerland) **LCA DESIGN TOOLS** ATHENA (Canada) BEE 1.0 (Finland, embodied energy & emissions) BES (Australia, value judgments score materials) ECOMethods (France) ECOit (Netherlands, gives results in Eco-Points) EcoQuantum (Netherlands) EcoScan (Netherlands, results in Eco-Points) Envest (United Kingdom) BRI-LCA (Japan) LCAiT (Sweden) LISA (Australia) Optimize (Canada, direct/indirect cost estimates) SIA D0123 (Switzerland)	**LCA CAD TOOLS** BEES USA (Building Research Establishment Environmental Assessment Method) BDA (USA, Building Design Advisor, uses artificial intelligence modeling) CSIRO (Australia) Ecopro (Germany) Ecotect (Australia) Energy 10 (USA) ENER–RATE (Australia) EPCMB (United Kingdom) EQUER (France) LCAid (Australia) Legoe (Germany) OGIP (Switzerland) PAPOOSE (France) SBI (Denmark) TEAM (France, LCA and cost modelling) **BUILDING ASSESSMENT SCHEMES** BEAVER / ESPII (USA) BREEAM (United Kingdom) BUNYIP (Australia) E2000 (Switzerland) GBTool (International) Granlund Energy Tool (Germany) HKBEAM Hong Kong LEED (USA) NatHERS (Australia) Okoprofile (Norway) SEDA (Australia) **GREEN PRODUCT GUIDES & CHECKLISTS** ECDG (Japan) BEPAC (Canada) LEED (USA) EcoSpecifier (Australia) Environmental Preference Method (EPM, Netherlands) Green Housing A-Z (Japan)

It was considered vital that the HA LCA/LCC model provides the required flexibility, relevance and accuracy to be used as a design tool during the construction process so as to accurately model alternatives. Based upon findings of the LCA review, it was concluded that whilst some of the general principles researched such as characterisation, regionalislation, normalisation and weighting could be applied, there was no one single overseas LCA methodology which could be adopted for the HA and local Hong Kong

context. Similarly, the LCC review also revealed that a localised LCC model should be applied for the assignment.

1.5.5 International LCA Databases

In addition to establishing an LCA model framework for HA, one of the prime objectives of this assignment has been to develop an in-house environmental database that is applicable in the local context. The compilation of this database involved the sourcing of relevant and reliable environmental information for building materials, which are material components within HA's *New Harmony 1 (Option 2) Block*, the building type used in this assignment. This database is stored within the developed model and comprises the normalized environmental data values. The following points consider some of the data quality issues in relation to this database.

1.5.5.1 Data Quality Considerations for LCA Databases

The basic criteria for the selection of an environmental database or databases that are suitable for use in a LCA model are numerous. From a practical standpoint, the *compatibility* of the selected database(s) to the LCA model is of prime importance, since the database and framework are very closely related. Furthermore, the database(s) need to be *adaptable* to allow the editing of data and methods required for regionalisation, to provide a credible source of information.

In addition to the above practical considerations, the *quality of the data* in respect of its accuracy, completeness, representivity, repeatability and variability (the commonly used data quality indicators, DQI's[11]) is also a key characteristic:

- *Accuracy* – the statistical representivity of the data, concerning whether the data is a result of a single measurement or averaged over repeated measurements (and if so, the number and frequency of measurements)
- *Completeness* – concerning the exhaustivity of mass balance flows at the process level, in other words whether sufficient information is available to adjust overall impact assessment results (some flows with significantly different environmental impacts may have been aggregated)
- *Representativity* – in terms of geography, technology and timescale (i.e. is the geographical representivity of the process clearly stated at a local, national, continental level, is the process technologically representative of today's mean or is it obsolete, and is the age of the data adequate?)
- *Repeatability* – the necessary transparency to lead any neutral expert to the same conclusion, providing the acceptance of the assumptions and of the assessment method used. Repeatability hinges upon the unambiguous and coherent definition of functional units and inclusion rules at the system level (which criteria decide to include a flow into the system or not – mass, energy, or environmental relevance?)
- *Variability* – all data should be given with an indication of its variability: minimum, maximum, standard deviation, etc. This information should allow the undertaking of sensitivity analysis, e.g. to test the robustness of a conclusion against the uncertainty of the data.

[11] This list comes from a collective study under publication made for a French association of 15 energy providers and product manufacturers.

Further considerations include the *acquisition method* (whether the data result from a measurement, theoretical calculation or an authorised guess of known or unknown origin and has been validated by an independent expert during a critical review) and the transparency, justification and relevance of its *Allocation Rules*. Very few existing databases give enough metadata (numeric information such as age, acquisition means, literature references, geographic and other factors described above) to perform a correct data quality assessment.

The *Society for the Promotion of LCA* (SPOLD) has developed a common format for LCI data, to facilitate data exchange and improve quality. Besides the classical input/output flows, the format does contain descriptive data (metadata): subsystem structure, boundaries, quality, representativity, energy/transport/waste models, supporting the choice of relevant data sets. An electronic version can be downloaded (free of charge) from the Internet, together with the paper specifications and an example (http://ipt.dtu/dk/~bow). Otherwise the structure of the SPOLD common format is essentially described in [Spo 96]. In spring 1999, the society opened the *SPOLD Data Network* (SDN), to offer a central contact point with an electronic directory of all LCI data available, the data itself remaining on the decentralised database servers of the data suppliers. This network is developed and hosted by the *Institute of Product Development* (IPU), Technology University of Denmark, DK-2800 Lyngby.

The Department of Materials of CSTB (the French BRI) at Grenoble has also developed a generic, conceptual object-oriented LCA data model called Equity Data Model (EDM). Written using ISO/STEP EXPRESS, a standardized language that provides the automatic treatment of computer implementation, EDM permits the definition of partial aggregation levels and a selective information display, qualitative data consideration, backtracking from valuation results to preliminary data and exportability. A computer implementation has been developed for internal use only, but the conceptual model is independent of its implementation and was published in 1999.

A relational database structure named SPINE (*Sustainable Product Information Network for the Environment*) has also been developed in Sweden by IVL, the Swedish Environmental Research Institute, Chalmers University of Technology and Chalmers Industriteknik (CIT), in order to allow communication between different software tools, in particular the Swedish *EPS System* and CIT's *LCA Inventory Tool*. SPINE is described in a standardised way in a SQL-code and may also be used as a common language for LCA data structures, although it is necessary to be familiar with the SQL-code datamodel description language to understand it.

Data suppliers in the SETAC Europe workgroup on data availability and quality recently created an implementation subgroup on the basis of the SPOLD and the SPINE formats.

1.5.5.2 Sources of LCA Data

Summaries of several sources of information reviewed are provided below, highlighting their focus, data source and availability for use.

Boustead Database

Focus: Plastics and electronic industry, energy, solid wastes, water pollution, air emissions
Source: Data collection from various sources
Availability: Included in standard database (commercial and educational versions).

This database was developed by Dr Ian Boustead, best known for his extensive LCA works for the building industry in the United Kingdom. The database consists of inventory product processing data for building materials such as paints, adhesives, metals, plastics, and transportation operations. Fuel producing industry data are also available for all of the OECD countries.

BUWAL 250

Focus: Packaging materials (plastic, carton, paper, glass, tin plated steel, aluminium), energy, transport, waste treatments.
Source: BUWAL 250 2nd edition. Fully documented and licensed database.
Availability: Included in standard database (commercial and educational versions).

Inventory of packaging materials for the Swiss Packaging Institute, made by EMPA. The inventory includes emissions from raw material extraction, energy consumption, production of semi-manufactures and auxiliary materials, transportation and the production process of the materials. BUWAL is based on the Swiss consumption of packaging materials and the imports and exports of materials, the origin of raw materials and the use of energy and electricity, and thus is therefore primarily determined by the Swiss situation. Energy systems are based on ETH data, without capital goods, plastics data are based on PWMI data. BUWAL 250 is published by the Swiss Federal Office of Environment, Forests and Landscape and the Swiss Packaging Institute (SVI).

Data-Archive

Focus: Materials, energy, transport, processing, waste treatment.
Source: Variety of older public sources (PWMI, BUWAL 132, ETH, SPIN, Chalmers, Kemna).
Availability: Included in standard database (commercial and educational versions).

These information contains older inventory data (around 1990) from PWMI, BUWAL132, Chalmers, Van den Bergh en Jurgens and others which is now outdated. This data however, can also be useful in a sensitivity analysis, or to estimate if the data is environmentally relevant when considering cut-off criteria.

Dutch Concrete Database and Scripts

Focus: Dutch data related to all aspects of concrete production and use. Can be used in combination with scripts. *Data and scripts are in Dutch.*
Source: Betonplatform, the Netherlands.
Availability: Free for Dutch users with service contract. Available on request for other customers with service contract, however no language support is given. This database is protected against copying and exporting.

EcoInvent Database

Focus: LCI data for energy, transport and waste treatment for industrial products in Switzerland and Europe.
Source: Swiss Centre for Life Cycle Inventories, Switzerland.
Availability: Included in standard database (commercial and educational versions).

The database consists of harmonised generic LCA data covering the following sectors: energy, transport, waste treatment, buildings, chemicals, detergents, graphical papers and

agriculture. The geographic scope of the information comprises of the supply situation in Switzerland and in Western Europe. In addition to quantitative information associated with inputs and outputs, supplementary data related to technology, temporal and geographical validity is also provided.

ETH ESU 96

Focus: Energy. Electricity generation and related processes like transport, processing, waste treatment. The 500 most important processes are included. Extensive documentation provided.
Source: Energy Materials Environment Group of the Swiss Federal Institute of Technology.
Availability: Included in standard database (commercial and educational versions).

Inventory data for Swiss and the Western European energy supply situation concerning production and imports of fossil and fissile fuels and production and trade of electricity, including emissions from primary energy extraction, refining and delivery, mineral resource extraction, raw material production, production of semi-manufactures, auxiliary and working materials, supply of transport and waste treatment services, the construction of infrastructures and energy conversion and transmission. The data cover the Swiss and Western European situation. Hereby the Swiss situation and life cycle inventory data is sometimes used to approximate an average European situation.

FEFCO Database and Scripts

Focus: European data on corrugated board production, partially based on BUWAL 250. Includes scripts to model the production and life cycle of corrugated board.
Source: FEFCO, European Association of Corrugated Board Manufacturers, France.
Availability: Only together with SimaPro Light license through FEFCO. The accompanying report is available free of charge.

The European Federation of Corrugated Board Manufacturers (FEFCO) was established in 1952 and provides this “European Database for Corrugated Board Life Cycle Studies, 2000”.

FRANKLIN US LCI Database

Focus: North American inventory data for energy, transport, steel, plastics, processing.
Source: Data collected by Franklin Associates, USA. Fully documented and licensed database.
Availability: Included in commercial versions. Must be purchased separately for educational versions.

Gabi Database

Focus: Chemical, metalwork, petrochemical, and automobile industry, energy and materials flow
Source: Data collection from various sources
Availability: Included in standard database (commercial and educational versions).

The GaBi software system was developed at the IKP University of Stuttgart in cooperation with PE Product Engineering GmbH and distributed by PE Product Engineering GmbH. The GaBi software system is used in many companies and scientific institutes. For this reason, numerous extension databases were established for customized use in the various

areas (chemical industry, petrochemical industry, metalworking industry as well as the energy business and automobile industry), and they are available for solving sector-specific problems.

GEMIS 3

Focus: LCA data for energy, materials, and transport for industrial products in Germany.
Source: Institute for Applied Technology, Germany.
Availability: Information available in the public domain.

The GEMIS database offers information on the following processes:

- fossil fuels (hard coal, lignite, natural gas, oil), renewables, nuclear, biomass (residuals, and wood from short-rotation forestry, miscanthus, rape oil etc) and hydrogen (including fuel composition, and upstream data)
- processes for electricity and heat (various powerplants, cogenerators, fuel cells, etc.)
- materials: raw and base materials, and especially those for construction, and auxiliaries (including upstream processes)
- transports: airplanes, bicycles, buses, cars, pipelines, ships, trains, trucks (for diesel, gasoline, electricity, and biofuels).

The GEMIS database provides the following LCA data for each process:

- efficiency, power, capacity factor, lifetime
- direct air pollutants (SO_2, NO_x, halogens, particulates, CO, VOC)
- greenhouse-gas emissions (CO_2, CH_4, N_2O, SF_6, all other Kioto gases)
- solid wastes (ashes, overburden, FGD residuals, process wastes)
- liquid pollutants (AOX, BOD_5, COD, inorganic salts)
- land use.

Idemat 2001

Focus: Engineering materials (metals, alloys, plastics, wood), energy, transport.
Source: Data collection from various sources supervised by Dr. Han Remmerswaal, Faculty of Industrial Design Engineering, Delft Technical University, The Netherlands.
Availability: Included in standard database (commercial and educational versions).

This database has been developed at Delft University of Technology, department of industrial design engineering, under the IDEMAT project. The focus is very much on the production of materials. The data is predominately original (not taken from other LCA databases), and comes from a wide variety of sources.

The database consists of life cycle inventory information for products during mining, concentration and processing in case of minerals, or harvesting and processing in case of agricultural materials. In general the average world situation is accounted for, because individual companies or persons are not able to select a specific history of materials. They have only influence on a small part of the resource system. Accordingly the transportation impacts are allocated to the world mining and production of the resources with Rotterdam as final destiny. Recycling of secondary material is taken into account according to average situation in Western Europe. The system boundary covers all processes back to the natural system.

Industry Data

Focus: Inventory data provided by industry associations. Mostly cradle to gate data.
Source: various, APME.
Availability: Included in standard database (commercial and educational versions).

This source of information contains data as collected by industry associations, such as APME and thus details of post factory gate environmental impacts of building materials are not normally available. In addition, since the original source of the information is provided by the polluters, the quality and integrity of the data could be impartial.

IVAM 3.0 Database

Focus: Materials, transport, energy and waste treatments. Mostly focused on Dutch data.
Source: Data collected by IVAM Environmental Research, Amsterdam, the Netherlands. Also ETH/BUWAL and PRé data included.
Availability: Purchase from IVAM Environmental Research.

The IVAM Environmental Research database is purpose-designed for environmental life cycle assessment (LCA). It consists of about 1000 processes leading to more than 300 materials for which data can be used for LCA applications in various sectors. The IVAM database contains environmental data of more than 250 processes relating to the production of building materials and components and covers chemical risks, sustainable building, energy, chain management, quality of living and cleaner production. This agency is affiliated with the University of Amsterdam.

1.5.5.3 Sourced Data Treatment

Based upon the above it has been considered that the Simapro system and its associated databases offered the complete test data source for this study and has therefore been one of the primary data sources.[12]

It should be noted however that it is the characterised, regionalised and normalised data from sources such as SIMAPRO which provides the basis of the HA LCA/LCC model. Since the raw data and tools themselves will not form part of the model, HA licensing of such sources will not therefore be required. The model therefore only contains the normalized outcomes rather than all the raw source data.

There are several methods to use the raw data in databases. The total environmental impact of a building material (or product) can be calculated by adding all relevant processes and materials. Processes adopted for data characterisation, normalisation and (ultimately) weighting are described separately and will largely determine the resulting impact.

1.5.6 The Principles of Life Cycle Costing

Life cycle costing (LCC) is the study of the financial implications arising from the development and usage of an asset, and in the case of this study, this would be a New Harmony 1 (Option 2) Block. These financial implications cover the whole life span of that asset are therefore well in excess of simply the capital cost of the building. All LCC studies consider different stages of a building's life starting from capital expenditure in creating the building, through its operation and maintenance phase and finally end of life expenditure issues, such as demolition cost.

[12] Simapro consists of various databases previously described and data from BUWAL 250, ETH-ESU 96, Industry Data and Idemat 2001 were identified as appropriate and were used in the study.

Ultimately any LCC study must include all these building life stages. Equally for the LCC study to be regarded as being complete, it should also address both expenditure and income aspects of the asset. Therefore all aspects of revenue generated from the occupation of the building as well as the residual value of the site upon demolition should also be accounted for. Notwithstanding this normal complete approach, in the case of this study the revenue streams are not included within the scope of the LCC calculation. This is because the building being studied is a rental premises and ultimately the asset remains with HA. This approach is also in line with usual government practice when dealing with government buildings.

It should be noted that real data for the life cycle cost of a New Harmony 1 (Option 2) Block is not yet available since no buildings of this type of block have completed a full life cycle. Other types of blocks are therefore considered so as to provide a historical point of reference particularly on the potential repair and maintenance profiles. A number of blocks of varying ages will be studied to establish an overall profile for consideration in the formulation of the LCC for the New Harmony 1 (Option 2) Block. These include Harmony, Trident and Cruciform block types. The older Slab or Linear blocks have been reviewed as well but only as a guide rather than a source of LCC data.

LCC has developed over many years as an evaluation tool for developers to consider and evaluate the true complete cost of their assets. Initially, LCC studies focussed on specific items or components of a building and this is still the most common current application. However more and more clients are looking to evaluate the long term expenditure implications of their completed assets. The evaluation process adopted for either a component or a complete building are similar, to the extent that they follow the same internationally recognised principles.

Unlike many other recognised processes, LCC assessments are not governed by many specific international standards. In fact, currently there are only two internationally recognised standards directly related to LCC evaluations:

- ASTM E 917 – 99 Standard Practice for Measuring Life Cycle Costs of Buildings and Building Systems (American Standard); and
- AS / NZS 4536: 1999 Life Cycle Costing – An Application Guide (Australian / New Zealand Standard)

Although these are the only two major internationally published standards, there are a number of other published and recognised methodologies available around the world. In terms of future trends, other international standards are being planned. The most notable of which will be the ISO standard number *ISO 15686-5*, which is still under development and is currently at committee stage.

The published methodologies around the world are generally very similar in their approach and they all encompass the general principles set out in the above two standards. Most major developers and client bodies in countries such as the United States of America, Australia and United Kingdom have developed LCC methodologies to suit their own practices and therefore emphasis has been placed on specific comparison criteria or evaluation procedures in these models.

As part of the overall background research carried out for this study, the consultant team have examined a number of client specific published methodologies in order to understand

the key differences and focus of the evaluation process, the main methodologies studied were :

- *Life Cycle Costing Guideline* (Jan 2001) NSW Government Asset Management Committee (Australia);
- *Life Cycle Costing Manual for the Federal Energy Management Program* (Feb 1996), U.S. Department of Commerce (United States of America);
- *Life Cycle Costing Analysis Guidelines 2002*, Department of Natural Resources, Iowa (United States of America);
- *Guidelines for Life Cycle Costing on State Building Projects*, (Dec 1997), Department of Administration, State of Wisconsin (United States of America);
- *Whole Life Costing*, (Nov 1998), Construction Best Practice Programme, DETR (United Kingdom); and
- *Life Cycle Costing, Public Competition and Purchasing Unit Guidance Notes*, (April 1992), HM Treasury (United Kingdom).

Coupled with the above, we have also reviewed from our own sources, methodologies adopted by other major United Kingdom clients, such as the British Airports Authority as well as those, Davis Langdon and Seah International has developed for internal use and for specific projects.

The above research has generally confirmed the initial conclusion that the underlying principles of LCC are the same throughout the world with focus being placed on different areas within each model. When the wider history of LCC is considered it is found that the origins of this assessment method are derived from the chemical and petroleum industries, which have used these evaluation tools for many years. Part of the reasoning for this has been the need for these industries to evaluate the revenue and viability potential of new facilities and equipment, which involve huge capital investment as well as substantial recurring maintenance costs. Therefore if the complete list of British and ISO standards are reviewed in detail it can be found that there are specific standards covering LCC and Whole Life Costing specifically tailored to the petroleum industry. These standards are generally arranged and set out in the same way as those standards discussed above and therefore are not examined in this report.

In Hong Kong, there is currently no recognised standard methodology for conducting a LCC study, however the Environment, Transport and Works Bureau's (EWTB) Policy Unit is in the process of finalising such a standard, with the help of DLS Management Ltd. and this methodology will be implemented shortly for all Works Departments. The details of the methodology set out in this report therefore closely follow the proposals being considered by the ETWB, hence ensuring that HA's system is compatible to any new government directives issued in the future.

Based upon existing research[13], the number of Hong Kong government departments currently adopting any form of LCC assessment methodology is extremely limited and all of these evaluations primarily focus on building services machinery or equipment investments. This is perhaps a reflection of the global trend that LCC assessments are centred around isolated or single large capital investments, such as machinery, rather than investigating complex and sophisticated investments such as buildings.

[13] Research Survey carried out by DLS Management Ltd. for the ETWB in October 2002 on "*The Application and Use of LCC in Hong Kong Government Departments*".

As a general conclusion, the major concerns expressed by clients, around the world in relation to the application of the LCC for construction projects is the lack of reliable information. Since capital costs and end of life demolition costs are readily available, these do not pose any significant problem in terms of data availability, it is however, the operational phase of the project life where information is scarce. This situation is compounded by the fact that many commercial projects in Hong Kong are sold by developers, hence diminishing the relevance of whole life assessments to these organisations, as well as the fact that even in owner/occupier developments, the maintenance and management tasks are controlled by a large group of remote managers, each responsible for a single aspect of the building. Few clients, even large organisations, have in the past taken the additional time and effort needed to consolidate all this operational information into a single central source with a view to evaluate the overall performance of the development. HA is therefore not alone in adopting their current segmental approach to building construction maintenance and operation. HA does however have the ability to collect all the information into a central location without major change in operating practice.

1.5.7 Local and International LCC Information and Models

There are a large number of LCA tools available as previously described, but very few of them have LCC modules attached to them. In fact in reality there are very few pure LCC tools commercially available. The main reason for this is that the composition of an LCC tool is relatively simple and therefore through using the basic functions of most modern computer spreadsheet packages, a functional tool can be created within a few hours. Obviously the complexity and level of detail contained in the LCC model can vary, but the underlying principles remain the same.

Based upon a snapshot of some of the major LCA models reviewed[14], which have a LCC module attached, virtually all are very general or generic in the level of detail actually provided. This is clearly driven by two key factors. Firstly the tool is designed for LCA assessments and not LCC evaluation, hence the focus is placed on the environmental aspects at the expense of the cost issues. Secondly for any tool to contain relevant cost information there has to be some dynamic means of keeping the cost information up to date. It is this latter point, which must be considered in more detail.

Construction costs change constantly, and at the very least on a monthly basis, therefore any LCC tool has to have an active cost database. This database must be able to be adjusted using tender price indices to keep pace with current pricing trends. Coupled with this, is the need for the costs to be specific to a particular location, even for places as small as Hong Kong, there are some pricing variances between for example Hong Kong Island and the New Territories. These two factors combined together mean that most international LCC tools provide only the framework for calculation but no actual cost information, relying instead on the end user to input the information to suit their particular project. Those that do provide cost information provide very generic costs applicable to a specific country or a region within a large country (a State in the US for example).

If a step back from the problem is taken, it could be considered that in the case of LCA data, the factors used to calculate the environmental impacts are generally fixed, to the extent that they are only varied or updated occasionally and when more scientific information is available. Construction costs on the other hand change frequently as discussed above, but

[14] BEES (USA), Ecotect (Australia), Ener-Rate (Australia), Legoe, OGIP (Switzerland), Team (France), Carnegie Melon (USA), NIRM (Japan), LISA (Australia), Granlung Energy Tool and Envest (UK)

also the same material may have different financial implications depending upon its usage within a single project. Therefore costs are very project specific and have to be suited to the studied example.

In the case of some of the more complex LCA models studied, such as Envest in the UK, the cost modules are generated and maintained by a panel of experts, however, even here the information is out of date very quickly and is ultimately only useful as a guide. Even in the case of the HA tool the cost database is intended to provide a guide and order of magnitude resulting from decisions rather than specific detailed answers.

With this overview, the next sub-sections consider in more detail the LCC processes adopted as well as some of the major methodologies found around the world. The emphasis is not on the data within the models but more emphasis is placed on the methodology itself.

1.5.7.1 Standard International LCC Practices

Generally the major LCC models from the USA, UK and Australia have been reviewed in detail and these individual methodologies have been considered where information is available. Within these methodologies there are two basic themes, the structured and systematic approach to the development of a comprehensive LCC study and secondly the development of a simplified LCC evaluation tool for use on a particular issue.

The comprehensive approach to LCC is adopted most commonly in Australia and the US, where LCC studies are complex and detailed exercises. These are usually necessary in order to obtain State or Federal funding. In the US for example, the Federal Energy Management Program of the National Institute of Standards and Technology sets out in detail, the procedures to be adopted in the evaluation process and this exercise has to be carried out for all energy and water related projects as a conclusion of funding approval. Coupled with these rules are supplementary information published annually to assist in the calculation process[15]. However these rules are directed at the analysis of specific machines or components within the development rather than the development of a complete facility. In fact, the main intention is to compare alternative systems and their respective capital and maintenance costs, but not to consider any of the associated impacts, such as builder's work or impacts on the building design as a whole. This US approach is by far the most common application of LCC and again stems from the origins of LCC in the petroleum industry.

In Australia very similar methods of LCC evaluation are used, but here there is generally a tendency to use LCC techniques for whole construction projects. The primary emphasis of the LCC study is therefore in evaluating the whole life impact of the development. The most common LCC assessment method is the six-stage approach[16] set out below:

- Stage 1 : Plan LCC Analysis
- Stage 2 : Select / Develop LCC Model
- Stage 3 : Apply LCC Model
- Stage 4 : Document and Review LCC Results
- Stage 5 : Prepare Life Cost Analysis
- Stage 6 : Implement and Monitor Life Cost Analysis

[15] "*Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – April 2002, Annual Supplement to NIST Handbook 135 and NBS Special Publication 79,* "U.S. Department of Commerce, April 2002, USA

[16] Set out in the "*Life Cycle Costing Guideline*", New South Wales, Government Asset Management Committee, NSW Department of Public Works and Services, January 2001, Australia

As with all LCC approaches, the estimation of the cost impacts is particularly difficult and often the necessary information is simply not available. To overcome this problem there are generally three recognised methods that can be adopted when no actual cost information is available, the *Engineering Cost Method*, *Analogous Cost Method* and the *Parametric Cost Method*. All of these are suggested in the Australian Standard on LCC, AS 4536.

The UK has perhaps the least formalised LCC process of all the studied countries, by virtue of the fact that most clients tend to adopt their own in-house methods. Even the government LCC rules are very basic and offer the practitioner little if any guidance on how the method should be applied in the field. Perhaps the largest client organisation to use LCC studies on a regular basis is the British Airports Authority (BAA) who has developed a comprehensive database of cost and durability information over the last ten years. In addition, BAA has devised an in house computerised LCC model to evaluate the financial impactions of proposed study alternative materials.

Due to changing directives for government procurement practices in the UK, more emphasis has been placed on Whole life Costing as an evaluation method for *Private Finance Initiative* or *Public Private Partnerships* tenders. However, as with most countries, there is still a major lack of published and recognised cost data on the operation and maintenance phases of the building life. Ultimately without this information, the accuracy of any LCC assessment is always questionable.

1.5.7.2 Local LCC Practices, Standards and Application

The situation in Hong Kong is perhaps even worse than that in other countries, primarily due to the structure of the construction market and partly due to the age of the local building stock. Ultimately there is currently no standard methodology adopted in Hong Kong for LCC and virtually no clients regularly adopt LCC in their project evaluation process. The only real exceptions to this generalisation are the building services orientated Government Works Departments such as Water Services Department and the Electrical and Mechanical Services Department, whom apply this technique for the purchases of their plant and equipment.

If the two issues set out above are considered in a more detail, the scale of the problem can be understood. Firstly, many of the buildings constructed over the last 20 years have been built primarily for commercial purposes, to the extent that they were constructed for subsequent sale by the developer to other ultimate users. This means that the original developer has less interest in the long-term performance of the building being constructed, because he intends to pass on this responsibility to the future occupants upon completion. Such an attitude has been further compounded by the need to build projects very quickly without, in some cases, the requisite care being paid to construction quality or review of potential design or material alternatives.

The second issue is the age of the buildings. Hong Kong is generally a very modern city and this is reflected in the average age of its buildings, which is around 15 - 20 years old and with few buildings over 30 years old. In terms of LCC assessments, this is a major problem. If very few of the buildings in a country have not been in existence for their complete or very close to their design life, reliable cost data will not be available. Equally the actual performance of the buildings, their materials and occupational patterns are difficult to predict. Since the repair and maintenance segment of a LCC study constitutes a significant proportion of the overall cost of the building, in whole life terms, this

information is very important. The climatic conditions in Hong Kong are relatively unique and therefore adopting historical data from elsewhere in the world could distort the calculation models and the prediction of the results.

With these points in mind, the situation in Hong Kong has to be looked at from two directions, the theoretical approach and the practical approach. In terms of practicality, if the data does not currently exist, then the calculation method adopted is diminished in terms of its accuracy and can only be validated in many years time, as more information is made available. In theory however, predictions can be made as to how buildings will perform and these can be used as a replacement for actual data. Ultimately the adoption of theoretical data, which is progressively replaced by current valid data, is the only way LCC assessments can be carried out in Hong Kong in the short term.

The HA situation is perhaps a little different to the overall Hong Kong situation, primarily due to the fact that HA possesses a substantial building stock, from which extensive historical data can be sourced. This is important because all the necessary cost information is already gathered and held within a single organisation, making the extraction process simpler. The fact that HA does not currently do this extraction and collation exercise is not a reflection of a management deficiency, merely a result of the respective lower importance placed on whole life issues in Hong Kong.

HA is therefore in a position to gather all the necessary information to generate a relatively comprehensive LCC assessment. Having said this, great care has to be taken when comparing repair and maintenance information and profiles from older estates, due to the nature of the construction methods employed as well as the building codes and standards in force at the time of the original development. Social and population Trends also have to be considered but do not form part of this study. Therefore although historical information is available it should be used only as the basis for providing a theoretical framework, rather than a comprehensive solution to the lack of current data.

1.6 LCA AND LCC IN THE HKHA CONTEXT

1.6.1 HA Building Material Procurement Arrangements

This section provides a brief background review of the major procurement practices adopted by HA, to allow the methodologies for the study to be placed in their overall context. The procurement of all products, services and projects within HA generally follows the established *Government Tendering Rules* as laid down by the Treasury and the Government Supplies Departments. However, within these rules there is a degree of flexibility and HA do adopt some variations unique to themselves, and these are described in more detail below.

1.6.1.1 Review of Existing Practices

In accordance with the *Government Procurement Rules* issued by the Government of the Hong Kong SAR, all tenders issued by HA must comply with *World Trade Organisation* regulations. Open and competitive tendering practices are therefore generally essential. Equally, HA implements and maintains a series of approved lists that control the contractors eligible to tender for HA projects. New contractors can apply to be placed on these approved lists although the approval process takes some time and does require the submission of details relating to the financial performance and standing of the company. This system does, in practice result in a limitation in the number of new contractors applying to join the approved lists.

The main approved lists managed by HA cover capital works and specialist sub-contract works, for a *New Harmony 1 (Option 2) Block* namely building services related to Electrical, Fire Services, Water Pumps, Lifts and Automated Refuse Collection Systems (ARCS). In the case of maintenance works, HKHA maintains similar lists that are operated in the same way. Unlike the Works Departments of the Government, HA does not generally follow any of the published *Works Bureau Contractor Listings*, except for certain works that have to be ultimately handed over to other government departments upon completion. However, HA does provide information on performance and safety amongst other issues to the Works Bureau for their information and record.

HA, within its organisational structure, monitors and controls contractors that are eligible to tender based upon various contractor performance schemes. In the case of new works in the *Development and Construction Division*, this is the PASS system, whilst in the case of the *Estate Management Division*, there are a number of performance based schemes for both contractors and service providers.

Coupled with the works contractors in the *Estate Management Division*, there are also the Property Services Contractors, who provide estate management services. These organisations act like facilities managers but on an estate basis, covering both housing management as well as repair and maintenance services. Within these contracts, although maintenance works are included in the *Property Services Contracts* (PSC), the contractors are free to select their own maintenance sub-contractors provided they are on the appropriate approved lists maintained by HA. As with works carried out directly by HA, these PSC contractors tend to select their sub-contractors using a simple tendering process revolving around the lowest price.

The most common theme running throughout all of the above tendering practices is the fact that the tenderer with the lowest overall price will generally be awarded the contract. Despite this generality, some projects are now tendered on the basis of a weighted technical and fee basis, although these are still often confined to service based tenders rather than construction works projects.

The final aspect of HA procurement practice that needs to be considered is in relation to the procurement of materials. In the past HA has maintained comprehensive lists of approved manufacturers and suppliers for various materials and products. These lists have covered a wide range of standard products used on all HA standard block designs.

The objective of these approved lists was threefold. Firstly to ensure that there was a degree of consistency within the construction of the standard blocks, both aiding quality control, testing and future maintenance. Secondly, they allow HA to better work with suppliers to ensure that the necessary stock of materials is available to meet its construction programme. Finally this approach allowed HA to develop innovations to aid in the overall development of the standard block designs and assist contractors in shortening the construction programmes. One benefit which these approved lists could have afforded, but was never adopted by HA, was to use its bulk purchasing power to leverage and negotiate lower costs. This was avoided due to concerns regarding corruption and the risk of HA having to take possession of excess materials if production quotas fell.

Despite the clear advantages of the above system, HA has over the last few months taken significant steps to eliminate these approved lists. The driver behind these changes has been recent concerns regarding collusion as well as the desire to open the lists up to greater competition within the local market. In some ways, this move is contrary to the trend in

many other countries where closer supply chain management practices are more fashionable.

1.6.1.2 Comparison with the Hong Kong Market as a Whole

Generally the practices adopted by HA mirror those used by all Works Departments, however when compared with the private sector there are some noticeable differences. The most striking variance is in relation to the procurement of specialist materials. HA generally measures and includes these works as part of the lump sum tender package, hence shifting the responsibility onto the main contractor to source and procure the materials. The private sector on the other hand prefers to adopt a more "hands on" approach, whereby the client wants to be directly involved in the selection and price negotiation process. This approach is possible in the private sector since the constraints on negotiation, laid down by the Government Supplies Department and Independent Commission Against Corruption for the public sector, are not applicable to them. Therefore, private developers and clients have greater freedom to tender and source lower cost materials.

The most common method for selecting specialist materials found in the private sector is through the use of *Prime Cost Sums* in the tender documentation. Under this approach the client can defer the decision on certain materials and then tender them at a later date to his own tender list of preferred suppliers. Then following all the price negotiations, a sub-contract can be appointed, either on the basis of a simple supply only or as a complete supply and install package. The main contractor under this approach then takes over the proposed sub-contractor usually as a nominated supplier or in some cases as a domestic sub-contractor. Generally this private sector strategy generates a more complex contractual administration arrangement, but can potentially result in lower overall construction costs.

The other major difference between HA practice and that adopted by the private sector is in the degree of standardisation found in HA projects. Unlike the private sector, HA builds a very standard product. Even the non-standard domestic blocks incorporate many, if not all, of the features found in the standard block designs. The result is therefore that HA has the benefit of repeat construction processes and procurement practices. This degree of standardisation is unique to HA and results in their ability to generally obtain lower overall construction costs when compared with other sectors of the Hong Kong construction market.

1.6.2 HA Building Material Specification Procedures

This section addresses the main specification library system as well as the material selection criteria. This is followed by a review of how the specification standards are applied to different categories of projects undertaken by HA.

1.6.2.1 HA's Standard Specification Library

The HA *Standard Specification Library* (SSL) has been developed over a number of years and was first published in its current form in 1996. The current format is generally divided into four sub-sections for each specification section, these are:

- Design
- Materials
- Workmanship
- Testing

There are then a number of general sections, covering issues such as preliminaries and construction tolerances. The fundamental feature of the SSL is the fact that it is designed for use on all construction projects undertaken by HA's *Development and Construction Division*. Therefore the format is such that each building type has a predetermined "end branch" which, once selected, automatically extracts all the relevant standard clauses into the project specification.

This overall approach allows all new projects to be constructed to the same standard specification criteria as well as allowing specification upgrades to be implemented across all projects at the same time. It is understood that the current specification format is under review, aiming towards adopting greater performance based specifications. This means that designers can specify outputs in terms of design performance as opposed to having to define in detail the operation or functional requirements of the material or system.

1.6.2.2 Material Selection – New Works

Following on from the above is the material selection process. As noted previously, most of the materials used by HA currently come from one of the approved lists of suppliers or manufacturers. However with the recent shift away from a rigidly maintained series of approved lists, the designer has been given greater freedom to specify products, which are more suitable or (environmentally) innovative, although not departing too far from the underlying principles of the standard block design.

In general the material selection process of HA is rigid, to the extent that the designer has to satisfy the primary development constraints. The two most critical of these constraints are an economic design and a durable functional usage. The economic design reflects the nature of the block being constructed – rental public housing. The durable functional usage on the other hand reflects the real life application of the materials in relatively high trafficked situations.

Notwithstanding these design constraints, the traditional view and approach to selecting materials for HA developments has tended to pay little attention to whole life issues, such as maintenance impacts or durability. Until recently the main routes for feeding back information on materials or designs, which were considered unsuitable for their actual usage, were through "Feedback Forms" prepared by Estate Managers, and advice from project teams and contractors. Although this system was efficient in identifying potential problems, it relied heavily on the different parties to pro-actively initiate the process. Under the proposals of this study, more consideration and involvement of all the key stakeholders from all stages within the building's life will be required and their input will be fed back into the system to allow future designers to benefit from the practical knowledge acquired.

Generally, all New Works projects are handled by the *Development and Construction Division* and their materials specification process is set out by the SSL. There are a few isolated situations or special projects, which do not follow this standard rule, but they are exceptional cases and limited in number.

1.6.2.3 Material Selection – Maintenance Works

The repair and maintenance of all existing buildings and facilities is handled by the *Estate Management Division*, which takes over the responsibility for maintenance upon the completion of the project. One of the most important points to consider for these works is that, although all new buildings are constructed to a standard specification, the older

buildings within HA portfolio are not. Therefore from a maintenance point of view, there could easily be a number of different specification standards on the same estate.

The above leads to two key issues, firstly the practical problem of maintaining buildings constructed to differing standards and secondly the lack of a uniform set of materials being used on the buildings. Whilst it is common for the materials to differ from building to building, it is not usual for that variation to be extended to within a single estate, and certainly not in the private sector where one contractor is usually employed to build the complete development. However in HA's situation, different contractors often construct the different phases of the same estate, and even though they are working to the same specification requirements they may not adopt exactly the same brand of materials.

When all of these points are considered in the larger context of HA, it is apparent that the optimum repair and maintenance cycles cannot be currently achieved because the replacement materials may not be entirely identical to the original provision. Therefore although within the scope of this study, consideration is being given to replacement of original materials with identical materials, this in reality is not happening, hence the predicted whole life analysis could be potentially distorted.

1.6.2.4 Material Selection – Property Management Works

The final aspect is the property management of the completed facilities. Unlike the other stages of the building process, this category covers the actual management of the buildings and how they are operated. This stage in the life cycle of the building is important since many of the specified materials are chosen on the basis of a certain usage pattern. However if the reality is different, then durability or suitability issues for the selected material may be less appropriate when real life usage is considered.

In the case of HA, the most critical management issue is probably the activities of the cleansing contractors. Current practice often involves the washing of corridor and lift lobby floors using large volumes of water. However, this is sometimes found to be incompatible with the detailing of the tiling and the floor construction, which in other areas of the building have waterproof membranes or treatments included before the screed is laid.

1.7 BUILDING MATERIAL SUPPLIES AND THE ENVIRONMENT IN SOUTH CHINA

Following the Hong Kong pattern of twenty years ago, China has a 'high-skilled-low-cost' economy that is driven both by internal demand from the sheer size of it's population and external demand from its ability to manufacture high quality and competitive goods.[17] As a consequence China has substantially higher growth forecasts when compared with other regional centres and by some economic forecasters, considered to become the future 'workshop of the world'. Indeed it is calculated that the Guangdong province (directly north of Hong Kong) alone produces 34% of the national industrial output.[18]

Over the last few years the majority of industrial production in Hong Kong has been moved over the border to the special economic zone of Shenzhen and beyond where labour costs are much lower due to the availability of large numbers of skilled migrant workers. Indeed a significant proportion of the property and industrial development in China is financed by Hong Kong capital (70% of total contracted amount of Guangdong investment).[19] Similarly international manufacturing organisations are looking to source materials and

[17] Analysis – Rivals envy Chinese mix of high tech, cheap labour, Reuters Company News, 21 August 2002.
[18] Editorial, Hong Kong-Guangdong Economic Integration, MingPao, 27 Aug 2002.
[19] Ibid.

products from around the world, where costs are substantially lower.[20] The Pearl River Delta region is an attractive location in this respect. Moreover, this trend is exacerbated by the continued rise of environmental standards set by governments in mature developed economies like the European Union, the consequence of which is now forcing manufacturers to either clean up their manufacturing operations or to look for new manufacturing bases elsewhere with lower labour costs and less stringent environmental standards.

At present, China still lacks an adequately robust system to regulate the environmental burdens caused by its manufacturing industries, and this continues to allow serious pollution to occur.[21] One of the most significant of these, that causes considerable atmospheric pollution, is the use of brown coal for energy generation, manufacturing processing and domestic heating and in South China, around the Pearl River Delta, its effect is felt as far as Hong Kong where there is rising concern about its damage to health.[22,23]

However China is taking environmental issues very seriously, especially when compared with some other developing countries (for example in its ratification of the Kyoto Protocol at the Earth Summit in South Africa, September 2002). Indeed the environmental strides made in the Peoples Republic of China (PRC) are impressive. But the size of the country and its population, together with the need to balance economic growth and social stability with environmental improvement means that time is required before significant results can be achieved.[24]

While the PRC concedes that there are both political and economic hurdles to be tackled before there can be a general environmental regulatory improvement, 'green movements' in the West are very alarmed by the prospect of unbridled industrialisation without effective environmental controls on such a vast scale, determined by China's huge population. However these genuine concerns are often perceived as political pressure applied by the West to improve environmental standards at the cost of halting or slowing down China's programme of industrial modernisation. In response these pressures are often construed by China as hypocritical, the West's conveniently forgetting its own history of 'environmentally dirty' industrialisation, and sometimes even considered to be a means of slowing its progress towards its inevitable fate as an economic super power.

Clearly then any moves towards a more sustainable construction industry in the region that rely on the measurement of existing practices and the quantitative assessment of more sustainable alternatives must intrinsically be sufficiently sophisticated enough to reconcile both economic and environmental impacts.[25] Anything else would just not be considered worthy of review. It is for this reason that a unified methodology that includes both LCC and LCA is considered essential to discern 'real' and acceptable improvement strategies.

[20] The Changing Dynamics of the Hong Kong Economy, Hang Seng Economic Monthly, December 1998.
[21] Susmita Dasgupta, Ashoka Mody, Subhendu Roy, David Wheeler, :- Environmental Regulation and Development: A Cross-Country Empirical Analysis, WorldBank Policy Research Working Paper #1448, March 1995.
[22] Cross Border Measures Needed Against Pollution, South China Morning Post – 15th September 2002
[23] Alarm Grows at Record Smog Levels, South China Morning Post, 8th September 2002
[24] Guangdong Survey: General Survey, Get GD. Net, 2000. (http://www.getgd.net/gd_surv/gd_sur1.html)
[25] Jintao Xu, China's Paper Industry: Growth and Environmental Policy During Economic Reform, International Development Research Centre, Ottawa, Canada, 21 June 2000.

1.7.1 The Hong Kong Construction Industry

The situation in Hong Kong, although a little different, is also one where the same conclusion is inevitable. Hong Kong has operated under a strictly "laissez faire" system and remains one of the most (if not the most) competitive and open economies in the world.[26] Again to hope to reduce environmental burdens without clearly demonstrating the economic implications of any mooted 'greener' construction practice is regarded as wishful thinking. If changes to reduce construction related environmental burdens are made that may affect the long-term ability to make money they must be shared with fairness and transparency across society and moreover arrived at by a consensual process.
Hong Kong's construction industry is inexorably linked with manufacturing in South China.[27] It imports much of its material from the South China region (approximately up to 70% in the housing sector). It is also acknowledged that the construction industry, as in other developed regions, is responsible for a proportion of Hong Kong's overall environmental burdens that are considerably in excess of its contribution to gross domestic product (GDP).[28] Hong Kong's construction industry understands these relationships and therefore accepts that it has a responsibility to ameliorate the situation especially if it is to demonstrate throughout the region a significant reduction in its environmental impact.

Ultimately the route to understanding how improvement in the sustainability performance of Hong Kong's buildings can be achieved is through the identification of the economic and environmental profiles of the buildings' designs. It is at this stage where the commitment is made to; use certain materials, construction elements and components, construct in such a way and to operate the building using particular systems; the consequence of which will last 50 years or even longer.[29] It is therefore at this point that suitable economic and environmental information must be delivered to the client and design team.

The best method of establishing this information is through the comprehensive life-cycle mapping of construction materials in terms of cost and environmental burdens resultant from the existing building designs. This is not as difficult as at first it might appear. Hong Kong, unlike most other country's construction sectors is dominated by a relatively standard design approach, based on tried and tested reinforced concrete construction.[30] Equally Hong Kong has a substantial number of high rise residential towers, of which HA accounts for 48% of the total market supply.[31] Therefore, studying this particular housing solution i.e. one of just a few housing block archetypes, will be definitely representative of Hong Kong's residential construction sector which in turn is a considerable proportion of the industry's total output.

Hong Kong and the South China region are strongly driven by costs so, in this context, LCC must be included in any assessment together with LCA. In this study, two of the three recognised environmental aspects of sustainability are measured: economics and environment. The third, the social impact, has been excluded because at present there is lack of data and an agreed methodology, specifically the difficulty in setting the scope of such a study, and setting recognised and appropriate 'yardsticks' to measure social indicators. This is an area that HA may in the future wish to further investigate.

[26] http://www.countryreports.org/content/hongkong.htm
[27] Hong Kong Leading Sectors for U.S. Export and Investment, U.S. Department of Commerce – National Trade Data Bank, September 3, 1999.
[28] Waste: Problem & Solutions, Environmental Protection Department, Government of the Hong Kong SAR, 2002 (http://www.info.gov.hk/epd/english/environmentinhk/waste/prob_solutions/waste_run_out.htm)
[29] Management of List: Components & Materials Team, Housing Authority, Jan 2002. (http://www.housingauthority.gov.hk/dcb/applist/manage6.htm)
[30] Burnett J, :- Conventional Approaches Which Improve The Environmental Performance of Large Buildings, Department of Building Services Engineering, Hong Kong Polytechnic University.
[31] Hong Kong Annual Digest of Statistics, 2001 Edition, Census and Statistics Department of Hong Kong

2. THE HA LCA/LCC MODEL DEVELOPED

This section of the report provides detailed explanations of the overall approach and methodologies adopted for the LCA/LCC model developed. This is then followed by a description of the sources, collection, treatment and review of quantum, environmental and cost data used in the model. A description of the architecture and functionality of the database framework for the purpose designed LCA/LCC computer software is also provided. Finally, an account of the integration of LCC and LCA as a decision making tool for the selection of better alterative building materials is given.

2.1 OVERALL APPROACH

The integration of LCA and LCC presents a powerful route to improving the sustainability of the construction industry. As argued previously, combining economic and environmental assessment tools to obtain "best value" solutions in both financial and environmental terms has the potential to make a significant contribution to achieving sustainable building design. The potential benefits of the combining of LCC and LCA include:

- It combines two of the key features of sustainability;
- It aids decision-making through a technique, which presents the available options based on both quantified environmental and financial criteria and this is seen as an absolute value;
- It provides a transparent decision-making process;
- Materials manufacturers can use this to demonstrate the environmental and financial benefits of their products; and
- The relative sustainability of competing or new construction system can be assessed, ranging from a simple substitution of material, to a revision of a key element, to a complete building redesign using a standard set of parameters.

To achieve this, the following key steps need to be undertaken :

- Building the New Harmony 1 (Option 2) Block Quantum model (providing the base information for the Initial, Repair and Refurbishment, and End of Life calculation);
- Building the HK specific LCA database;
- Building the LCC database model;
- Building the Life Cycle Operational Energy model;
- Building the software delivery system including the LCA/LCC decision-making tool.

Key reference documents referred to in the course of this methodology stage include the SETAC documents *A Technical Framework for Life-Cycle Assessment* [32] and *LCA in Building and Construction: A State-of-the-art report of SETAC-EUROPE* [33], and the UK Building Research Establishment *BRE Methodology for Environmental Profiles of Construction Materials, Components and Buildings* [34].

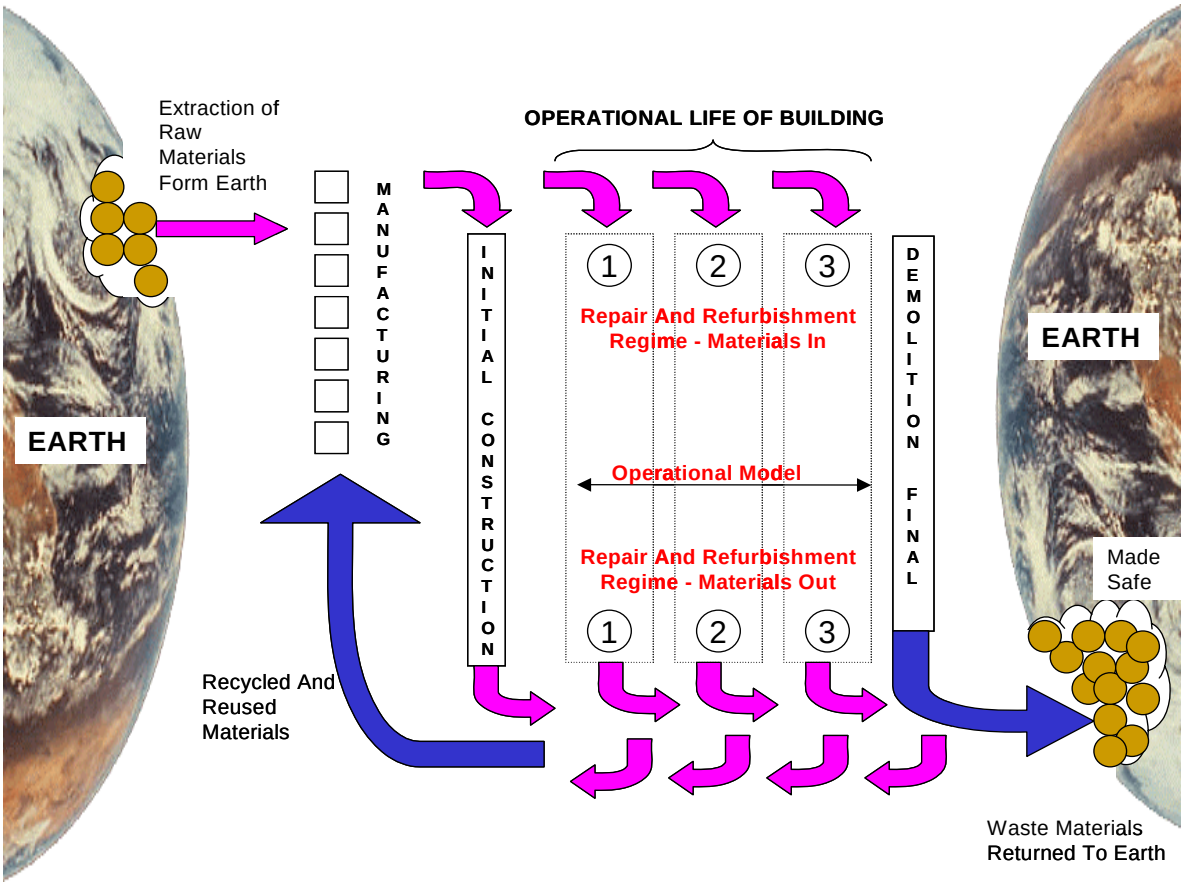
[32] *"A Technical Framework for Life-Cycle Assessment"*, SETAC, Europe: Fava, et.all. 1991.

[33] *"LCA in Building and Construction: A State-of-the-art report of SETAC-EUROPE:- Final Report"*, SETAC-Europe Working Group LCA in Building and Construction, Europe: Shpresa Kotaji, Agnes Schuurmans and Suzy Edwards. 2001.

[34] "BRE Methodology for Environmental Profiles of Construction Materials, Components and Buildings", BRE, London: Nigel Howard, Suzy Edwards and Jane Anderson. 2001

Before proceeding, it is helpful to outline the "full life cycle" of the building to be used as the basis of this report so as to provide the necessary context. This cycle is illustrated below and described in the following section.

Life Cycle Process Flow of a Building Material



2.2 LIFE CYCLE MODEL – BUILDING LIFE STAGES

The purpose of this section of the report is to explain and place in context some of the terms and definitions adopted in the LCA/LCC methodology developed. Since the overall objective of any LCC and LCA study is to assess and evaluate the performance of the building over its complete life span, it is necessary to divide the whole building life into the major life stages. The most widely accepted division of these building life stages, which shall also be used for the purposes of the HA LCA/LCC model are as set out and defined below.

2.2.1 Initial Stage

The initial stage of a building life is defined as the development or construction phase. This includes the physical development of the building and the creation of all the materials used in the construction process. In terms of the materials used in the original construction of the building, this initial phase would include the extraction of the raw materials and their delivery to the production facility, the manufacturing process and finally the transportation from the factory gate to the construction site. Once the materials are on site, there is then the construction process itself[35] and all the associated impacts that this induces. Therefore

[35] It should be noted that in this study the impact of on site activities are not included in the assessment, with the exception of construction waste.

for the LCA portion of this study, this phase would include all the measurable impacts from extraction of the basic raw materials through to the completion of the new building. Turning to the cost aspects of the development, the initial phase is primarily the capital cost of the building, but it would also include all the associated costs such as consultant fees and connection charges.

In summary therefore the initial phase of any building would be all costs and impacts involved in the creation of the finished building. The impacts measured during the manufacturing and transportation to the site are therefore also included within this stage of the building's life.

2.2.2 Repair and Maintenance Stage

Once the building has been constructed, the repair and maintenance phase commences. Whilst there are differing degrees of repair and maintenance required, during the whole duration of the building's life from the completion of the new building through to the demolition, these would all be classified as the repair and maintenance phase. It should also be noted that this stage would generally start when the building is handed over at the practical completion, although some of the repair and maintenance works would be included in the defects liability period and these again do not form part of the current study.

Within this stage and for the purposes of this study, there are also a number of categories of repair and maintenance works, which are classified as follows:

Day-to-Day Repair and Maintenance. As with any product or material, a building requires a great deal of minor repairs and activities, which take place on a daily basis. It is these items, which are classified as day-to-day repairs. Examples include changing light bulbs and replacing worn out filters and fittings in relation to building services items. In order to clearly define the scope included in this category, the boundary limit has been set at those works, which could be carried out by the building managers without the need for on site assistance from trained or qualified workers.

Planned Maintenance. This category includes those items of work that have to be carried out on a regular basis during the lifetime of the building and consist of:

- *Routine Repair and Maintenance* – many items of plant and equipment are installed on the basis that a certain amount of regular maintenance has to be carried out to ensure that they remain in full working order. Planned maintenance also covers those works that are carried out in advance of their actual need often referred to as preventative maintenance. Since all materials and systems have a design life and would, at the end of this period normally be replaced (refer to *Replacement* below), there would also be a point when the material is more economical to replace than repair.
- *Replacement Repair Works* - covers the replacement of materials and equipment that have reached the end of their life and need to be replaced. The replacement of some individual materials can take place at various stages during the whole life of the building and therefore they constitute a genuine maintenance activity. Also in replacing some items, other materials are affected, hence adding to the overall replacement cost impact.
- *Vacant Flat Refurbishment* – The maintenance work associated with various cycles of occupiers moving in and out of residential units are included in this category. In line with current HKHA policy four main categories of work have been used in the model, including *Touch Up*, *Repainting*, *Minor Works and Repainting*, *Major Internal*

Refurbishment, and *Internal and External Renovation*. The frequency of these work vary over the building life depending upon the occupancy profile.

Emergency Repairs and Maintenance. All buildings have incidents where repairs and maintenance works are required despite the materials having a substantially longer life span. These unpredictable and unexpected incidents do occur and for any whole life assessment to be considered as being complete they must be both addressed and included. Therefore for the purpose of this study a standard percentage allowance has been included to reflect the annual rate of these incidents. Although there are statistics available for these events, they are relatively limited in their applicability due to the fact that they vary widely based upon the location of the block and the nature of the tenants.

2.2.3 Operation Stage

Running in parallel to the repair and maintenance of the building is the general function of the building. In terms of the cost of the building, this includes the utility bills and the cost of the building management services and activities such as cleaning and security. In the case of the environmental aspects this would include the energy usage and associated impacts generated from the building's operation, from such items as the lighting, lifts and air conditioning. Therefore this category includes all impacts in respect of the usage of utilities such as electricity and water. For the purposes of this study the building will be divided into two primary areas, the public and the occupier areas, this allows for a more detailed analysis of the usage patterns of the premises to be performed.

Information on the cost and environmental impact associated with the operational energy consumption of the base building has been obtained using an *Operational Energy Model*, described in separately, as well as by marking reference to published data from the Electrical and Mechanical Services Department (EMSD) and actual utility bills. This operational energy component is important in providing context for alternative designs (e.g. the addition of fabric insulation or double glazing) and management practices that are known to affect operational energy use. Where such alternatives are known to affect operational energy use, the *Operational Energy Model* can therefore be used to assess their likely life cycle impacts. Where alternative materials are to be considered that are known not to affect operational energy (e.g. substituting one tile for another) the base data will remain valid and the *Operational Energy Model* need not be rerun. In other words, the *Operational Energy Model* provides an additional tool for use when it is necessary to review the impact of specification changes to the building envelope or HVAC regime that might increase embodied impacts but reduce operational energy use. Without such a predictive model the affect of such changes upon operational energy impacts and costs cannot be calculated.

2.2.4 End of Life Stage

The final category reflects the end of the building's serviceable life span and includes the demolition and removal of the building as a whole. Coupled with this is the reinstatement of the land to a state where it could be redeveloped in the future, hence it would include the total demolition and removal of the structure from the site as well as site clearance. The two other aspects considered at this stage are the potential for recycling arising from the demolished building materials, particularly those which are metal based and secondly the credit value obtained from any recycling of materials. For the purposes of this study no allowance is made for the land issues, since this is considered as being likely to distort the financial comparison of the development as a whole.

2.3 THE QUANTUM MODEL

The quantum model is the driver behind the whole LCA/LCC study since all the environmental impacts are derived based upon the overall mass of the individual materials. Therefore it is important to understand how and where the information for this model originates and how it is subsequently handled.

2.3.1 Objective of the Quantum Model

The objective of the quantum model is threefold, firstly to provide the necessary data for calculation and generation of environmental impacts, secondly it provides a context and measure for use in evaluating impacts associated with repair and maintenance regimes and finally it provides the comparison criteria for use when alternative materials or functional units are being considered. Taking each of these issues in turn, the overall objective of deriving the quantum model and its respective place in the overall methodology will be placed into the context of this study.

As noted above, the evaluation of the environmental impact of a building or for that matter a functional unit is derived from the individual masses of the particular materials. Since each environmental impact is a factor, this factor has to be multiplied by a mass to generate the overall impact associated with the material under study. Hence materials with higher resultant environmental impact mean that they would be less beneficial in comparison to another material with a lower impact, after due consideration of their total mass used for the same application. Perhaps the best illustration of this point is the comparison between steel and concrete. It is generally known and accepted that steel has a higher environmental impact per kilogram to that of concrete, however, in terms of mass, substantially less steel is required to form a structural frame than a similar structural frame made of concrete. Therefore the fact that concrete has a lower environmental impact on a per kg basis, this may not be the case when a whole building system is considered. Therefore the quantum of each material used in the building has to be measured in detail so that the real relationship between each material's total mass can be assessed.

Whilst the above addresses the situation at the initial stage, the same is also true during the repair and maintenance stage, where again the quantum of each material used is the benchmark against which all other materials in the context of the whole building's life are evaluated. Therefore the objective of this model is to extract and identify all the quantities for each material within the building over the whole life of that building. These quantities are then converted to individual masses that can then be used both to compare with other materials as well as derive the environmental impact of each material category.

2.3.2 Data Collection and Information Sources

The quantum data used in this study has been sourced from a number of sources and documents, most of which closely track the cost data. These documents include the bills of quantities and schedules of rates used on main construction contracts as well as property services contracts. These documents provide a detailed itemised breakdown of all the materials used in the building, although not a comprehensive schedule of construction material quantities, they are considered to be detailed enough for this study because they can be converted into individual material masses. Generally little adjustment to the gathered data has been carried out, except where a greater level of detail is required. In these cases actual measurement from drawings has been undertaken.

It should be noted that since a standard bill of quantities is not provided by HA for the building services elements of the New Harmony 1 (Option 2) block, data is instead

obtained from the information provided by nominated sub-contractors in their submitted tenders. Whilst it is understood that these quantities are not necessarily accurate for the completed building, they are still considered as an acceptable reference guide within the context of the whole model, particularly since building services elements are not intended to be the focus of this study.

Generally there are four major categories of construction contracts used during the building's life, excluding the repair and maintenance phase. These are the foundation, building, building services and demolition contracts.

The foundation contract comprises general site formation, piling and pile cap works, whilst not all buildings have piled foundations, the vast majority in Hong Kong do, therefore it is representative to use a generic set of foundation designs for the purpose of developing an initial model[36]. Also it is necessary to include foundations to allow a comprehensive whole building profile to be generated.

The building contract includes the main construction works for the building and covers all physical works from the top of the pile caps. Within the contract there are a number of sub-contracts, which are defined as the building services contracts, these include packages for Electrical, Fire Services, Water Pumps, Lifts and Automated Refuse Collection Systems (ARCS)[37]. The plumbing installation is included within the main building contract. It is these contracts that provide the majority of the quantitative data for application in the quantum model and they are used to represent the base mass of the building as a whole.

The final major contract is the demolition contract, which covers both the physical removal of the building at the end of its life as well as the identification of the recycling potential of certain material.

The major contracts, as noted above, exclude the repair and maintenance phase of the building life. During this stage the situation becomes more complicated since the quantities of materials are established based upon no fixed or predetermined schedule or scope. Therefore there are two possible approaches, firstly the actual quantities used in the repair and maintenance operations are identified based upon past historical records or alternatively all the materials in the building are analysed based upon their potential repair and maintenance cycles. For the purposes of this study a combination of both these two approaches has been adopted, since some materials can be accurately quantified from maintenance records whilst others require a more generic allowance to be made.

In this respect, those materials which are involved in routine and preventative maintenance cycles as well as in replacement works are quantified by making reference to existing historical records, while in the case of the day-to-day repairs and emergency work, these are quantified, using generic allowances. One final point to consider is the fact that the building being studied, the New Harmony 1 (Option 2) block is new, and therefore there are no current maintenance records available. In order to overcome this deficiency analysis of similar block types (mainly existing Harmony 1 blocks and, for older buildings, Trident and other cruciform shaped buildings) over the last 20 years to study their repair and maintenance trends has been carried out to build up a picture which could be regarded as representative of what the maintenance profile of the New Harmony 1 (Option 2) block would look like in the future. It should however be noted that this only provide a guide as

[36] Which in this case has been selected as in-situ concrete bored piles, the design quantities being taken from actual HKHA projects, since this is considered to be the most representative of the foundation systems used in Hong Kong.
[37] For this study the ARCS is not included due to its current limited usage on HKHA projects.

to the likely profile. In order to provide consistency with the published ISO standards[38] the factor approach to repair and maintenance has been applied whereby each functional unit has been evaluated to assess the potential likelihood and impact of repair work occurring.

The factor method comprises on three stage process :-

- Stage 1 – Using a 9 level scale of percentage likelihood each material in a functional unit is changed based upon how likely repair or replacement would occur.

- Stage 2 – Using a 10 level scale of percentage intervals the extent to which the identified replacement would apply. This determines the percentage amount of a functional unit involved.

- Stage 3 – the final allowance factor is their calculated using the product of the outcomes from stages 1 and 2 above.

Turning to the format of the data generated, as noted above all the materials will be quantified but ultimately they will be converted into a common unit, in this case kilogrammes. Mass has been selected as the common unit since all the environmental impacts are measured based upon a mass denominator and also for the calculation of transport and other associated construction impacts, mass will be the overriding factor. The conversion factors adopted for this study are the internationally recognised densities of primary materials, which are widely published.

The final factor to consider as part of the quantum model is the allowance for wastage in the generation of the overall material mass. In all construction processes, there will be a degree of wastage, the amount of which varies depending upon both the stage in the construction process as well as the nature of the material being used. Coupled with this, the same material may have different wastage patterns at any building life stage depending on what the material is being used for. Therefore each functional unit and the respective sub-materials are evaluated separately to ensure that the wastage is correctly accounted.

In terms of sourcing data for these materials there is generally limited published information not only in Hong Kong but around the world. The Architectural Services Department has a technical circular that was issued in the 1980's, advising on the wastage patterns of certain materials and this information has been considered for the study. However the most reliable and widely accepted wastage pattern information is derived from interim payment applications prepared on construction projects by consultants, results of which are agreed with the contractor. Therefore although information is generally lacking on this complex area, the most up to date information from the consultant's interim payment applications has been considered along with advice from contractors involved in HA projects so that the most representative allowances can be included.

As noted, the quantum data has been collected from published Housing Authority standard documents and through the review and interpretation of historical records. Since accurate historical records are not available, assumptions and professional judgment interpretations have been applied for most material and functional units. It is expected that these would be validated in time by HKHA themselves as these information become available from completed New Harmony 1 Block premises.

[38] ISO 15686-1

In summary, the initial quantum data for the superstructure works comes largely from the Standard BQ for the new Harmony 1 (Option 2) Block (6/00 Revision to 1/00 Edition) documents prepared by the Housing Authority, whilst the repair and maintenance data is sourced from historical data for existing Housing Authority estates covering typical standard cruciform block types. Foundation quantities have been sourced from Harmony 1 block foundation tenders (contractor design options).[39] Building Services quantities have generally been obtained from the standard quantified schedules of rates prepared for the New Harmony 1 blocks as well as Nominated Sub-Contract tender pricing for Harmony 1 blocks. Finally the waste data is based upon previous research carried out by the Hong Kong Polytechnic University, DLS internal data, contractor's feedback and published government guidelines.[40]

2.4 FUNCTIONAL UNITS

Derived from the quantum model, functional units are the core of the LCA/LCC model and are the base against which all other aspects of the LCC/LCA calculation process are cross-referenced.

2.4.1 Definition

A functional unit is a group of materials which together constitute a component or system within the building, for example a cooking bench or a letter box. The model as developed for the New Harmony 1 block comprises 154 functional units from the foundations through to the building services installations, a complete list is given in *Appendix A*.

Within each functional unit there are a series of component materials which make up that functional unit. The number and type of materials within each functional unit vary depending upon the unit itself. There are initially 105 different base materials identified and used in the different functional units. This number of materials is considered to represent a significant proportion of all materials used in all Hong Kong construction projects.

Based upon the detailed quantification process it has became clear that not all of these materials should be considered in detail in this study since where the quantity of material (in terms of mass) was calculated to be less than 0.0001kg, their overall impact was found to be too insignificant and hence these items were excluded. This threshold was selected since the excluded items represent only those very minor materials, both in terms of quantity and cost. Additionally the environmental impact of these items is insignificant in the context of the overall building.

Another group of materials which are excluded from the individual functional units are those items which are impossible to accurately quantify or which are not usually fully designed and detailed by the Housing Authority. The best example would be the plastic spacers used in the setting out of reinforcement, which whilst they do have a mass and hence an environmental impact, their quantities are determined by the Contractor, usually on site and are therefore both inconsistent in usage and generally un-quantifiable. It is for these reasons that these items are excluded from the current model database, although they could be included in the future if more reliable data was available.

[39] Foundation quantities have been sourced from Harmony 1 blocks rather tham New Harmony 1 blocks primarily because the number of foundation tenders for this new block type is limited to 1 or 2. In addition the foundation system considered most appropriate for the HK ground conditions would be the one used on the majority of projects. It is suggested also that there is likely to be minimal difference between the foundation costs of the H1 block and the NH1 blocks.

[40] ASD Technical Circulars

2.4.2 Identification

As noted above the determination of the different functional units has been driven by two aspects, the ability to quantify and primarily the logical grouping of materials. It has been an important task to classify and define all functional units in such a way as to allow and aid the future application of the tool. Whilst some of the functional units are obvious in definition others are less readily classified. In generating the final list of functional units all these factors have been taken into account, as has the future need for these units to be examined in the context of alternative comparisons or future analysis processes.

In the case of the building services items it was concluded that from an analysis point of view a system grouping approach was the most appropriate and hence was adopted.

2.4.3 Selection

The final phase of the functional unit creation process has been to consider how the units inter-relate and together form the complete building. In this context each functional unit has been classified against a standard elemental code. This process ensures that in each report all related functional units can be grouped by element for presentation purposes.

The elemental division adopted follows the internationally accepted approach of the Building Cost Information Service (BCIS) in the UK and represents the most widely adopted practice in Hong Kong. The fundamental breakdown (of principal categories) is as follows:

- Foundation & Substructure
- Carcase
- Finishings
- Furniture & Fittings
- Services; and
- Miscellaneous

Within each of the above there are a series of sub-elements. It should be noted that these sub-elements are intended to be standard and not just specific to the New Harmony 1 Block. This approach allows for future expansion of the model for other building types as well as the possibility of evaluating a whole estate.

2.5 THE LCA MODEL AND DATABASE

As discussed in *Section 1*, information from an environmental database can rarely be input directly into an LCA model without some manipulation to ensure the appropriate context. This section describes the adoption of the following four key processes that have been undertaken, in accordance with ISO14042 and international practices, to ensure that the use of overseas environmental data for building materials is appropriate in the HA context:

- *Regionalisation* – the adjustment of overseas environmental data for "cradle to factory gate" processes to ensure their applicability in the local context, taking into account of factors such as energy mix and method of power generation, production processes, raw materials used, and transportation to the construction site;
- *Characterisation* – the analysis and classification of the many different environmental outputs arising from the provision of a building material into ten more manageable but representative and informative environmental impact categories using common units

appropriate to each (e.g. tonnes of carbon dioxide equivalent for releases associated with climate change);

- *Normalisation* – the conversion of the characterised environmental impact data to a notional regional average to allow different environmental impacts to be compared and investigated under a common basis (for example, per person, per square km of land, per unit Gross National Product or, as used in this study, nominal *Hong Kong Eco-Points representing per HK citizen*); and
- *Weighting* – assigning the relative importance of each environmental impact to arrive at a single consolidated environmental impact indicator. The weighting is based upon the consensus achieved from the series of weighting workshops conducted for the study

The approach used in the adoption of these principles, processes and techniques for this assignment for the development of the LCA database are detailed in the following sections. It should be noted that it is the characterised, regionalised and normalised *data* from sources such as SIMAPRO which provides the basis of this study with only the final normalised impacts being contained within the HA LCA/LCC model. Since the raw data and LCA tools themselves do not form part of the final model, licensing of such sources is not therefore required.

2.5.1 Environmental Impact Data Collection

The objective of the Environmental Impact/Life Cycle Assessment (LCI) data collection process is to match the material inputs and outputs of the identified materials with the recorded local production profile. This is achieved by matching the production processes, raw material inputs, pre-manufactured material inputs, the proportion of each material and by-products generated, to those of the local production profile. In this study, as set out in the Stage 1 report, a detailed transport study was carried out to identify the major sources of the materials used in the New Harmony 1 block.

This study was further extended in Stage 2 to address the mode of transportation as well as the physical distances involved. Therefore whilst many of the materials used in the studied block are commonly adopted in European countries, the origin of these materials differs for Hong Kong projects. These differences have therefore been used as the basis of the regionalisation process described below.

The production of a building material may involve multiple manufacturing processes, which may have significant differences in the following areas:

- Raw material inputs
- Pre-manufactured material inputs
- Sources of raw material and pre-manufactured materials
- Proportion of each material
- Quantities of water used
- Processes of manufacturing
- By-products generated

For example, in the context of the Hong Kong construction industry, steel reinforced bars are made from steel bars produced by both Basic Oxygen Furnaces (BOF) in China and Electric-Arc-Furnace (EAF) in South Africa. The major raw material used in the BOF steel production process is iron ore while the raw material used in the EAF steel productive process is iron scrap. These raw material sources, production processes and fuels used are very different for each method of production. To reflect the mixed use of BOF and EAF

steel in the local supply chain, the LCI data is arrived at by applying an average, based on the proportional contribution of each production source used in the local market derived from our own research and local market feedback.

Establishing the production profile of local building materials is crucial as the appropriateness of the LCI data is evaluated against it. In order to establish the production profile, a data gathering exercise with the suppliers and manufacturers of key materials that are produced locally was undertaken. Key material manufacturers (identified in the table below) have participated in two workshops (held on 17 and 19 September 2002) to discuss their production processes in light of the above five factors, and establish the availability of their own environmental data or other information sources for local production.

Participants in the Environmental Data Collection Workshops

Steel wire mesh Golik Metal Manufacturing **Water proofing** Shell HK Ltd. Wo Lung Engineering and Construction Ltd. **Precast and ready mixed concrete** Redland Precast Concrete Products Yau Lee Wah Concrete Precast Products Ken On Concrete Pioneer Concrete Daido Group Unicon Concrete Products	**UPVC pipes and fittings** Universal Hardware & Plastic FTY. **Tiles** BSC Ceramic Tiles Supply Ltd L.F. Sam (HK) Ltd. **Paints** China Paint MGF Co (1946) Ltd. **Sanitary fitting and wares** BSC Building Material Supply Co. Ltd. The Jardine Engineering Co., Building products
Timber Doorsets Jardine Engineering Kwong Yin Wing Koo Timber Tai Wah Aluminium Engineering Tai Wah Construction Ltd.	**Aluminium Windows** Everlink Aluminium Works Million Hope Industries Tai Wah Aluminium Engineering

These workshops followed a methodology in accordance with ISO 14040 and international LCA conventions established in the construction sector. The reason and significance of this study as well as the reasons for the environmental parameters and impacts chosen to measure were explained to the manufacturers.

During the workshops delegates were invited to discuss and contribute their ideas and technical information. Participants were briefed on the use of default environmental indicators where regionalised date from international sources was not available, and invited to the particulars provide their own data to either substantiate or prove that their emissions and energy consumption profiles were better than the default figures. Additional information was requested where possible on SO_x and NO_x emissions/particulates, water consumption etc.

The team also discussed with these local manufacturers methods of improving their environmental performance. It is hoped that the client/materials manufacturers group will continue meeting after the study to regularly discuss environmental improvements and investigate more favourable products and construction systems.

Where environmental data was obtained, the team reviewed it for accuracy, methodology and bias, and took this information into account when using it for the regionalization of the SimaPro database.

The local production profile generally comprised information on the following processes:

- Source of raw materials
- Transportation method for each raw material identified
- Manufacturing location
- Manufacturing process
- Waste generated from manufacturing process
- Finished goods transportation method
- Possible future environmental improvements
- Barriers to make possible environmental improvements
- Identification of specific environmental regulations governing manufacturing process

When evaluating LCI data the team used the following criteria:

- Match of production process
- Match of raw material inputs
- Match of pre-manufactured material inputs
- Match of proportion of each material
- Match of by-product generated

To illustrate the evaluation process we have adopted using the above criteria, we have selected cement as an illustrate example. LCI data for cement was extracted from the published ETH-ESU European database for use in this study. Then the production process used in this database was compared against the Hong Kong scenario which comprised the following:

- *Match of production process* - Hong Kong suppliers supply, cement produced by the dry method. The raw materials are extracted, ground to a power, blended, and fed into a kiln in a dry state. The ETH-ESU database contains data for cement produced using the dry production method and was therefore selected.
- *Match of raw materials inputs and pre-manufactured inputs* – As stated by local suppliers, the raw materials used in cement production are limestone, clinker, sand, gypsum, additives and clay. ETH-ESU contains data with matching ingredients and was therefore selected.
- *Match of proportion of each material* – No information is provided. We can only assume the proportions and are similar in West Europe and the South Asia region.
- *Match of by-product generated* - No information is provided. As ETH-ESU contains data for mass balance inputs and outputs, we assume it aligns with the South East Asia production profile.

After determining that the data is a suitable match, the quality of the data must be determined. The following criteria are used:

- *Accuracy* – does the data come from repeated measurements?
- *Completeness* – does the data's mass inputs and outputs balance?
- *Representativity* – is the data based on average technology and collected within ten years?
- *Repeatability* - is the data bias in one of the impacts?
- *Variability* – do the energy and CO_2 emission figures vary greatly from those of previous studies and published data?

The cement production data contained in the ETH-ESU database is of excellent quality, as is evidenced by the following:

- *Accurate* - The data is derived from repeated measurement in various production plants.
- *Completeness* - The data balances mass and energy flow including all raw material inputs.
- *Representativity* - The data is referenced to the production in 1990-1994.
- *Repeatability* - All inputs and outputs of the ten impacts are studied.
- *Variability* - The energy consumption and CO_2 emission figures align with previous local figures.[41]

The last step of LCI data collection process is to determine whether the data is suitable for regionalisation. This requires investigating the existence of energy inputs and outputs and transport components. In the ETH-ESU database for example, energy inputs and outputs and transport components are clearly stated and can be regionalised independently such that we can easily swap the mode of transport from truck to ship. Similar processes were adopted for all the other LCI databases used for this study ensuring that all the results reflected the Hong Kong market situation.

2.5.2 Transportation Considerations

Transportation considerations are an integral part of the overall methodology of the LCA study and in conjunction with the findings from data gathering workshops are necessary to allow captured environmental impact data (from SIMAPRO databases) to be converted into a regionally based set of factors. This section will briefly set the detailed methodology for this section of the *Transportation Study*, conducted specifically for this assignment as well as a summary of the key results. The information generated from this study has been used within the overall regionalisation process.

2.5.2.1 Purpose and Objectives of the Transportation Study

As noted above, the key purpose of the transportation study is to develop a graphical representation of the material transportation profiles for the New Harmony 1 (Option 2) Block. To place this into context, all environmental impact data is generated for a specific location, therefore for this data to be usable within another jurisdiction there has to be a process of regionalisation. This process, involves consideration of transportation at two stages: of the raw materials to the processing and manufacturing facilities (i.e. “to the factory gate”); and of processed materials to the construction site (i.e. “from factory gate”). The Transportation Study discussed here addresses the second stage, the transportation distances of construction materials from the manufacture plant to the construction site. The first stage (transportation to factory gate) is inseparable from the extraction and processing of raw materials and manufacture of finished materials, and is therefore being handled during the regionalisation of raw material extraction and production processes.

2.5.2.2 Methodology for the Transportation Study

The process adopted for developing the transport study was broken down into two key stages. Firstly, the majority of materials making up the initial construction of the New

[41] We refer to “Analysis of embodied energy use in residential building of Hong Kong. T. Chen, J. Burnett and C.K. Chau. Energy – The International Journal, Vol. 26, No. 4, 2001, pg. 323-340.

Harmony 1 Block (Option 2) building were identified[42]. Secondly the location of the origin for all of these materials was then sourced.

The material scan of the New Harmony 1 (Option 2) Block building comprised all materials used in the base building construction including both the substructure superstructure and the building services elements, it did however exclude, for the purposes of this transport study the temporary works element. The temporary works were excluded due to the fact that the majority of the material mass involved was timber and the sourcing location of this timber was found to be divided between three primary locations, China, Malaysia and Indonesia. This variation was also driven by the specific contractor used on the particular project as well as the location of the site. This information has been used in the other LCA data treatment stages of the study.

In scanning all the materials, information from the standard bills of quantities was used as a basis, but further division of the material components was carried out to generate a detailed list of all the primary materials used in the block, therefore components were further divided into all their constituent parts. This therefore generated a comprehensive list of all the materials used as well as their respective functional usage, which resulted in a total of 154 material units being identified[43]. The second stage of the material scan involved the quantification of the identified material units in terms of their own unit of measurement; metres, square metres, cubic metres, kilogrammes. These differing units of measurement were then converted into a uniform mass unit (kilogrammes) that could then be compared on an equal basis. As part of this conversion process, the respective wastage factors, discussed previously were then included to generate the gross mass of each material unit. It was then this gross mass that would be used as the basis of all subsequent comparisons. The purpose of using the gross mass was that this would represent the actual amount of material transported from the factory gate to the site and not simply the net mass of material that ended up in the finished building.

The next stage of the process was the identification of the country of origin for all of the identified material units from Materials Approval Forms from representative Harmony Block projects (although "place of manufacturing" would be more accurate, only the country of origin is stated on these forms). The Material Approval Forms contain details of all materials submitted by the contractor to the project team for approval and the approved materials are then used in the final construction of the building. Under current HA practices, all materials have to be approved prior to incorporation within the building, therefore this is clearly the most comprehensive record of all the materials which are to be found within a HA block. If materials are not approved or included on material record forms, they should not form part of the building. These material approval forms contain a number of items of information, the most important of which are the name of the supplier/manufacturer and their country of origin. Whilst there is some inconsistency in how these forms are completed, the contents are generally adequate for the purposes of this transport study.

The next stage of the study, after having separated all the respective material approval forms for a New Harmony 1 (Option 2) Block, was to identify the country of origin for each of the 154 material units. In carrying out this process, it was found that some of the

[42] The transportation study excludes some items such as accessories that are not separately quantified and have indistinguishable costs, for example: plastic and rubber spacers (for rebar, tiles, precast façades, glazing, plywood packer pieces), structural and silicone building adhesive, panel wall reinforcing tape, toilet and pipe sealant, conduit accessories, cable lugs and cleats, cork stoppers, tying wire, screws, nuts and nails etc.

[43] The difference between the 105 materials in the database and the 154 materials identified here is due to the same material being used for different functions within the building.

material units still comprised a number of minor sub-components, which involved separate material approval submissions, items such as doorsets fell into this category. Clearly a distinction had to be draw between the primary materials and those that could be regarded as minor sub-components and had minimal mass impact on the material unit as a whole. Therefore in the definition of the country of origin, the main material components were used and those minor sub-components were disregarded.

It should be noted that, during this origin identification process, some materials could be sourced from different countries. This situation occurred most frequently in the case of the building services items, but also arose for some of the structural components such as steel. In order to overcome this divergence, the location with the dominant share of the material sourcing was used as the country of origin for the material unit. Whilst this is probably not the most scientific method that could be applied, it does provide a representative profile of the material's counties of origin. In addition, in instances where this situation occurs, the overall impact on the material mass profile was checkable ensure the results were not distorted. The findings were that since the mass of the materials involved was relatively minor in the context of the whole building no distortion occurred. Once each material unit had its country of origin identified this information could then be collated and presented, as part of the overall results, which is set out below in more detail.

2.5.2.3 Overview of the Transportation Study Findings

Turning to the results of this transport study, it is perhaps unsurprising that the vast majority of the materials used in the New Harmony 1 (Option 2) Block originate from either Hong Kong or China. In terms of results, there are two ways of looking at the allocation of materials, either on the basis of mass for each location or on the basis of number of different products.[44] For the study analysis, mass is clearly the most important feature, therefore the number of products whilst interesting is less important in environmental terms than the mass of material originating from each location, hence only mass has been considered in these results.

The other factor influencing the results is that certain materials are manufactured in a number of locations and depending upon which supplier was involved in the projects, the study results may be distorted. The best example of this aspect is the precast concrete panel walls used inside residential flats, there are currently 6 approved suppliers, four from mainland China, one in Hong Kong and one in Malaysia. It is known from other previous research[45] that of these 6 suppliers only five are active and within these five, four are directly attached to main contractors on HA's Premier League. However the remaining supplier has over 60% of the total market share and this supplier is based in Hong Kong.

The chart below shows graphically the distribution of the materials used in the studied building and based upon percentage of the total building mass and divided across each geographical region.

In terms of mass, the obvious dominant materials will be insitu concrete and reinforcement and these are sourced from Hong Kong and China, respectively. Therefore in any analysis Hong Kong and China will dominate the results. On a wider scale, there are still relatively few other countries from which the materials used in the New Harmony 1 (Option 2) Block are sourced.

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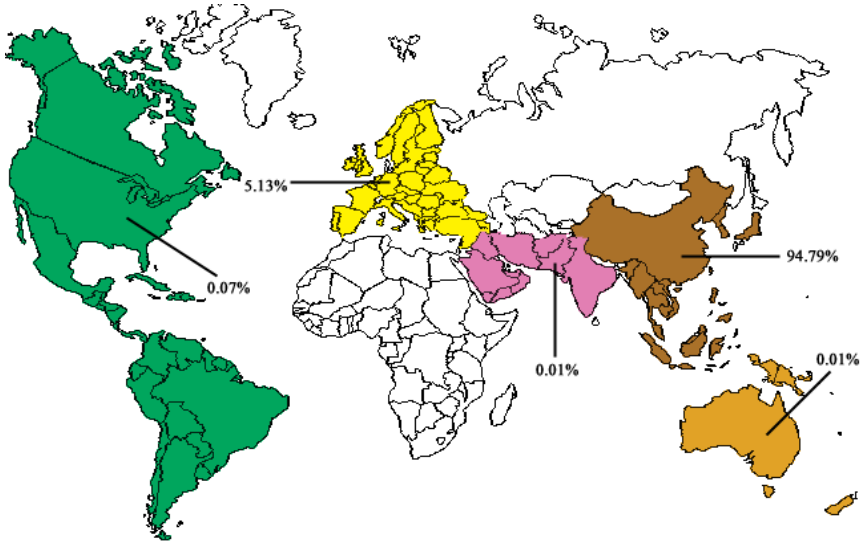
[44] In terms of building product origins, the study revealed that although Hong Kong generally does not produce many materials within its territorial boundaries, many companies mark their products with Hong Kong as the point of origin.

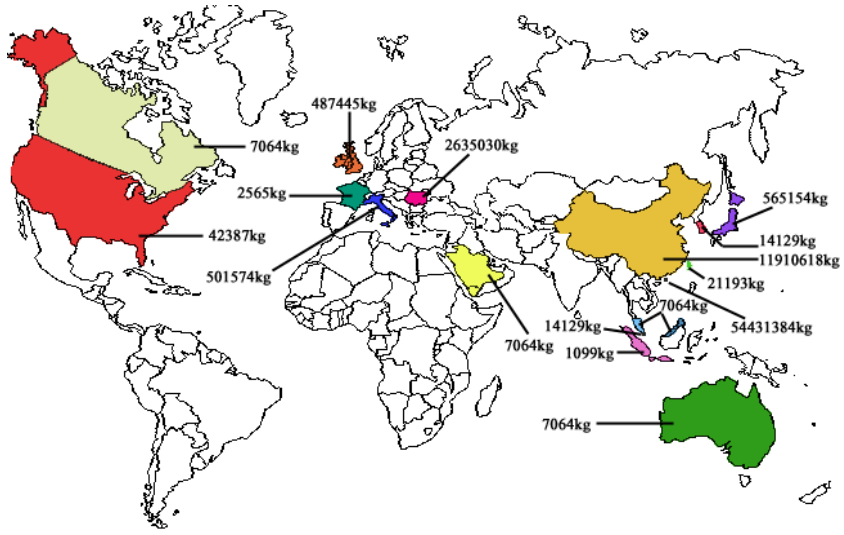
[45] Research into Precast Panel Wall Market in Hong Kong, carried out by DLS Management Ltd.

To place the percentages in the chart below into context, the map is reproduced overleaf using the mass values for individual countries. It can be seen from these illustrations that over 94% of the total mass of the building is sourced from within the Asia Pacific region, which although geographically a huge area should be regarded as being within the close proximity of Hong Kong. When this region is examined in more detail it can be seen that only a few countries dominate the material sourcing.

NH1 (Option 2) Building Materials: Global Origins (Percentage Mass)

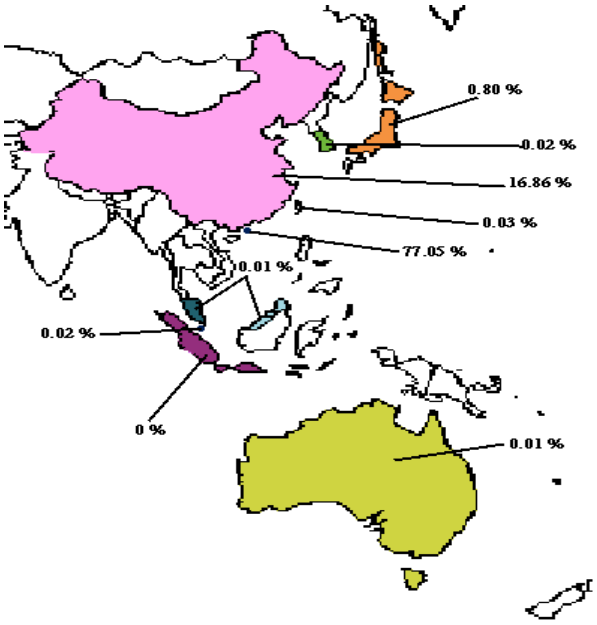


NH1 (Option 2) Building Materials: Global Origins (by Mass)



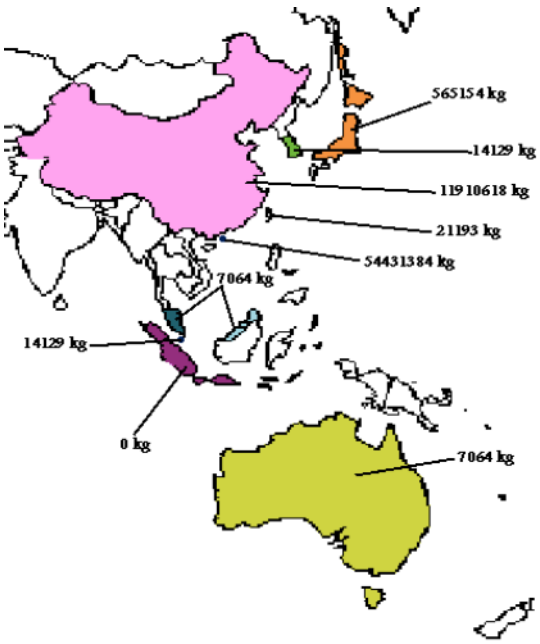
In fact Hong Kong and China bear the most significant percentage in terms of building materials by origin. In terms of the transportation profile of the New Harmony 1 (Option 2) Block it is apparent that the distances travelled for the vast majority of the materials involved are relatively short.

NH1 (Option 2) Building Materials: Asia Pacific Origins (Percentage Mass)



Translation of the above regional percentages into mass values is illustrated below. Even allowing for proportional adjustments for differing scale of projects, mass values of building materials would be centred close to the construction sites in Hong Kong. In fact, a more detail study illustrates that the majority of the materials for a New Harmony 1 (Option 2) Block originate from locations within 1,000 km of Hong Kong.

NH1 (Option 2) Building Materials: Asia Pacific Origins (by Mass)



If other construction markets in different countries around the world are considered it could be argued that the environmental impacts associated with the transportation (from factory gate to site) of the New Harmony 1 (Option 2) Block in Hong Kong are in fact less significant where compared with other developed nations, certainly this would be the case if North America, Australia and probably the European Union were considered.

2.5.2.4 Conclusions from the Transportation Study

Given the above discussion, the main conclusions that can be drawn from this transportation study are that the vast majority of the materials used in a New Harmony 1 (Option 2) Block, are sourced locally and regionally. With respect to the distances involved, these are similar to distances travelled in Europe for most of the major materials. Hence it could be argued that using unadjusted international (European) environmental data (for transportation from factory gate to site) would not be unreasonable in the context of Hong Kong although this approach has not been adopted in this study.

It should also be noted that the New Harmony 1 (Option 2) Block may not be totally representative of the whole Hong Kong construction market since the material technology and variety of products are relatively limited in this building. However since the major material mass for buildings in Hong Kong is centred on generally two materials, concrete (both insitu and precast) and reinforcement, the key question has to be the sourcing of these two materials. In the case of the Hong Kong construction industry and HA, these materials are sourced from either within Hong Kong or Southern China and thus the outcome of a similar study for other local building types is unlikely to be significantly different.

The results from the above study was used as part of the overall regionalisation process and allow data from the SIMAPRO to be adjusted to suit the local market conditions.

2.5.3 Regionalisation

As part of the Life Cycle Assessment (LCA) process it is necessary to measure and quantify the environmental inputs and outputs created in the manufacturing process from raw material acquisition through to incorporation on site. During the LCI phase, data is collected and organised for all the inputs and outputs connected with the industrial processes associated with the manufacture of building materials. However, the compilation of a comprehensive LCI database would require conducting extensive research, interviews with manufacturers and site visits. As these are all outside the scope of this study, the project team has opted to use commercially available products such as SimaPro and other published data sources for generating the necessary LCI data used in the model.

European data such as that used by the SimaPro LCA tool uses information predominantly relating to materials manufactured in Europe and used in industrial processes, including construction. Since a significant proportion of the materials used by HA are produced in Hong Kong and Southern China, it is necessary to regionalise the SimaPro 5.0 database [46]. The team has followed the *ISO 14041: Goal and Scope Definition and Inventory Analysis* standard when undertaking the regionalisation process.

[46] It should be noted that characterised, regionalised and normalised data from databases and tools such as SIMAPRO provides the basis of the HA LCA/LCC model. The raw data and tools themselves do not form part of the HA LCA/LCC model, and HA's licensing of such sources is therefore not required.

Aligning with the ISO 14041 requirements, the regionalisation process comprises the following major steps:

- Collection of LCI data which match the production profiles of local materials,
- Fuel input and output Regionalisation
- Electricity Generation Regionalisation
- Regionalisation of fuel mix

2.5.3.1 Regionalisation of Fuel Inputs and Outputs

Different countries and in some instances different states or provinces use different fuel sources for providing their energy, for example, in China electricity is mainly generated from coal while in Canada hydropower is the dominant mode. As such, the inputs and outputs for the production of the building materials used in Hong Kong can be very different depending on their country of origin. These differences will alter the resulting efficiency and emissions data for materials and hence have to reflected within the HA environmental profiles. In general, the regional differences in energy inputs and outputs are determined by:

- Quantities of impurities in fuels
- Combustion emissions of fuels
- Fuel mix in electricity generation
- Clean-up technology

Electricity generation and fuel combustion are the two major areas where energy regionalisation is applied. Fuel-combustion regionalisation focuses on the difference in the quantities of impurities in fuels, combustion emissions of fuels and clean-up technology. Electricity generation regionalisation focuses on the differences in the fuel mix of electricity generation and differences in fuel combustion.

To regionalise these differences, we used data from the best available sources. For the fuel mix of electricity generation, we referred to the World Bank 2002: "2002 World Development Indicators on CD-ROM". For information on the quantities of impurities and combustion emissions, we referred to the Global Emission Model for Integrated Systems (GEMIS)[47], the ETH-ESU database[48], BUWAL250[49], Data Archive and the IVAM LCA[50] database. Clean-up technology data was sourced from environmental reports published by utility companies and national emission or pollutant inventory data relating to electricity generation.

The energy consumed during the manufacturing process of any product is called "delivered" energy. However, some energy loss is incurred during the transmission of electricity, extraction of fuels, refining of fuels and finally the delivery of energy to the factory. These losses must be taken into account in order to fully assess the impacts from the manufacturing process. When the figures for delivered energy are corrected to account for these losses the results are called "primary" energy values. We have used the conversion factors from the BRE methodology to convert delivered energy to primary energy. The conversion factors used are listed overleaf.

[47] From Germany
[48] From Switzerland
[49] From Switzerland
[50] From Netherlands

Primary energy and delivered energy factors

Fuel	Primary and delivered energy factors
Natural gas	1.110
Petroleum product	1.110
Coal	1.013
Electricity	3.083

Source: BRE methodology for environmental profiles of construction materials, components and building.

These values, whilst based upon UK and European standards are considered to be consistent and suitable for this study.

2.5.3.2 Electricity Generation Regionalisation

The focus of the electricity generation regionalisation process is the identification of the key differences in the fuel mix and the differences in fuel combustion. Typically electricity is generated from:

- Coal
- Oil
- Natural gas
- Hydropower
- Nuclear power
- Renewable energy (solar, wind and tidal)

Mixing the electrical energy generated from different energy sources generate different overall environmental impacts. A power station may emit large amounts of greenhouse gases if it is fired by fossil fuels such as coal, oil and natural gas. Hydropower on the other hand produces large amounts of non-toxic waste. Nuclear powered stations produce radioactive waste.

The energy mix regionalisation procedure has the following steps:

- Identify the location of production
- Collect energy mix profile

To identify the location of production we referred to information provided by suppliers in the workshops and technical literature.

The collected energy mix profile acts as the basic framework of the electricity generation profile of a country. To ascertain the energy mix profile we referred to the World Bank 2002: "2002 World Development Indicators on CD-ROM" and LCI databases such as GEMIS. For example, to regionalise the data for a material manufactured in China, we refer to GEMIS for the Chinese energy mix profile, which is as follows:

- Coal 74.99%
- Hydropower 23.20%
- Nuclear 1.78%
- Geothermal 0.01%

The next stage is to regionalise the fuel combustion of electricity generation. Although the energy mix profile has been identified, the detailed regional differences in the inputs and

emissions of the energy sources need to be determined. For example, in China, there are four types of coal used to generate electricity. Each type of coal has different resource inputs, waste and emission outputs which would mean different overall environmental impact results.

To regionalise the inputs and outputs for each fuel type, we again use the GEMIS database to identify the regional differences between the European data and the country of production. For example, the major differences between the coal used in China and Europe are the higher energy inputs, higher photochemical smog emissions, higher acidification emissions and higher solid waste produced.

Using the information gathered about the differences in energy mix, resource inputs, waste and emission outputs, we have built up specific LCI data for electricity generation in each of the production locations to the materials being studied, for example, if the production took place in China, the major impact variations between electricity generated in China and the Netherlands are higher resource depletion, global warming, ozone depletion, human toxicity, eco-toxicity, photochemical smog, waste, acidification and higher energy inputs but lower water inputs.

The regionalisation of electricity generation helps to identify the full regional impact of electricity supply on the production of industrial materials.

Fuel mix profiles for China and the Netherlands

China		**Netherlands**	
Coal	74.99%	Coal	34.90%
Hydropower	23.20%	Hydropower	2.00%
Nuclear	1.78%	Nuclear	4.70%
Geothermal	0.01%	Oil	4.30%
		Gas	54.50%

2.5.3.3 Regionalisation of Fuel Mix

In the production of a material, the manufacturing plant uses fuel for heating processes and running machines. The fuel mix used to generate heat or combustion energy differs from one manufacturing plant to another. In general, however, the major fuel types used are:

- Coal
- Oil
- Gas
- Diesel
- Wood

The efficiency of these different fuel types will vary. For example, 1kg of coal yields 18-30.6MJ of energy; 1kg of oil yields 41-45.6 MJ of energy; $1m^3$ of natural gas yields 31.65-42 MJ of energy, 1kg of Diesel yields 42.8MJ of energy. To produce the same amount of energy outputs for each fuel type requires a different amount of fuel to be inputted to the combustion process at the start. Any combustion, each fuel produces different amounts of emissions, for example, 1MJ of European coal emits 1.6 times more global warming gases than 1MJ of European gas.

Therefore, it is necessary to regionalise the fuel mix of each production method, for Hong Kong construction materials, most production takes place in other countries. Particular

information for fuel mix used in most production plants was identified from local suppliers. This information formed the basis of the fuel mix regionalisation process and comprised the following major steps:

- Identify fuel mix of LCI inputs
- Identify fuel mix differences between region and original LCI data
- Adjust fuel mix ratio to regional production profile

After fuel mix regionalisation, fuel inputs and outputs must be regionalised to reflect the regional impacts from production profile.

2.5.3.4 Regionalisation of fuel inputs and outputs

Fuels used in the manufacturing process are sourced from different countries and extracted from different mines. As the raw material sources differ, so to do the inputs to the fuel mixes. For example, imported coal has more energy inputs due to the transportation required, which requires more energy. Therefore, the fuel inputs of fuels sourced from different countries vary considerably. Fuel outputs also produce different energy outputs and emissions. For example, 1kg of coal can yield 18 - 30.6MJ, which varies according to the quality of the coal. Clean technology, such as flue gas desulphurisation, which removes sulphur dioxide from emissions, differs from country to country. In order to account for the regional differences, we use the following databases to regionalise the fuel input and output profile for different countries:

- Global Emission Model for Integrated Systems (GEMIS) 4.1 (Germany)
- ETH-ESU database (Switzerland)
- BUWAL250 (Switzerland)
- Data Archive (various European countries)
- IVAM LCA Data 4.0 (Netherlands)

For example, coal combustion in plants in China show regional differences of inputs and outputs in the GEMIS database for 1998. By incorporating the differences into LCI data of coal combustion, we derive new LCI data for China coal combustion in 1998. We incorporate the new LCI data into the production profile of the materials and derive the inputs and outputs for the local production profile.

2.5.3.5 Regionalisation of transport impacts

The transportation modes (e.g. road, rail, sea) and distances of raw materials delivered *to the factory gate* are expected to be only slightly different in Hong Kong, China and South East Asia than in Europe. Similarly, the transport modes and distances required to move goods from the production *factory gate* to the sites in Hong Kong may not vary significantly from those used in the UK and Europe.

As described previously, the sources and transport modes for materials consumed by HA have been investigated. In fact, based upon findings from the study, the country with the largest import ratio to Hong Kong is China, which supplies 94.79% of materials (by percentage of total mass) used in a HKHA New Harmony 1 Block (Option 2).

To transport the raw materials from their individual extraction point to the factory or manufacturing plant and from these factories to the construction site requires vehicles and fuel. Depending on the distance travelled and the physical size of the materials being transported, the mode of transportation many be by road, rail, ship or air. The

environmental outputs of each mode of transportation are measured as the emissions from the fuel combusted by the vehicle transporting the materials.

Energy inputs and emission outputs differ for each mode of transport, for example, a truck with a 40T capacity consumes 2.28 MJ of energy to carry 1 tonne of material for 1km; electric rail consumes 0.15 MJ of energy to carry 1 tonne of material for 1km; intercontinental air travel consumes 16.2 MJ of energy to carry 1 tonne of material for 1km; container shipping consumes 1.7 MJ of energy to carry 1 tonne of material for 1km.[51]

To measure the transport impacts, we required data for the following specific information:

- Distance between the point of origin or extraction and the factory or manufacturing facility
- Distance between the factory and the intermediate manufacturing or processing point
- Distance between this intermediate point and the construction site
- Mode of transportation at each of the above stages
- LCI data on inputs and outputs for each mode of transport used

Distance information was collected from shipping companies, air freight companies and surface distance information while, the different modes of transport used were obtained from the different product suppliers. The LCI data for each mode of transport has therefore been derived from the following databases:

- ETH-ESU database for road and rail transport
- IDEMAT database for air freight
- ETH-ESU database for inland navigation
- IDEMAT database for containerised shipping

The transport component of the raw materials and material inputs of each material's LCI data is regionalised individually using the Simapro software programme. The LCI data is regionalized using the following criteria:

- Mode of transport – For example, clinker for cement is sourced from Northern China. In the regionalisation process, a rail transport component is added to the LCI data to account for the transport impact of this raw material
- Distance – The LCI data of rail transport (ETH-ESU database) is in t/km unit. As the distance between Northern China and Dongguan (manufacturing point) is approximately 1,900 km, the LCI data is adjusted to 1.9 t/km for 1kg clinker to account for the transport impact.

After regionalising the transport components of raw material inputs and material delivery, the LCI data now contain completely regionalised energy inputs and outputs as well as regionalised transportation components. Using this we can now proceed to characterise and quantify the ten environmental impacts being measured in this study.

[51] ETH-ESU LCI database

2.5.4 Classification and Characterisation

As described, one of the common problems of any environmental assessment is deciding the scope of the assessment and the point at which an impact should be assessed on the chain of events between cause of impacts and their effects. For example, to boil a cup of water might involve:

- "A" joules of energy going into the water in an electric kettle;
- "B" joules of energy coming into the building containing the kettle;
- "C" joules of energy produced at a power station;
- "D" Kg of coal entering the power station;
- and "E" litres of diesel oil for transporting the coal;
- "F" kg of coal mined from the ground;
- releasing "G" kg of carbon dioxide to the atmosphere, "H" kg of methane, "I" kg of VOCs;
- all acting like "J" kg of carbon dioxide in promoting climate change;
- causing "J" deg centigrade of global average temperature rise for "K" years;
- causing "L" angstroms of sea level rise and "M" cm^2 of land to desertify and be lost to flooding;
- at a cost of "N" Hong Kong dollars;
- which will put "O" people out of business;
- make "P" people starve and
- kill "Q" micro-organisms at the base of a food chain for "R" species.

At any of these levels, we can measure one or several parameters that might be used as a proxy measure for the upstream causes or downstream effects of impacts on sustainability. To derive useful results, we must select the most appropriate unit within the chain of causes leading to effects. As with many sustainability issues, there is no agreement between experts on suitable proxy units. However, for some impacts, there is consensus e.g. for climate change, the unit adopted is the kg of carbon dioxide (CO_2) equivalent.

The *Classification and Characterisation* stage combines contributing components to each issue taking account of their relative potencies for example the global warming implications of different gases are all converted to kg of CO_2 equivalent by means of Global Warming Potential (GWP) factors. These factors take account of the relative potency of the different gases as well as their atmospheric residence times. The methods by which different contributing emissions or resource consumption can be accounted for also vary for each issue, and the scientific basis of the HA Methodology are described in the following paragraphs.

2.5.4.1 Energy (Megajoules, MJ)

When any form of energy is used, an energy resource is consumed. In the case of fossil fuels, this can easily be recognised as the depletion of a finite resource, but the use of energy derived from hydroelectric schemes or from PVs are also limiting the availability of this renewable resource to other users, as the capacity is not limitless. This category recognises that all energy forms should be used as efficiently as possible and is measured using Embodied or Primary Energy.

For any manufacturing, transportation or heating process, energy is supplied from a number of different sources used as fuels, including waste materials. The data collected on the quantities of this energy used in a process provides a value for the "process" or "delivered" energy. However, all fuels suffer losses and fuel expenditure in their extraction, their

refining, their supply and transmission, requiring additional energy expenditure to extract, refine and distribute them. So that the full impact of manufacture and processing can be assessed, the quantities of each form of delivered energy and fuel must be adjusted to take account these losses. Values for corrected delivered energy, taking into account production and delivery losses, and expenditure are known as "primary" or "embodied" energy.

2.5.4.2 Resource Depletion (tonnes)

This unit was selected to reflect the total quantity of mineral resource extracted. This applies to all minerals, including metal ore and applies to both Hong Kong and overseas extraction. The extraction of minerals for building is a high profile environmental topic but the minerals themselves are not considered to be scarce. It would be useful to develop a method that also includes reference to scarcity, for example of particular metal ores. This information is not currently available to make such a distinction. The assumption is that this unit is a proxy for levels of local environmental impact from mineral extraction such as noise, landscape disturbance and dust. The characterisation method assumes that all mineral extractions are equally disruptive of the local environment and a characterisation factor of 1 is used per tonne of material extracted.

2.5.4.3 Water Consumption (litres)

This unit was selected to reflect the depletion, disruption or pollution of aquifers or disruption or pollution of rivers and their ecosystems due to over abstraction. The characterisation factor is 1 per cubic metre and assumes that all abstractions are equally damaging.

2.5.4.4 Waste (tonnes)

At the present time, it is most practical to use a tonne of waste as a proxy for the impacts arising from waste disposal. This unit was selected to reflect the depletion of landfill capacity, the noise, dust and odour from landfill (and other disposal) sites, the gaseous emissions and leachate pollution from incineration and landfill, the loss of resources from economic use and risk of underground fires. The characterisation factor is 1 assuming that 1 tonne of any waste is equally deleterious. In practice, wastes will vary in their putrescible content, combustibility, leachability of toxic substances etc. The exception to the "proxy" status of the associated impacts is for greenhouse gases. The greenhouse emissions from landfill and incineration are included in the fifty-year life Profile.

2.5.4.5 Climate Change (tonnes CO_2 eq.)

"Global warming" is associated with problems of increased desertification, rising sea levels, climatic disturbance and spread in disease. It has been the subject of major international activity, and methods for measuring it have been presented by the Intergovernmental Panel on Climate Change (IPCC). Gases recognised as having a "greenhouse" or radiative forcing effect include CFCs, HFCs, N_2O and methane. Their relative global warming potential (GWP) has been calculated by comparing their direct and indirect radiative forcing to the emission of the same mass of CO_2 after 100 years. E.g. CFC-11 is 3400 times more powerful as a greenhouse gas than CO_2 and therefore one tonne of CFC-11 is equivalent to 3400 tonnes CO_2. Global warming potential is measured in CO_2 equivalents for each emission, which can be added and entered into the Profile under "Climate change" as CO_2 equivalents (100yrs).

A timescale is applied to the GWP figure because the GWP of different gases is related to the amount of time they will spend in the atmosphere and the amount of radiative forcing

they will induce over that period. It is important to recognise how long the gases will last in the atmosphere. For example, both carbon dioxide and CFC-11 are greenhouse gases but they have different half lives in the atmosphere and they will thus have a different relative effect over different timescales. Three different scenarios are available for GWP: 20 years, 100 years and 500 years. The 100 year scenario is most commonly used and has been applied here.

2.5.4.6 Acid Rain (kg SO_2 eq)

Acid deposition on landscapes causes ecosystem impairment of varying degree, depending upon the nature of the ecosystems. Gases are related to the acidification of one tonne of Sulphur Dioxide (SO_2) and include Nitrous Oxides, Sulphur Oxides, Hydrochloric acid, Hydrogen Fluoride and Ammonia. Equivalence is calculated by dividing the contribution of protons (H+) to the ecosystem from a compound with the contribution from SO_2.

2.5.4.7 Photochemical Smog (kg ethene eq.)

In atmospheres containing nitrogen oxides, ozone creation occurs under the influence of radiation from the sun. Different hydrocarbons react to form ozone at different rates and both NO_x and volatile organic compounds (VOCs) can control the rate of this photo-oxidation process. Increased ozone in the lower part of the atmosphere is important at a local, regional and global scale but impact assessment methods only concentrate on the local and regional impacts. The formation of ozone and other oxidants, such as nitrogen dioxide, hydrogen peroxide and aldehydes, are implicated in impacts as diverse as crop damage and increased incidence of asthma and other respiratory complaints. The method used for characterisation in the Profile comes from Centre for Environmental Studies (CML), Netherlands, and compares the photochemical ozone creation potential of VOCs to that of ethene.

2.5.4.8 Ozone Depletion (kg CFC11 eq.)

Following the implementation of the Montreal Protocol, the major Ozone Depleting Gases, CFCs, have been banned from manufacture since 1996 in the developed world, however China, as a developing country which signed the Montreal Protocol in 1991, has until 2010 to stop production, with gradually decreasing limits. The use of ozone depleting substances within construction can be very simply prevented by careful specification of insulation foams and finding alternatives for halons within fire systems.

2.5.4.9 Toxicity to Humans (kg. Tox eq)

The subject of toxicity is a particularly complex area within impact assessments and a variety of different techniques have been developed. The four categories proposed by Heijungs (1992) at the University of Leiden for the CML method is the most widely accepted method and BRE for example therefore advocates the use of this technique in the absence of more definitive works. CML developed a provisional method of toxicological weighting factors. For human toxicity these are then calculated as (human toxicological classification factor) x (kg body weight/kg substance). The factors are based on tolerable concentrations in air, air quality guidelines, tolerable daily intakes and acceptable daily intake.

2.5.4.10 Toxicity to Ecosystems (kg. Tox eq)

Similar to the above, the subject of toxicity when applied to ecosystems is a particularly complex area within impact assessment and a variety of different techniques have been

developed. Again the four categories proposed by Heijungs (1992) at the University of Leiden for the CML method are the most widely accepted method and BRE for example therefore advocates the use of this technique in the absence of more definitive works. CML developed a provisional method of toxicological weighting factors that are based on tolerable concentrations in air, air quality guidelines, tolerable daily intakes and acceptable daily intake.

2.5.4.11 Characterisation Process

Once the energy inputs, outputs and transport components of the LCI data have been regionalised to the local production profile, it is necessary to characterise them. As stated in the BRE methodology, the purpose of characterisation is "*to translate different inventory inputs and outputs into directly comparable impact indicators".*

Against each of the impact categories, it is necessary to translate their own relative burdens into comparable impact indicators, for example, the contribution of 1kg of CO_2 to climate change is deemed to have a potency of 1. All other environmental outputs, such as methane, are converted into a relative potency that can be compared to CO_2. As an illustration the relative potency of 1kg of methane is 21. Therefore, the potency of 1kg of methane to global warming is 21 times that of 1kg of CO_2. Similarly, all the other global warming contributors are characterised in the same way and this method is then used across all the materials being studied.

There are many methods that can be used when performing the characterization process. However, it is recommended that only methods adhering to the requirements of ISO 14041 standard be used, although different methods may be used for different impact categories. The following are the methods employed for this study for each of the impact categories:

1. *Energy* – Centre for Environmental Studies, University of Leiden (CML) 1992 Characterisation Method
2. *Resource Depletion* – CML 2 baseline 2000 Characterisation Method
3. *Water Consumption* – LCI inventory for all water inputs
4. *Waste* – CML 1992 Characterisation Method
5. *Climate Change* - CML 2 baseline 2000 Characterisation Method
6. *Acid Rain* - CML 2 baseline 2000 Characterisation Method
7. *Photochemical Smog* - CML 2 baseline 2000 Characterisation Method
8. *Ozone Depletion* - CML 2 baseline 2000 Characterisation Method
9. *Toxicity to Human* - CML 2 baseline 2000 Characterisation Method
10. *Toxicity to Ecosystem* - CML 2 baseline 2000 Characterisation Method

Using the above methods inventory inputs and outputs are converted into comparable impact indicators with the following characterised units of measurement:

- Energy – MJ
- Resource depletion – tonnes
- Water consumption – litre
- Waste – tonnes
- Climate change – kg CO_2 eq.
- Acid rain – kg SO_2 eq.
- Photochemical smog – kg ethane
- Ozone depletion – kg CFC-11 eq.
- Toxicity to human – kg toxic eq.
- Toxicity to ecosystem – kg toxic eq.

After transferring the LCI data to the comparable and consistent impact indicators as shown above, each of the materials now have their own characterised profile. The characterisation profile of 1kg of fibreglass is shown below or illustrative purposes.

Characterisation profile of 1 kg of fibreglass

Environmental impacts	Characterised Units	Characterised data - fibreglass
Energy	MJ	30.9
Resource depletion	Kg	0.0000000624
Water consumption	Litre	6.6
Waste	Tonnes	0.0000201
Climate change	Kg CO_2 eq.	0.774
Acid rain	Kg SO_2 eq.	0.00613
Photochemical smog	Kg ethane eq.	0.000147
Ozone depletion	Kg CFC-11 eq.	0.0000000245
Toxicity to humans	Kg tox. eq.	0.049
Toxicity to ecosystem	Kg tox. eq.	124.0089

The data shown above represents the relative potency of the extraction and manufacture of fibreglass in contributing to the formation of environmental impacts, for example, the extraction and manufacture of 1 kg of fibreglass contributes 0.774 times the potency of 1kg of CO_2 in contributing to global warming.

2.5.5 Normalization

LCA gives a variety of impact assessment data values and this poses a difficulty to the decision maker – how important are different impacts and how can they be compared to give an understanding of the relative importance of one process or product compared to on other? This is made possible through the further assessment of the data and is especially effective if the analysis culminates in a single score.

An important stage in the analysis of the LCA data is to normalise the characterised impacts so that they can be weighted on a common basis. When the values are normalised, there is an underlying assumption that the participants in the weighting exercise will assume that their judgements were being made in the context of current local, regional or global activity. In other words, peoples' weightings will be made based on their own perception of environmental impacts that affect them. It is therefore important that the normalisation is based on a concept that can be clearly explained to the participants in the weighting exercise, and readily understood.

As most raw materials used by HA are neither extracted nor manufactured within Hong Kong, a purely Hong Kong based norm could be inappropriate. Two options therefore present themselves, the first of which (would be the more accurate) is to ascertain the "footprint for Hong Kong", in other words to estimate the exact impacts in other countries and Hong Kong that are the result of consumption within Hong Kong (deducting impacts relating to goods which are then exported from Hong Kong). However this type of study requires extensive input/output analysis, and readily accessible data relating the environmental impacts to the different inputs and outputs.

To undertake a foot-printing exercise for Hong Kong would be well beyond the scope of this project – therefore data was found for a more representative China and Asia based

norm, as this is the region that is the main source of raw materials used in Hong Kong. The Environmental Design of Industrial Products (EDIP), Denmark, has published environmental data from 1990 for different areas of China, including Guangdong and Guangshi and this data has been used in this study.

Similar to other European methods [52], normalisation against the quantity of each measurement parameter caused by or resulting from a single member of the population (Asian or Chinese Citizen or Regional population) in a year, is known as Eco-Points. This classification has an added benefit that 1 Eco-Point can be set to be the equivalent of the typical impacts of a single citizen over a year, giving a comprehendible scale to the unit.

In essence, to make a meaningful comparison possible between conventional building materials and alternative products, we require a means to compare all ten environmental impacts together on the same basis to make selection decisions. As described by the BRE methodology, the purposes of normalisation are:

- *To allow the decision maker to compare the impacts across different environmental impacts*
- *To understand their relative significance in terms of quantity in comparison with the norm*

To obtain this comparable indicator across each of the ten environmental impacts, we divided each characterised impact by a "norm" This norm represents the total annual impact of one citizen and in the case of this study, that citizen is a Hong Kong citizen. The result is a factor showing the proportion of each material impact in relation to the annual impact one Hong Kong citizen. The objective is to derive the percentage impact a materials production has in relation to that of a typical person. By dividing the characterised profile of fibreglass by the "norm", 1 kg of fibreglass has the normalised profile listed below:

Normalisation profile of 1 kg fibreglass

Environmental impacts	One citizen of one unspecified developed country	Normalised data fibreglass
Energy	201493MJ/person/year	0.0001533552
Resource depletion	27.13 kg/person/year	0.0000000023
Water consumption	417580 litre/person/year	0.0158052260
Waste	7.19 tonnes/person/year	0.0000027955
Climate change	12300 kg CO_2 eq./person/year	0.0000629268
Acid rain	58.90 kg SO_2 eq./person/year	0.0001040747
Photochemical smog	32.20 kg ethane eq./person/year	0.0000045652
Ozone depletion	0.29 kg CFC-11 eq./person/year	0.0000000857
Toxicity to humans	16923.61 kg tox. eq./person/year	0.0000028954
Toxicity to ecosystem	152433.75 kg tox. eq./person/year	0.0008135265
Total Normalised value		0.0169494533

Based on this information, it is possible to compare the environmental performance of a material across the ten environmental impacts, for example, energy can be compared with acid rain as they are in the same unit.

[52] Ecopoints normalization approach have been adopted in the United Kingdom, Netherlands, Denmark and Switzerland.

We can also use the average normalised value to compare the environmental performance of two materials. The table below compares the normalised data for 1kg of fibreglass against the values for 1kg of mineral wool.

Normalised values of 1 kg fibreglass and 1 kg mineral wool

	Normalised data – fibreglass	Normalised data – mineral wool
Total Normalised values	0.0169494533	0.0120483732

Based on the local "norm", mineral wool would have a better environmental performance than fibreglass on an impact derived from a kg for kg comparison.

2.5.5.1 Calculation of Norm

We have referred to different statistical sources for the calculation of the different norms used in this study such as there is the norm for one HK citizen (local norm), norm for South China citizen (regional norm) and norm for a world citizen (global norm). The Tables below indicate the statistical sources we have used for the calculation of the global, regional and local norms within our normalization process:

References of normalised impact of one global citizen

Impact Category	Reference of the norm for one global citizen
Energy	(1)
Resource depletion	(2)
Water consumption	(3)
Waste	(4)
Climate change	(5)
Acid rain	(6)
Photochemical smog	(7)
Ozone depletion	(8)
Toxicity to humans	(9)
Toxicity to ecosystem	(10)

(1) United Nation, Statistical yearbook/Statistical Division, Department of Economic and Social Information and Policy Analysis, New York: UN. for energy consumption figure.
(3) The reference of total water consumption of 1995 is "Global Water Outlook to 2025: Averting an Impending Crisis".
(4) The reference of statistic figure on world solid waste generation is from website of office of solid waste reduction and recycling in Francis Marion University, 2000.
For (2), (5) to (10) – the reference is the normalisation factors 1995 stated on the spreadsheet version (July 2002) as published by CML.

Normalised impact of one Southeast China citizen

Impact Category	Reference of the norm for one Southeast China citizen[53]
Energy	(1)
Resource depletion	(2)
Water consumption	(3)
Waste	(4)
Climate change	(5)
Acid rain	(6)
Photochemical smog	(7)
Ozone depletion	(8)
Toxicity to humans	(9)
Toxicity to ecosystem	(10)

(1) Commercial (utility) energy use per capita figure from World Bank 2002: "2002 World Development Indicators on CD-ROM".
(2) The China Statistics Press, China Statistical yearbook, 1999, Beijing: China Statistical Press for consumption figures.
(3) The China Statistics Press, China Statistical yearbook, 2000, Beijing: China Statistical Press for consumption figures
For (4) to (8), Jianxin Yang and PER H. Nielsen, Chinese Normalization References and Weighting Factors - according to the EDIP-method for solid waste, climate change, acid rain and photochemical smog figure.
For (9) and (10), normalisation factors 1995 as published by CML.

Normalised impact of one Hong Kong citizen

Impact Category	Reference of the norm for one Hong Kong citizen
Energy	(1)
Resource depletion	(2)
Water consumption	(3)
Waste	(4)
Climate change	(5)
Acid rain	(6)
Photochemical smog	(7)
Ozone depletion	(8)
Toxicity to humans	(9)
Toxicity to ecosystem	(10)

(1) Commercial (utility) energy use per capita figure from World Bank 2002: "2002 World Development Indicators on CD-ROM".
(2) The Census and Statistic Dept. for oil, coal and natural gas consumption per capita figure. For aluminium, lead, iron, copper, manganese, nickel, zinc and tin consumption per capita figure, we refer to the normalisation factors of CML 1995.
(3) Annual fresh water consumption figure in 2000 from Water Supplies Department, HK SAR Government.
(4) Environmental Protection Department of HK SAR Government website, on the waste figures in 2000.

[53] Jianxin Yang and PER H. Nielsen, Chinese Normalization References counted Hainan, Guangxi, Guangdong, Shandong, Jiangxi, Fujian, Zhejiang, Liaoning, Hebei, Tianjin and Beijing as Southeast China region, 1999.

(5) Hong Kong Greenhouse Gas Emission Inventory 2000 website for the total potency data.
(6) Hong Kong Air Pollution Emission Inventory 2000 website for the SO_2 and NO_x emission data. The characterisation of the emission potency factor is according to CML 2 baseline characterisation method.
(7) Environmental Protection Department, HK SAR Government website for NM VOC, CO, methane, NO_x and SO_2 emission figure. The characterisation of the emission potency factor is according to CML 2 baseline characterisation method.
(8) Environmental Protection Department, HK SAR Government website for CFC emission figure, 2000.
For (9) and (10), normalisation factors 1995 as published by CML.

2.5.6 Weighting

The normalized impact data set out previously allows a detailed environmental comparison to be made between each of the different materials as well as allowing an overall combination of impacts generating a single unit total to be calculated. Whilst this calculation process generates the desired single total representing all environmental impacts it assumes that each impact is of the same relative importance, which is not necessarily a true reflection of the views from society.

2.5.6.1 Approaches to Weighting

The earliest attempt at a practical weighting scheme was the Swiss Ecoscarcity method[54]. This method used the so-called "distance to target" method as a means for weighting between the different issues where the target values are those set by national policy objectives. The distance referred to is how far current levels of emissions depart from national policy targets. In other words, the environmental issues where the greatest relative improvements are required will have the greatest weighting. Ecopoints on this basis are available for Swiss, Norwegian and Dutch policy targets. However, experts in the field have been critical of this approach because the politically derived targets are considered somewhat arbitrary, inconsistent between countries and believed to seriously underestimate the importance of some key impacts e.g. greenhouse gas emissions.

The Swedish EPS system[55] was developed for Volvo in Sweden. This method attempts to determine the externality cost (the financial cost of mitigating the environmental impact) of 5 different modes of impact and uses this to form the basis of a weighting. The method is very complex and limited to a small range of impacts.

The Dutch Eco-indicator[56] and NSAEL[57] are methods that use expert panels as part of their methodology to derive weightings. In its latest variant, the Dutch Ecoindicator 1997[58] appears to offer a relatively simple method of determining a weighting value. The method

[54] Methodik fur Oekobilanzen auf der Basis Okologischer Optimierung – Ahbe S, Braunschweig A & Muller-Wenk R - Schriftenreihe Umwelt Nr. 133, Bundesamt fur Umwelt, Wald und Landschaft (BUWAL), Bern -1990
[55] The EPS-Enviro-Accounting method. An application of environmental accounting principles for evaluation and valuationof environmental impact in product design - Steen B & Ryding S-O - IVL report no B1080, IVL, Gothenburg, Sweden - 1992
[56] The Eco-indicator 1995, Weighting Method for Environmental Effects that Damage Ecosystems or Human Health on a European Scale – Goedkoop M - NOH Report 9523 -1995
[57] Towards a single indicator for emissions – an exercise in aggregating environmental effects - Kortman JGM, Lindeijer EW, Sas H, Sprengers M, Interfaculty department of environmental science, University of Amsterdam, Amsterdam, The Netherlands - 1994
[58] The Ecoindicator 1997 explained – Goedkoop M - Pre Consultants – Plotterweg 12, Amersfoort, The Netherlands - 1997

entails characterising the impacts arising from the inventory of a product or process in terms of nine environmental effects. Fate analysis using a methodology called EUSES[59] is then used to determine the fate of a flow of pollutants or environmental stressors into the environment and the extent to which they impact on human health and ecosystem damage:

- *Daily Adjusted Life Years* (DALY's), pioneered by the World Health Organisation[60], are used to represent both human fatalities and health damage by assessing the periods of illness or lost life from an average life expectancy;
- The *Potentially Affected Fraction* (PAF) of species at the bottom of the food chain exposed to environmental stressors is also used as a basis for assessing ecosystem impairment.

The effects predicted to arise from any emission are normalised against the effects caused by an average European citizen so that they can be assessed relative to each other on a common basis. The normalised results can then be expressed in terms of just 3 parameters – DALYs for human fatalities and human health impairment and PAF for ecosystem impairment. A subjective assessment of the relative importance of just these 3 parameters by expert panels can then be used to derive the Eco-indicator value. However, DALY and PAF data are not readily available and the lack of this data is already limiting the opportunities to develop this method further.

2.5.6.2 A Practical Example of Impact Normalisation and Weighting

The following example shows how two example materials, A and B can be compared, first using characterised impacts; then by comparing them to a theoretical Hong Kong citizen's impacts as normalised impacts; and finally, using Weightings, as Ecopoints. The characterisation, normalisation and weightings have been based on the current UK BRE *Environmental Profiles* and *Ecopoints* methodologies and are used in this instance only for illustrative purposes. The table below first compares the two materials using their characterized environmental impacts.

WORKED EXAMPLE: CHARACTERISED IMPACTS FOR MATERIALS A AND B

Environmental Impact	Characterised Values		Characterised Unit
	Material A	Material B	
Acid Deposition	10	20	kg SO_2 eq.
Climate Change	5000	2000	kg CO_2 eq. (100 years)
Fossil Fuel Depletion	5	5	Tonnes of Oil Equiv
Minerals Extraction	1	2	Tonnes
Ozone Depletion	0.05	0.02	kg CFC11 eq.
Pollution to Air: Human Toxicity	10	20	kg Tox.
Photochemical Ozone Creation Potential	50	25	Kg Ethene eq

[59] EUSES the European Union System for the Evaluation of Substances, National Institute of Public Health and the environment (RIVM), The Netherlands – European Chemicals Bureau (EC/JRC), Ispra, Italy -1996
[60] The Global Burden of Disease – WHO, World Bank & Harvard School of Public Health – Boston – 1996

WORKED EXAMPLE: CHARACTERISED IMPACTS FOR MATERIALS A AND B

Environmental Impact	Characterised Values		Characterised Unit
	Material A	Material B	
Pollution to Water: Ecotoxicity	1000	20000	m^3 Tox.
Pollution to Water: Eutrophication	1	2	kg PO_4 eq.
Pollution to Water: Human Toxicity	0.005	0.0005	kg Tox.
Waste Disposal	3	5	Tonnes
Water Extraction	30000	40000	Litres

At this stage in the process, it can be very hard to make an assessment regarding the relative environmental performance of the two materials. Material A has lower impacts for a number of the environmental impacts measured. However, not knowing the relative scale of the units used to measure many of the different issues, it is not possible to decide which material really has a lower overall environmental impact.

Normalising the results allows us to compare the impacts across different issues and understand their significance in terms of quantity. In the table below, the impacts of a UK citizen over a year have been calculated by taking the impacts of the UK over a given year (1996) and dividing by its population. This is then used as "norm". Each Characterised Impact is then compared to the corresponding impact of a UK citizen, giving a dimensionless value, the Normalised Impact. The higher this value, the greater the impact.

WORKED EXAMPLE: NORMALISED IMPACTS FOR MATERIALS A AND B

Environmental Impact	UK Normalisation (1 UK Citizen)		Normalised Value	
	Value	Unit	Material A	Material B
Acid Deposition	58.9	kg SO_2 eq.	0.17	0.34
Climate Change	12300	kg CO_2 eq. (100 yrs)	0.41	0.16
Fossil Fuel Depletion	4.09	Tonnes of Oil Equiv	1.22	1.22
Minerals Extraction	5.04	Tonnes	0.20	0.40
Ozone Depletion	0.286	kg CFC11 eq.	0.18	0.07
Pollution to Air: Human Toxicity	90.7	kg Tox.	0.11	0.22
Photochem Ozone Creation Potential	32.2	Kg Ethene eq	1.55	0.78
Pollution to Water: Ecotoxicity	178000	m^3 Tox.	0.01	0.11

WORKED EXAMPLE: NORMALISED IMPACTS FOR MATERIALS A AND B

Environmental Impact	UK Normalisation (1 UK Citizen)		Normalised Value	
	Value	Unit	Material A	Material B
Pollution to Water: Eutrophication	8.01	kg PO_4 eq.	0.13	0.25
Pollution to Water: Human Toxicity	0.00117	kg Tox.	4.270	0.43
Waste Disposal	7.19	Tonnes	0.42	0.70
Water Extraction	418000	Litres	0.07	0.10
Total	**N/A**	**N/A**	**8.74**	**4.78**

Once the materials have been compared to the same norm (in this illustrative case a UK Citizen) it is easier to review the impacts of the two products. All the values are now using the unit, a proportion of the norm, and they can therefore be compared, not only for a single issue, but from issue to issue. Material A still has lower impacts than Material B for 7 of the 12 impacts, but if all impacts are considered equally, then it has almost double the impact of Material B, with most of the impact coming from *Pollution to Water: Human Toxicity*, *Photochemical Ozone Creation Potential* and *Fossil Fuel Depletion*.

However, all issues may not have the same significance, and using weightings (in this illustrative case derived from industry stakeholders), a more balanced view of the overall impact can be obtained as presented in the table below. For each environmental impact, a panel of UK Construction Industry stakeholders provided the weightings. These weightings are then applied to the Normalised Values to give an Ecopoints Score. 100 Ecopoints are equivalent to the impact of a UK Citizen over one year. The higher the Ecopoints Score the greater the environmental impact.

WORKED EXAMPLE: ECO-POINTS SCORES FOR MATERIALS A AND B

Environmental Impact	UK Weighting	Ecopoints Score	
		Material A	Material B
Acid Deposition	5.09%	0.9	1.7
Climate Change	37.77%	15.5	6.0
Fossil Fuel Depletion	11.96%	14.6	14.6
Minerals Extraction	3.46%	0.7	1.4
Ozone Depletion	8.15%	1.4	0.6
Pollution to Air: Human Toxicity	7.02%	0.8	1.5
Pollution to Air: Photochemical Ozone Creation Potential	3.82%	5.9	3.0

WORKED EXAMPLE: ECO-POINTS SCORES FOR MATERIALS A AND B

Environmental Impact	UK Weighting	Ecopoints Score	
		Material A	Material B
Pollution to Water: Ecotoxicity	4.30%	0.0	0.5
Pollution to Water: Eutrophication	4.30%	0.5	1.1
Pollution to Water: Human Toxicity	2.57%	11.0	1.1
Waste Disposal	6.14%	2.6	4.3
Water Extraction	5.42%	0.4	0.5
Total	**100%**	**54.3**	**36.3**

Using the weightings from the UK Ecopoints exercise, the overall impact of the materials can be compared. Again, Material A has greater impact than Material B, but now the main impacts are from *Climate Change*, *Fossil Fuel Depletion* and *Pollution to Water: Human Toxicity*, reflecting the increased importance placed on Climate Change and reduced importance placed on Photochemical Ozone Creation Potential by the weightings exercise.

Thus using such a methodology, a weighted value can be built up not only for just one material but for a whole building element or even a whole building.

2.5.6.3 LCA/LCC Weighting Determination – Stakeholder Consultation Workshops

The integration of the concept of sustainable development into the life-cycle of buildings (residential or commercial) calls for inter-disciplinary resources. The benefit or impact of this integration is maximized if implemented at the building's infancy. In the past, stakeholders in the building industry have focused primarily (if not exclusively) on building solutions that optimise economical gains. While we are far from placing environmental concerns as the utmost importance, a decision tool with objective guidance will be very valued. This would allow us to attempt to balance concerns on the economic and environmental costs. In these difficult times, both costs need to be managed strategically. The process of the HA LCA/LCC instrument development therefore involves stakeholders across the industry, since all are affected to some extent.

In order to obtain environmental, cost and life cycle stage significance factors for the LCA/LCC model, which are pertinent in the local and HA context, a series of weighting workshops were held in December 2002. These workshops also served to fulfil the normalisation and weighting approach previously described.

The objective of the workshops was to collect stakeholder information and opinions to form the foundation of a decision tool that accounts for the economic and environmental costs associated with building construction. The instrument is the first of its kind that allows decision makers to balance environmental and economical concerns according to consensual preferences from representative groups. To develop this instrument, the workshops to collected information that revealed the relative importance of ten relevant environmental factors.

Participants in the workshops were required to evaluate the importance of the ten environmental factors in relation to others, ranking the factors in order of importance from the perspective of their own personal views and (after the focus group discussions) from perception of industry consensus.

Participants were grouped into teams between 5 to 15 persons and encouraged to provide justifications and explain the rationales underlying their choice from various evaluative perspectives (in turn to be used by the analysts to resolve any discrepancies between preferences between industry representatives). The focus groups also explored how each participant perceives the contributions other organizations have on the environmental factors.

The workshops proceeded as follows, gearing towards the derivation of an industry consented index:

- *Quantitative Survey 1* – probing personal perceptions. Participants were briefly introduced to the goals and purposes of the workshop and asked to complete a survey, which was used to measure how they perceive the importance of various environmental factors on 'sustainable development' in the construction industry. Participants also asked completed an exact copy to be used for the focus group.
- *Presentation* – the relationships between environmental factors and the construction industry. After a brief recess, the participants viewed a presentation on the relationship between environmental factors and the construction industry. The purpose was to stimulate their thinking about the topic and orient them for the focus group discussions.
- *Quantitative Survey 2* – probing personal perception prior to presentation. The second measurement of the preference took place after the presentation. This was used to gauge the effect of the presentation on the audience.
- *Focus Groups* – probing rationale for personal perceptions. Participants sat in groups of 5 to 15 persons. Moderators facilitated the participants to express their attitudes, viewpoints as well as the rationales underlying their response in survey 1.
- *Quantitative Survey 3* – probing group consensus preferences. After a brief recess, each group was asked to elect a representative to summarize views from all the participants. The person then completed the same survey to reflect the optimal consensus on how the factors should be ranked in relation to other factors. Other questions relating to their decision criteria on building costs and issues were asked and also required consensus.

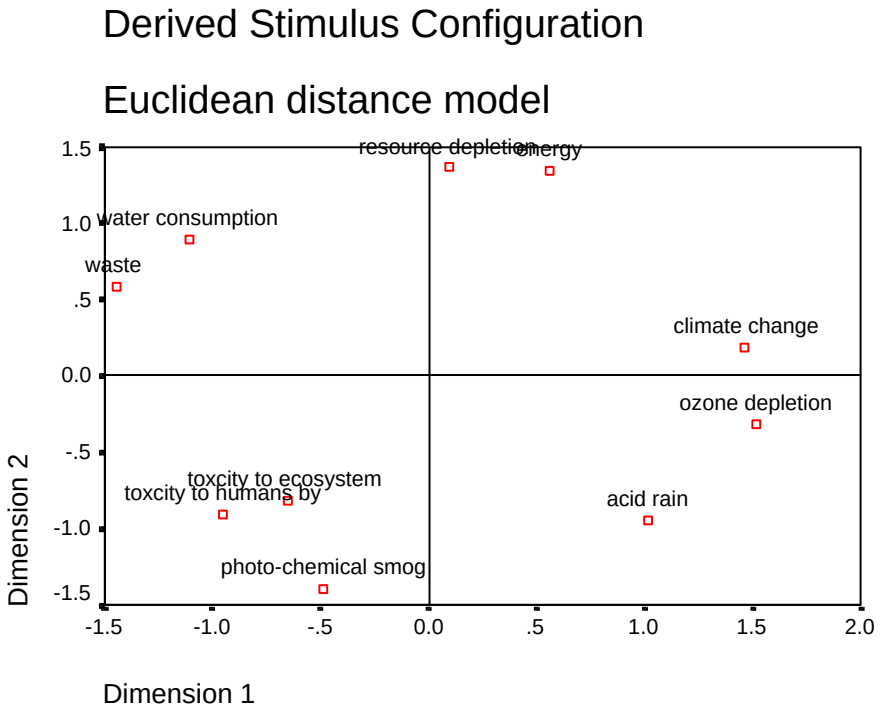
One hundred and five participants took part in the workshop and this aggregated to twenty-two teams in the focus groups. On average, five to seven participants compose a typical focus group in this investigation.

Ratings made during the first preferential survey (i.e., personal preference 1) are used as inputs to analyse whether the ten impact factors are perceived by the participants as belonging to some simplified dimensions and the results are shown in the figure below.

Distribution of Environmental Concerns Amongst Participants

The Euclidean distance is a measure of distance between two points. The distance between two points is the square root of the sum of the squared values for each variable. In mathematical terms the definition is as follows:

The straight line distance between two points. In a plane with p1 at (x1, y1) and p2 at (x2, y2), it is $\sqrt{(x1, y1)^2} \div \sqrt{(x2, y2)^2}$. Hence, an Euclidean distance model is a model derived from distances between points.



This indicates that participants perceive the ten factors as relating to four groups:

- "waste management" (waste and water consumption, in the top left quadrant);
- "resource concerns" (energy and resource depletion, in the upper centre quadrant);
- "climate concerns" (ozone depletion and climate change, in the right hand quadrant); and
- "concerns for pollution" (Toxicity to Humans by Air & Water, Toxicity to Ecosystems by Air & Water, and Photo-Chemical Smog).

From a two-dimensional perspective, 'resource concerns' and 'concerns for pollution' is one of the bipolar dimensions. The other bipolar dimension belongs to 'waste management' and 'climate concerns'. Acid Rain is seen to lie between "climate concerns" and "concerns for pollution".

Group preferences were calculated with the assumption that the six interest groups are equal in terms of their ability and influence on the life-cycle of a building. However this may under-estimate (or over-estimates) the actual balance that leads to sustainable development of the industry. It is reasonable to suggest that some groups have more (or less) influence over others. The ranking of the importance as well as the ability of the interest groups allows the investigators to assess the extent a particular group can impact on the ten environmental factors.

To develop a weighting system, different groups were asked to rank which interest groups would have the most (or the least) impact on the ten environmental factors in terms of importance and ability. The average ranks based on the ranking of the 22 groups were taken as an indication on how the interest groups are related to each other.

The table below shows that on average, group A (i.e., Academics, Government Departments and Professional Institutions) was judged as the most importance and able to impact on the ten environmental factors. On the other hand, group B (i.e., Building Services Installation Contractors) was judged as having the least impact. The top three most important groups were group A, F, and C. The bottom three were group D, E, and B. 'Relative distances between adjacent groups' is measure of the relative distance between one group (e.g., Group A) and another (e.g., Group F). In the case of the first two groups, the distance is 1.09.

Weighting of Group Influence on Environmental Impact Factors

Interest Groups	Mean rank	Order of rank	Relative distances between adjacent groups
Group A - Academics, Government Departments and NGOs'	1.18	1	1.09
Group F - Professional Institutions, Estate Managers and Tenant Representatives	2.28	2	0.25
Group C - Housing Department Internal Staff	2.53	3	0.89
Group D - Leading Construction Contractors	3.42	4	0.61
Group E - Major Material Suppliers	4.03	5	0.28
Group B - Building Services Installation Contractors	4.31	6	0.01

The concept of weighting the scores is analogous to giving more credibility or attention on a given score rated by a given group. Views or opinions from groups that are elected as the most influential group afford more weight over other groups that played a relatively minor role. To ensure that the opinions from those with weights are not offset by those playing a less influential role, influential groups are multiple by a large constant. The magnitude of the constant is proportional to the figures in 'relative distances between adjacent groups'. Hence, preferences rating on each of the ten environmental factors for each of the 22 interest group are multiple by the weights listed in 'relative distances between adjacent groups'.

The following three tables show the weighted preferences for local, regional and global ratings.

Weighted Group Preferences (Global)

Weighted scores	Impact Factors	Rank
12.76	Energy	1
12.71	Climate Change	2
11.64	Ozone Depletion	3
10.56	Resource Depletion	4
10.09	Acid Rain	5
9.12	Water Consumption	6
8.92	Waste	7
8.43	Toxicity to Humans	8
8.21	Toxicity to Ecosystems	9
7.56	Photo-Chemical Smog	10

Weighted Group Preferences (Regional)

Weighted scores	Impact Factors	Rank
11.77	Energy	1
11.68	Photo-Chemical Smog	2
11.23	Waste	3
10.45	Toxicity to Ecosystems	4
10.25	Toxicity to Humans	5
9.66	Climate Change	6
9.23	Resource Depletion	7
9.41	Acid Rain	8
8.61	Water Consumption	9
7.71	Ozone Depletion	10

Weighted Group Preferences (Local)

Weighted scores	Impact Factors	Rank
14.91	Waste	1
13.68	Photo-Chemical Smog	2
10.80	Toxicity to Humans	3
10.57	Energy	4
10.39	Water Consumption	5

Weighted Group Preferences (Local)

Weighted scores	Impact Factors	Rank
9.11	Toxicity to Ecosystems	6
8.34	Resource Depletion	7
8.02	Climate Change	8
6.95	Ozone Depletion	9
7.23	Acid Rain	10

The series of workshops geared toward the derivation of the weighted group preferences yielded preferences that are based on: local, regional and global concerns. All these weighted concerns can be used concurrently so that the benefits from each source can be cross-verified.
However, since the decision tool (i.e., the acceptability curve) is a dynamic system that builds its strength from previous experiences, therefore, the best decision on which source of preference (i.e., local, regional, or global) is likely to come once the system is in operational mode (or "run-in").

The preferences at local, regional and global levels after being weighted according to perceived importance of the stakeholders are as follows and these have been used in the final model:

Impact	Local	Regional	Global
Acid Rain	7.23%	9.41%	10.09%
Climate Change	8.02%	9.66%	12.71%
Energy	10.57%	11.77%	12.76%
Ozone Depletion	6.95%	7.71%	11.64%
Photochemical Smog	13.68%	11.68%	7.56%
Resource Depletion	8.34%	9.23%	10.56%
Toxicity to Ecosystems	9.11%	10.45%	8.21%
Toxicity to Humans	10.80%	10.25%	8.43%
Waste	14.91%	11.23%	8.92%
Water Consumption	10.39%	8.61%	9.12%
Totals	100%	100%	100%

Whilst the above weightings represent the defaults applied within the model, they can be adjusted to suit the policy of the Housing Authority or particular project demands.

In the application of the default weightings above the three different sets of normalized data are used for each category (local, regional and global), for example regional weightings are automatically used where regionally normalised impact data is used. This approach ensures consistency in data usage as well as trackability in calculations.

2.6 THE OPERATIONAL MODEL

The operational data is a sub-model of the LCA/LCC tool. It is used to measure the environmental impacts and cost implications of different equipment selection as well as occupation patterns during the 50-year operational period of the building life cycle. It measures the energy and water consumption of the building in both the tenant and landlord areas. The following types of consumption are therefore accounted for:

- Electricity consumption in tenant area - Cooling/heating, lighting, small power loads/cooking appliances and direct vent/extracts
- Gas consumed in tenant area - Cooking and water heating
- Water consumed in tenant area - Potable water demands and salt water
- Electricity consumed in landlord area - Lighting, air conditioning (ground lobby), small power loads, water pumps and lift operation, etc.
- Water consumed in landlord area - Cleaning and fire service water, etc.

As noted above, specific consumption data has also been sourced from the following sources which has been used as a secondary check:

- DLSM and market surveys - electricity consumption in tenant areas.
- DLSM's current surveys of housing estates - electricity consumption in landlord areas.
- DLSM and market surveys - gas consumption in tenant areas.
- DLSM and market surveys - water consumption in tenant areas.
- DLSM's current surveys of housing estates - water consumption in landlord areas.

This operational energy component is important in providing context for alternative designs and management practices that are known to affect operational energy use. Where such alternatives are known to affect operational energy use, the *Operational Energy Model* can be used to assess their likely life cycle impacts.

The *Operational Energy Model* is a key part of the overall study, since previous work has shown that the energy consumed (and hence costs and environmental impacts) during the operational life of buildings can be significant, if not the most significant.[61] Thus its inclusion puts the embodied (material) modelling in context and shows whether it is better to focus on specification changes or operational energy reductions. Where alternative materials are to be considered that are known not to affect operational energy, however, (e.g. substituting one tile for another) the base data will remain valid and the *Operational Energy Model* need not be rerun.

Most energy consumption within the New Harmony 1 (Option 2) Block is attributable to cooling, lighting, small power loads and cooking in the tenant areas and cooling, ventilation, lighting and lift transport in the public areas. Performance-based modelling enables HA to compare specification changes to the building based on the numerical output of the operational model. For the landlord areas operational energy/water consumption and cost information was derived from the associated cost model while for the tenant areas the operational energy model itself will produce data in kWh consumed which can be costed.

Current *Hong Kong Building Energy Codes* and codes of practice for energy efficiency will form part of the model through their use as benchmarks (e.g. thermal conductivity "K" values from the "Code of Practice for OTTV in Buildings, 1995"). Decision-makers are able to assess the environmental, cost and performance implications of any proposed

[61] Energy consumed in operational stage can be up to 55% of the life-cycle (50-year) energy used in residential building.

specification change over whatever operational period is desired (5 years, 10 years whole operational life), for example:

- Predicting, measuring and quantifying the operational energy usage regime
- Predicting and making consequent decisions on alternative mechanical & electrical components/equipment based on their environmental performances.
- Predicting the effect of alterative materials and components on the operational regime.
- Identifying where the biggest cost items and areas of environmental impact are within the operational regime and thus target the most fruitful areas for improvement

In essence, the *Operational Energy Model* provides an additional tool for use when it is necessary to review the impact of specification changes to the building envelope or HVAC regime that might increase embodied impacts but reduce operational energy use. HA's designers, engineers, contractors, suppliers, and estate managers will be able to assess the environmental impacts of new building materials/components that are expected to change its operational energy consumption over its 50-year operational life[62]. Based on a database relevant to a model New Harmony 1 (Option 2) Block operation, a computer simulation programme (VisualDOE) simulates the energy-material inputs and outputs in tenant areas and landlord areas. With the utility practice profile, environmental impacts are characterized, normalized and evaluated in terms of HK E-points. Without such a predictive model the affect of such changes upon operational energy impacts and costs cannot be calculated.

2.6.1 The Operational Energy Modelling Process

To model the energy consumption in the New Harmony 1 Block, the VisualDOE computer software package was used. VisualDOE is a detailed building energy simulation computer programme that models a building's:

- climate
- construction
- occupancy scheduling
- heating, cooling, water heating and other equipments

It simulates building energy consumption on an hourly basis. It is a dynamic heat-flow simulation programme and is user-friendly, which allows architects and engineers to evaluate the energy performance of their building design options.

The operational energy models the amount of electricity and gas consumed by:

- Cooling/heating (electricity)
- Lighting (electricity)
- Small power load (electricity)
- Water heating (gas)

[62] Where the alternatives are known not to affect operational energy, however, the base data will remain valid and the *Operational Energy Model* need not be rerun.

Flats and public areas within the New Harmony 1 Block are modeled as follows:

- Flat 1P/2P on 32 orientations
- Flat 1B on 32 orientations
- Flat 2B on 32 orientations
- Common areas of typical floor
- Lift lobby of ground floor

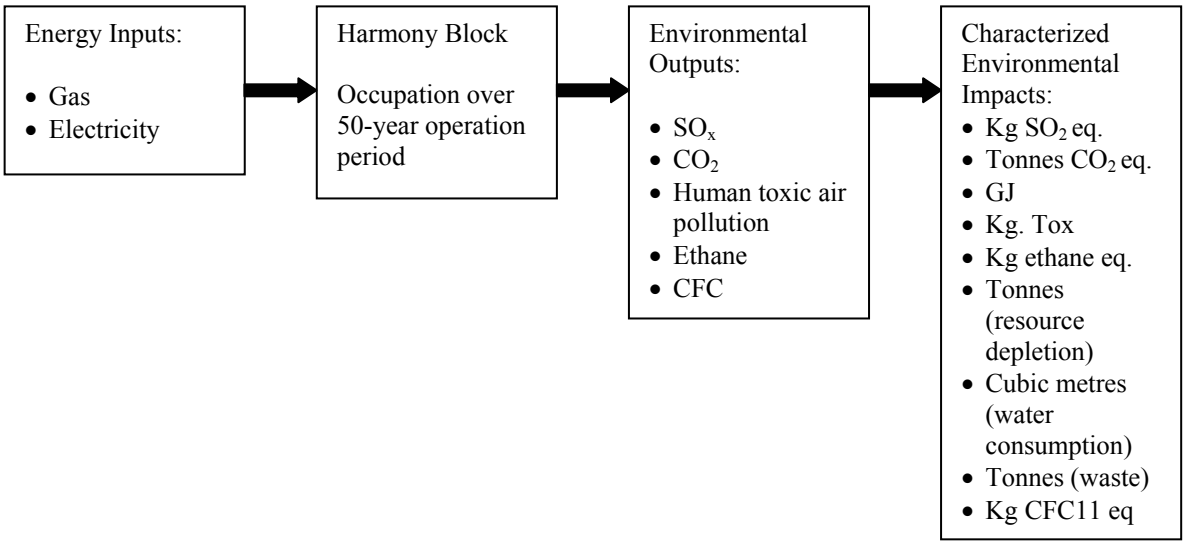
Energy consumption is simulated in VisualDOE according to the hourly, monthly and seasonal occupancy patterns of modelled spaces:

- People occupancy levels (weekday/weekend)
- Lighting operation patterns (24-hour pattern)
- Equipment operation patterns (weekday/weekend, winter/summer)
- Cooling/heating operation patterns (summer/winter)
- Water heating operation patterns (summer/winter)

Equipment and lighting power density for flats are derived from the market survey on the 24-hour equipment operation pattern (winter/summer), HKU data for appliance ratings and their associated ownership levels as well as validated power density data.

VisualDOE simulates indoor daylight illuminance in accordance with window size, window arrangement and shading arrangements, type of glazing of building and typical metrological year (TMY)[63] daylight illuminance levels. External heat, solar heat and internal heat gain are simulated according to the thermal conductivity of building materials, shading coefficient, light transmission, and the U-factor of glazing. It simulates internal heat gain from lighting, various items of equipment and the occupants.

This process can be represented by the following diagram:



[63] TMY means the weather data for a typical metrological year and are data sets of hourly values of solar radiation and meteorological elements (including temperature, wind speed, sky cover, relative humidity, solar radiation and day light luminance level) for a 1 year period. In the case of Hong Kong the TMY weather data used in the modeling is the hourly data set (1960 – 1990) provided by Visual DOE (Eley Associates 2001). They are based on more recent and accurate data and make more accurate performance and economic analysis of energy systems possible.

The scope of the assessment is therefore limited to the operational activities shown in table below and their related building materials/components. In each case, the assessment methods and the key determinant inputs for each operational activity are also listed.

Operational Energy Model: Activities and Assessment Methods

Tenant Areas	Methods for Assessment
1. Space cooling load	Transfer function method Domestic energy end-use survey 1999-2000 of cooling usage pattern of Harmony Block ASHRAE Handbook Code of Practice of Overall Thermal Transfer Value
2. Space lighting load	Load calculation method Domestic energy end-use survey 1999-2000 of lighting usage pattern of Harmony Block Code of Practice of Energy Efficiency of Lighting Installations
3. Small power load	Domestic energy end-use survey 1999-2000 of Harmony Block Code of Practice of Energy Efficiency of Electrical Installations
4. Cooking load	Fuel utensil efficiency level Domestic energy end-use survey 1999-2000 of cooking usage pattern of Harmony Block Harmony Block Fuel Supply Profile
5. Water heating	Fuel utensil efficiency level Domestic energy end-use survey 1999-2000 of water heaters of Harmony Block
6. Supply of potable water	Water input calculation Water consumption statistic
7. Supply of salt water	Water input calculation Water consumption statistic

Landlord Areas	Methods of Assessment
1. Public area cooling load (G/F lift lobby)	Domestic energy end-use survey 1999-2000 of Harmony Block
2. Public area lighting loads (lift lobbies, staircases)	Load calculation method Domestic energy end-use survey 1999-2000 of lighting installation ratings Code of Practice of Energy Efficiency of Lighting Installations
3. Lifts	Lift usage pattern Code of Practice of Energy Efficiency of Lift and Escalator Installations
4. Other Demands (potable water, small power, other power consumption)	Estimations checked with estate management information

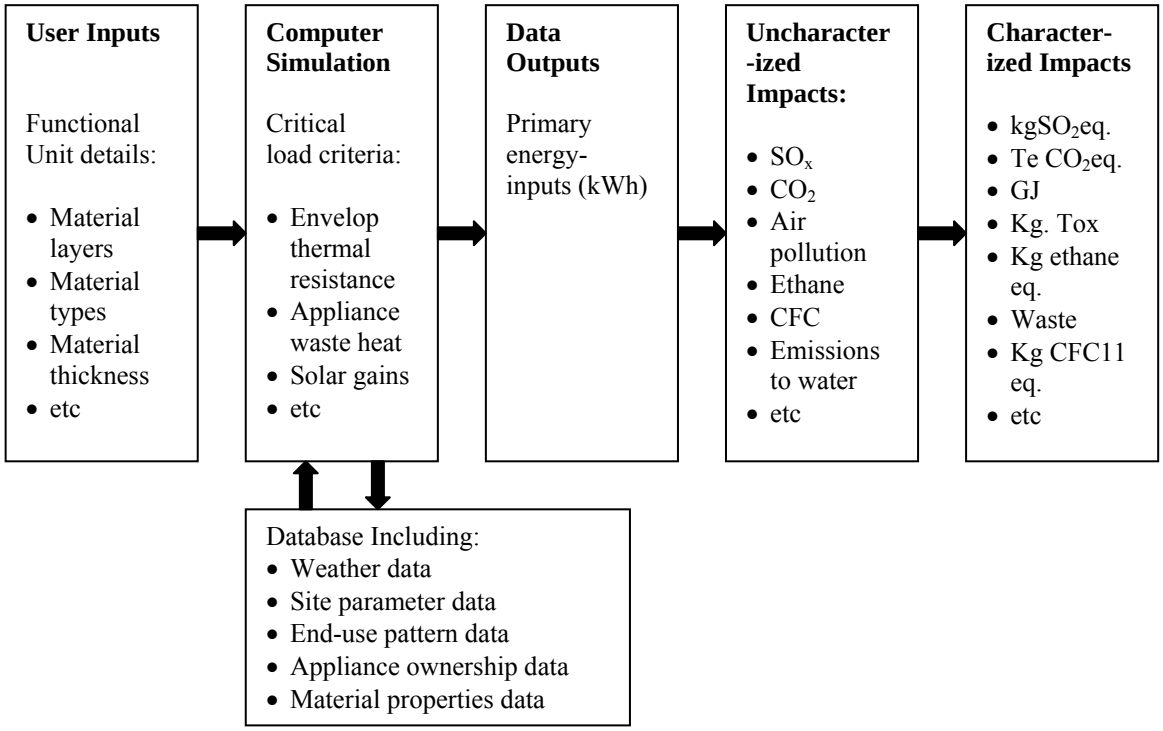
Note: "Domestic energy end use survey 1999-2000" refers to the 1999 survey undertaken by City U Consultants Ltd on behalf of CLP Power.

As shown in the figure below, energy inputs and outputs in tenant areas (upper and lower areas in four orientations) was modelled by a DOE-3 based computer programme using:

- Operational end-use patterns (1999-2000);
- Mean metrological data (from 1960-90s) and a site parameter database;
- Appliance ownership levels (1999-2000) and ratings; and
- Material/component performance-values.

The operational activities required input from the user including specific and accurate data for key determinants such as the functional units (walls, roof, floors, windows, doors, partitions, etc), an example for flat cooling is shown below. To assess small power load in tenant areas, the operational model includes databases for operation end-use pattern, daily energy-loading pattern, typical household appliance types and ratings and appliance ownership levels both as shown below.

Operational Energy Model: Modelling Process[64]



Operational Energy Model: Domestic Appliance Ratings[65]

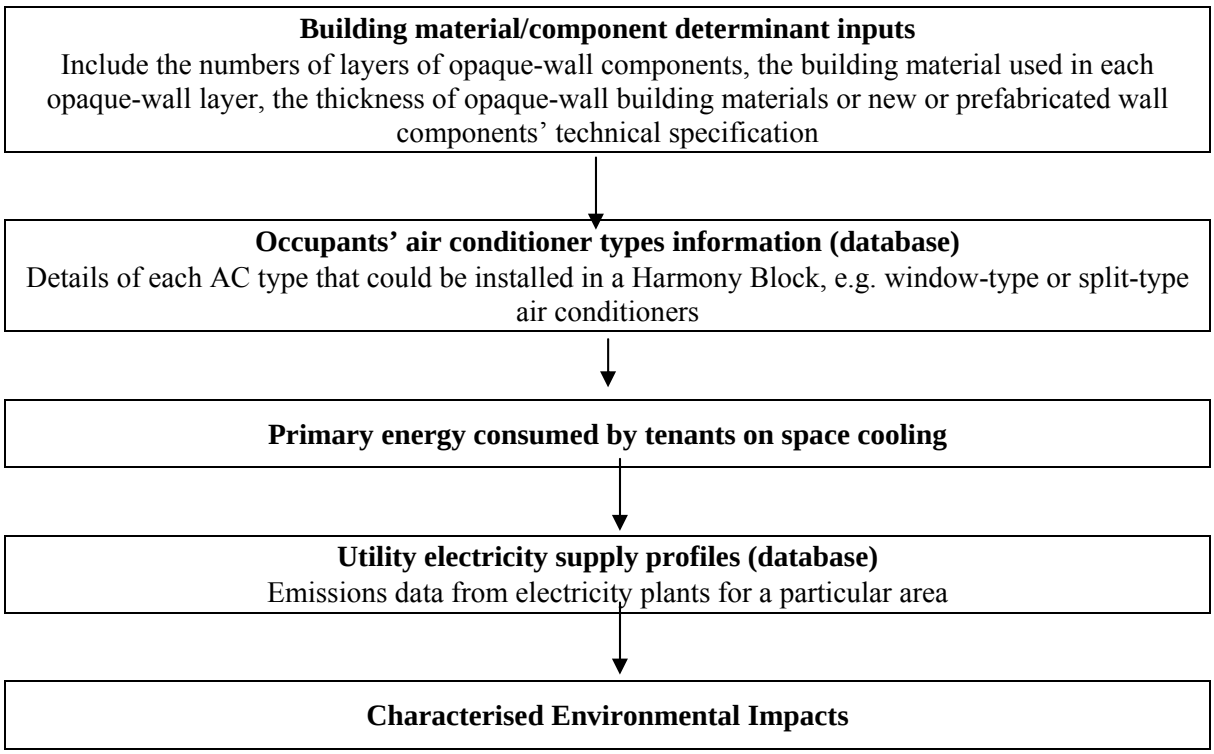
Appliance Ratings	Typical Rating (in Watt)			
Electric rice cooker	546	600	100	1,500
Microwave oven	904	882	500	2,800
TV	750	820	100	1,200

[64] Primary energy is real energy consumed and excludes delivered energy used in energy/ fuel transportation.
[65] Source: "Domestic energy end use survey 1999-2000", CLP Power.

Appliance Ownership in Public Rental and Home Ownership Scheme (Selected Appliances Shown as Examples)[66]

Appliance	Ownership Level (%)	Number of Appliance
Electric rice cooker		
Public Rental	95.8%	1.1
HOS	94.2%	1.0
Microwave oven		
Public Rental	49.5%	1.1
HOS	71.8%	1.0
Computer		
Public Rental	60.4%	1.0
HOS	75.8%	1.0
TV		
Public Rental	99.4%	1.0
HOS	99.6%	1.0

Operational Energy Model: Heat Flow Modelling in Tenant Areas



2.6.2 Data Verification

The validity of the data and dry-run results were verified by WSP Hong Kong and focussed on the following key areas (see *Appendix B* for validation report). Using the model, eight sets of operational data, that address eight different orientation scenarios for the whole block, were generated and installed in the base model.

[66] Source: "Domestic energy end use survey 1999-2000", CLP Power.

Future system users can choose any one of these eight block orientations to measures the operational implications for the whole building in the context of a particular site.

- Modelling
- Input Data
- Output Data
- Existing Statistical Data
- Changing Parameters

2.6.2.1 Modelling

The heating and cooling load calculation method used by the modeling program, VisualDOE, is based on American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) standards. The cooling load components are made up of heat gain through the building structure and windows, occupancy levels, equipment, lighting, small power and infiltration. These are all recognized standard parameters.

2.6.2.2 Input Data

The first set of input data has been compared against the base design and the following parameters were adjusted to ensure that the results were more reflective of the actual block design.

- Supply air temperature from air condition changed to 14.5°C[67].
- Occupancy level split into weekdays and weekends instead of uniform all week.
- Small power in living/dining room and kitchen to allow for domestic appliance.
- Lighting intensity and usage pattern in living/dining room, kitchen, bathroom and bedroom.
- Bathroom ventilation added.
- Domestic hot water supply temperature.
- Bathroom and kitchen exhaust fan efficiency.

2.6.2.3 Output Data vs. Statistical Data

In comparing the output data against the statistical data both the initial and the adjusted annual electricity consumption were calculated:

Input Data Verification	CALCULATED ANNUAL ELECTRICITY CONSUMPTION **(Kwh)**	**Statistical [68]Annual Electricity Consumption (Kwh)**	**Difference (%)**
Initial Input	3,373,000	3,936,000	14%
Adjusted Input	3,928,807	3,936,000	0.5%<

It has been found that after adjustment was made to the initial input parameters the difference between the calculated and statistical annual electricity consumption (based upon actual utility bills) was reduced from 14% to less than 0.5%. This means that the

[67] This temperature represents the air temperature at the blowers.

[68] Source : Compiled using data from 10 existing Housing Authority estates, averaged to avoid distortions. Due to the NH1 block not being built to date, recently completed estates have been used as the primary source of data.

figures shown above represent the results prior to assumption refinement and post refinement. The specific adjustments made are set out in the previous point.

2.7 THE LCC DATABASE AND MODEL

This section of the report focuses on the cost elements of the model, which will form the basis of the LCC assessment. The basic methodology for the LCC has been set out previously and will not be repeated again here, but the focus here will be the sourcing and collection of data used in the cost model.

2.7.1 Objective of the Cost Model

The objective of the cost model is to derive a complete whole life evaluation of the building in terms of the financial impacts as at a given point in time. As noted previously the income and revenue streams for the building were not considered since this would significantly distort the model outcomes and diminish its overall value as a decision making tool for HKHA. To achieve the above objective, all construction related costs associated with the building were divided into the different life stages of the building and evaluated separately.

2.7.2 Sourcing and Collection of Cost Data

The cost data used in the model has been obtained from a number of sources including current tenders and existing term contracts. The data as a whole is all prepared on the basis of current prices as at the time when the model data was being prepared (October 2003). However, the model does have internal facilities to modify this base the information to a future or past date.

The collection of cost data can be divided into a number of sections:

- *Capital*
- *Repair & Maintenance*
- *Operational*
- *Demolition*
- *Standard Adjustments*

It is important to note at the outset that the New Harmony 1 (Option 2) block being studied has only just been introduced. Therefore from a financial point of view, limited historical information is available. Equally due to the relatively young age of Housing Authority blocks of this style (40 storey cruciform shaped blocks) very little historical maintenance and demolition data are also available. Whilst reference to other block types is possible and has been adopted for this study, they are no substitute for genuine historical records which will need to be generated over time.

2.7.2.1 Capital Cost

Capital costs for use in the model have been gathered by making reference to the most recent Housing Authority tenders received by DLS, in particular for those projects comprising free standing Harmony 1 blocks. Due to the newness and limited available data for this particular block type a range of Harmony 1 blocks tendered in 2002 and 2003 have been used to ensure representative prices are obtained. These rates have also been checked against market prices to ensure there are no distortions in the tender pricing. It should be noted that single block projects would attract a premium in excess of rates currently included in the model, therefore all rates are based upon projects comprising a number of

blocks but not necessarily all New Harmony 1 blocks. Also, all rates are inclusive of preliminaries and in the case of building services they also include all profit and attendance. Contract price fluctuations and contingencies are excluded from the model as are all fees and direct contract amounts. The provision and cost of an ARCS is also excluded since systems these are still a relatively rare provision with in Housing Authority estates as a whole.

2.7.2.2 Repair & Maintenance

As noted previously the availability of reliable information on the likely repair and maintenance costs for this particular block type are limited. Although historical information exists and has been used where appropriate, the reliability of this specific information would require further verification. Generally a sample of 20 existing rental housing estates have been studied, in terms of their expenditure profiles. These estates have been selected based upon a number of criteria. Firstly data is available within DLSM, they cover a wide range of building ages and they involve blocks of a similar design or layout. Therefore this information gives a reasonable representation of how the Housing Authority buildings perform on average.

As set out previously, the repair and maintenance costs are divided into four main categories:

- Minor
- Emergency
- Routine
- Vacant Flat

Costs associated with tenant to pay works have been excluded since accurate records are limited and those that are available show wide fluctuations from estate to estate. In addition most of these works relate to minor repairs which in some cases might be carried out by the tenant themselves. In terms of the specific rates used, recent District Term Contracts and CARE Contracts have been used as a basis for estimation, with some minor adjustments to suit this particular block type and current market conditions.

2.7.2.3 Operational Cost

These costs are derived from the current published utility charges from China Light and Power, Town Gas and the Government. Although these rates may change over time, the sensitivity and impact of these changes has not been analysed in the model and this has not formed part of this study.

One key factor in relation to the operational cost calculation is what costs should be included, whether only those in relation to the base building provision or if the costs associated with the occupier installed equipment should also be included. Although opinion is generally divided on this matter, all main standards and methodologies available suggest that only those costs which are directly related to the equipment and facilities associated with the capital costs should be included in any LCC assessment. Whilst therefore the base LCA/LCC model does not include the investment costs of occupier installed equipment, such appliances are required for the operational energy model, which is available for use when necessary to assess design alternatives that will have an impact on operational energy such as fabric insulation or double glazing. This issue reveals an interesting deviation between current LCA and LCC standards, however since the operational energy model for this assignment is to be used for comparison alongside the

LCA/LCC model, this difference will not affect the effective functioning of either component of the system.

2.7.2.4 Demolition Cost

The cost of demolishing a 41-storey tower is still relatively unknown in Hong Kong. Whilst having been constructed by the Housing Authority for a number of years, these blocks have never been demolished in reality. Therefore accurate information as to the current demolition costs for this block type are not available. Despite this there are recent examples of 36-storey blocks being demolished (Shatin Area 14B) being the one example which we have used as an illustration for this model. A credit value has also been included in the whole life costing, based upon historical experience, although it is acknowledged that in many cases this value is included in the contract sum and not separately identified therefore again wide variations are common.

2.7.2.5 Standard Adjustments

There are a few standard adjustments which are applied to the costs within the LCC segment of the model. The two critical ones are:

- Discount Factor
- Tender Price Inflation Factor

Discount factors are the conversion of current prices to take into account future inflation and values of money. For this study an overall discount rate of 4% has been adopted which has been calculated based upon an interest rate of 7.9% and an inflation rate of 3.75%. Both of these values have been established by making reference to published records and current government guidelines on applying discount factors as well as examination of historical trends. In practice however, it is possible to adjust these and generate alternative scenarios.

Tender price indices are included within the model to allow future global adjustment of the costs to reflect tender pricing movements. The calculation method is designed in such a way that the October 2003 HKHA TPI index value can be inserted as the base and then the latest value would be inserted as the current index. The difference between these values would then constitute the index adjustment factor, which is then applied to all the financial values in the model.

2.8 ASSUMPTIONS AND DATA VERIFICATION

In all aspects of this study, and no more so than in the research and generation of the data within the model, the greatest care has been taken to ensure that all data used is both correctly sourced and cross-checked. The final verification process undertaken to further confirm the validity of the data and study findings are described below.

2.8.1 Clarification of Assumptions

There are a host of assumption attached to every aspect of the data used in this model, the key ones are :

- The base building is a standard block, without site or project specific modifications.
- The foundation system has been generally selected as a bored pile design.
- Standard HA policies and practices will apply to this block.

- The building will have a 4 year construction period (12 months for foundations and 30 months for building works[69]), 24 month defects period, a 50 year operational life followed by a 12 month demolition and evacuation period.
- The building will be used as a public rental block throughout its life.

All of the above assumptions are fundamental to the model structure and calculations as well as to the data gathering process. Having said this, it is possible in the future to modify these assumptions and the model does allow alternative scenarios to be created and run.

2.8.2 Review of Sources of Data

With a model as complex and varied as this, the data necessary to produce the model has been gathered from a wide range of sources. In view of this a series of reviews and checks have been carried out to ensure both the integrity and consistency of the data used.

The data can be classified into three broad headings

- Environmental
- Quantum
- Cost

2.8.2.1 Environmental Information

This data has primarily been sourced from European databases and then processed using the Simapro database module. All the output of characterised data (based upon European impact criteria) has then been verified against a range of published sources[1] to ensure consistency as well as identifying anomalies. Whilst this process has been possible for some of the environmental impact data, it is not possible to verify all the data using this method. Therefore, where no specific published data is available, general orders of magnitude and inter-relationship analysis has been carried out. This has involved comparing the results of similar materials to ensure large deviations within the results are not generated. These results have also been checked by BRE as part of their overall review process.

Finally at the end of the regionalisation process a high level verification review has been carried out by BRE in the UK to ensure consistency with international methodologies and that the results are in the correct order of magnitude. Refer to the separate report prepared by BRE in *Appendix B* of this report.

2.8.2.2 Quantum Information

The quantum data has fewer sources, but is divided into three broad areas, initial, repair and maintenance and end of life waste. Each of these areas have relied upon data from a few sources and each source has been used to cross-check the results of other sources.

The initial quantum data for the superstructure works comes largely from the Standard BQ for the new Harmony 1 (Option 2) Block (6/00 Revision to 1/00 Edition) documents

[69] Based upon previous projects and considering that the model is designed to reflect a premises with 3 towers, the normal construction time is approximately 30 months (depending upon the associated other works and with some allowance for extensions of time). Only very large contracts and complicated projects would need a longer construction duration. It is possible to change the construction duration to reflect any change in the contract period, but since the durations in the model are measured in years, the model has assumed a 12 month foundation contact and a 36 month building contract.

[1] Amato, Burnett, Howard and Lawson

prepared by the Housing Authority with some specific measurement being made from both contract and shop drawings, whilst the repair and maintenance data is sourced from historical data for existing Housing Authority estates covering typical standard Harmony 1 and other cruciform block types. Foundation quantities have been sourced from Harmony 1 block foundation tenders (contractor design options). Building Services quantities have generally been obtained from the standard quantified schedules of rates prepared for the New Harmony 1 blocks as well as Nominated Sub-Contract tender pricing documents for Harmony 1 blocks. Finally the waste data is based upon previous research carried out by the Hong Kong Polytechnic University, DLS and published government guidelines.[2]

2.8.2.3 Cost Information

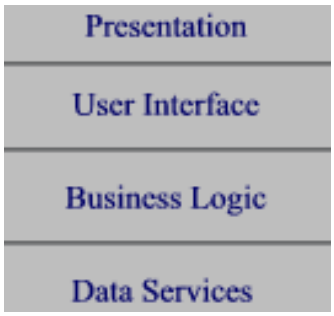
The final category is the cost data, again a number of sources have been considered but primarily data from recently tendered similar projects have been used for the capital and demolition costs. In the case of the repair and maintenance costs these have relied on the published term maintenance contract rates used by the Housing Authority and in particular those rates from district term contracts and CARE contracts. It should be noted that since this block type is comparatively new and current Housing Authority construction volumes are diminishing prices in this study would vary from typical cost yardsticks. It should however be noted that the objective of the LCC is not to match the cost yardstick exactly but reflect current market trends, and allow relative comparisons to be made.

2.9 LCA/LCC COMPUTER SOFTWARE DEVELOPED

Based upon the methodologies and approaches described previously, a purpose designed computer programme has been developed for processing the information and to yield results from the LCA and LCC models. (For clarification, the basis of these methodologies applied is demonstrated by a detailed step-by-by worked example of data collection and treatment to derive LCC and eco-points for an example functional unit provided in *Appendix C*). As such the remainder of the discussion in this section focuses, at a conceptual level, on the architecture of the software program and the functionality provided by the computerised model. (For full operation and maintenance details of the LCA/LCC software, refer to *User Manual for the LCA/LCC Model*)

2.9.1 Architecture of the LCA/LCC Software Model

Conceptually the computer model can be thought of as being divided into four distinct layers, as presented below.



Conceptual Layers of the LCA/LCC Computer Model.

The presentation layer communicates with the user interface layer, which communicates with the business logic layer which in turn communicates with the data services layer.

[2] ASD Technical Circulars

2.9.1.1 Presentation Layer

The presentation layer displays information to and receives information from the model's users. It provides the mechanism by which the user interacts with the system, and contains the various navigational elements that enable users to perform particular activities and accomplish their intended task. This is often referred to as the User Interface (UI) and for this model is a graphical user interface, which has been developed using the Visual programming language is adopted.

Taking advantage of the Windows graphical user interface gives the model the standard Windows look and feel that most users are familiar with. As such no special training is required in order to use the model because users will be able to navigate through the model using their existing knowledge of other Windows applications.

Sample toolbar buttons and their functions are given below:

New

Properties

Delete

Sample keyboard shortcuts and their functions are given below:

Ctrl-C Copy
Ctrl-V Paste
Ctrl-X Cut
F1 Help

As the UI has been designed with simplicity and ease of use in mind users from novices to advanced computer users will find the model intuitive and easy to use.

It is worth noting that the model has not been internationalised and the UI has not been localized. The UI is written in English and as such displays text, captions, titles, and error messages in English, it is not planned or intended to have a Chinese language version and such would be outside the scope of this study.

2.9.1.2 User Interface Layer

Not to be confused with the physical user interface of the presentation layer described above, the user interface layer contains the underlying UI-centric business rule objects. When the user interacts with the model through the UI, the request or entered data is passed to the user interface layer where it is processed. Similarly, data is passed from the business logic layer to the user interface layer where it is processed for display in the UI.

2.9.1.3 Business Logic Layer

Data-centric business rule objects the complex business logic and associated processing takes place in the business logic layer.

Primarily mathematical and requiring large amounts of number-crunching, the business logic has to a large extent been developed using Microsoft Excel. The team chose Excel to

build the complex business logic components responsible for performing the calculations, because Excel makes the perfect calculation engine. Also an Excel workbook can be thought of as a business component, a cell containing data is an input to the component, and cells with formulas are outputs.

This reduced the development effort and cycle time that is normally associated with hand coding such logic in a programming language. Furthermore, because the business rules have been developed in Excel it was much easier for the domain area experts to review and verify them. In other words, testing the business logic in Excel was much easier than testing it in a hand coded application.

2.9.1.4 Data Services Layer

The data layer contains the data persistence objects and the database in which the model's data is stored. Given the size of the database, its anticipated growth and the transactional throughput it will be required to process, Microsoft Access was chosen as the database management system.

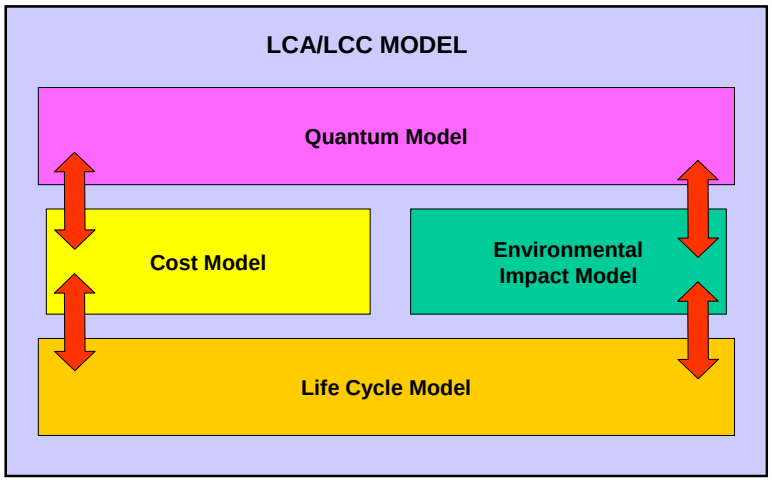
Data persistence objects are responsible for communicating with the database and performing insert, update and delete operations. Database connections are made using the Microsoft.Jet.OLEDB.4.0 provider.

2.9.2 Functionality of the Computer Model

Using minimal data entered through simple input screens, the model enables users to quickly and easily identify those functional units in a building, which have the greatest influence on the overall impact of the building.

Extremely easy to use, the simplicity of the model belies the wealth of research data on materials, operational use, environmental impacts and weightings that underpin its calculations. In fact, the complex logic that drives the model is encapsulated in the business components and is completely transparent to the user.

As can be seen below, the model can be thought of as four separate but interrelated sub-models. Each sub-model reflects different functionality, data and data flows within the model. A full description of each is given in the following sections.



Modular Structure of the LCA/LCC Computer Model.

2.9.2.1 Quantum Model

Arguably this is the most important sub-model since the quantum of the materials contained in the each of functional units drives the overall model.

To use the model it is only necessary to input the quantities of building materials in a particular functional unit, in kilograms. A series of linked spreadsheets and databases then automatically calculates and summarizes the weight and environmental impacts of the functional unit. Although this approach means "off-model" calculations are necessary (to convert volume of materials in to masses), the reduction in data processing time ensures that the model is more responsive.

Initial Impact: Generates initial quantities of materials. Retrieves the quantities from the quantum database and multiplies them by the functional unit data. The generated quantities are then multiplied by the environmental impact data to give overall results.

Repair & Maintenance: Takes the results from the Initial Impact module and multiplies them by the quantum of the functional unit. Applies the input replacement factors then applies the inputted maintenance factors, generating annual results.

Operation: Operational energy data sourced from utility bills and the Operational Energy Model's simulation data is used to calculate the:

- Power consumption of the building in kwh
- Gas consumption of the building in m3
- Water consumption of the building in m3

All this data is presented in a single series of data screens and covers eight possible building orientations.

End of Life: Contains algorithms to calculate the demolition and removal impact of the building. Through this process it establishes the quantum of the waste material at end of life as well as the recycled content of each material.

2.9.2.2 Cost Model

All the cost information entered into the model is processed in this sub-model. It contains algorithms to:

- Calculate the capital cost for each functional unit and for the quantum of each functional unit in the building
- Generate a whole of life profile
- Calculate annual cost impacts of repair and maintenance

In order to simplify the data processing "all-in"[70] rates / kg are used in the model.

2.9.2.3 Environmental Impact Model

For the sake of simplicity, consistency, security and to minimise processing time, the environmental impact data contained in the database is only in a normalised format. All previous process calculations are carried out outside the model.

[70] "All-in" rates are those rates which incorporate an allowance for labour, plant, materials, overheads, profit and preliminaries.

The model contains algorithms for calculating HK E-points. Simply, this involves taking weighting factors and applying them to the normalised data for each of the ten environmental impacts.

Sets of default weighting factors have been established and are contained in the database, for each of the environmental impacts. These weightings are based upon local, regional and global views and were obtained during the opinion workshops conducted during Stage 1 of the study. In addition users can create their own set of weighting factors (within the context of a total weighting allocation of 100) and choose to apply those rather than the default factors.

2.9.2.4 Life Cycle Model

Given known quantities of the functional units that make up the building, the model calculates the environmental impact of the building over its whole life. It merges embodied and operational environmental impact values into a total environmental value for each functional unit for this it creates a whole life annual profile based upon the HK E-points generated.

The model also contains algorithms for calculating the whole life cost of the building. Taking into account the building's lifetime the whole life costs are represented in the same format.

2.9.3 Summary

The LCA/LCC computer model/software provides an integrated and yet flexible tool through which data is processed to aid easy comparison and interpretation of results for the assignment. As part of the methodology validation, the application and practicality of the LCA/LCC software was reviewed and verified by DHV Buildings and Industry. DHV's validation report is provided in *Appendix B*.

2.10 SUMMARY OF ASSUMPTIONS AND LIMITATIONS

There are a large number of assumptions and limitations associated with the development of this model many of which are specifically covered elsewhere in this and previous reports. For ease of reference below is a summary of some of the most significant factors to be considered when using the developed model.

- The model is designed as a decision making tool and therefore does not claim to be an estimating software package, hence cost information generated is for information and guidance purposes only and not for estimating the actual cost of a building.
- The information contained within the model is based upon the best available data, since the NH1 block has not been constructed no actual data exist on the operational phase of the building.
- The model has been designed specifically for the NH1 block and therefore although other blocks can be inserted, the model is not specifically designed for them.
- The quantum, cost and operational energy modelling are all carried outside the main model, for a combination of technical (separate software being used) and practical reasons (to ensure that the model can run at a reasonable speed).
- The data contained in the model is based upon a standard NH1 block without any site specific adjustments.

3. RESULTS FROM MODEL

3.1 TYPES OF RESULTS AND FORMAT

The model produces a number of reports presenting the results and in a variety of formats. In all cases the objective is to illustrate the profile and relative importance of each functional unit within the context of the whole building.

The three main report types are:

i) Ranking of Functional Units
ii) Elemental Analysis
iii) Whole Life Profile

This section of the report examines these results and provides specific commentaries.

The ranking of different functional units has been carried out using a number of criteria and at varying stages in the building's whole life. Clearly the primary objective has been to identify the high impact or "hot spot" items within the building so that strategies can be put into place to minimize or reduce their overall impact. These ranking processes are set out below.

3.2 KEY COMPARISON CRITERIA

As part of the study brief there are a number of aspects which are to be used as the basis of the comparison, these include:

- Cost
- Quantity (Mass)
- Environmental Impact
- Whole Life Profile

The above criteria provide a broad assessment of which are the areas of greatest concern as well as the magnitude of the issue being faced. As noted in previous sections the most reliable area of the whole life model, in terms of actual historical data is the initial impact. However the results for the whole life profile are also presented.

The other key factor to note is that this assessment has been carried out on the basis of functional units, rather than individual materials. This approach reflects how materials are actually combined into the building.

3.2.1 Initial Cost Ranking

In terms of the overall expenditure profile, it is relatively unsurprising that the items with largest physical quantity dominate the top portion. Therefore the top 10 functional units, in terms of capital cost are (see *Appendix D* for full listing of functional unit initial cost ranking):

1. Piles
2. RC Walls – Fairfaced
3. RC Slabs - Fairfaced
4. Small Power Installation Flats
5. Lift Equipment

6. Panel Walls – Internal
7. RC Walls – Generally
8. RC Water Tanks
9. Main Equipment - Switchboards
10. Precast Facades – Type 1

The results also demonstrate that approximately 20% of the functioned units have a cost impact in excess of HK$1 million. Equally these 20% of items also constitute 86% of the total capital cost. Clearly this demonstrates that the primary focus should be placed on these major item, if substantial economic savings are to be achieved. An elementary breakdown of the initial capital costs is provided in *Appendix E* for reference.

The above results also highlight that architectural items, whilst significant are generally less dominant when compared with the structure and building services items. This conclusion is not surprising given the nature of the building's design and ultimate functional usage profile.

3.2.2 Initial Quantity (Mass) Ranking

The calculation of total mass of all the functional units has been a key component of the model and is the driver behind the calculation of the environmental impacts. As with all other aspects the large quantity items dominate the results and again the structural items top the results listing. The top 10 functional units, based upon initial mass are:

1. RC slabs – Fairfaced
2. RC walls - Fairfaced
3. Piles
4. RC walls - Generally
5. Pile Caps
6. Precast Facades Typed
7. RC Beams - Fairfaced
8. RC Water Tanks
9. Precast Facades Type 2
10. RC Beams - Generally

In this case the options available for assessing alternative strategies will be more limited without fundamentally revising the structural design of the building. Since the quantity of material required in the construction of the building is in part limited to the density of each material, it is important to appreciate that whilst metals, for example, have a relatively higher density when compared with concrete or timber, the quantity of material required to fulfil the same function is less, hence making a direct mass comparison difficult.

The above results ultimately are not remarkable and were expected. In the context of the whole life profile these items do not have as large an impact since they are not replaced frequently. However, due to their dominance at the initial stage they remain in the top rankings even on a whole life basis.

3.2.3 Initial Environmental Impact

The calculated overall environmental impacts in the model are expressed as a HK Eco-point[71] and based upon the weighted normalised environmental data within the LCA module. This approach means that the generated results are in the form of a single figure,

[71] One HK Eco-point represents the environmental impact of one Hong Kong citizen over a complete year.

allowing easy comparison. As noted in earlier sections the environmental impact of different materials within each functional unit are driven in largely by the mass of the material, therefore the environmental impact results are similar to the quantum ones shown previously.

Based upon the detailed analysis the top 10 functional units based upon their initial Environmental impact are (see *Appendix F* for full listing of functional unit initial environmental impact ranking):

1. RC Walls – Fairfaced
2. Precast Facades – Type 1
3. RC Slabs – Fairfaced
4. RC Water Tanks
5. RC Walls – Generally
6. Piles
7. Precast Facades – Type 2
8. Pile Caps
9. RC Beams – Fairfaced
10. Aluminium Windows - Bedrooms

The above list highlights one key environment point which is that Aluminium is a material which has a very high environmental impact and as such should perhaps be avoided, or at least its usage minimised. An elementary breakdown of the initial environmental impacts is provided in *Appendix G*.

3.2.4 Whole Life Cost Profile

This is a more difficult area to analyse simply because the results vary dramatically depending upon the occupation patterns assumed for the building as well as the maintenance regimes applied. Therefore the most appropriate analysis has been to examine which component of the block has the greatest recurring impact. It should also be noted that since this block type has yet to be operated, specific results / data on the whole building's performance is not available. This means that the results below are a guide rather than a definitive answer.

Based upon the above the top 10 functional units in terms of whole life cost are (see *Appendix H* for full listing of functional unit whole life cycle cost ranking):

1. RC Slabs – Fairfaced
2. RC Walls – Fairfaced
3. Wall Finishes – Internal Flat Areas
4. Floor Finishes – Kitchens and Bathrooms
5. Piles
6. Small Power Installation – Flats
7. Panel Walls – Internal
8. Fresh Water System - Distribution
9. Lighting Installation – Flats
10. Internal Waterproofing

The above again confirms that for those items which have a substantial capital cost, this situation will carry through to the whole life profile and rankings.

Graphical representations of the whole life cycle cost profile in terms of elementary breakdown and functional units are given in *Appendix I and J*, respectively for reference.

3.2.5 Whole Life Environmental Profile

Adopting the same approach, the top ten functional units ranked by their whole life environmental profile are (see *Appendix K* for full listing of functional unit whole life cycle environmental impact ranking):

1. Precast Facades – Type 1
2. RC Walls – Fairfaced
3. Precast Facades – Type 2
4. RC Slabs - Fairfaced
5. RC Water Tanks
6. Aluminium Windows – Bedrooms
7. RC Walls – Generally
8. Aluminium Windows – Living Area
9. Piles
10. Mains & Distribution

What the above results do demonstrate is that over 90% of the total impact is attributable to just 17% if all the functional units. This means that the environmental impacts are concentrated on a small group of items. Graphical representations of the whole life cycle environmental impacts in terms of elementary breakdown and functional units are given in *Appendix L and M*, respectively for reference.

Based upon the results of this study it is clear that the cost and environmental impact arising from the vacant flat works are the largest single contributor to the whole life profile of the functional units within block. This conclusion is driven by two key issues, firstly the nature of the blocks and secondly the age and tenant usage patterns.

It is clear that the New Harmony 1 block is a rental block and therefore has a more transitional population to that of a Home Ownership block. This means that the internal churn rate (using Housing Authority's own data) would be higher than similar designed ownership blocks and as a direct result more maintenance work is likely to be required. Coupled with this point is the question of the social status of the occupants. Previous work, particularly in relation to the drafting of the estate management privatisation contracts, has revealed that rental tenants tended to be less conscious of the need to maintain their building, therefore allow the building quality to deteriorate faster than in other social bands before raising complaints. This means that rental building tend to last for shorter periods of time and have a proportionally increasing demand for more extensive maintenance.

3.2.6 Combined Whole Life Results

The final set of ranking reports generated are the combined cost and environmental impacts. These rankings are the closest possible set of results to a single consolidated functional unit score. The combined ranking is generated by calculating the percentage, that each functional unit represents in terms of total cost and environment. These percentages are then combined to produce a total which in turn is sorted by order of magnitude as given by the formula below :

$$\text{Combined LCA/LCC indices} = \left\{ \frac{\text{LCA of functional unit}}{\text{LCA of whole building}} + \frac{\text{LCC of functional unit}}{\text{LCC of whole building}} \right\} / 2 \times 100\%$$

* There is no weighting of the LCC and LCA at this stage because this would lead to distortions and misrepresentation of the results, therefore this method is simply used to establish a numerical ranking. The decision making tool should be used to establish the trade-off between competing environmental and economic considerations.

Using this method the combined ranking at the initial stage has the following as the top functional units (see *Appendix N* for full listing of functional unit combined initial environmental impact and cost ranking):

1. RC Walls – Fairfaced
2. RC Slabs – Fairfaced
3. Piles
4. Precast Facades – Type 1
5. RC Water Tanks
6. RC Walls – Generally
7. Precast Facades – Type 2
8. Small Power Installation – Flats
9. Pile Caps
10. Mains and Distribution

While the combined LCA/LCC ranking at the whole life level, the top of functional units are (see *Appendix O* for full listing of functional unit combined whole life cycle environmental impact and cost ranking) :

1. Precast Facades – Type 1
2. RC Walls – Fairfaced
3. RC Slabs – Fairfaced
4. Precast Facade – Type 2
5. Wall Finishes – Internal Flat Areas
6. Piles
7. Small Power Installation – Flats
8. Floor Finishes – Kitchen and Bathrooms
9. Aluminium Windows – Bedrooms
10. Aluminium Windows – Living Area

Again these results highlight the dominance of structure and building services items in the context of the complete building.

Since the focus of this study is architectural materials the top is architectural functional units on a combined whole life basis have also been extracted and these are:

1. Wall Finishes – Internal Flat Areas[72]
2. Floor Finishes – Kitchen and Bathroom
3. Aluminium Windows – Bedrooms
4. Aluminium Windows – Living Area
5. Internal Waterproofing [73]
6. Panel Walls – Internal[74]
7. Wall Finishes – Corridors and Lobbies [72]
8. Gatesets[75]
9. Doorsets Kitchen
10. Doorsets – Bathrooms (1B/2B)

[72] These high ranking wall finishes have not being investigated for alternatives since currently there are no economical and practical alternatives to the render & paint system already specified by HA.

[73] The internal waterproofing was not investigated for alternatives because there are no technically acceptable alternatives. The proposed alternative of deleting it completely is addressed under the alternative for kitchen bathroom floor finishes.

[74] Items 6 and 15, Panel walls relate to those which divide two adjacent units (located in the kitchen) and those which are used as internal partitions around kitchen / living area and bathroom / living area.

[75] The gatesets were not investigated for alternatives because these are no longer provided by HA to future tenants.

11. Sink Units
12. Doorsets – Flat Entrance
13. Roof Finishes – Paving
14. Aluminium Windows – Kitchen
15. Panel Walls – Inter-flat[73]

It is from these items that the proposed alternatives have generally been selected.

3.3 COMPARISONS WITH EPP REPORT

This section reviews the May 2001 *Environmental Procurement Policies* (EPP) Report and highlights key considerations associated with the development of the HA LCA/LCC model. Finally, a comparison of the building material ranking between the EPP report and model developed is given.

3.3.1 Product Life Cycle Approach

An integral part of the EPP report is the systematic methodology to assign environmental risk rankings to building materials and products and thus allow the prioritisation of those with the highest impact. In assigning a product risk ranking for a building material, the EPP report considers environmental impacts at the *Raw Materials Extraction, Manufacture, Use* and *Disposal* stages of the product life cycle. The approach adopted for this LCA/LCC model employs a similar life cycle approach as described previously, although for an entire functional units rather than a single product or material. As such the evaluation of environmental impacts considers the *Initial* stage (including *Raw Materials Extraction*, *Manufacturing and Transportation* from factory gate to site), its *Use and Maintenance*, and finally *Disposal* upon building demolition. This means that the EPP report simply flags high impact materials rather than placing them in the context of the whole building.

3.3.2 Environmental Impact Categories for Performance Appraisal

In the next stage of the environmental risk ranking, the EPP approach classifies impacts associated with any given building product under ten categories considered most significant and pertinent to HA[76]. This studies methodology also adopts impact categories to address most of these environmental concerns as shown below.

EPP and HA LCA/LCC Model Impact Categories Compared

EPP REPORT	HA LCA/LCC MODEL
Resource Use (including Timber)	Resource Depletion
Air Pollution	Photochemical Smog, Acidification, Climatic Change, Human Toxicity, Ecotoxicity
Water Pollution/Use	Water Consumption, Human Toxicity, Ecotoxicity
Waste Generation/End of Life Disposal	Waste Management
Use of Dangerous Substances (Including Asbestos)	Human Toxicity, Ecotoxicity
Ozone Depletion	Ozone Depletion
Energy Use	Energy Consumption

[76] As indicated by "*Development of an Environmental Procurement Policy and Implementation Strategy Report*", page 9, Environmental Resource Management, November 2001

EPP REPORT	HA LCA/LCC MODEL
Carbon Dioxide Emissions (Global Warming Potential)	Climatic Change
Reputational Risk[77]	Not Applicable
Noise Pollution[78]	Not Applicable

As illustrated above, for the majority of environmental issues considered for product risk ranking in the EPP report, there is a direct corresponding environmental impact category being adopted for the LCA of building materials in this study, namely *Resource Use* (including Timber), *Waste Generation/End of Life Disposal*, *Ozone Depletion*, *Energy Use* and *Carbon Dioxide Emissions* (*Global Warming Potential*).

For other EPP impact categories that are more general, the LCA methodology cannot specifically quantify them with the same degree of accuracy and they are hence excluded.

3.3.3 Single Environmental Performance Indicator for Building Materials

In this final step of the environmental risk ranking, the EPP approach considers the extent of environmental impacts associated with a given building material for each of the ten impact categories and subsequently assign a score (on a semi-quantitative and subjective basis). This is applied for the proposed four stages of the product life cycle and by simple addition of these sub-scores, a single total environmental risk score is then assigned for the environmental performance ranking of building materials.

The approach for this study has also investigated the extent of the environmental impacts associated with a building material under their respective impact categories over the three-stage product cycle proposed. However, this evaluation is performed on a scientific and quantitative (rather than a subjective and semi-quantitative) basis, with the application of authentic and reliable data, and analytical techniques such as *classification* and *characterisation*, as required by the inherent LCA nature of the study methodology. The characterised data is then further treated through LCA analytical techniques namely, *normalisation* and *weighting* which standardise the differing environmental impact categories and allows them to be compared under a common basis, and takes into account of the relative significance of each impact category from a local and HA viewpoint. Ultimately, the normalised and weighted data provides an overall standardised environmental performance indicator for a building material representative of its true product life cycle impacts from LCA, local and HA perspectives.

3.3.4 Ranking of Building Materials

As indicated in the EPP report, the environmental risk scoring methodology devised is a somewhat primitive and non-scientific tool to provide a preliminary broad overview of the environmental impacts associated with building materials. Therefore, taking into consideration the sophistication, complexity, scientific and inherent LCA approach adopted in this study, discrepancies of environmental ranking for building materials between the two methodologies is inevitable. A comparison of these two approaches is given overleaf .

Further to the above, the EPP report was a general review of materials used by HA in their construction process and was primarily focused towards the initial impacts generated by

[77] This is considered to be too subjective a category and could be influenced by many other factors and therefore has not been included in this study.
[78] This is a local impact and not directly related to the use of the material itself, hence has been excluded.

specific material usage. In terms of the impact results contained in this report only 25 products were considered and each was evaluated based upon a subjective risk ranking scale as previous discussed.

Using this approach a final ranking of just these studied 25 materials was published. Using this methodology it is clear that economic or quantum considerations were excluded, meaning that materials alone are ranked by their impact rather than by their impact within the context of the building. Based upon the results in the EPP report it is also noted that many dissimilar items are grouped together, for example PVC Drainage pipes/windows/frames are all classified as a single item following material rather than usage profiles.

EPP and HA LCA Methodologies Compared

EPP METHODOLOGY	HA LCA METHODOLOGY
Appraisal of environmental issues for building materials under *selected* stages of product life cycle: Raw Material; Manufacture; Use; and Disposal.	Appraisal of environmental issues for building materials under *all* stages of product life cycle: Initial (including Raw Materials Extraction, Manufacturing and Transportation); Use and Maintenance; and Disposal.
Semi-quantitative Approach – subjective with a high degree of uncertainties and assumptions	Quantitative Approach – scientific (based on ISO 14040 series), consistent and reproducible
Product environmental risk score for a building material derived from simple addition of (arbitrary assigned) environmental sub scores without due consideration of impact standardisation and their relative importance	Single LCA Environmental Performance Indicator evaluated for a building material – based on authentic data analysed scientifically, taking into consideration of standardisation of different impacts and their relative significance from a local and HA perspectives

Ultimately the results of the EPP study highlight some high impact materials, however based upon a scientific approach using chemical properties, as adopted by this study, the top 10 materials from the LCC / LCA analysis, based upon the average locally weighted impacts would be as set out below. We have also presented the top 10 materials from the EPP report for comparison purposes.

	EPP Report	HA LCC/LCA Study
1.	PVC	Aluminium Paint (Timber Paint)
2.	Galvanised Iron with Spray Painting	Copper (Generally)
3.	Multilayer Acrylic Paint	Aluminium (Generally)
4.	Emulsion Paint	Wood Preventative Paint (Timber Paint)
5.	Synthetic Paint	Synthetic Paint (Paint Generally)
6.	Cement	Chromium Brass (Ironmongery / Taps)
7.	Precast Concrete	Alkali Resisting Primer Paint
8.	Stainless Steel	Polysulphide Sealant (Movement Joints)
9.	Aluminium	Silicone Sealant (Joint Filler)
10.	Iron	Zinc Chromate Paint (Metal Work Primer)

In view of the unscientific nature of the EPP results it is difficult to identify underlying reasons for the differences but the above EPP list does perhaps identify a series of materials which should be avoided, or at the very least minimized in their usage.

In summary therefore, whilst the EPP report provides one view of the material ranking it has limited factual or scientific support and also does not consider two key aspects, namely quantum and cost.

4. SELECTION OF ALTERNATIVES

The main objective of this study has been to identify areas within the New Harmony 1 block (Option 2) where improvements both in environmental and cost performance could be achieved. These improvements are both environmentally and cost driven but most importantly consider the building as a whole and over its whole life. This section examines the methods adopted for identifying alternatives as well an explanation of the proposed alternatives and then the evaluation process undertaken. The methodology for the decision making tool used in this assessment process is also set out in this section.

4.1 SELECTION RULES

There are few rigid rules which could be established for the selection of alternatives within the context of this study. The main limitation criteria are that no structural or building services items should be considered (it should be noted that plumbing pipeworks are not classified as building services items for the purposes of this study). Clearly this has a impact on the range of alternatives which can be proposed, especially since 17 out of the top 35 functional units, based upon whole life combined ranking, are either structured or building services related functional units.

Despite the above limitations, alternatives have generally been selected based upon their overall environmental impact, cost implication and ease of revision. Whilst other alternative solutions are available, if they result in a knock on implication to the design or operation of the building as a whole they would constitute a less practical solution certainly in the short term. In addition care has been taken to ensure that overall buildability is not impaired, hence avoiding programming issues and cost impacts elsewhere in the project. This is important since construction periods, if lengthened may have a significant cost impact.

The final consideration included has been the overall context of the building. It is considered that all proposed revisions should be sensitive to the current building usage profile and not seen by external parties as being a downgrading or value reduction in the finished block. This is particularly important in the wider context of the provision of public housing in Hong Kong.

4.2 THE DECISION MAKING TOOL – INTEGRATION OF LCA AND LCC

Based upon the above selection criteria it is therefore important to balance the environmental and cost impacts of any proposed alternative. Therefore the decision making tool developed under this study is designed to illustrate this balance and to allow users the opportunity to trade off between economic and environmental gains.

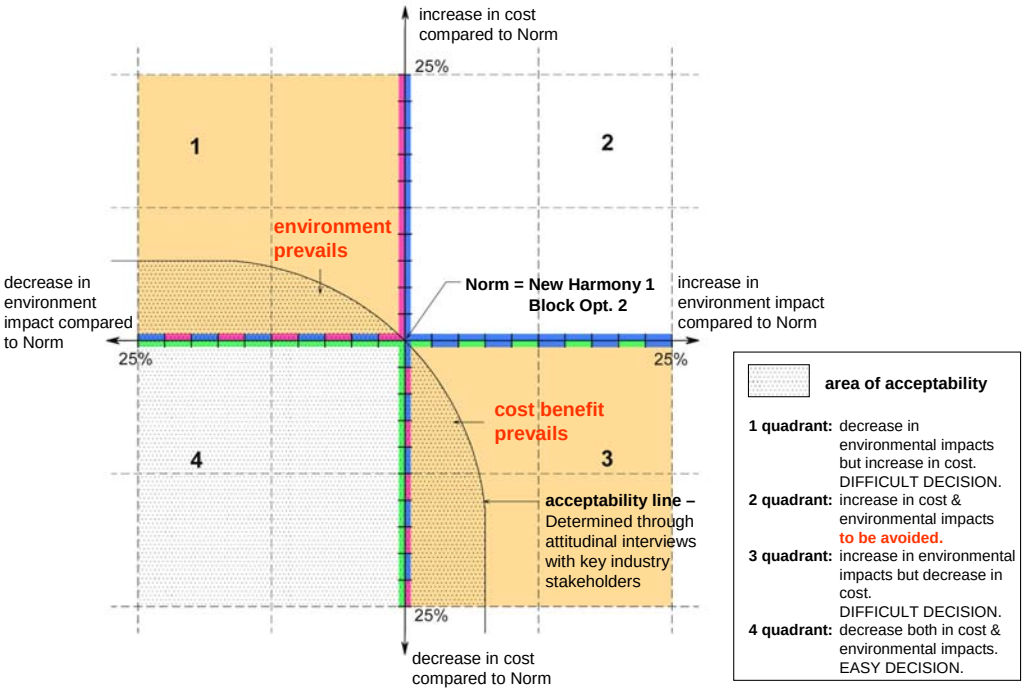
Since there is no scientific method of combining different parameters that have dissimilar impacts like global warming and biodiversity it is necessary to find an appropriate mechanism. Energy is a robust indicator of environmental impact, largely because of the way energy is generated using fossil fuels and therefore there is a demonstrable relationship between energy consumption and CO_2 emissions. High-energy usage is also associated with other impacts such as acidification and local impacts. However energy consumption or CO_2 emissions do not have a direct relationship with cost and where a relationship is evident it is likely to be both complex and particular to one material or even one production method.

Although methodologies do exist for combining dissimilar parameters and impacts like 'Activity Based Life Cycle Assessment' they are inevitably reliant on qualitative values and are often overly complex and are often not transparent.

The methodology applied in the study is both straightforward and once established can provide both an optimisation tool and more importantly a decision making tool for whatever different form of specification is to be 'interrogated' by the model. Equally it is also transparent to the external observers.

Our methodology for combining both LCA & LCC assessments is illustrated below and basically can be described as expressing the proposed specification changes as a percentage of the overall building costs and the normalised environmental impacts. In this way one can compare the significance of a proposed specification change in terms of its environmental deterioration (percentage increase in the overall energy/CO_2 life-cycle total) or improvement (percentage decrease in the overall energy/CO_2 life-cycle total). The environmental percentage figures that emerge can then be directly compared with the percentage change in cost.

Combining LCA Environmental Impacts with LCC Price Mechanisms: The Decision Making Tool (for illustration only)



The acceptability curves have been established by undertaking attitudinal interviews with key industry stakeholders in a series of workshops as discussed in previous sections. These acceptability curves represent the boundaries of what the workshop participants, considered to be acceptable. Once percentage change figures are generated a simple decision making framework can then be put into practice where for example it is suggested that all alternatives that fall within the acceptability curve are deemed to be all satisfactory.

Currently the LCA/LCC model generates the base impact of the New Harmony 1 (Option 2) block (6/00 revision to 1/00 Edition) design and this therefore represents the centre point of the "cross-hair" chart (refer to illustration above). As alternative options are run the overall answer changes. These changes are represented as a revised numerical outcome. In order

that the relative changes in environmental and cost impact can be measured, the difference between the base results and the revised outcome are expressed as a percentage difference and plotted on the "cross hairs". This percentage therefore shows how much more or less impact the alternative has when compared back against the base design. The newly plotted point represents therefore the impact of the revised design in the context of the complete building. In other words, the further this point is away from the centre of the cross hairs, the greater the percentage impact, either positive or negative, the proposed change has had.

In practice, it is anticipated that the majority of any proposed percentage change would be relatively small (in-percentage terms) because within the context of the whole building only remains or substitute materials can be considered to a few items unless a complete structural redesign is proposed. In view of this, big swings or fluctuations in the results after the assessment of the proposed alternatives are not likely but these changes can represent significant a impact in the context of the Housing Authority's whole portfolio which comprises multiple blocks.

Although the above comparison process is predominantly based upon the whole life impact of the alternatives, it will also be possible to compare the impact at the initial stage as well. Clearly this type of comparison will allow different branches within the Housing Authority to evaluate the impact of alternative materials in the context of their own work.

In summary therefore the decision making tool is a direct application module within the main model to the extent that it presents the impact outcome of the alternative materials being selected. The objective is to establish the relative benefit or disadvantage of accepting the proposed alternative within the framework of the whole block.

4.3 PROPOSED ALTERNATIVES

It should be noted that the identification of the proposed alternatives in this section has been carried out based upon the results of the previous ranking exercise. However it should be noted that due to the nature of the building and the degree of refinement which has already been carried out on the design (from the original design version of the Harmony 1 block range) over the last 10 years the scope for improvement is limited. This is not to say that the building is perfect, but that the opportunities for making enhancements without diminishing the functionality and quality of the building are very limited.

In view of this the alternatives proposed below are more cosmetic in nature rather than radical revisions. It is also acknowledged that some of these revisions are already alternatives or options within the existing HKHA standard block arrangement. However, despite this these are options or alternatives which are not commonly adopted by contractors for many different reasons, but if a potential benefit in terms of LCC / LCA can be derived then these should perhaps become the base option, rather than an alternative.

All the alternatives presented below are therefore have been identified on the basis of the whole life environmental and cost impacts as well as the practicality of making material substitutions or revisions.

4.3.1 Alternative 1 - Aluminium Windows

Original Design

Scope : The standard building design uses aluminium as the primary material for the window frames within the domestic units and in the general circulation areas.

Concern : Aluminium as a material is ranked as one of those with the highest environmental impact and therefore should be used as little as possible (from an environmental point of view).

Proposed Alternative

Scope : Currently there is a standard design alternative to aluminium, which is UPVC. The use of this alternative has to date been very limited, primarily due to the perceived higher capital costs and the unfamiliarity. Technically therefore it is proposed to test this standard alternative to examine which material offers the best whole life option. Although other material options were considered following detailed review they were found to be less desirable and hence not analysed in detail as part of this study. The comparison comprised all aluminium windows within the building, excluding those within plant rooms.

Results

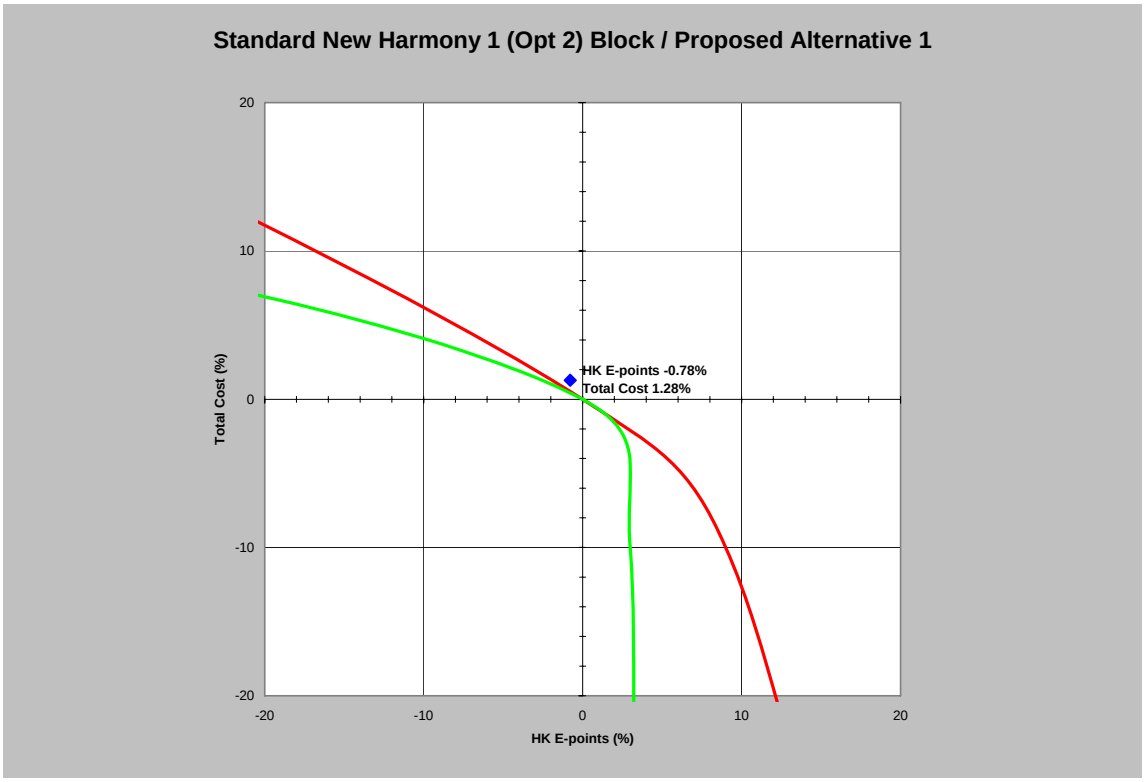
Whole Life : Based upon the whole life simulation of the both the environmental and cost impacts for the proposed revision it can be seen from the chart below that the environmental impact arising from this proposed revision is an improvement, while the cost impact is an increase. Therefore whilst this proposal offers environmental opportunities there is a financial impact.

The specific results, in relation to the whole life of the complete building, are and overall environmental improvement of 0.78% but a cost increase of 1.28%[79], this is outside the lines of acceptability. It should be noted that the cost increase is based upon the current pricing level in the market which is considered to be an unrealistic comparator. This is primarily due to the fact that the aluminium window design has been in use for many years and suppliers and contractors are familiar with it, hence have optimised the cost. This same level of optimization is not available for the uPVC window option, but would come if the widespread adoption were achieved.

In this case it is necessary to review this result against the lines of acceptability set during the workshops held during the study. As can be seen from the graph below, this result falls within the "accepted" region of the chart and therefore the increase in cost was considered by the workshop participants to be acceptable in consideration of the potential environmental benefit achieved.

As an addition note to this particular alternative, it is anticipated that in the short term the tender price for aluminium will increase following global market trends, therefore the identified financial burden may actually be lower.

[79] The initial environmental impact is a 0.26% reduction while the capital cost impact is a 1.28% increase.



4.3.2 Alternative 2 - Internal Precast Panel Walls

Original Design

Scope : The current design comprises the use of precast concrete lightweight panel wall units. These units are usually made out of solid panels, although some manufacturers use reinforced sections or hollow panels. These panels also come with a 3mm thick skin coat allowing a paint finish to be applied directly to the exposed surface. In bathrooms and kitchens these walls are covered on one side with ceramic tiles.

Concern : Due to the substantial quantity, both in physical size and mass these items have a noticeable whole life impact. Equally during the repair and maintenance phase these materials experience a high degree of churn.

Proposed Alternative

Scope : Since mass is a key driver in terms of environmental impact, it is therefore proposed to evaluate the potential for using gypsum dry wall system. The identified design would provide the same performance requirements and fulfill the same technical functionality. In general the proposed design comprises gypsum board of 12.7mm thick on either side of a metal framework (refer to *Appendix P1* for construction details and sample specification). For the inter-flat partitions it is proposed to use a double layer system with the central void being filled with insulation material.

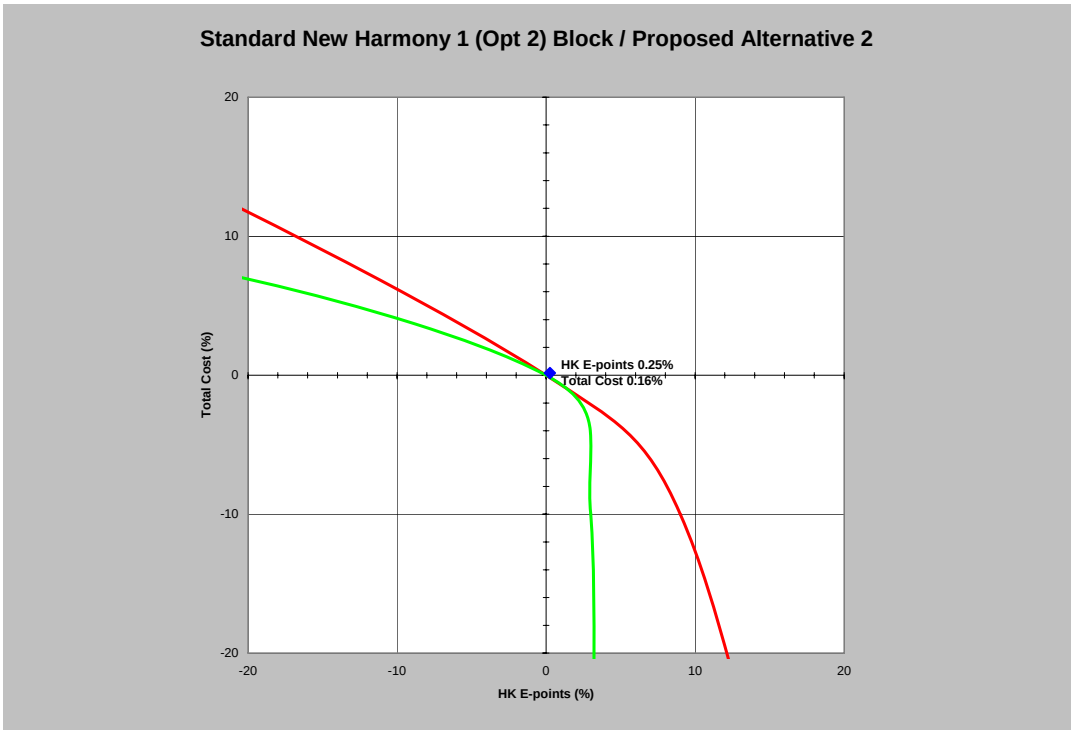
Results

Whole Life : As can be seen from the graphical results below, the proposed alternative does not offer any specific financial or environmental benefit over the whole life of the building.

The primary reason for the above result is the relatively higher environmental impact of the gypsum board as well as the increased quantity of steel required in the installation process. The overall results, in the context of the complete building's whole life, are a 0.25% increase in environmental impact and a 0.16% increase in the cost[80], this is outside the lines of acceptability.

As was the case with the windows in alternative 1, there is clearly significant potential for the supply and installation cost of the gypsum dry wall system to come down if the volume of demand was higher. It is known that elsewhere in the market that the use of gypsum dry wall system are a more economical option (in capital cost terms) than panel walls, often by as much as 20 – 30%. The other significant benefit achievable is the advantages this system offer for installation of building services items and the overall quality of the finish which is often smoother. There would also be an enhanced safety and on site storage benefit by using a gypsum dry wall system. In terms of the environmental impact, this could be reduced through the refinement of the panel thickness to reflect more accurately the needs of HKHA.

In view of the above points it is possible that both the cost and environmental impacts from this alternative could be made to be closer to the current design and certainly in the context of non standard designs, this system does offer a potential benefit to HKHA.



[80] The initial environmental impact is a 0.10% increase and the capital cost impact is a 0.07% increase.

4.3.3 Alternative 3 - Cooking Units

Original Design

Scope : In the current standard block designs a prefabricated cooking unit, made from concrete with stainless steel cladding is used in all the kitchen areas of the flats.

Concern : Whilst the cost of these units are not high, their mass is significant which means that their overall environmental impact is also significant. Coupled with this point is the fact that during the whole life of the building these components are replaced relatively frequently[81], hence durability whilst a consideration should not be an over-riding concern.

Although the above statement appears to contradict the principles of sustainability, the practical situation must be considered, especially in the context of HKHA where high levels of flat churn are experienced.

Proposed Alternative

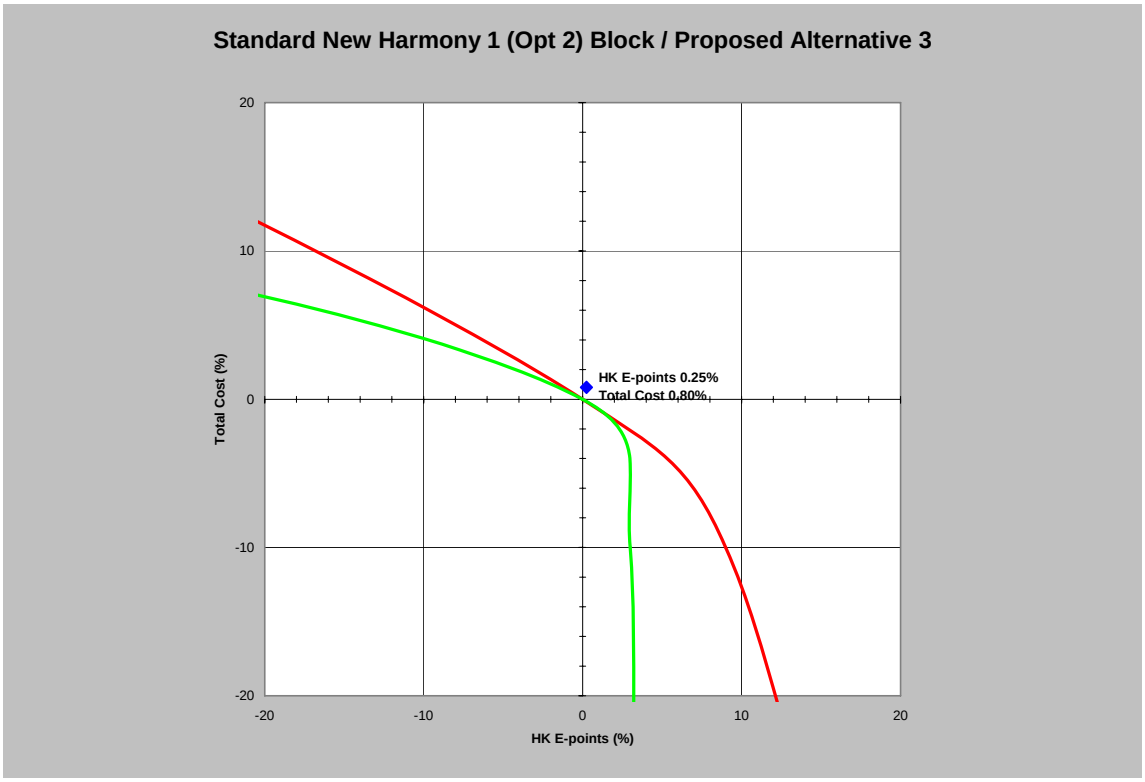
Scope : Based upon the usual practice in the private sector it has been found that custom-made timber framed units. These types of units are considered to be quick and easy to make and can be relatively inexpensive. By using a typical design it would be possible to provide cabinet storage space below the cooking top which may be regarded as enhancing the quality. Although the durability would not be as good as the existing design when the extent of replacement is considered this is not likely to impact on the overall whole life performance.

Based upon the above, it is proposed to replace the cooking unit with a timber framed plastic laminated plywood faced unit with a stainless steel covering on the counter top. Although more suitable solutions could be found to the counter top, it is considered that the stainless steel option offers a more durable proposal.

Results

Whole Life : As illustrated below the perceived benefits in terms of environmental and cost performance are not achieved through this proposal. Whilst the proposed design is common throughout the market and is considered to offer a higher quality of end product it is found to be more expensive than the current design solution. The overall results in the context of the whole building are a 0.25% increase in environmental impact and a 0.80% increase in whole life cost[82], this again is outside the line of acceptability.

[81] This high level of replacement is driven by the frequency of churn within the flats and the extent of the vacant flat refurbishment works carried out.
[82] The initial environmental impact is a 0.31% increase and the capital cost impact is a 0.34% increase.



4.3.4 Alternative 4 - Floor Washing Pipework

Original Design

Scope : Current design include the use of UPVC Lined Galvanised Steel pipes for the floor washing pipework system and this pipe specification is unique to HKHA.

Concern : The use of this type of pipe material for the floor washing system is considered to be unbeneficial since the same material is only normally used for the fresh water system. Whilst this system is fed from the same source, there is no reason to adopt the same pipework. Especially since there are concerns about higher costs arising form using the UPVC lined pipe solution.

Proposed Alternative

Scope : The proposal therefore is to replace the existing piping material with standard PVC pipes, similar to those found in the fire services and flushing water systems. This would therefore be a straight material substitution.

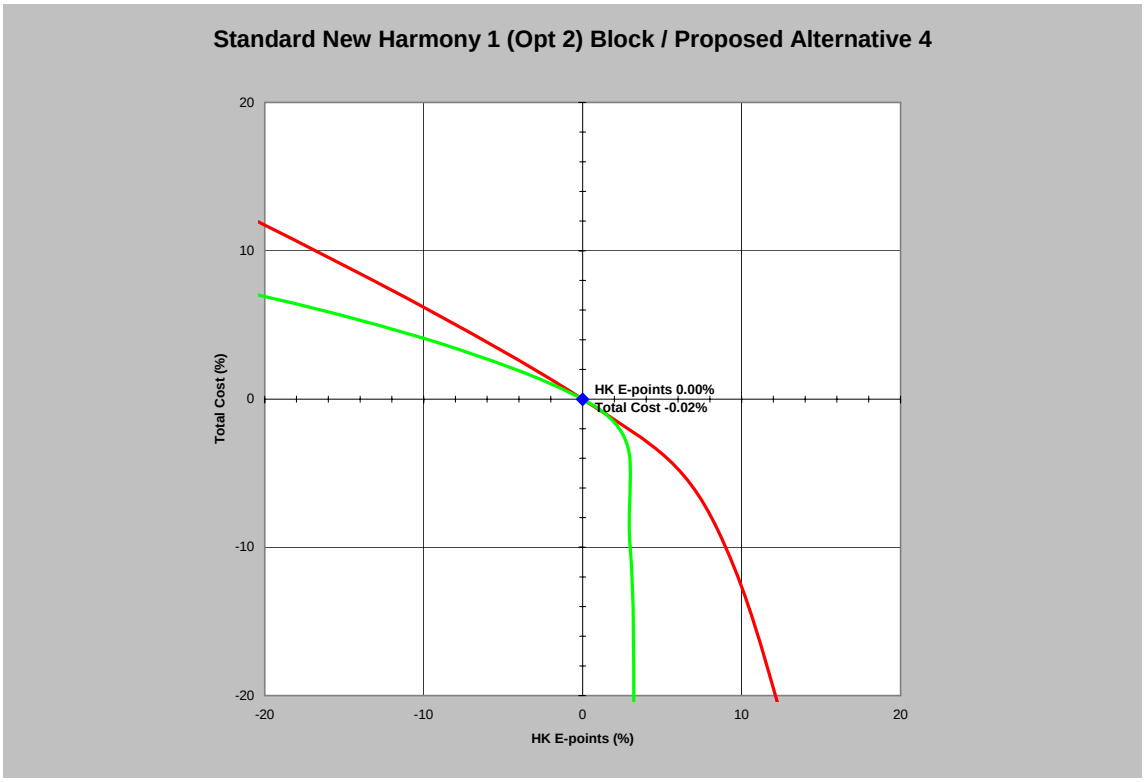
Results

Whole Life : Again the results from this alternative are illustrated in the graph below.

As can be seen, the impact of this revision is very minor, in the context of the whole building, primarily due to the scope of work involved. However it does offer a financial saving of 0.02% with only a very minor environmental impact increase[83], this would be on the line of acceptability.

Based upon the above this alternative clearly offers some benefits to the client and reduces the dependence on a rather unique pipework material.

[83] The initial environmental impact is a minimal increase and the capital cost impact is a 0.04% decrease.



4.3.5 Alternative 5 - Flat Entrance Doorsets

Original Design

Scope : All flat entrance doors are currently designed to be a 50mm thick solid cored timber doorsets with a ½ hour fire rating with a plywood facing.

Concern : Although this is a typical door design and economical to construct, the replacement cost and frequency suggest that perhaps a more durable door material may offer long term benefits.

Proposed Alternative

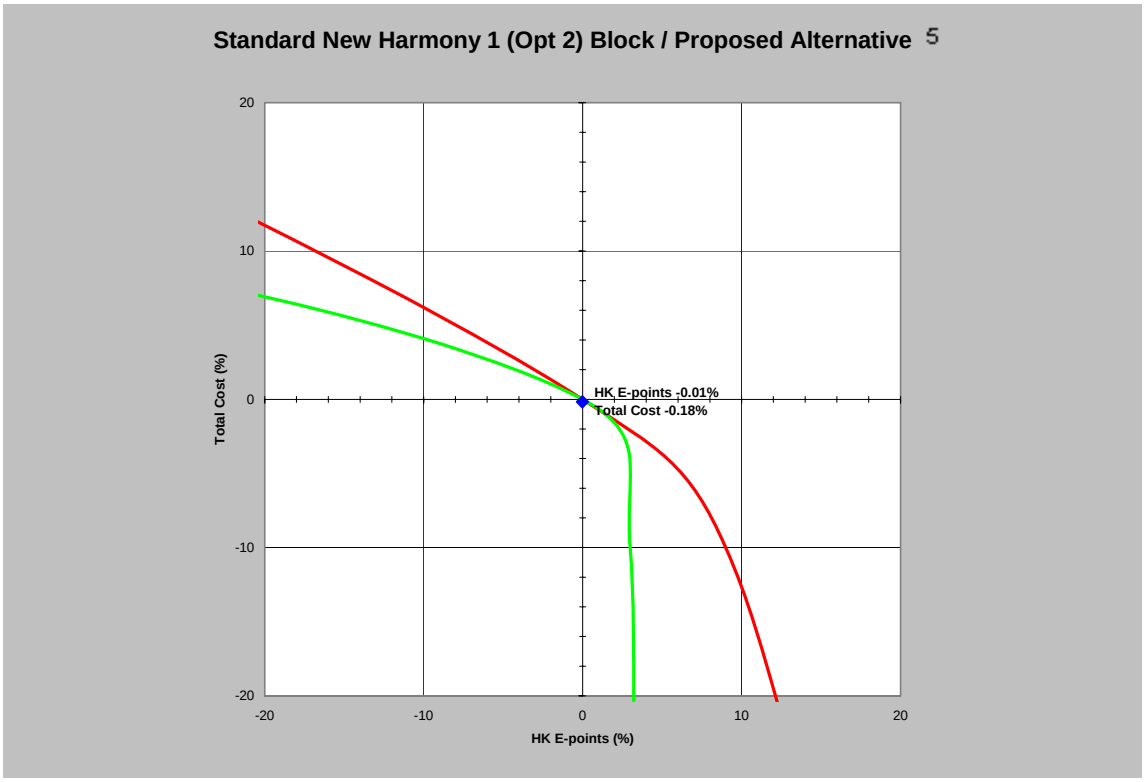
Scope : Two alternative materials have been examined, fire rated softwood and GRP. Both are technically suitable for the proposed use but each has differing cost and environmental profiles. The overall thickness and framing details are not proposed to be revised and the associated ironmongery should also have no change (refer to *Appendix P2* for construction details and sample specification). Based upon the research carried out in the market and the potential benefits to be generated it was established that a softwood solution would be the most beneficial and was therefore analysed in detail.

Results

Whole Life : Again the results from the analysis are illustrated below and show that there would be both an environmental and cost benefit from adopting softwood as an alternative material choice.

Based upon the results and in the context of the whole life of the building, there would be a 0.01% reduction in environmental impact and a 0.18% reduction in whole life cost[84], this would be within the lines of acceptability.

Clearly this proposal does offer a benefit to HKHA and the performance of this alternative material is considered to be no less than the current specification, especially considering the current replacement rates.



4.3.6 Alternative 6 - Kitchen Doorsets

Original Design

Scope : All kitchen doors are currently designed to be a 50mm thick solid cored timber doorsets with a ½ hour fire rating with a plywood facing and with a Georgian wired glass window.

Concern : Although this is a typical door design and economical to construct, the replacement cost and frequency suggest that perhaps a more durable door material or alternatively a cheaper material may offer potential long term benefits.

[84] The initial environmental impact is a 0.01% reduction and the capital cost impact is a 0.26% reduction.

Proposed Alternative

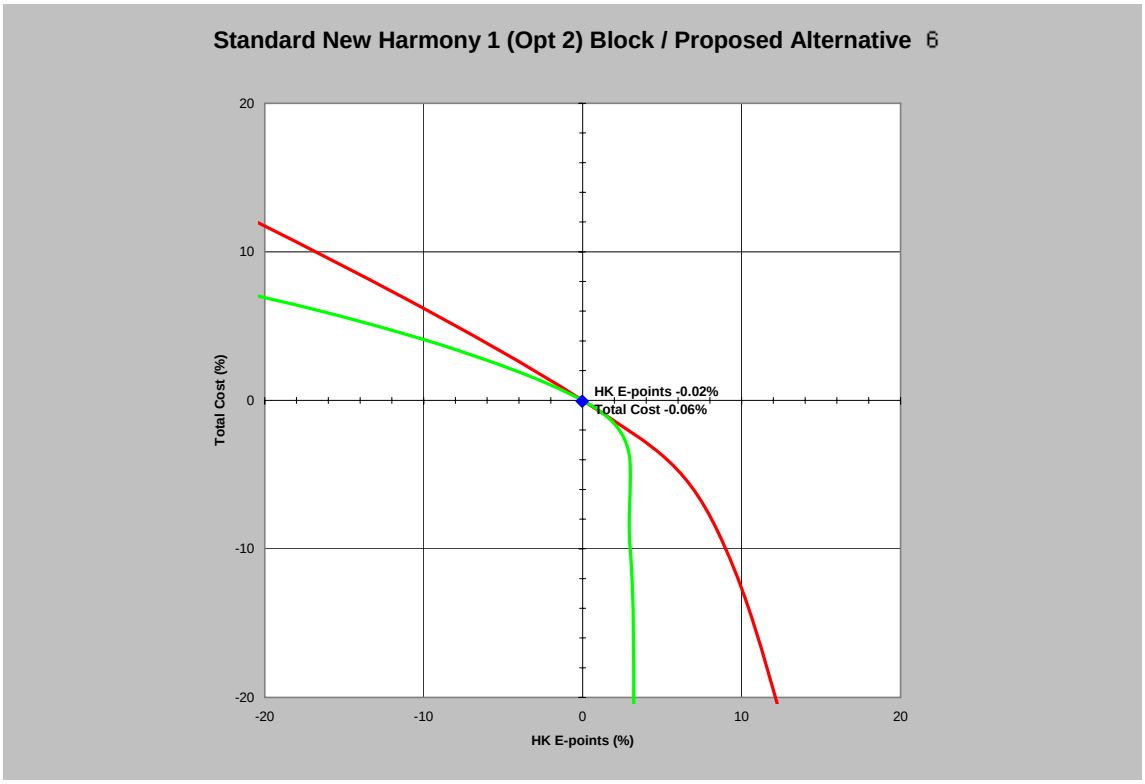
Scope : Two alternative materials have been examined, softwood and GRP. Both are technically suitable for the proposed use but each has differing cost and environmental profiles. The overall thickness and framing details are not proposed to be revised and the associated ironmongery should also have no change (refer to *Appendix P3* for construction details and sample specification). As was the case with the flat entrance doors the outcome of the initial review was that the use of softwood would be the optimum solution in the HKHA context.

Results

Whole Life : Below is the graphical presentation of the result from this comparison and as can be seen the same environmental and cost benefits are achieved. In the context of the while life of the complete building there is a environmental saving of 0.02% while there is also a cost saving of 0.06%[85], this would be within the lines of acceptability.

It has been noted that although the current design utilizes doorsets, as is the case with the flat entrance doors, there is in practice little if any financial benefit by adopting this approach. The cost of a door and frame, when compared with a doorset unit does not produce significant savings. Whilst in times of large construction volume the need for standardization was important, the current development output of HKHA clearly does not justify such an approach.

On the question of durability, it is considered that since the current rate of churn inside HKHA flats is so high, the need for exceptionally durable materials is a less critical issue.



4.3.7 Alternative 7 - Floor Finishes – Kitchen & Bathroom

Original Design

Scope : The current design comprises a cold applied waterproofing system overlaid with a 40mm minimum thick screed, with 7mm thick homogeneous tiles bedded on a 8mm thick mortar backing.

Concern : Due to the frequency of repair and maintenance work, the cost of replacing this system is very high, hence consideration as to whether other design details could offer either greater durability or lower cost.

Proposed Alternative

Scope : It has been considered whether reducing the overall thickness of the screed by 15mm to a minimum of 25mm thick would be suitable. Whilst there are concerns over cracking and performance, based upon the current repair and maintenance cycle and quality control measures, this should not be a problem.

Results

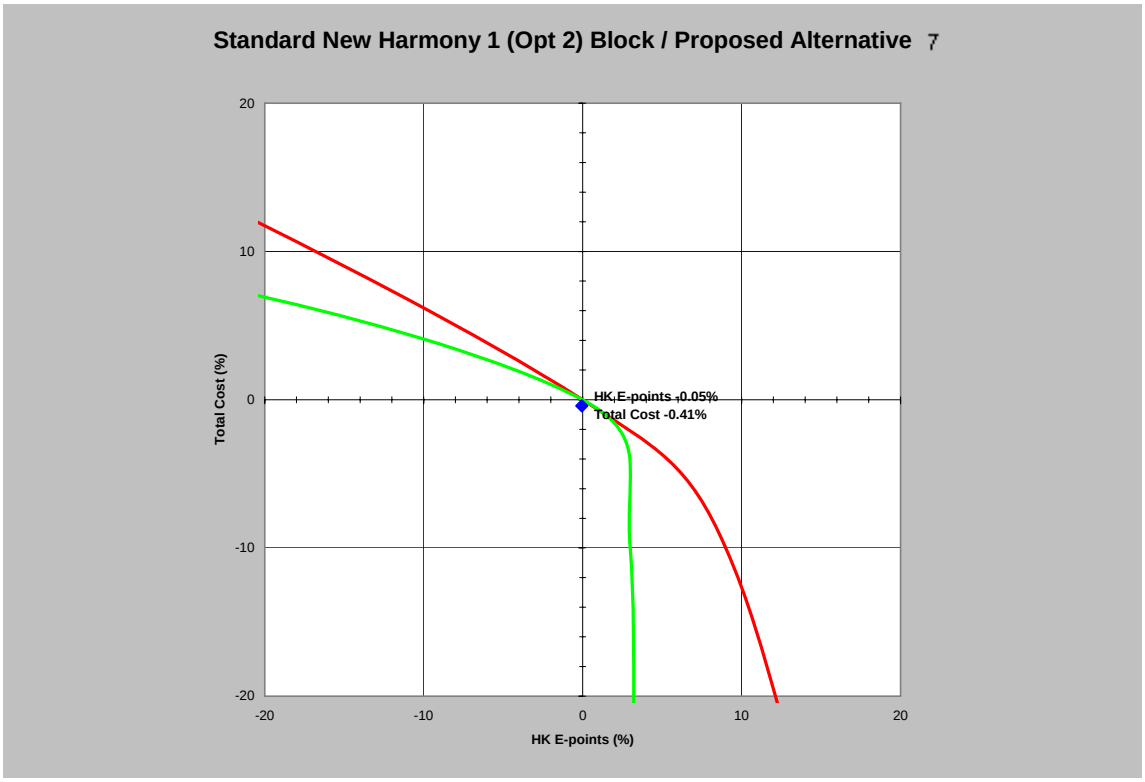
Whole Life : Again the results of the details analysis of this proposal is graphically represented below.

Unlike many of the other proposals this option has a significant impact on the whole life performance of the building. The above shows that in the context of the while building over its whole life, there would be a 0.05% reduction in the environmental impact and there would be a 0.41% reduction in the cost impact[86], this again would be within the lines of acceptability.

The main reason for the significant cost reduction is the recurring maintenance cost which would be greatly reduced through the reduction in material consumption. Clearly this proposal offers a noticeable benefit to HKHA and there would be no reduction in overall performance or quality.

It should also be noted that the reduction in the extent of this "wet trade" would also have a slight benefit on the construction process and programme as well. This item is a recurring issue throughout the design of the current building, in that the extensive use of screeds has a high financial and environmental impact. More radical options are available but these mostly involve the use of alternative structural design solutions, which are outside the scope of this study.

[85] The initial environmental impact is a 0.01% reduction and the capital cost impact is a 0.31% reduction.
[86] The initial environmental impact is a 0.01% reduction and the capital cost impact is a 0.29% reduction.



4.3.8 Alternative 8 - Floor Finishes – Corridor and Lift Lobbies

Original Design

Scope : Currently main corridors and lift lobbies have a floor finish comprising 40mm minimum thick screed with 7mm thick homogeneous tiles on a 8mm thick bedding.

Concern : Inconsistency in the thickness of tiling means that the floor finishes have a higher environmental impact than is perhaps necessary. In addition the thickness of the screeds is again questioned.

Proposed Alternative

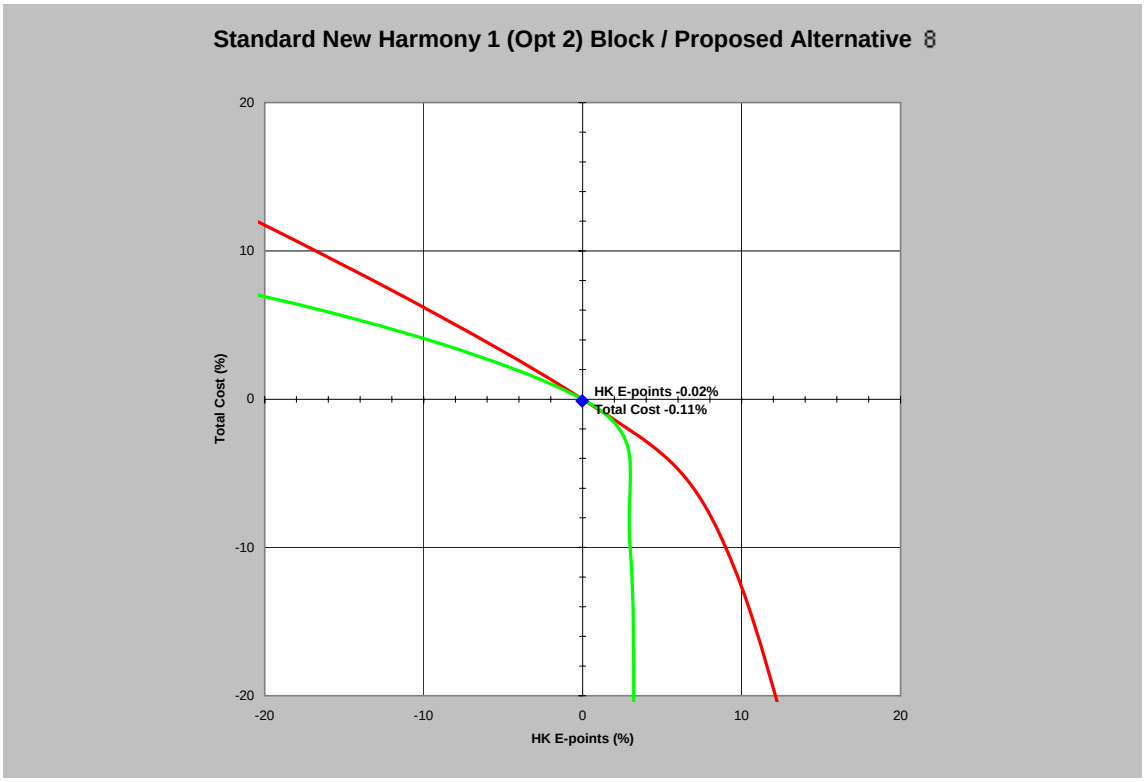
Scope : It is proposed to reduce the screed thickness by 15mm to a minimum of 25mm thick, adopting the same rational as for the kitchen area previously.

Results

Whole Life : The overall results of this analysis are again illustrated below.

The results illustrate that in the context of the whole life of the complete building that here would be a 0.02% reduction in the environmental impact and a 0.11% reduction in the cost impact, this would be within the lines of acceptability. This result is not surprising given the fact that the proposal

comprises a reduction in the quantity of material used in the building[87].



4.3.9 Alternative 9 - Bathroom Doorsets

Original Design

Scope : Currently bathroom doors are currently designed to be a 46.3mm thick hollow cored timber doorsets with a plastic laminate plywood facing in the larger flats, while in the small flat units a plastic folding partition is adopted.

Concern : Although the timber door is a typical door design and economical to construct, the replacement cost and frequency suggest that perhaps a more suitable door material may offer long term benefits.

Proposed Alternative

Scope : Based upon an analysis of a number of potential options it has been concluded that the use of the plastic folding door could offer potential benefits to HKHA (refer to *Appendix P4* for construction details and sample specification). There is question as to the acceptability of the proposal, from a visual point of view, but it is considered to be a minor point in the context of the whole building and the functionality is not compromised by this proposal.

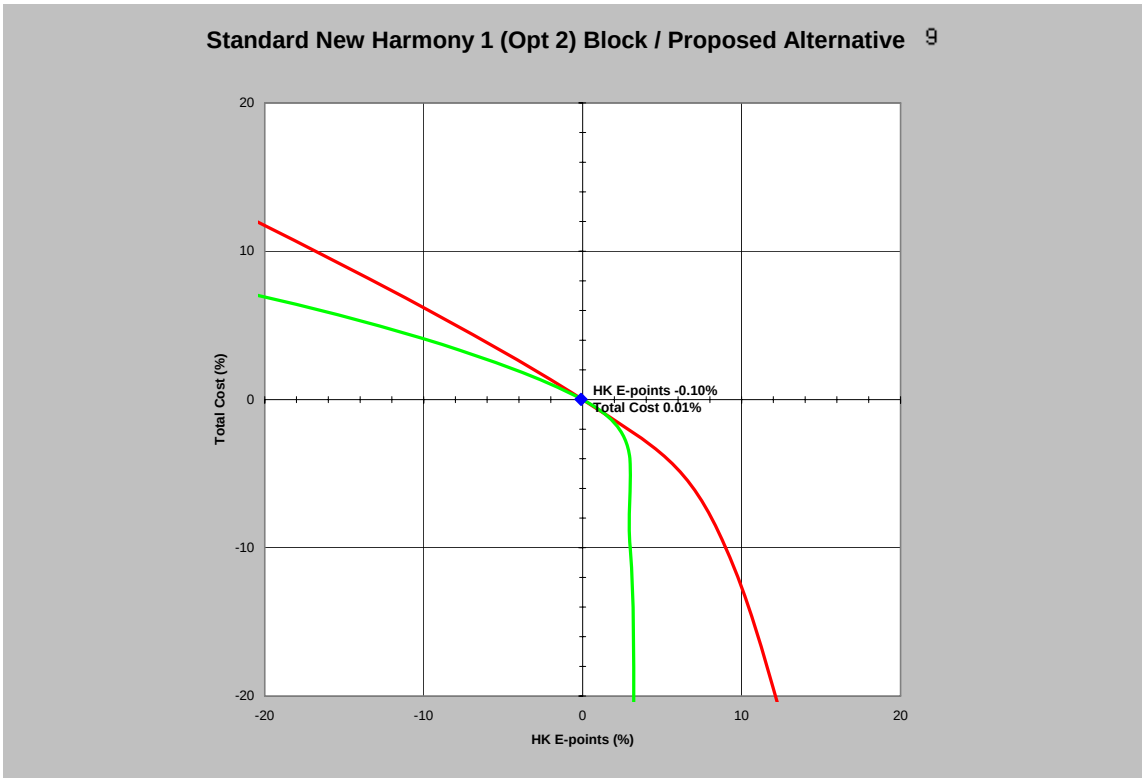
[87] The initial environmental impact is a 0.04% reduction and the capital cost impact is a 0.19% reduction.

Results

Whole Life : As before, the whole life results of this proposal are illustrated in the graph below. As can be seen, the proposal generates a whole life environmental saving of 0.10% but there is a whole life cost increase of 0.01%, in the context of the whole building [88], this would be within the lines of acceptability.

This is one of the proposals which requires reference to be made to the overall lines of acceptability established during the workshops. It can therefore be seen that this proposal would be considered to be an acceptable trade-off.

In addition to the above, it is also suggested that if the quantity of these folding partitions were increased further financial benefits could be achieved.



4.3.10 Alternative 10 - Fresh Water Pipework

Original Design

Scope : Current designs include the use of UPVC Lined Galvanised Steel pipes for the fresh water distribution and installation systems and this pipe specification is unique to HKHA.

[88] The initial environmental impact is a 0.18% reduction and the capital cost impact is a 0.01% increase.

Concern : Although through extensive flat production the cost of these special pipes has fallen, they still represent a deviation from the usual market practice. Therefore it is considered beneficial for HKHA to open the material options up so as to encourage greater options from materials available within China.

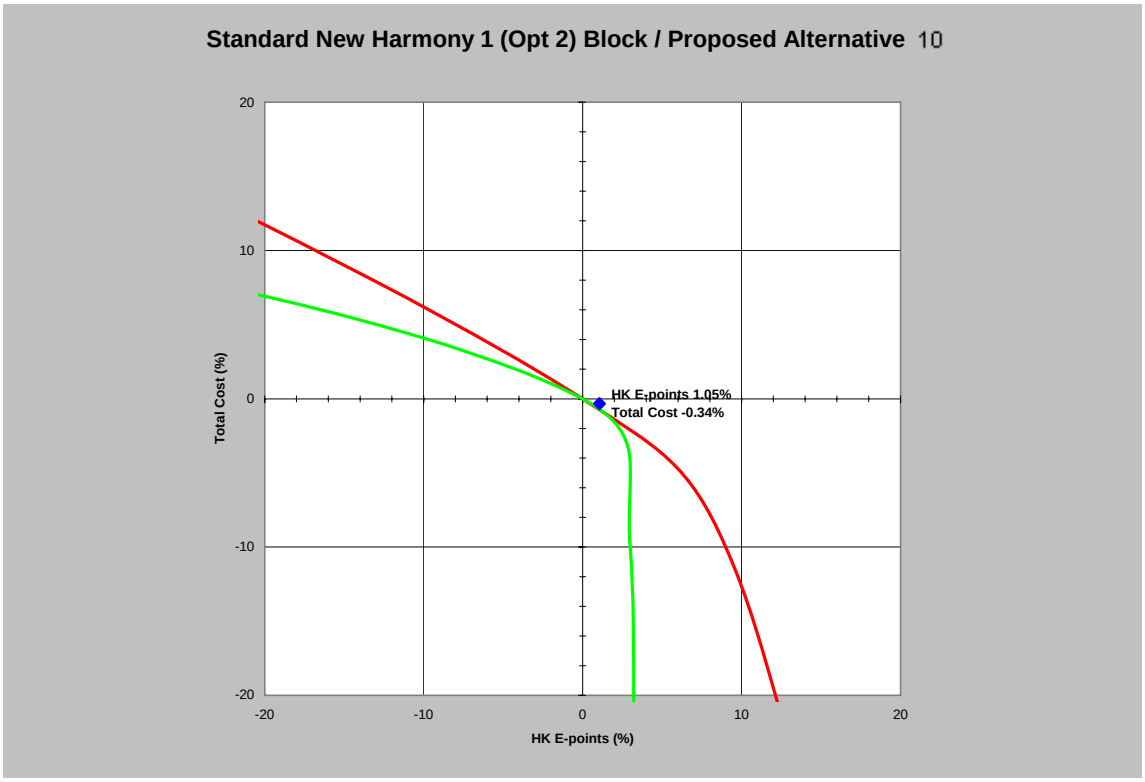
Proposed Alternative

Scope : The proposal therefore is to replace the existing piping material with copper pipes, similar to those found on most other residential developments. This would therefore be a straight material substitution.

Results

Whole Life : As illustrated below, there is currently no environmental benefit to be obtained form this proposal. In the context of the whole life of the building, this proposal would result in a 1.05% increase in the environmental impact, while there would be a 0.34% reduction in the whole life cost[89], this would be outsider the lines of acceptability.

As with other options, reference has to be made to the lines of acceptability established under this study and it can be seen that this proposal, although being a financial benefit would not be acceptable due to the higher environmental impact.



[89] The initial environmental impact is a 0.08% increase and the capital cost impact is a 0.67% reduction.

4.3.11 Alternative 11 - Revision to Lift Lobby and Corridor Finishes

Original Design

Scope : Current designs include the use of homogenous wall tiles within the typical lift lobbies and corridors, below dado level with a plastic emulsion paint to part of the upper area.

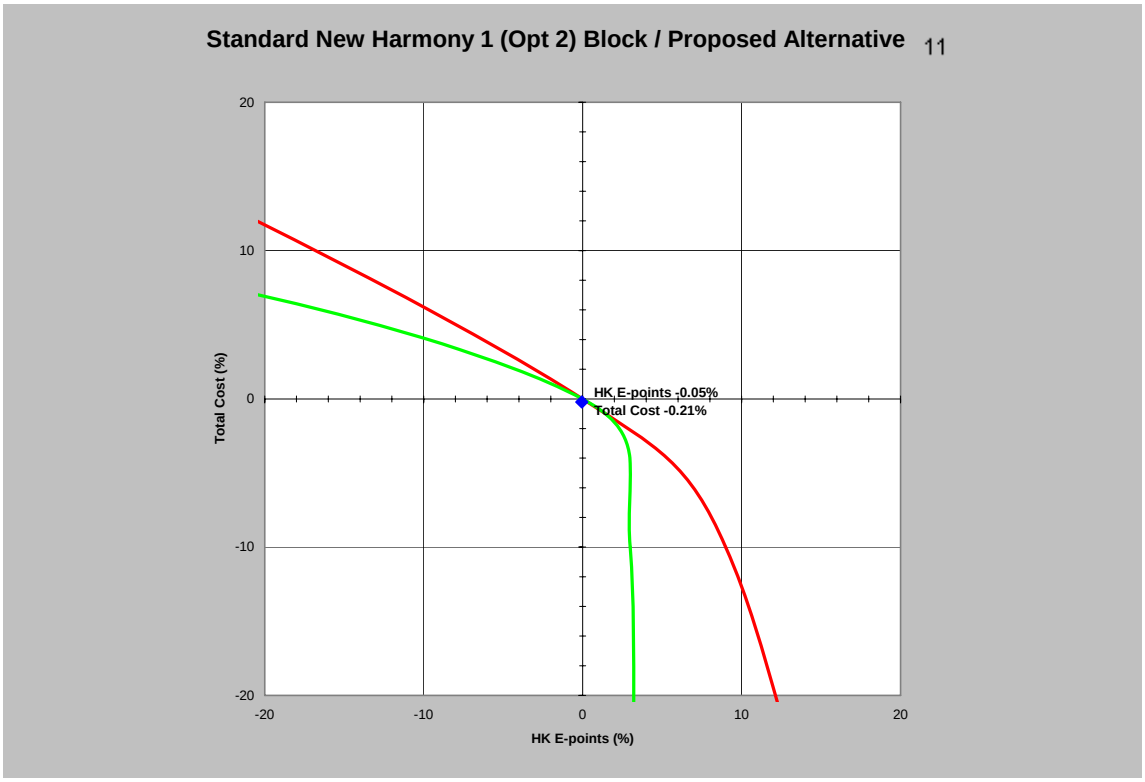
Concern : From a pure economic perspective a change in the wall finishes from a tile paint combination to acrylic paint is considered a possible alternative.

Proposed Alternative

Scope : The proposal therefore is to replace the existing tiled and paint finish with an acrylic paint coating. Since the walls are not fairfaced concrete it is proposed to retain the render background hence making this therefore a straight material substitution.

Results

Whole Life : As illustrated below, there would be benefits in both the environmental and economic impacts of this revision. In the context of the whole life of the building, this proposal would result in a 0.05% reduction in the environmental impact, while there would be a 0.21% reduction in the whole life cost[90], this would be inside the lines of acceptability.



[90] The initial environmental impact is a 0.22% reduction and the capital cost impact is a 0.75% reduction.

4.4 TECHNICAL SPECIFICATION FOR ALTERNATIVES

In general all of the proposed specification clauses relating to the above alternatives follow the structure, format and composition of the Specification Library used by HKHA. In fact most of the proposed materials are already contained within the standard specification library of descriptions (Appendix P contain sample specification sections for those proposed materials not currently adopted by HKHA). It should be noted that the majority of the alternatives being proposed have been used on other HKHA projects either in full or in part (although not necessarily residential blocks) hence material and technology knowledge is less of a concern. In addition to the above, all of the proposed alternatives make use of materials and systems commonly available in Hong Kong.

Whilst the above may appear to have broken little in the way of new ground, in terms of material selection, it must be remembered that this standard block is very basic in design and material usage. Equally the design itself has been refined over many years to be as optimum as possible. Whilst other alternatives do exist most would be instantly eliminated on the grounds of cost alone.

5. RECOMMENDED WAY FORWARD FOR HA LCA/LCC MODEL

5.1 FUTURE OPERATION OF THE LCA/LCC MODEL, AND MAINTENANCE AND UPDATING OF DATABASES

The details is to how the model operates and is to be maintained are set out in detail in the Life Cycle Console Software User's Manual and are not repeated again here.

However at a strategic level it is considered unbeneficial for the environmental data to be revised in the short-term. In addition until this block type has been in use for a number of years, it is unlikely that better repair maintenance and operational data would be available.

5.1.1 Updating Regime

In view of the above it is proposed that the different aspects of the model are updated at the following frequencies:

Model Component	Updating Frequency
1. Repair and Operational Cost Data	Annually or every time term contract rates are reviewed
2. Quantum Data	
- Initial	as Design changes
- Repair & Maintenance	After 5 – 10 years of use
- Operation	After 5 – 10 years of use
3. Environmental Impact Data	Every 5 years

5.1.2 Updating Party

Following on from the above and previous discussions it is proposed that the responsible parties for this updating process would be:

Task	Responsible Party
1. Maintaining Cost Data	*CQS* for initial building cost (builder's works) *CBSE* for initial building cost (B.S. works) *EMD* for repair & maintenance cost
2. New Quantities – Initial	CQS for builder's works CBSE for B.S. works
3. New Quantities – R+M	SMS/TNS
4. New Quantities – Operational	Externally sourced [91]
5. New Environmental Impact Data	Externally sourced

[91] As previously explained, operational data required for updating the LCA/LCC databases needs to sourced from market surveys and consumption records in tenant areas from utility companies and HA's building services section does not have the resources to obtain such information. However, the EMD may be able to provide operational data for the public areas.

Despite the above proposal it may prove both more economical and beneficial for HKHA to outsource the whole of the model maintenance, to ensure that the latest possible information is available as well as future model enhancements being made available.

5.2 APPLICATIONS OF THE LCA/LCC MODEL AND DECISION MAKING TOOL

Many of the operational applications of this LCC/LCA model have been discussed and highlighted in this report and throughout this study. Ultimately the model has been developed with the objective of allowing degrees within HKHA to compare and contrast material and design alternatives. It is not an estimating tool it is there to provide relative orders of magnitude information during the design process only. It is also hoped that in the long term more building types would be introduced into the model to allow a wider applicability of the tool. The current single building set up does hamper the wider usage of this tool, however the current data would provide a solid foundation for testing alternatives and policy revisions.

It is recommended that a core group of HKHA staff are assigned to the maintenance and operation of the model to ensure both consistency as well as the derivation of the optimum advantage. Since this tool is designed to test alternatives within a standard block, this core group should be focussed within the standard block design team. It has always been envisaged that the model would be used to test various design scenarios prior to widespread implementation within HKHA. The model was not intended to be a design tool for use on every project because the focus should be on determining policy rather than exploring multiple alternatives on each project, this is because many of the individually examined alternatives will be duplication of effort, resulting in inefficiencies. The development of rules of thumb and policy guidelines would be by far the most constructive use of the model in the future.

5.3 PROMOTION OF LCA/LCC

To aid the long term promotion of whole life assessments within HKHA and amongst other government departments, three specific documents have been produced within this study. These are:

- Promotional Guide to LCC/LCA
- LCC Best Practice Guideline
- User Guide to LCC and LCA methodologies

All of these documents are separate to this report but provide a mechanism for raising awareness as well as stimulating activity in this whole area of sustainability.

6. ASSIGNMENT FINDINGS AND CONCLUSIONS

The main goal of the study has been to develop, in HA's context, an integrated decision support tool that will aid the selection and procurement of building products and components in an environmentally responsible and cost efficient manner from a whole life cycle point of view. The findings from each of the three stages of the assignment, in line with the study objectives are provided in the following sections.

6.1 FINDINGS FROM STAGE 1 – DEVISE THE LCA/LCC METHODOLOGY

Stage 1 of the assignment involved devising in the local context, a method to combine LCA and LCC indices of the various building materials and engineering provisions used by HA. The findings from this stage of the study include :

6.1.1 Need for a LCA/LCC Decision Making Tool

A review of HA's business divisions' activities indicate that majority of the alternative building materials (and components) proposed (in *Development & Construction Division* trial projects) have apparent environmental benefits for only one or a few impacts and often only at one stage of their life span. The overall environmental impact of these alternative materials over their life cycle have not been fully evaluated, and there don't appear to be financial considerations for these materials. In response to these gaps, HA requires an evaluation model that appraises the environmental performance and expenditure implications of building material selection, over a complete life cycle.

6.1.2 Building Materials and the Environment in Hong Kong

Hong Kong's construction industry has operated under a strictly "laissez faire" system and is arguably one of the most competitive in the Asia Pacific region. If changes to reduce construction related environmental burdens are made which may affect the long-term ability to make money, they must be shared with fairness and transparency across society and moreover arrived at by a consensual process. Clearly then any moves towards a more sustainable construction industry that rely on the measurement of existing practices and the quantitative assessment of more sustainable alternatives must intrinsically be sufficiently sophisticated enough to reconcile both economic and environmental impacts. It is for this reason that a unified methodology that includes both LCC and LCA is considered essential to discern 'real' and acceptable improvement strategies.

6.1.3 Review of LCA/LCC International Tools and Practices

The review of international practices and tools revealed limited adoption of LCA for buildings. Over 30 methods were however reviewed in terms of their applicability to this study and none were considered appropriate for direct adoption. Nevertheless, all of these overseas tools employs the principles of the ISO 14040 Series of Standards which is the international accepted standard for LCA evaluation, and these forms the basis of the HA LCA model developed. The review also included environmental data sets, of which there are no comprehensive sources for the Hong Kong region, to be adopted and adjusted for the HA model and thus resulted in the selection of the overseas *SimaPro* suite and its databases for the study. In terms of LCC, although there is no universal standard, most nations adopt similar guidelines and the approach for this study is to aligned with that developed for the *Environment, Transport and Works Bureau* by DLSM.

6.1.4 The HA LCA and LCC Database Model

The methodology for the LCA and LCC database model developed consists of three sub modules:

- The *Quantum Model*, which contains the type and quantity of every material used throughout the building's life (i.e. construction, operation, maintenance, repair, refurbishment, and demolition);
- the *LCA model*, which assigns an environmental impact to every material used throughout the building's life; and
- the *LCC model*, which assigns a cost of every material used throughout the building's life, in the context of its whole life costs.

6.1.4.1 The Quantum Model

The *Quantum Model* identifies the mass (kg) of each material used throughout the three key stages of the buildings life – construction, use and demolition. These quantities are used with the LCC and LCA models to establish the cost and environmental impacts of each material at each stage (including construction, building use and demolition) and, ultimately, of the whole building across all stages.

The *Quantum Model* groups the materials into *Functional Units* so that they can be investigated in context. As such, data in the *Quantum Model* can be visualised in simple terms as follows (for illustration only):

"Type 1" Window	**Mass**
Aluminium	xx kg
Glass	yy kg

Information included in the *Quantum Model* is illustrated below :

STAGE 1: CONSTRUCTION

Material quantities (from *Bill of Quantities*, *Specifications*, etc) in:

Temporary works;
Foundations;
Superstructure;
Service Installations;
and
Fixtures/Finishes; etc

STAGE 2: BUILDING USE

Material quantities from repair and maintenance (R&M) over 50 years (accounting for "*Churn Rates"**, etc) in:

Day-to-day R&M;
Planned R&M and;
Emergency R&M, etc

AND, energy consumption in public and private areas (from the *Operational Energy Model*)

STAGE 3: DEMOLITION

Includes the material quantified in the *Construction* and *Use* stages, and also accounts for:

the extent of material recovery;
quantities disposed of at public fill;
quantities disposed of landfill;
temporary works for demolition; etc

* Churn rate is an estimated allowance to cover the rate at which typically occupants within a building will change. This information is both necessary and important as part of the overall establishment of the rate of refurbishment and renewal within the premises. In terms of the whole life profile, this would have obvious cost implications from the associated refurbishment and maintenance works.

6.1.4.2 The LCA Model

The LCA of each material for this study follows the principles set out in the ISO14040 series of standards. The environmental impact categories adopted by the HA LCA model (ten in number) were also identified during the review stage. These are: *acid rain* (kg SO_2 eq); *climate change* (tonnes CO_2 eq); e*nergy* (Megajoules, MJ); *photochemical smog* (kg C_2H_2 eq); *ozone depletion* (kg CFC-11 eq); *resource depletion* (kg SB); *toxicity to humans* (kg. 1,4-DB); *toxicity to ecosystems* (kg. 1,4-DB); *waste* (kg Waste); and *water consumption* (litre).

There are at present no comprehensive data sets of environmental information relating to product manufacture, use and disposal for the Hong Kong region. As a consequence, international data has been sourced and analysed to provide a basis for the HA LCA model. Preparation of the environmental data associated with each individual material for use in the HA model, illustrated overleaf, consists of the following steps:

- **regionalisation** – the adjustment of overseas "cradle to factory gate" environmental data to ensure their applicability in the local context. This takes into account factors such as the type, source and extraction of raw materials, the energy mix and method of power generation used in the processing, the production processes themselves, and transportation modes and distances, etc[92];
- **characterization** – the classification of the many different impacts associated with a substance into the ten selected impact categories mentioned above, using common units to provide more manageable and informative environmental information.
- **normalisation** – the comparison of regionalised and characterised data to a notional regional average to allow different environmental impacts to be compared and investigated under a common basis (nominal *Hong Kong Eco-Points (HKEP)*, representing the environmental impacts associated with the average Hong Kong person[93], have been adopted for this study; and
- **weighting** – assigning the relative importance of each category to arrive at a single environmental indicator. This weighting process has been based upon the consensus achieved from a series of weighting workshops conducted for the study in December 2002 to solicit views of delegates from HA, other government departments, tenant and community groups, contractors, suppliers and other building professionals. The workshops also provided information for the comparison of environmental impacts with costs.

The LCA model applies weighted *Hong Kong Eco-Points* for each material to the quantities in the *Quantum Model* to establish the impacts, at each stage of the building's life, of each material and functional unit (or indeed of the building as a whole). Materials/Functional Units can be changed to alternative quantities or types for comparison

[92] The regionalisation process has for example included a detailed study of the transport modes and distances of materials used in the model NH1 (Option 2) block with reference to information from *Material Approval Forms*, etc. Two workshops have also been held at which selected HA suppliers have provided information on the origins and production processes associated with their materials and products.

[93] ie 1Eco-point sets to be equivalent to the typical impacts caused by a HK citizen in a year.

The LCC Model

LCC addresses the financial implications of an asset over its whole life span, starting from the capital expenditure in creating the building, through its operation and maintenance, and finally its end of life demolition. *Figure B* below illustrates the key costs included in the HA model developed to provide necessary context and aid interpretation.

The HA LCA and LCC Models

INITIAL IMPACTS

Impacts (in terms of HKEP) of all Materials / Functional Units used in construction (from Quantum Model)

IMPACTS IN USE

Environmental Impacts (in terms of HKEP) of all Materials / Functional Units used for replacement during the building's operation and maintenance (from the Quantum Model)

PLUS, the Environmental Impacts (in terms of HKEP) arising from energy consumption in public and private areas (from the Operational Energy Model)

END OF LIFE IMPACTS

Environmental Impacts (in terms of HKEP) of all Materials / Functional Units recovered, sent to public fill or landfill (from the Quantum Model)

INITIAL COSTS

Material / Functional Unit costs, plus; Site Formation, Foundations, Main & Direct Contracts; Professional Fees; Connection Charges; etc

COSTS IN USE

Material replacement costs, plus; Repair, Maintenance, Refurbishment, Building Mgt / Cleansing costs; etc PLUS, the costs arising from energy consumption in public and private areas (from the Operational Energy Model)

END OF LIFE COSTS

the value of materials recovered; and the demolition contract cost (includes all associated costs such as materials removal, transportation, the cost of public filling; the cost of landfill disposal; etc)*

LIFE CYCLE IMPACT (Hong Kong Eco-Points)

LCA of any material, functional unit, or the building as a whole at any or all stages of building life:

- Can track the environmental impact of any single change (e.g. Type 1 to Type 2 window)
- Can compare the impacts of such a change to the associated costs from the LCC Model

LIFE CYCLE COST ($$$)

LCC of any material, functional unit, or the building as a whole at any or all stages of building life:

- Can track the cost of any single change (e.g. Type 1 to Type 2 window)
- Can compare the costs of such a change to the associated impacts from the LCA model

In terms of the materials, the LCC cost model applies unit prices (i.e. per kg) to the *Quantum Model* to establish the purchase costs, at each stage of the building's life, of each material and functional unit (or indeed of the building as a whole).

Costs are presented in terms of costs at current levels (i.e. the cost of performing all works at the base date, ignoring value of money adjustments and inflation), and future costs discounted back to the Net Present Value (NPV, to establish how much money is really required to construct and maintain the building over its whole life). Since costs (e.g. of construction and maintenance contracts, materials, utilities, etc) change often, the cost database should be frequently updated at least every quarterly.

6.1.4.3 Generation of Life Cycle Environmental and Cost Data

Using the approaches described above, the Quantum Model, LCA Model and LCC Model can provide data on the type, quantity, cost and environmental impacts (either as individual impact categories such as acid rain, climate change, etc, or as combined *Hong Kong Eco-Points*) for each and every material used in the building. This information can be accessible in terms of each individual material or as appropriate functional units (e.g. precast elements, windows, etc), at each or all three stages of the building's life. Conceptually, the data in the model can be visualised as follows (for illustration only).

	Construction			**Building Use**			**De-Construction**		
Type 1 Window	**Mass**	**Cost**	**Impact**	**Mass**	**Cost**	**Impact**	**Mass**	**Cost**	**Impact**
Aluminium	kg	$	EP	kg	$	EP	kg	$	EP
Glass	kg	$	EP	kg	$	EP	kg	$	EP
Etc									

6.2 FINDINGS FROM STAGE 2 – APPLY THE LCA/LCC TOOL AND IDENTIFY IMPROVEMENTS

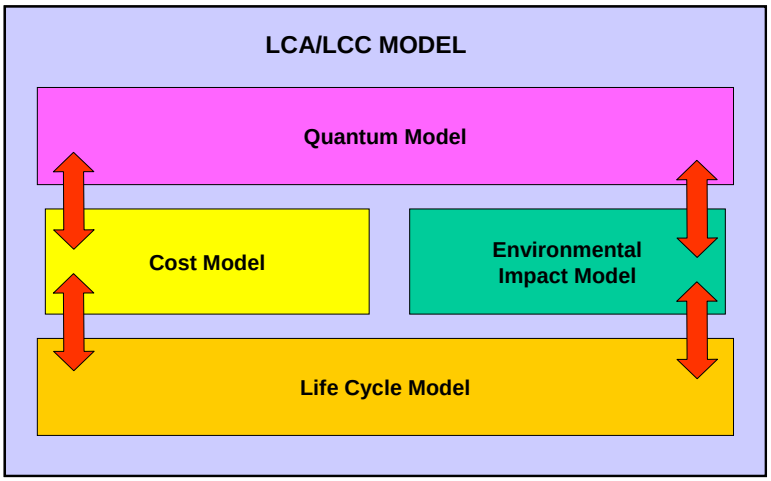
Stage 2 of the assignment involved the development of an LCA and LCC database model of the materials and components in a typical New Harmony 1 (Option 2) block (6/00 revision to 1/00 Edition), rank the materials (in terms of consumption volume, environmental impact and money spent), and propose 'better'[94] alternatives for the top ten selected materials (focusing on architectural components). The principal findings from this stage of the study are as follows :

6.2.1 LCA/LCC Computer Software Developed

Based upon the methodologies and approaches reviewed and sourced in *Stage 1*, a purpose designed computer programme was developed for processing the information and to yield results from the LCA and LCC models developed.[95] As illustrated in the figure overleaf, the computer software can be thought of as four separate but interrelated sub-models, with each sub-model reflecting different functionality, data and data flows within the model.

[94] 'better' means of no lesser technical performance which are locally available, but less environmental and affordable economic impact

[95] For full operation and maintenance details of the LCA/LCC software, refer to the *Life Cycle Console Software User/Maintenance Manual*



Modular Structure of the LCA/LCC Computer Model

6.2.2 Building Materials Ranking

Based upon application of the computerised LCA/LCC software developed, the whole life top ten rankings of the functional units used in the New Harmony 1 (Option 2) block in terms of cost are :

1. RC Slabs – Fairfaced
2. RC Walls – Fairfaced
3. Wall Finishes – Internal Flat Areas
4. Floor Finishes – Kitchens and Bathrooms
5. Piles
6. Small Power Installation – Flats
7. Panel Walls – Internal
8. Fresh Water System - Distribution
9. Lighting Installation – Flats
10. Internal Waterproofing

The above ranking pattern suggest that for those functional units which have a substantial capital cost, this situation will carry through to the whole life profile and rankings.

Through application of the computerised LCA/LCC software developed, the top ten functional units ranked by their whole life environmental profiles are:

1. Precast Facades – Type 1
2. RC Walls – Fairfaced
3. Precast Facades – Type 2
4. RC Slabs - Fairfaced
5. RC Water Tanks
6. Aluminium Windows – Bedrooms
7. RC Walls – Generally
8. Aluminium Windows – Living Area
9. Piles
10. Mains & Distribution

What the above results do demonstrate is that over 90% of the total impact is attributable to just 17% if all the functional units. This means that the environmental impacts are concentrated on a small group of items.

Based upon the results of the study it is clear that the cost and environmental impact arising from the vacant flat works are the largest single contributor to the whole life profile of the functional units within block. This conclusion is driven by two key issues, firstly the nature of the blocks and secondly the age and tenant usage patterns.

It is clear that the New Harmony 1 block is a rental block and therefore has a more transitional population to that of a Home Ownership block. This means that the internal churn rate (using Housing Authority's own data) would be higher than similar designed ownership blocks and as a direct result, more maintenance work is likely to be required. Coupled with this point is the question of the social status of the occupants. Previous work, particularly in relation to the drafting of the estate management privatisation contracts, has revealed that rental tenants tended to be less conscious of the need to maintain their building, therefore allow the building quality to deteriorate faster than in other social bands before raising complaints. This means that rental building tend to last for shorter periods of time and have a proportionally increasing demand for more extensive maintenance.

Based upon results of the LCA/LCC software developed, in terms of life cycle cost and environmental impacts, the top ten rankings of the functional units used in the New Harmony 1 (Option 2) block are :

Top Ten LCA and LCC Ranking Functional Units in a New Harmony 1 (Option 2) Block

	Life Cycle Cost Impact	**Life Cycle Environmental Impact**
1	RC Slabs – Fairfaced	Precast Facades – Type 1
2	RC Walls – Fairfaced	RC Walls – Fairfaced
3	Wall Finishes – Internal Flat Areas	Precast Facades – Type 2
4	Floor Finishes – Kitchens and Bathrooms	RC Slabs - Fairfaced
5	Piles	RC Water Tanks
6	Small Power Installation – Flats	Aluminium Windows – Bedrooms
7	Panel Walls – Internal	RC Walls – Generally
8	Fresh Water System - Distribution	Aluminium Windows – Living Area
9	Lighting Installation – Flats	Piles
10	Internal Waterproofing	Mains & Distribution

On the whole architectural items, whilst significant, are generally less dominant than the structure and building services items in cost terms. Similarly, structural elements dominate in environmental terms since their impact is driven largely by the substantial mass of the material they contain.

The top ten ranking of the functional units based upon their predicted usage throughout whole life of the New Harmony 1 (Option 2) block in terms of a combined cost and environmental impact[96] are :

1. Precast Facades – Type 1
2. RC Walls – Fairfaced
3. RC Slabs – Fairfaced
4. Precast Facade – Type 2
5. Wall Finishes – Internal Flat Areas
6. Piles
7. Small Power Installation – Flats
8. Floor Finishes – Kitchen and Bathrooms
9. Aluminium Windows – Bedrooms
10. Aluminium Windows – Living Area

Again these results highlight the dominance of structure and building services items in the context of the complete building.

6.2.3 Comparisons with EPP Report

As indicated in the EPP report, the environmental risk scoring methodology devised is a somewhat primitive and non-scientific tool to provide a preliminary broad overview of the environmental impacts associated with building materials. Therefore, taking into consideration the sophistication, complexity, scientific and inherent LCA approach adopted in this study, discrepancies of environmental ranking for building materials between the two methodologies is inevitable. A comparison of these two approaches is given below.

EPP and HA LCA Methodologies Compared

EPP METHODOLOGY	HA LCA METHODOLOGY
Appraisal of environmental issues for building materials under *selected* stages of product life cycle: Raw Material; Manufacture; Use; and Disposal.	Appraisal of environmental issues for building materials under *all* stages of product life cycle: Initial (including Raw Materials Extraction, Manufacturing and Transportation); Use and Maintenance; and Disposal.
Semi-quantitative Approach – subjective with a high degree of uncertainties and assumptions	Quantitative Approach – scientific (based on ISO 14040 series), consistent and reproducible
Product environmental risk score for a building material derived from simple addition of (arbitrary assigned) environmental sub scores without due consideration of impact standardisation and their relative importance	Single LCA Environmental Performance Indicator evaluated for a building material – based on authentic data analysed scientifically, taking into consideration of standardisation of different impacts and their relative significance from a local and HA perspectives

[96] The combined LCA/LCC ranking of the functional units is based upon summing LCA and LCC ratios (to the whole building) as given by the formula below :

$$\text{Combined LCA/LCC indices} = \left\{ \frac{\text{LCA of functional unit}}{\text{LCA of whole building}} + \frac{\text{LCC of functional unit}}{\text{LCC of whole building}} \right\} / 2 \times 100\%$$

There is no weighting of the LCC and LCA at this stage because this would lead to distortions and misrepresentation of the results, therefore this method is simply used to establish a numerical ranking. The decision making tool should be used to establish the trade-off between competing environmental and economic considerations.

Ultimately the results of the EPP study highlight some high impact materials, however based upon a scientific approach using chemical properties, as adopted by this study, the top 10 materials from the LCC/LCA analysis, based upon the average locally weighted impacts would be as set out below (top 10 materials from the EPP report is also included for comparison purposes) :

	EPP Report	HA LCC/LCA Study
1.	PVC	Aluminium Paint (Timber Paint)
2.	Galvanised Iron with Spray Painting	Copper (Generally)
3.	Multilayer Acrylic Paint	Aluminium (Generally)
4.	Emulsion Paint	Wood Preventative Paint (Timber Paint)
5.	Synthetic Paint	Synthetic Paint (Paint Generally)
6.	Cement	Chromium Brass (Ironmongery / Taps)
7.	Precast Concrete	Alkali Resisting Primer Paint
8.	Stainless Steel	Polysulphide Sealant (Movement Joints)
9.	Aluminium	Silicone Sealant (Joint Filler)
10.	Iron	Zinc Chromate Paint (Metal Work Primer)

In view of the unscientific nature of the EPP results it is difficult to identify underlying reasons for the differences but the above EPP list does perhaps identify a series of materials which should be avoided, or at the very least minimized in their usage.

In summary therefore, whilst the EPP report provides one view of the material ranking it has limited factual or scientific support and also does not consider two key aspects, namely quantum and cost.

6.2.4 The Combined LCA/LCC Decision Making Tool

In line with the objective of the study, alternatives proposed must address both the environmental and cost impact considerations. Therefore the decision making tool developed is designed to illustrate this balance and to allow users the opportunity to trade off between economic and environmental gains.

In the LCA/LCC software, the types and quantities of materials and/or functional units in the Quantum Model, and their costs in the LCC model, can be changed to investigate the resultant cost and environmental impacts of alternative materials/systems for comparison.

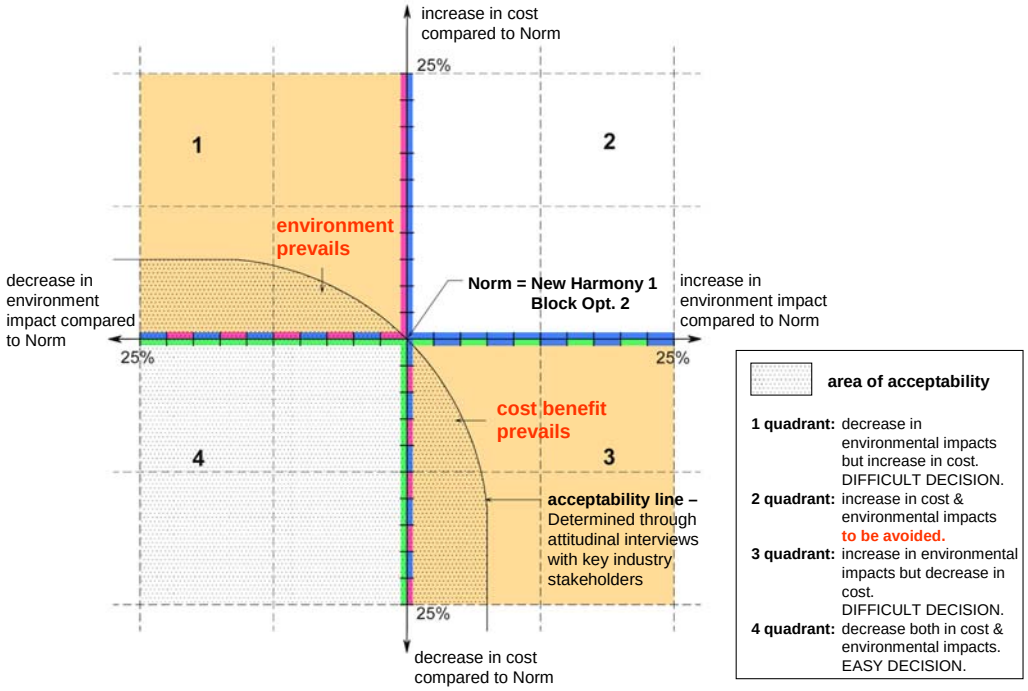
The methodology to investigate/reconcile the LCA and LCC assessments is illustrated in the figure overleaf and forms an integral part of the software report output. The methodology expresses proposed specification changes as a percentage of the overall building costs and the normalised environmental impacts. In this way one can compare the significance of a proposed specification change in terms of its percentage environmental deterioration or improvement to the percentage change in cost.

The acceptability curves shown on the graph have been established by undertaking attitudinal interviews with key industry stakeholders in a series of workshops as discussed in *Section 2*. These acceptability curves represent the boundaries of what the workshop participants, considered to be acceptable. Once percentage change figures are generated, a simple decision making framework can then be put into practice where for example it is suggested that all alternatives fall between the respective acceptability curves and the X

(environmental impact) and Y (cost) axes in Quadrant 1, Quadrant 3 as well as those fall into Quadrant 4 are deemed to be satisfactory

Currently the LCA/LCC model generates the base impact of the New Harmony 1 block design and therefore represents the centre point of the "cross-hair" chart (refer to illustration below). As alternative options are run the overall answer changes. These changes are represented as a revised numerical outcome. In order that the relative changes in environmental and cost impact can be measured, the difference between the base results and the revised outcome are expressed as a percentage difference and plotted on the "cross hairs". This percentage therefore shows how much more or less impact the alternative has when compared back against the base design. The newly plotted point represents therefore the impact of the revised design in the context of the complete building. In other words, the further this point is away from the centre of the cross hairs, the greater the percentage impact, either positive or negative, the proposed change has had. All alternatives which fall within the acceptability curve illustrated below is deemed to be a satisfactory option.

Combining LCA Environmental Impacts with LCC Price Mechanisms: The Decision Making Tool



6.2.5 Proposed Alternatives

Due to the nature of the building and the degree of refinement which has already been carried out on the design (from the original design version of the Harmony 1 block range) over the last 10 years the scope for improvement is limited in these premises. This is not to say that the building is perfect, but that the opportunities for making enhancements without diminishing the functionality and quality of the building are very limited. Based upon separate and previous studies where private sector blocks have been examined there are significantly more options available. Part of this is due to the "higher" grade of provision found in the private sector, where more and varied architectural materials are adopted. The "functional" nature of the design of the Harmony 1 range and public rental housing generally means that the materials selected must be durable and economically to ensure

that they survive the extended usage by the occupiers. Coupled with this is the fact that the population within a rental block is substantially higher than the private sector (who would typically have less than 300 flats in an average block). Equally this population would tend to comprise a higher percentage of day-time residents (due to their lower income, age distribution and social status), meaning that the building receives greater "use" and hence wear and tear.

In view of these, the alternatives proposed in the study, are more cosmetic in nature rather than radical revisions. It is also acknowledged that some of these revisions are already alternatives or options within the existing HKHA standard block arrangement. However, despite this these are options or alternatives which are not commonly adopted by contractors for many different reasons, but if a potential benefit in terms of LCC / LCA can be derived then these should perhaps become the base option, rather than an alternative.

6.2.6 LCA and LCC Assessment of Proposed Alternative Materials

With application of the LCA/LCC model, the life cycle environmental and economical benefits of the identified alternatives were evaluated (refer to Section *4.3* for detailed LCA/LCC evaluations and illustrations) and these are summarised in the table overleaf, with practical considerations for adopting these proposed alternative designs/products.

6.3 FINDINGS FROM STAGE 3 – DEVISE THE LCA/LCC IMPLEMENTATION STRATEGY

Stage 3 of the study compromised of preparing technical specifications for the identified alternatives, developing a maintenance strategy for the database and technical guidelines, and recommend best maintenance practices to optimise LCC. Findings from the final stage of the study is given below.

6.3.1 Technical Specifications for Alternatives Identified

As mentioned above, alternatives identified in this study are design refinements rather than radical revisions which would yield LCA and/or LCC benefits. Therefore, with the exception of specifications being developed for Alternatives 2, 5 and 6, details for the remaining products are already included in HA's specification library. The developed specifications (sustainable timber doorset for flat entrance and sustainable timber doorset for kitchen) are included in *Appendix P*.

Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
1. Aluminium Windows – Bedrooms	UPVC Window	0.78 %	- 1.28 %	N	Widespread adoption of UPVC windows by HKHA should result in cost reduction for this alternative and with short term (5 years) global trend for aluminium cost escalation, financial burden may be further lowered. ***This is considered as a "dubious" alternative since although there is environmental benefits to be gained through its adoption, life cycle expenditures would cost more than the original design. The shape of the acceptance curve (subject to constant review) would be the critical factor in deciding its adoption.***
2. Internal Precast Panel Walls	Within flat wall systems to comprise of gypsum board (12.7mm thick) on either side of a metal framework. For inter-flat partitions, use a double layer system with central void filled with insulation material.	-0.25 %	-0.16 %	N	Potential economical benefits for gypsum dry wall system if volume of demand increases – up to 30% reduction (in capital cost) for private sector. Other benefit include better (smoother) finishing, potential installation of building services items, enhanced safety and better on site storage. Potential environmental benefit by refining panel thickness to accurately match required function. ***This is considered as a non viable alternative since neither environmental or cost saving benefits could be gained through the adoption of this alternative.***
3. Cooking Unit/Bench (Prefabricated concrete with stainless steel cladding)	Timber framed plastic laminated plywood faced unit with a stainless steel covering on the counter top.	- 0.25 %	- 0.80 %	N	Perceived benefits not achieved but offer a better quality product with enhanced durability. ***This is considered as a non viable alternative since neither environmental or cost saving benefits could be gained through the adoption of this alternative.***
4. Floor Washing Pipework [1](Galvanised steel pipe with UPVC lining)	Standard PVC pipes (similar to products used for fire services and flushing systems)	0.00 %	0.02 %	Y	Reduce dependence of HKHA on a unique piping system for floor washing. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***
5. Flat Entrance Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating and plywood facing)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied	0.01 %	0.18 %	Y	Alternative design is of at least equal performance to origin and should lead to reduced replacement rates. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***

[1] This alternative was investigated (though not ranked amongst the top 10 architectural materials with the most LCA, LCC impacts) because it was particular interest to HA.

Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
6. Kitchen Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating, plywood facing and Georgian wired glass window)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied.	0.02 %	0.06 %	Y	Insignificant financial benefit in adopting doorset systems – should consider separate doors and frames since current rate of churn means little advantage for using exceptionally durable systems. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***
7. Floor Finishes – Kitchen and Bathroom (cold applied waterproofing system overlaid with 40 mm thick screed, with homogenous tiles bedded on mortar backing).	Reduce overall thickness of screed to 25 mm.	0.05 %	0.41 %	Y	Based upon HKHA's current repair and maintenance cycle and quality control measures, performance deterioration should not be an issue. Significant cost and environmental benefits are attributable to reduction in recurring maintenance works with noticeable savings in terms of screed consumption. ***There are both life cycle environmental and cost benefits to be gained through the adoption of this design modification. However, it is considered as a "dubious" alternative since there are concerns regarding its practical application for HA projects and further investigative works which is beyond the scope of this study would be required..***
8. Floor Finishes – Corridors and Lobbies (40mm thick screed with homogenous tiles bedded on mortar backing)	Reduce screed thickness to 25 mm	0.02 %	0.11 %	Y	Based upon HKHA's current repair and maintenance cycle and quality control measures, performance deterioration should not be an issue. ***There are both life cycle environmental and cost benefits to be gained through the adoption of this design modification. However, it is considered as a "dubious" alternative since there are concerns regarding its practical application for HA projects and further investigative works which is beyond the scope of this study would be required..***
9. Bathroom Doorsets (for larger flats : 46.3 mm hollow cored timber doorsets with plastic laminate plywood facing and for smaller flats : plastic folding partition)	Plastic folding door for all flats	0.10 %	-0.01 %	Y	Although the alternative design currently has a slightly higher whole life cost, with increased demand from HKHA projects, cost reductions should yield. Although, there is a difference in terms of appearance – the alternative does not compromise functionality of the original doorset. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be***

Proposed Alternative Architectural Materials/Designs, LCA and LCC implications, and Practicality for Adoption

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Remark
					gained through its adoption.
10. Fresh Water Pipework [2](Galvanised steel pipe with UPVC lining)	Copper piping	-1.05 %	0.34 %	N	With reference to the acceptance curve, although there is whole life cycle cost savings, this alternative should not be acceptable on the basis additional life cycle environmental burden. Alternatives were still investigated because they were of HD's particular interest. ***This is considered as a "dubious" alternative since although there is potential life cycle cost savings to be gained through its adoption, life cycle environmental impacts would be more adverse in comparison to the original design. The shape of the acceptance curve (subject to constant review) would be the critical factor in deciding its adoption.***
11. Lift Lobby Wall Finishes (tiles)	Acrylic Paint	0.05%	0.21%	Y	This proposal appears to offer benefits in both cost and environment, although the question of durability and overall quality of completed building would require careful consideration. ***This is considered as a viable alternative since there are both life cycle environmental and cost benefits to be gained through its adoption.***

[2] This alternative was investigated (though not ranked amongst the top 10 architectural materials with the most LCA, LCC impacts) because it was particular interest to HA.

6.3.2 Maintenance of LCA and LCC Model

The details is to how the model is to be maintained are set out in detail in the Life Cycle Console Software User's Manual and are not repeated again here. However at a strategic level it is considered unbeneficial for the environmental data to be revised in the short-term. In addition until this block type has been in use for a number of years, it is unlikely that better repair maintenance and operational data would be available. In view of the above it is proposed that the different aspects of the model are updated at the following frequencies:

Model Component	Updating Frequency
1. Repair and Operational Cost Data	Annually or every time term contract rates are reviewed
2. Quantum Data	
- Initial	as Design changes
- Repair & Maintenance	After 5 – 10 years of use
- Operation	After 5 – 10 years of use
3. Environmental Impact Data	Every 5 years

Following on from the above and previous discussions it is proposed that the responsible parties for this updating process would be:

Task	Responsible Party
1. Maintaining Cost Data	*CQS* for initial building cost (builder's works) *CBSE* for initial building cost (B.S. works) *EMD* for repair & maintenance cost
2. New Quantities – Initial	CQS for builder's works CBSE for B.S. works
3. New Quantities – R+M	SMS/TNS
4. New Quantities – Operational	Externally sourced [1]
5. New Environmental Impact Data	Externally sourced

Despite the above proposal it may prove both more economical and beneficial for HKHA to outsource the whole of the model maintenance, to ensure that the latest possible information is available as well as future model enhancements being made available.

[1] As previously explained, operational data required for updating the LCA/LCC databases needs to sourced from market surveys and consumption records in tenant areas from utility companies and HA's building services section does not have the resources to obtain such information. However, the EMD may be able to provide operational data for the public areas.

6.3.3 LCC Best Practice Guidelines

Detailed descriptions of LCC best practices is provided in the *Life Cycle Costing Best Practice Guidelines* prepared for the study and will not be repeated again here. However, in summary, it can be concluded that complete LCC profiles should be compared for all competing project options, as a matter of principle,. The objective of this comparison is to determine which option has the best overall profile to the Department.

In general the objective is to identify the option which has the lowest overall whole life cost, rather than purely focusing on the option with the lowest initial capital investment. Where competing maintenance and refurbishment options are being considered, the length of the alternative payback periods is likely to be one of the key comparators. In most HKHA studies the comparison will be the time it takes for savings in operating or repair and maintenance costs to cover the additional capital investment involved, this is because the under most HKHA blocks there would be no enhancement in property value being derived from an enhanced quality product (in the same way a private sector block may increase in value or sale price through the use of enhanced quality materials).

The objective of all best practice guidelines is to present the optimum approach for dealing with a particular assessment method. The guidelines provided cover the basic broad principles and are not intended to be a comprehensive guide nor rigid framework within which all assessments must take place. LCC is supposed to be a flexible management tool and must respond to the particular needs of the project, but in all cases a consistent approach within the same assessment must be adopted.

6.4 OVERALL CONCLUSION

Many of the operational applications of this LCC/LCA model have been discussed and highlighted in this report and throughout this study. Ultimately the model has been developed with the objective of allowing degrees within HKHA to compare and contrast material and design alternatives. It is not an estimating tool it is there to provide relative orders of magnitude information during the design process only. It is also hoped that in the long term more building types would be introduced into the model to allow a wider applicability of the tool. The current single building set up does hamper the wider usage of this tool, however the current data would provide a solid foundation for testing alternatives and policy revisions.

It is recommended that a core group of HKHA staff are assigned to the maintenance and operation of the model to ensure both consistency as well as the derivation of the optimum advantage. Since this tool is designed to test alternatives within a standard block, this core group should be focussed within the standard block design team. It has always been envisaged that the model would be used to test various design scenarios prior to widespread implementation within HKHA. The model was not intended to be a design tool for use on every project because the focus should be on determining policy rather than exploring multiple alternatives on each project, this is because many of the individually examined alternatives will be duplication of effort, resulting in inefficiencies. The development of rules of thumb and policy guidelines would be by far the most constructive use of the model in the future.

In conclusion, this study has examined a wide range of issues relating to the environmental and whole life cost performance of the New Harmony 1 (Option 2) block from a material usage point of view. The computer model produced provides a detailed assessment method for designers and decision makers within HKHA. However, this study is very limited in both its scope and ability to deliver meaningful results.

As set out in the previous sections the proposed alternatives do offer environmental and cost benefits over the whole life of the building. In the context of the whole building over its complete life, it could be possible to achieve a 0.25 % environmental saving, coupled with this there would be a 0.98% cost saving (through adoption of all alternatives tabulated in Section 6.2.5 which fall within the acceptance curve i.e. Alternatives 4, 5, 6, 7, 8, 9, and 11). Alternatively, based upon purely financial considerations, it could be possible to achieve a 1.33 % economic benefit but this would have an increased adverse environmental impact of 0.90 % (through adoption of Alternatives 4, 5, 6, 7, 8, 10 and 11). Similarly from a purely environmental point of view the best case would be a 1.03 % reduction with a 0.30 % increase in whole life cost (through adoption of Alternatives 1, 4, 5, 6, 7, 8, 9 and 11).

Clearly this is where the trade-off between environmental and economic benefits could be used to determine what would be acceptable. In general the maximum cost benefit would be acceptable even though there is an environmental penalty.

In summary therefore this study has provided the methodology and framework within which HKHA can develop and examine alternative materials and design options. However, the current limitation to a single block, which has yet to be fully developed renders the model of only limited value at present. In view of this it is recommended that HKHA look to expand the model database to cover more buildings within their portfolio so that more assessments and comparisons can be considered.

APPENDIX A : FULL LISTING OF FUNCTIONAL UNITS

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
1	A/C Drain Pipes	Paint - Acrylic Plastic Pipes
2	Air Duct Trunking	Neoprene Gaskets Paint - Synthetic Paint - Zinc Chromate Rubber Steel - Galvanised
3	Aluminium Door & Window - 1/F	Aluminium - Anodised Glass - Georgian Wired Obsc
4	Aluminium Louvres - Plant Rooms	Aluminium - Anodised Glass - Georgian Wired
5	Aluminium Windows - Bathroom	Aluminium - Anodised Glass - Georgian Wired, transluscent Glass - Translucent
6	Aluminium Windows - Bathroom Stainless Steel Grilles	Aluminium - Anodised Glass - Georgain Wired Glass - Translucent Stainless Steel - Mill
7	Aluminium Windows - Bedrooms	Aluminium - Anodised Glass - Clear Float
8	Aluminium Windows - Bedrooms Stainless Steel Grilles	Aluminium - Anodised Glass - Clear Float Stainless Steel - Mill
9	Aluminium Windows - Corridor	Aluminium - Anodised Glass - Georgian Wired
10	Aluminium Windows - Kitchen	Aluminium - Anodised Glass - Clear Float Glass - Georgian Wired
11	Aluminium Windows - Kitchen Stainless Steel Grilles	Aluminium - Anodised Glass - Clear Float Glass - Georgian Wired Stainless Steel - Mill
12	Aluminium Windows - Lift Lobby	Aluminium - Anodised Glass - Georgian Wired
13	Aluminium Windows - Living Area	Aluminium - Anodised Glass - Clear Float
14	Aluminium Windows - Living Area Stainless Steel Grilles	Aluminium - Anodised Glass - Clear Float Stainless Steel - Mill
15	Aluminium Windows - Plant Rooms	Aluminium - Anodised Glass - Clear Float Glass - Georgian Wired
16	Angle Protectors - Ground Floor	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
17	Automatic Sprinker System	Paint - Zinc Chromide Plastic - Sheet Steel - Galvanised
18	Bearing Pads - Tanks & M&E	Rubber
19	Bin Guards	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
20	Cat Ladders	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
21	Ceiling Finishes - Main Entrance Lobby	Aluminium - Stove Enamel Steel - Galvanised
22	Ceiling Finishes - Plant Rooms	Cement Sand Render Paint - Acrylic Paint - Alkali Resisting Primer Paint - Prepolymer Sealer Paint - Synthetic
23	Cooking Benches	Aluminium - Mill Cement Sand Screed Concrete - 20/20 Paint - Formwork Paint - Zinc Chromate Silicone Sealant Stainless Steel - Mill Steel - Galvanised Timber - Formwork
24	Curtain Rails	Paint - Zinc Chromate Silicone Sealant Stainless Steel - Mill Steel - Galvanised
25	Doors - Pipe ducts	Paint - Aluminium Paint - Synthetic Paint - Wood Preservative Polyethylene Foam Stainless Steel - Mill Timber - Hardwood Timber - Plywood Luan
26	Doorsets - Bathroom (1/2P)	Paint - Aluminium Paint - Synthetic Paint - Wood Preservative Plastic Door PVC Mastic Sealant Stainless Steel - Mill Steel - Galvanised Timber - Hardwood
27	Doorsets - Bathroom (1B /2B)	Aluminium - Mill Paint - Cellulose Lacquer Paint - Wood Preservative Plastic Laminate PVC Mastic Sealant Stainless Steel - Mill Steel - Galvanised Timber - Hardwood Timber - Plywood Luan
28	Doorsets - Exit Staircases	Glass - Georgian Wired Neoprene Gaskets Paint - Cellulose Lacquer Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Timber - Hardwood Timber - Plywood Luan

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
29	Doorsets - Flat Entrance	Paint - Aluminium Paint - Synthetic Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Timber - Hardwood Timber - Plywood Luan
30	Doorsets - Ground Floor	Paint - Cellulose Lacquer Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Timber - Hardwood Timber - Plywood Luan
31	Doorsets - Kitchen	Glass - Georgian Wired Neoprene Gaskets Paint - Cellulose Lacquer Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Steel - Galvanised Timber - Hardwood Timber - Plywood Luan
32	Doorsets - Refuse Rooms	Glass - Georgian Wired Neoprene Gaskets Paint - Aluminium Paint - Synthetic Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Timber - Hardwood Timber - Plywood Luan
33	Doorsets - Plant Rooms	Paint - Aluminium Paint - Synthetic Paint - Wood Preservative PVC Mastic Sealant Stainless Steel - Mill Steel - Galvanised Timber - Hardwood Timber - Plywood Luan
34	Drainage	Ductile Iron - Pipes
35	Drying Rails / Laundry Poles	Paint - Synthetic Paint - Zinc Chromate Rubber Silicone Sealant Stainless Steel - Mill Steel - Galvanised
36	Earthing and Bonding	Copper - Cable Copper - Sheet PVC Coating - Cable Steel - Cable
37	Earthworks	Timber - Formwork Timber - Hardwood
38	External Ceiling Finishes	Cement Sand Render Steel - Zinc Coated Tiles - Glass Mosaic

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
39	External Step Finishes	Cement Sand Screed Paint - Acrylic Tiles - Glass Mosaic
40	External Wall Finishes - Facades	Tiles - Glass Mosaic
41	External Wall Finishes - Generally	Cement Sand Render Paint - Acrylic Silicone Sealant Stainless Steel - Mill Steel - Zinc Coated Tiles - Glass Mosaic
42	Fire Alarm & Detection System	Copper - Cable Paint - Zinc Chromide PVC Coating - Cable PVC Conduits Stainless Steel - Hairline Steel - Galvanised
43	Fire Fighting System	Cast Iron - Piping Concrete Gunmetal Paint - Zinc Chromate Stainless Steel - Mill Steel - Galvanised UPVC Pipes - Class D
44	Fire Hydrant & Hose Reel System	Paint - Zinc Chromide Plastic - Sheet Steel - Galvanised
45	Flashing - Refuse Chute	Paint - Synthetic Paint - Zinc Chromate Stainless Steel - Hairline Steel - Galvanised
46	Floor Finishes - Corridors & Lobbies	Cement Sand Screed Tiles - Homogenous
47	Floor Finishes - Kitchens & Bathrooms	Cement Sand Screed Steel - Zinc Coated Tiles - Granite Tiles - Homogenous
48	Floor Finishes - Main Entrance Lobby	Cement Sand Screed Tiles - Granite
49	Floor Finishes - Movement Joints, etc	Aluminium - Extruded Polysulphide Sealant Silicone Sealant Stainless Steel - Mill
50	Floor Finishes - Plant Rooms	Cement Sand Screed Paint - Epoxy Paint - Plastic Emulsion Paint - Polyurethane Sealer
51	Floor Finishes - Refuse Room	Cement Sand Screed Tiles - Clay Quarry
52	Floor Finishes - Staircases	Cement Sand Screed Tiles - Homogenous Tiles - Rubber
53	Floor Washing System	Cast Iron - Piping Concrete Gunmetal Steel - Galvanised UPVC Lining

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
54	Flush Water Pump System	Copper - Cable Ductile Iron - Pipes Paint - Zinc Chromide Plastic Sheet PVC Coating - Cable PVC Conduits Stainless Steel - Hairline Steel - Galvanised
55	Flushing Water System - Installation	Cast Iron - Piping Concrete Ductile Iron - Pipes Gunmetal Lead - Sheet Mineral Wool Stainless Steel - Mill UPVC Pipes - Class D UPVC Pipes - Class E
56	Flushing Water System - Distribution	Plastic Pipes UPVC Pipes - Class D UPVC Pipes - Class E
57	Fresh Water Pump System	Copper - Cable Paint - Zinc Chromide Plastic Sheet PVC Coating - Cable PVC Conduits Stainless Steel - Hairline Steel - Galvanised UPVC Lining
58	Fresh Water System - Installation	Chromium Plated Brass Concrete Copper Pipes Gunmetal Lead - Sheet Mineral Wool Paint - Acrylic Stainless Steel - Mill Steel - Galvanised UPVC Lining UPVC Pipes - Class D
59	Fresh Water System - Distribution	Chromium Plated Brass Copper Pipes Steel - Galvanised UPVC Lining
60	FS Inlet Doors	Paint - Synthetic Paint - Zinc Chromate Polycarbonate Sheet Steel - Galvanised
61	FTNS & STDN System	PVC Conduits Steel - Sheet
62	Gates - Refuge Area	Cement Board Paint - Aluminium Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
63	Gatesets	Rubber Silicone Sealant Stainless Steel - Hairline
64	Glass Blocks - Ground Floor	Glass Blocks Silicone Sealant
65	Glazed Door & Window - Entrance	Aluminium - Anodised Glass - Georgian Wired
66	Ground Floor Block Walls	Concrete Blocks - Solid Plastic Pipes Steel - Galvanised
67	Handrail & Balustrade - Staircases	Paint - Synthetic Paint - Zinc Chromate Stainless Steel - Mill Steel - Galvanised
68	Hose Reel Doors - Hairline	Glass - Frangible Polysulphide Sealant Silicone Sealant Stainless Steel - Hairline
69	Hose Reel Doors - Polished	Glass - Frangible Silicone Sealant Stainless Steel - Polished
70	Hot Water System	Copper Pipes Mineral Wool Plastic Sheet
71	Inspection Panels - Refuse Chute	Rubber Stainless Steel - Hairline
72	Internal Waterproofing	Paint - Bitumastic
73	Letter Boxes	Paint - Zinc Chromate Stainless Steel - Polished Steel - Galvanised Timber - Marine Plywood
74	Level 1 Canopy	Stainless Steel - Mill Steel - Galvanised Steel - Zinc Coated
75	Lift Car Finishes	Stainless Steel - Mill Tiles - Granite
76	Lift Cars	Aluminium - Anodised Steel - Galvanised
77	Lift Equipment	Aluminium - Mill Concrete Paint - Synthetic Paint - Zinc Chromide Stainless Steel - Mill Steel - Galvanised Steel - Hot Rolled Sections
78	Lift Vent Covers	Stainless Steel - Mill
79	Lighting Installation - Flats	Copper - Cable PVC Coating - Cable PVC Conduits

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
80	Lighting Installation - Public Areas	Aluminium - Mill Copper - Cable Glass - Clear Float Paint - Synthetic Polycarbonate Sheet PVC Coating - Cable PVC Conduits Steel - Cable
81	Not Used	Not Used
82	Lightning & Earthing	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised Steel - Reinforcement
83	Lightning Protection System	Aluminium - Mill
84	Louvres - Stainless Steel	Silicone Sealant Stainless Steel - Hairline
85	Louvres - GMS	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
86	Louvres - Refuge Room	Glass - Georgian Wired Paint - Synthetic Paint - Zinc Chromate PVC Mastic Sealant Steel - Galvanised
87	Main Equipment - Generator	Copper - Cable Paint - Zinc Chromate PVC Coating - Cable PVC Mastic Sealant Stainless Steel - Hairline Steel - Galvanised Steel - Hot Rolled Sections
88	Main Equipment - Switchboards	Copper - Cable PVC Coating - Cable Stainless Steel - Hairline Steel - Galvanised
89	Mains & Distribution	Copper - Cable Paint - Synthetic PVC Coating - Cable PVC Conduits Steel - Cable Steel - Galvanised Timber - Plywood Hardwood
90	Metal Cages	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
91	Metal Doors - Plantrooms	Glass - Georgian Wired Paint - Synthetic Paint - Zinc Chromate Stainless Steel - Hairline Steel - Galvanised

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
92	Minor RC Concrete Items	Concrete Concrete Concrete - 20/20 Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Plastic Pipes Steel - Reinforcement Timber - Formwork
93	Mirrors	Glass - Mirrored Paint - Wood Preservative Rubber Silicone Sealant Stainless Steel - Mill Timber - Plywood Luan
94	Movement Joints	Polystyrene Polysulphide Sealant Polyurethane Sealant
95	Notice Board	Acrylic Sheet Paint - Cellulose Lacquer Paint - Synthetic Stainless Steel - Mill Stainless Steel - Polished Timber - Hardwood Timber - Plywood Luan Timber - Tackboard
96	Panel Walls - Inter Flat	Concrete Blocks - Hollow Paint - Plastic Emulsion Steel - Galvanised
97	Panel Walls - Internal	Concrete Blocks - Hollow Paint - Moisture Sealer Paint - Plastic Emulsion Steel - Galvanised Steel - Zinc Coated Tiles - Glazed Ceramic
98	Pile Caps	Concrete Concrete Blinding Paint - Formwork Steel - Reinforcement Timber - Formwork
99	Piles	Concrete Steel - Reinforcement Steel - Sheet
100	Precast Cills	Paint - Formwork Precast Concrete Silicone Sealant Steel - Reinforcement Timber - Formwork
101	Precast Curbs	Paint - Formwork Precast Concrete Timber - Formwork
102	Precast Facades Type 1	Paint - Acrylic Paint - Formwork Precast Concrete Steel - Reinforcement Timber - Formwork

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
103	Precast Facades Type 2	Paint - Acrylic Paint - Formwork Precast Concrete Steel - Reinforcement Timber - Formwork
104	Precast Lintols	Paint - Formwork Precast Concrete Steel - Galvanised Steel - Reinforcement Timber - Formwork
105	Precast Stairs	Aluminium - Powder Coated Paint - Formwork Precast Concrete Stainless Steel - Mill Steel - Galvanised Steel - Reinforcement Timber - Formwork
106	Railings - Generally	Paint - Synthetic Paint - Zinc Chromate Plastic Pads Steel - Galvanised
107	Railings - Refuge Area	Aluminium - Powder Coated Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
108	Rainwater Pipes & Outlets	Aluminium - Cast Cast Iron - Piping Concrete Lead - Sheet Paint - Bitumastic Plastic Pipes Stainless Steel - Mill Stainless Steel - Piping
109	RC Beams - Fairfaced	Concrete Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Steel - Reinforcement Timber - Formwork Timber - Hardwood
110	RC Beams - Generally	Concrete Paint - Formwork Steel - Reinforcement Timber - Formwork Timber - Hardwood
111	RC Columns - Fairfaced	Concrete Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Steel - Reinforcement Timber - Formwork Timber - Hardwood

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
112	RC Columns - Generally	Concrete Paint - Formwork Steel - Reinforcement Timber - Formwork Timber - Hardwood
113	RC Slabs - Fairfaced	Concrete Concrete Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Steel - Reinforcement Steel - Sheet
114	RC Slabs - Generally	Concrete Concrete Paint - Formwork Polystyrene Steel - Reinforcement Timber - Formwork Timber - Hardwood
115	RC Stairs	Concrete Concrete Paint - Formwork Steel - Reinforcement Timber - Formwork Timber - Hardwood
116	RC Walls - Fairfaced	Concrete Concrete Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Steel - Reinforcement Steel - Sheet
117	RC Walls - Generally	Concrete Concrete Paint - Formwork Polystyrene Steel - Reinforcement Timber - Formwork Timber - Hardwood
118	RC Water Tanks	Cement Sand Render Cement Sand Screed Concrete Waterproof Paint - Formwork Stainless Steel - Mill Steel - Reinforcement Tiles - Glazed Ceramic Timber - Formwork Timber - Hardwood
119	Roller Shutters - MAC Room	Aluminium - Anodised Paint - Zinc Chromate Silicone Sealant Steel - Galvanised Timber - Marine Plywood
120	Roof Block Walls	Concrete Blocks - Solid Steel - Galvanised

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
121	Roof System - Paving	Cement Sand Screed Extruded Polystyrene Mastic Asphalt Polyurethane Sealant Precast Concrete Paving
122	Roof System - Screed	Cement Sand Screed Mastic Asphalt
123	Sanitary Fittings - Flats	Chromium Plated Brass Plastic Pipes Plastic Sheet Silicone Sealant Vitreous China
124	Sanitary Fittings - Other Areas	Chromium Plated Brass Vitreous China
125	Screens & Grilles	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
126	Seating Benches	Aluminium - Anodised Fibreglass Silicone Sealant
127	Security Guard Counter	Chromium Brass - Ironmongery Paint - Aluminium Paint - Cellulose Lacquer Paint - Synthetic Plastic Laminate Rubber Silicone Sealant Stainless Steel - Mill Stainless Steel - Polished Tiles - Granite Timber - Hardwood Timber - Plywood Luan Timber - Plywood MDF Timber - Teak
128	Security System - CCTV System	Copper - Cable PVC Coating - Cable PVC Conduits Steel - Galvanised
129	Security System - Door Monitoring	Copper - Cable PVC Coating - Cable PVC Conduits Steel - Galvanised
130	Security System - Doorphone	Copper - Cable Paint - Synthetic PVC Coating - Cable PVC Conduits Stainless Steel - Hairline Steel - Galvanised
131	Signage	Acrylic Sheet

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
132	Sink Units	Cement Sand Screed Concrete - 20/20 Paint - Formwork Paint - Zinc Chromate Silicone Sealant Stainless Steel - Mill Steel - Galvanised Timber - Formwork
133	Sliding Shutters	Rubber Stainless Steel - Hairline
134	Small Power Installation - Flats	Copper - Cable PVC Coating - Cable PVC Conduits
135	Small Power Installation - Public Areas	Copper - Cable PVC Coating - Cable PVC Conduits Steel - Cable
136	Soil and Waste - Distribution	Plastic Pipes
137	Soil and Waste - Installation	Cast Iron - Piping Concrete Lead - Sheet Mineral Wool Paint - Acrylic Paint - Bitumastic Plastic Pipes Stainless Steel - Mill
138	Spun Concrete Refuse Chutes	Concrete Concrete - Spun Paint - Formwork Steel - Reinforcement Timber - Formwork
139	Stainless Steel Door - Plant Rooms	Paint - Bitumastic Silicone Sealant Stainless Steel - Hairline Steel - Galvanised
140	Stainless Steel Doorset - Plant Rooms	Glass - Georgian Wired Stainless Steel - Hairline
141	Stainless Steel Window & Doors	Glass - Georgian Wired Paint - Bitumastic Silicone Sealant Stainless Steel - Hairline Steel - Galvanised
142	Stainless Steel Windows - Lobby	Glass - Toughened Paint - Bitumastic Silicone Sealant Stainless Steel - Hairline Steel - Galvanised
143	Staircase Enclosure	Paint - Synthetic Paint - Zinc Chromate Plastic Pads Steel - Galvanised
144	Substructure Tanking	Asphalt
145	Towel Rails	Paint - Zinc Chromate Stainless Steel - Mill Steel - Galvanised

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials
146	Typhoon Guards	Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised
147	Typical Floor Block Walls	Concrete Blocks - Solid Steel - Galvanised
148	Wall Finishes - Corridors & Lobbies	Cement Sand Render Paint - Plastic Emulsion Steel - Zinc Coated Tiles - Homogenous
149	Wall Finishes - Internal Flat Areas Areas	Cement Sand Render Paint - Plastic Emulsion Steel - Zinc Coated Tiles - Glazed Ceramic
150	Wall Finishes - Main Entrance Lobby	Tiles - Granite
151	Wall Finishes - Movement Joints, etc	Polyurethane Foam Stainless Steel - Mill
152	Wall Finishes - Plant Rooms	Cement Sand Render Gypsum Plaster Paint - Acrylic Paint - Alkali Resisting Primer Paint - Plastic Emulsion Paint - Prepolymer Sealer Paint - Synthetic Steel - Zinc Coated Tiles - Glazed Ceramic
153	Wall Finishes - Refuse Room	Cement Sand Render Steel - Zinc Coated Tiles - Glazed Ceramic
154	Wall Finishes - Staircases	Cement Sand Render Paint - Synthetic Steel - Zinc Coated Tiles - Homogenous
155	Water Meter Doors	Silicone Sealant Stainless Steel - Hairline

APPENDIX B : LCA METHODOLOGY VALIDATION REPORTS

APPENDIX B1 : Operational Energy Methodology Validation Report by WSP Asia

Appendix B2 : LCA Methodology Validation Report by UK's Building Research Council

Appendix B3 : LCA/LCC Software Methodology Validation by DHV Buildings and Industry

APPENDIX B1 : Operational Energy Methodology Validation Report by WSP Asia

Your Ref:-
Our Ref: J1553-1100-0002-AY

23 April 2004

TO WHOM IT MAY CONCERN

RE: HKHD AGREEMENT NO. CB20020024
LCA & LCC Study of Building Materials and Components

WSP Hong Kong Limited is pleased to confirm that we have completed a validation exercise between May and June of 2003 on the data inputs as well as the methodology of application of the operational energy models used in the above Study.

The final results from the outputs of the energy model are within 1% difference to the statistical data used for comparison purposes.

Yours faithfully,

Andy YIU
Director

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METHODOLOGY OF VALIDATION ON THE ENERGY MODELS

The validation exercise focused on the follow key areas:

- ***Modelling***
- ***Input Data***
- ***Output Data***
- ***Existing Statistical Data***
- ***Changing Parameters***

MODELLING

Confirmation of the heating and cooling load calculation method of the modeling program is based on American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) standard and the cooling load components are made up of heat gain through building structure and windows, occupancy, equipment, lighting, small power and infiltration.

INPUT DATA

Review of the Input Data including the followings to ensure they are within the practical range or industry standards.

- Thermal Properties of building materials
- HVAC Systems
- Supply air temperature from A/C equipment
- Infiltration Rates
- Lighting power load and operation patterns
- Occupancy level split into weekdays and weekends
- Small Power load for living/dining, bedroom and kitchen
- Equipment operation profile for living/dining and kitchen
- Hot water supply temperature
- Bathroom Ventilation load
- Electrical usage load for lifts, potable and flushing water pumps

OUTPUT DATA & EXISTING STATISTICAL DATA

Review the output data from the simulation and compare against the statistical energy consumption data of the Harmony Block.

CHANGING PARAMETERS

Refine the input parameters such as occupancy levels and operation patterns to reflect the usage or characteristic of the Harmony Block.

To evaluate the model further, alterative window glass is used to ascertain the impact. Anti-sun solar single glazed glass is used instead of normal single-clear glass for a further simulation.

Your Ref:
Our Ref: J1553-EM-001-HKUArch-1200-00002-ML-fl

By Fax (2559 6484) / Post

19 August 2004

Felix Wong
The University of Hong Kong - Dept of Architecture
3/F
Knowles Building
Pofulam Road
Hong Kong

Dear Sirs

Life Cycle Assessment Study of the Harmony Block for Housing Authority
Verification of Input Data for Public Areas

We have reviewed the actual data provided from the operational reading and find that whist higher reading compared with our estimation it is within 5.8%. Also the final reading includes some equipment that was not allowed in the original calculation. We are pleased to forward for your perusal herewith the following that update the original estimate in line with the current knowledge:

1. List of Electrical Equipments for Landlord Application
2. Operational Energy Simulation Data

We hope this meets with your approval.

Yours faithfully

Malcolm Laverick
Director
For and on behalf of WSP Hong Kong Ltd.

Response Required No

Encs Yes

cc

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Operational Energy Simulation Data - Orientation1_NS

Occupier Areas | Public Areas

Electricity Load (Space Lighting)

Area Type	Annual kWh
Indoor lighting	231,622
~~Exhaust Fan~~ Small power load.	224,212
Total Electricity End-Use (space lighting) (kWh)	455,834

Electricity Load (Space Cooling)

Area Type	Total (kWh)	Multiplier	Annual kWh
Lift lobby (ground floor)		1	0
Total Electricity End-Use (space cooling) (kWh)			0

Electricity Load (Other Consumption) lifts + pumps

Total Electricity End-Use (other consumption) (kWh)	249,065

Water Consumption

Total Water Consumption (m3)	107,016.57

List of Electrical Equipments for Landlord Application**

	Area / Location	Electrical Equipments**	Rated operation current (A) ***	Design Power kW	Assume minimum operating hour / day	Annual Consumption
G/F	M.R. & R.S. ROOM	Ventilation fan	3	1	3.0	1,064
	Additional M.R. & R.S. ROOM	Ventilation fan	3	1	3.0	1,064
	R.S. & M.R. Chamber for ARCS Option	System	32	18	3.0	19,603
	F.S. Water Pump Room	F.S. Feed Pump	61	34	0.1	996
		Ventilation fan	3	1	4.0	1,419
	Fresh & Flush Water Pump Room	Fresh Water Pump	149	75	2.0	54,750
		Flush Water Pump	61	22	2.0	16,060
		Ventilation fan	3	1	4.0	1,419
	TBE Room	System (allow 70%)	40	22	24.0	137,222
	Meter Room D	20A connection unit for Fire Control	6	2	24.0	17,024
	Meter Room D	13A fused connection unit for Exit Door Security System	4	1	24.0	11,349
	Meter Room D	13A fused connection unit for CCTV	4	1	24.0	11,349
	Meter Room D	13A fused connection unit for Lift Alarm Panel	4	1	24.0	11,349
	G/F Equipment					**284,669**
	G/F Lighting					**16,502**
	Sub-Total					**301,171**
8/F	Meter Room D	13A fused connection unit for Doorphone system in F1	4	1	24.0	11,349
19/F	F.S. Booster Pump Room	F.S. Booster Pump	61	34	0.0	-
Roof	Fresh Water Booster Pump Room	System	20	22	2.0	16,060
	Flush Water Booster Pump Room	System		11	1.0	4,015
	Refuse Chute Roof Extractor		6	2	24.0	17,024
	Lift	System	32	24	16.0	140,160
	Above G/F Equipment					**188,608**
	Above G/F Lighting					**215,120**
	Sub-Total					**403,728**
	Grand-Total					**704,899**

** **exclude lighting fittings & power sockets.**

*** **data based on nominal rating of protective devices shown in NH1-Opt. 1 Standard Electrical Installation Drawings**

	Pump					90,885

Appendix B2 : LCA Methodology Validation Report by UK's Building Research Council

BRE

Centre for Sustainable Construction

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Pokfulam Road
Hong Kong

Our Reference ja 160604

16 June 2004

Dear Alex

Review of HKHA LCA and LCCTool

Following my visit to Hong Kong in November 2003, I am writing to confirm that BRE undertook a review of the HKHA LCA and LCC Tool during the visit, culminating in a presentation by BRE to the HKHA client team.

The review covered:

- General Data & Principles
- LCA Data & Principles
- WLC Principles

and was based on a demonstration of the tool and description of the underlying principles by the development team undertaken during the visit.

In general we were satisfied with the approach taken by the tool developers with regard to these aspects. In particular, the review focussed on the aspects of LCA covered by the relevant ISO standards ISO14040-14043 and BRE were satisfied that the tool was compliant with these standards.

Yours sincerely

Jane Anderson

Jane Anderson
Principal Consultant

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Appendix B3 : LCA/LCC Software Methodology Validation by DHV Buildings and Industry

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Eindhoven, 15 October 2004

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file	:	
project	:	HKHA LCC LCA
subject	:	LC Console Review
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Dear Mr Edmunds,

DHV has reviewed the provided software tool 'LCconsole'. Objective of the assessment is to review the underlying methodology, databases and the applicability of final results.

Conclusion 1: One of the qualities of the model is certainly the user interface that allows for quick comparisons between design alternatives. Users do not need expert knowledge of cost calculations and environmental issues to use the tool and to calculate useful results. The results of the tool give above all an overall judgement of the building performance.

It is recommended to add guiding screens in the model by which users understand which elements are under-performing and need improvement. In this respect, and is not yet a decision tool to optimise design variants.

Conclusion 2: Important advantage is that costs and environmental impact are simultaneously reviewed. Using the tool means giving general input into the tool and work with the final integral results. The result is a quick overview of estimated costs and environmental performance of the design, based on standard design alternatives. Because of working with standard design alternatives, the estimation of quantities is fairly approximate, giving rough estimations of costs and environmental performance. This is good for comparing design alternatives by the project team but might be too general for other comparisons or use in directives and building codes.

Conclusion 3: The inventory of environmental impacts from materials in LCconsole is based on the CML methodology. However extra environmental impact categories have been added which are not independent (double counting might have been introduced).

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The quality management system has been approved against NEN ISO 9001. Kiwa certificate number K11814.

It is recommended for future development to restructure the model so that it becomes fully consistent with ISO 14.040-43 standards with respect to impact categories and weighting. This will allow an information flow from environmental databases elsewhere in the world to LC Console.

Conclusion 4: The databases of LC Console are not transparent. It is essential to understand the exact way regionalisation has been performed, the way allocation is carried out in different material chains (particularly that of steel) and the characterisation, normalisation and weighting factors that have been used, because international datasets have been converted to the Hong Kong situation.

It is recommended to achieve such transparency, since this allows manufacturers to provide new datasets independent from research institutes and therefore create a transparent level playing field in the relation between government and market parties.

We think LC Console has met its objective in providing a simultaneous assessment of the Life Cycle Costs and the environmental life cycle impact in a pragmatic and user-friendly way.

We would be pleased to work for HKHA and BEC again to address these issues, because these recommendation result into a stronger interface with the market and the international community.

Yours sincerely,

Chiel Boonstra
DHV Sustainability Consultants

APPENDIX C : DETAILED STEP-BY-STEP ILLUSTRATION OF DATA ACQUISITION AND TREATMENT TO DERIVE LCC AND ECO-POINTS FOR AN EXAMPLE FUNCTIONAL UNIT

Illustrative Step By Step Guide to the LCC / LCA Model

This illustrative step by step guide provides an overview of the whole LCC / LCA model developed for the Hong Kong Housing Authority by setting out all the major functions performed in the process of arriving at the Whole Life Cost and Whole Life Environmental Impact profiles.

For the purposes of illustration an aluminium window unit (comprising aluminium and glass) has been selected for this guide. It should be noted that not every calculation and outcome can be illustrated simply due to the volume of data involved. Instead this guide has been structured into two parts, first to present the process flow (using flowcharts for each stage showing the inter-relationships with different stages and data) and second to provide illustrative examples of the data produced at each stage (either in the terms of reproduced numbers or output captures) plus the mathematical functions used in their computation. Data sources are illustrated where practical or otherwise identified by reference.

This guide is intended to be comprehensive but not exhaustive. It should be noted that the data presented may not match exactly that produced by the working model because (i) values in the example are rounded to aid presentation (whilst calculations in the model are to the full number of decimal places) and (ii) data input into the model (e.g. material quantities and types) has changed in accordance with HKHA comments since the production of this model. Despite any differences in results between this example and the model due to these two reasons, the mathematical principles and processes in this example are exactly the same as those in the model and provide an accurate illustration of the computational tool.

The flowcharts showing the overall process flow consist of:

Process Flow	Page
Development of Environmental Impact Data (see Fig 1, 2, 3, 4, 5, 6, 7)	(iii)
Calculation of Material Quantities and Masses (see Fig 8, 9, 10, 11)	(v)
Calculation of Initial E – Points for Each Functional Unit (see Fig 12)	(vi)
Calculation of Repair and Maintenance Quantities for a Functional Unit (see Fig 13, 14, 15, 16)	(vii)
Calculation of Repair and Maintenance Cost and E-Point for a Functional Unit (see Fig 17, 18)	(viii)
Calculation of Whole Life E-Points for a Functional Unit (see Fig 19)	(ix)
Calculation of Repair and Maintenance Costs for a Functional Unit (see Fig 20)	(x)
Calculation of Initial Rates for a Functional Unit (see Fig 21)	(x)
Calculation of Initial Cost for Each Functional Unit (see Fig 22)	(x)
Calculation of Operational Energy and Operational Costs (see Fig 24)	(xi)
Calculation of Whole Life Cost for a Functional Unit (see Fig 23)	(xii)

The supplementary figures providing illustrative data and calculations consist of:

Supplementary Figure	Page
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Figure 4 – Regionalised LCI Data Set	xx
Figure 5 – Characterisation of Regionalised LCI Data Set	xxix
Figure 6 – Normalisation of LCI Data	xxxix
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Figure 9 – Material Densities	xliv
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Figure 22 – Calculation of Initial Costs for Functional Unit	lvii
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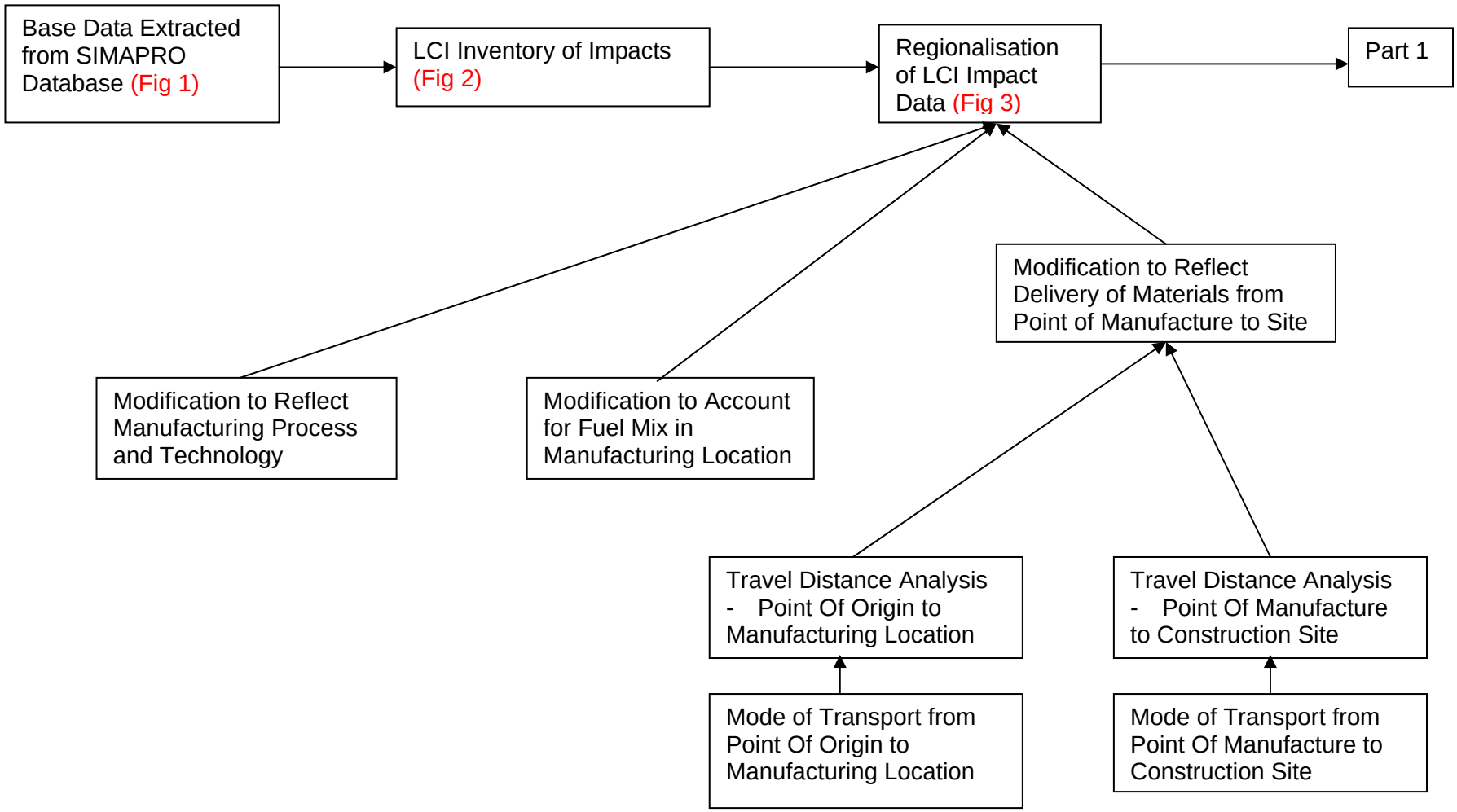
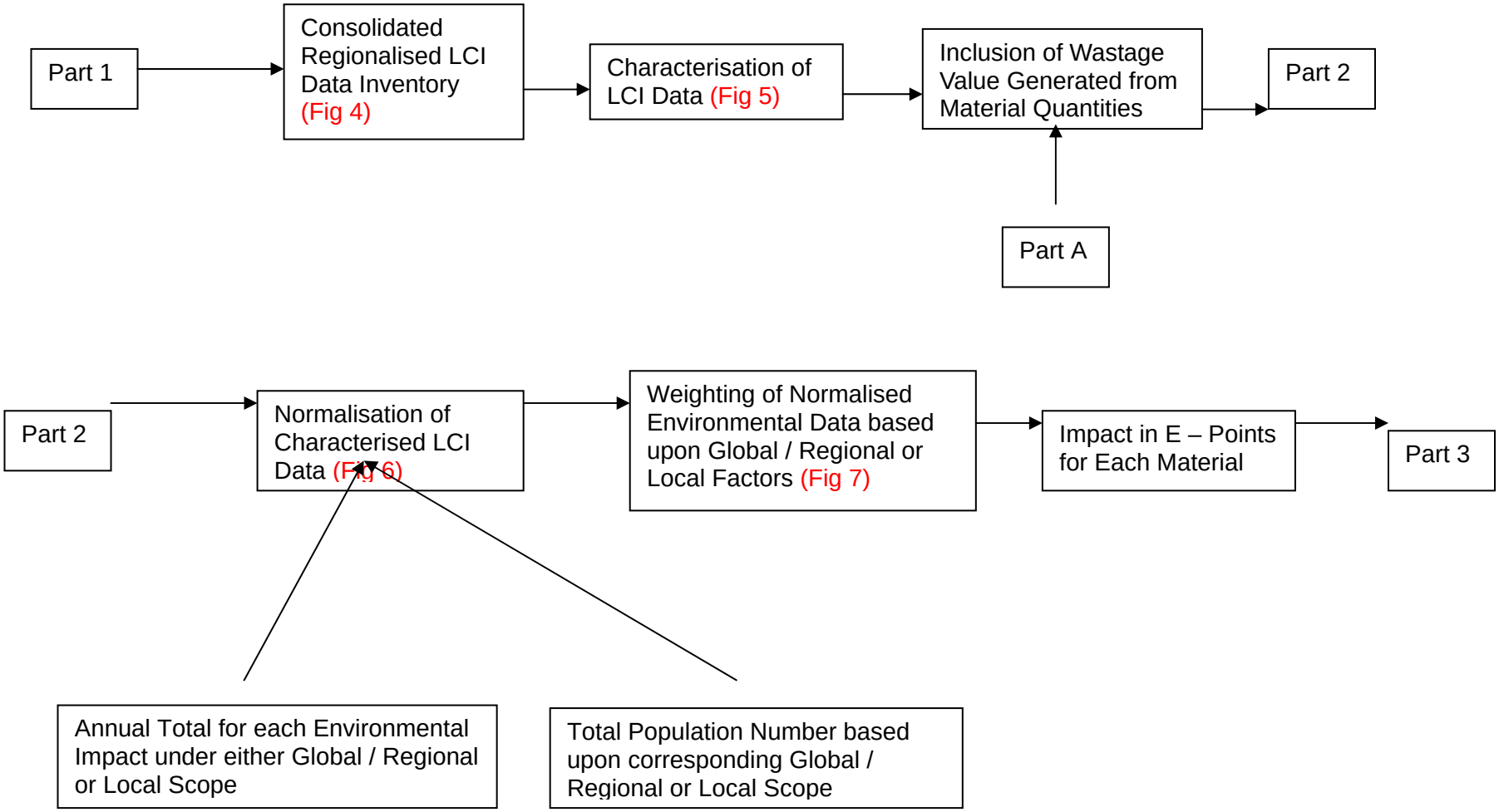
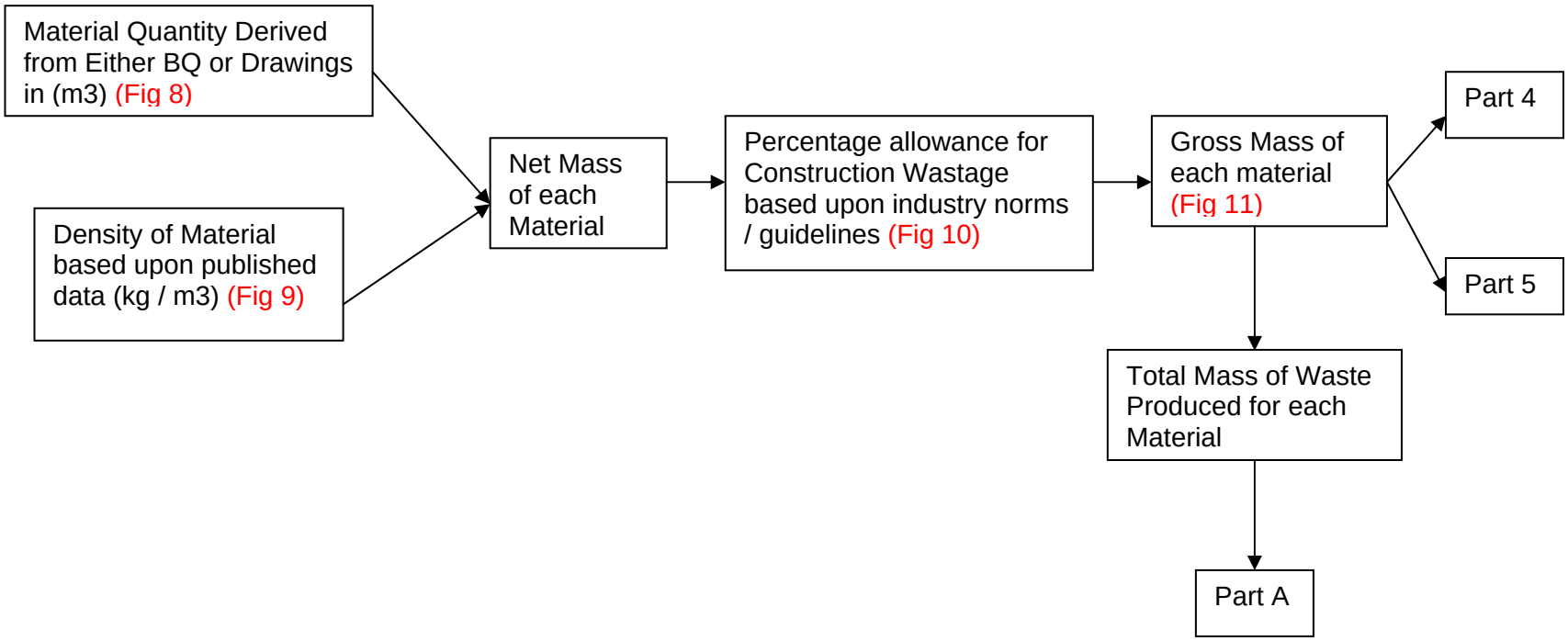
Development of Environmental Impact Data



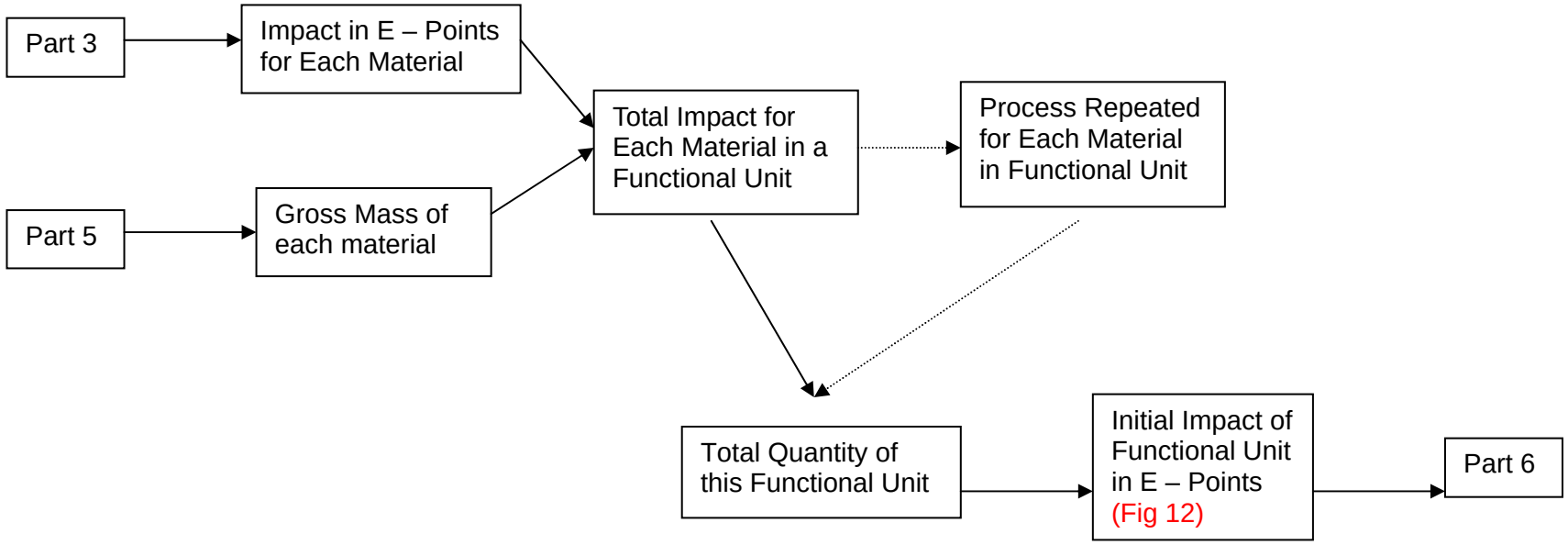
Development of Environmental Impact Data (Cont'd)



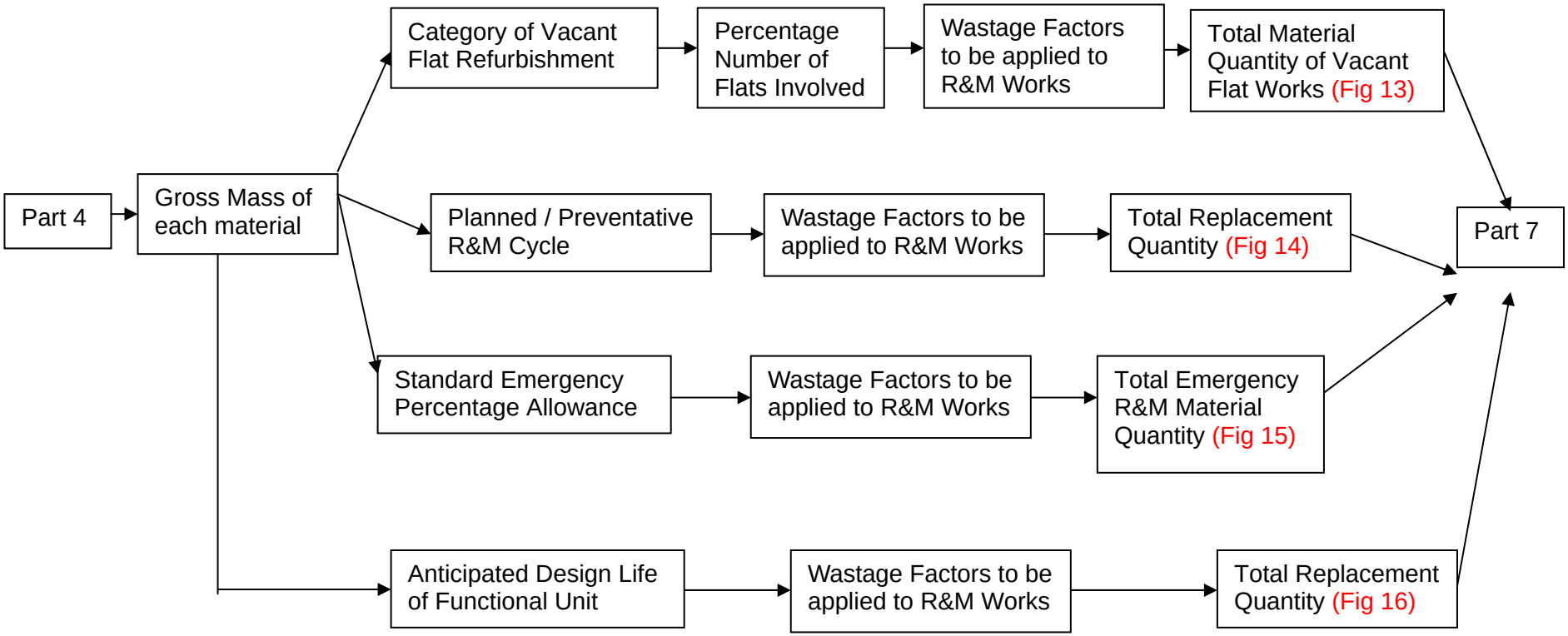
Calculation of Material Quantities and Masses



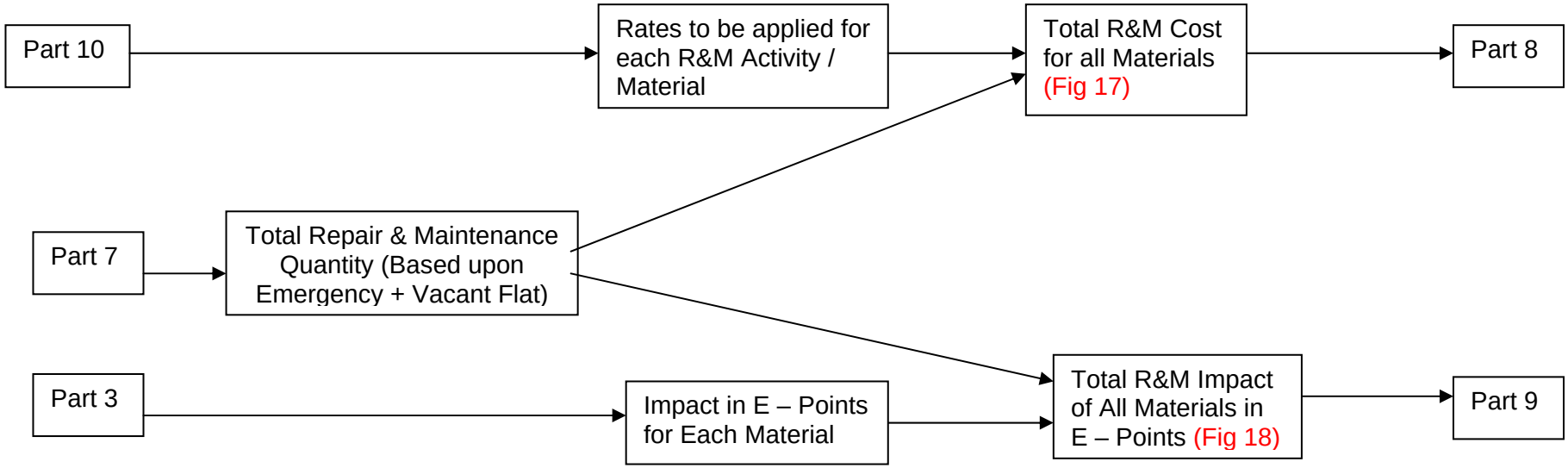
Calculation of Initial E – Points for Each Functional Unit



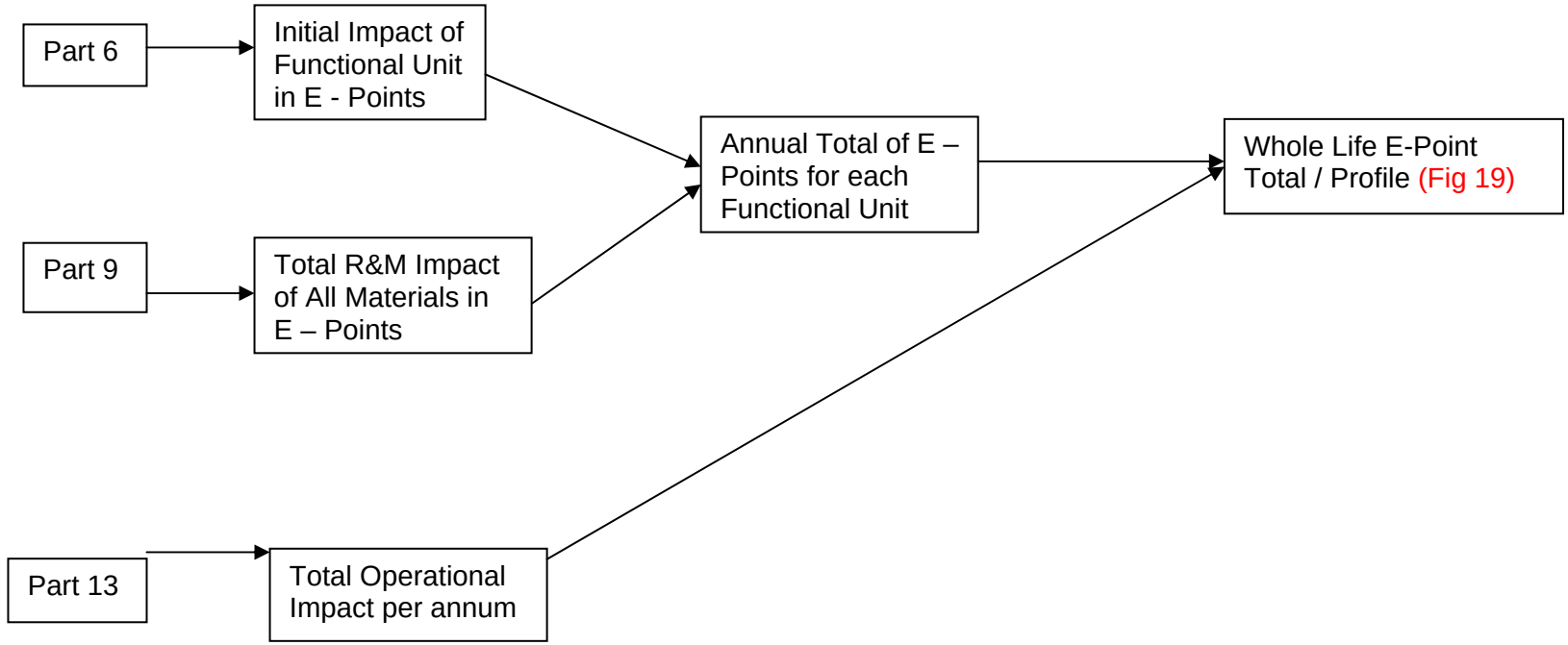
Calculation of Repair and Maintenance Quantities for a Functional Unit



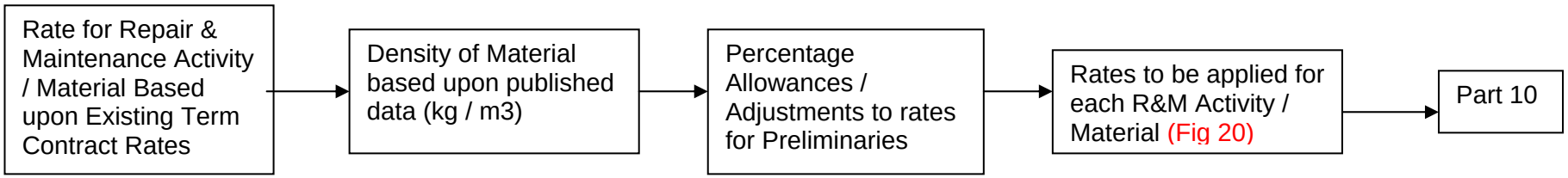
Calculation of Repair and Maintenance Cost and E-Point for a Functional Unit



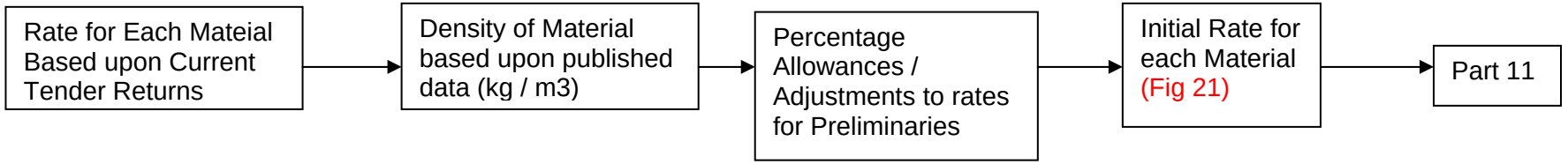
Calculation of Whole Life E-Points for a Functional Unit



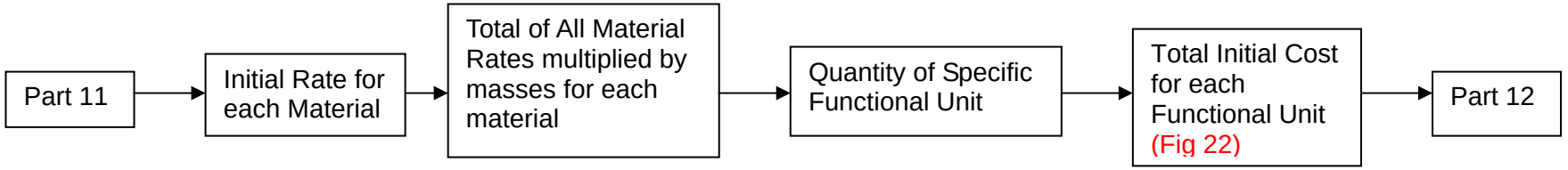
Calculation of Repair and Maintenance Costs for a Functional Unit



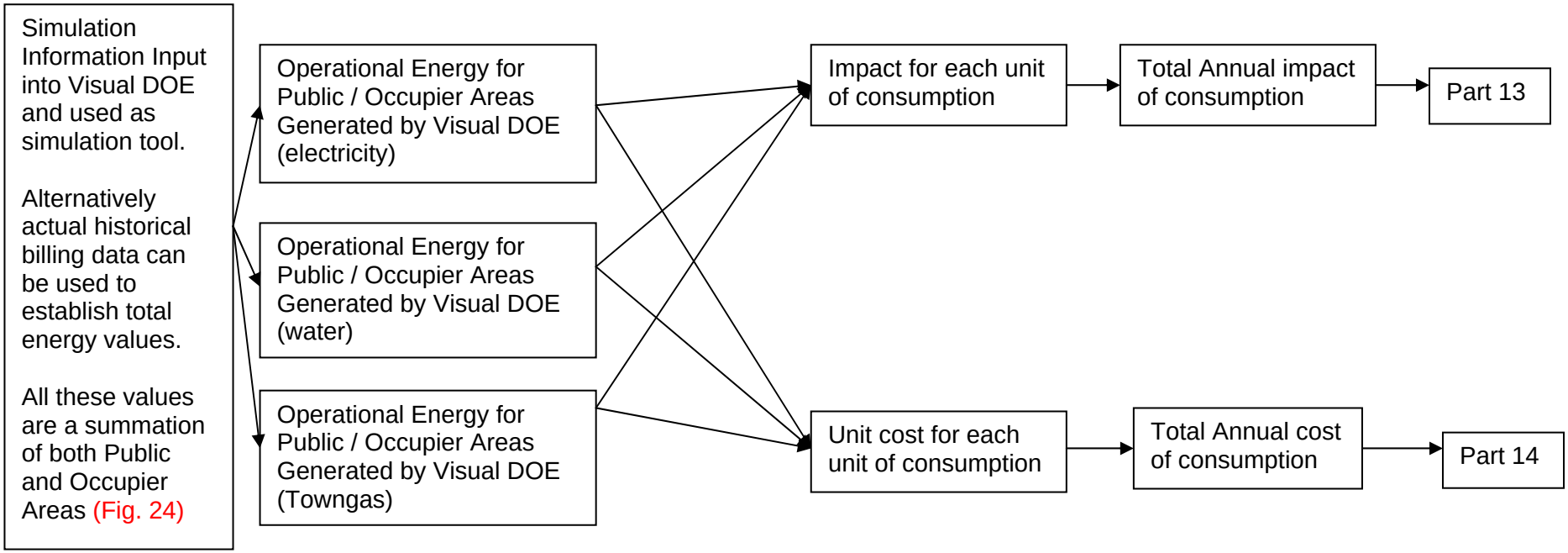
Calculation of Initial Rates for a Functional Unit



Calculation of Initial Cost for Each Functional Unit



Calculation of Operational Energy and Operational Costs



Calculation of Whole Life Cost for a Functional Unit

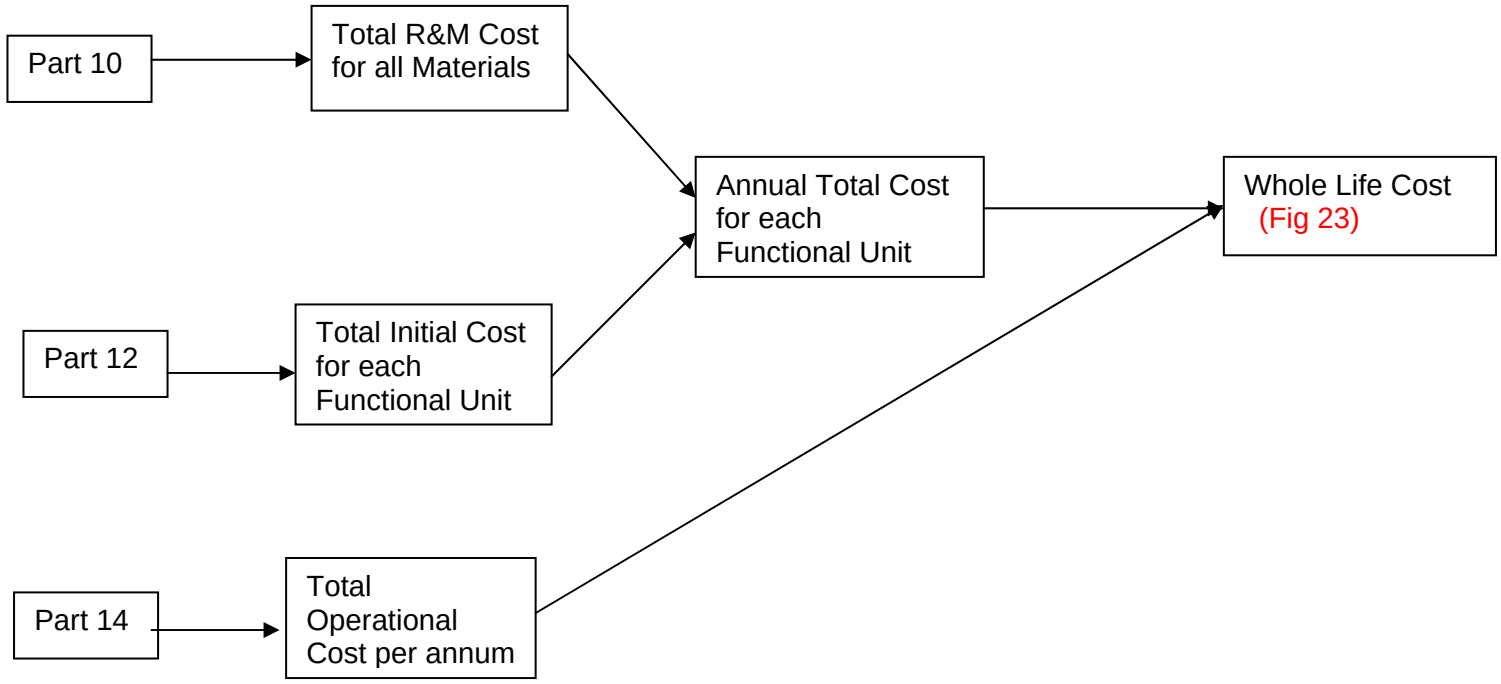


Figure 1 - Input and Output Tables for 1kg of Aluminium

The first stage within the environmental impact calculation process is to generate the raw input output tables from the Simapro software package. This information forms the starting point and basis of future calculations because it is based upon verified European data. Below is an illustration of the output from Simapro at this stage.

Input and output tables for 1kg aluminum 70/30 extruded profile + anodising)

A Aluminium extruded profile 70/30 EAA IVAM data

	material inputs	Classification	Amount	Unit	
1	Aluminium ingot (primary) EAA 70 primary / 30 secondary		1.009	kg	LCI1
2	Wood spruce (package)		0.032	kg	LCI2
3	Steel cold rolled (package)		0.0022	kg	LCI3
4	HDPE A (package)		0.0014	kg	LCI4
	energy inputs				
5	Electr. Hydro UCPTE		0.12999	kWh	LCI5
6	Electr. nuclear UCPTE		0.20627	kWh	LCI6
7	Electr. oil UCPTE		0.05985	kWh	LCI7
8	Electr. Lignite UCPTE		0.05031	kWh	LCI8
9	Electr. coal UCPTE		0.10681	kWh	LCI9
10	Electr. gas UCPTE		0.05148	kWh	LCI10
11	Heavy fuel oil (0.95 kg/l)		0.09328	l	LCI11
	Fuel gas (0,795kg/m3; set @ ETH#		0.038	m3	LCI12
	process inputs				
	process emissions				
E1	dust	emission to air	0.000078	kg	E1
E2	SO2	emission to air	0.00239	kg	E2
E3	CxHy	emission to air	0.000072	kg	E3
E4	NO x	emission to air	0.00074	kg	E4
E5	N2O	emission to air	0.00014	kg	E5
E6	CO	emission to air	0.000035	kg	E6
E7	CO2 fossil)	emission to air	0.35427	kg	E7
E8	HF	emission to air	0.0000058	kg	E8
E9	filter dust (tw)	emssion to soil	0.00258	kg	E9
E10	dust - not specified	emssion to soil	0.00536	kg	E10
E11	aluminium scrap		0.00624	kg	E11

B Anodising process

LCI 13

Figure 2 - LCI Inventory of Data for 1kg of Aluminium

The LCI inventory of data is generated next from within Simapro and produces the main list of chemicals and raw materials which need to be used in the regionalisation process. Below are the illustrative results from this stage using aluminium as an example.

LCI data (1 kg aluminium extrusion profile + anodising)

No	Substance	Compartment	Unit	Total Amounts	ref.	LCI 1 Aluminium ingot primary / (70%	LCI 2 Wood spruce (MCdry 12%)	LCI 3 Steel rolled (BOF)	LCI 4 cold HDPE A	LCI 5 Electr. UCPTE	LCI 6 hydro Electr. UCPTE	nuclear
1	air	Raw	kg	0.0023892	0.0023892	0.0017224	0.0000100	0.0004896	0.0001671	x	x	
2	aluminium post consumer scrap	Raw	kg	0.3736600	0.3736600	0.3736600	x	x	x	x	x	
3	aluminium process scrap	Raw	kg	0.0311780	0.0311780	0.0311780	x	x	x	x	x	
4	baryte	Raw	kg	0.0056525	0.0055487	0.0049629	0.0000247	0.0000011	0.0000000	0.0000002	0.0000013	
5	bauxite	Raw	kg	2.6311281	2.6311000	2.6309000	0.0000215	0.0000672	0.0000504	0.0000016	0.0000180	
6	bentonite	Raw	kg	0.0015335	0.0015042	0.0013440	0.0000042	0.0000083	0.0000000	0.0000007	0.0000706	
7	calcium sulphate	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
8	chalk	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
9	chromium (in ore)	Raw	kg	0.0000870	0.0000860	0.0000784	0.0000010	0.0000000	0.0000000	0.0000004	0.0000040	
10	Cl	Raw	kg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x	x	x	
11	clay minerals	Raw	kg	0.0016289	0.0016289	0.0014163	0.0000380	0.0000413	0.0000000	x	x	
12	coal (18 MJ/kg) ETH	Raw	kg	2.0315000	2.0315000	1.9589000	0.0017214	0.0001340	x	0.0001291	0.0002320	
13	coal (27.1 MJ/kg)	Raw	kg	0.0000050	0.0000050	0.0000050	0.0000000	0.0000000	x	x	x	
14	coal (29.3 MJ/kg)	Raw	kg	0.0427950	0.0427950	0.0413930	0.0000362	0.0013660	x	x	x	
15	cobalt (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000	0.0000000	
16	copper (in ore)	Raw	kg	0.0001892	0.0001817	0.0001677	0.0000021	0.0000001	x	0.0000001	0.0000018	
17	copper (ore)	Raw	kg	0.0296050	0.0296050	0.0296050	x	x	x	x	x	
18	crude oil (41.9 MJ/kg)	Raw	kg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x	x	x	
19	crude oil (42,6 MJ/kg) ETH	Raw	kg	1.1247000	1.1247000	1.0051000	0.0041286	0.0001236	x	0.0000363	0.0001728	
20	crude oil (42,7 MJ/kg) IDEMAT	Raw	kg	0.0005838	0.0005838	0.0005838	x	x	x	x	x	
21	crude oil (44 MJ/kg)	Raw	kg	0.0000086	0.0000086	0.0000086	x	x	x	x	x	
22	dolomite	Raw	kg	0.0000974	0.0000974	0.0000646	x	0.0000327	0.0000000	x	x	
23	energy (undef.)	Raw	MJ	0.0880330	0.0880330	0.0785050	0.0017190	0.0000184	0.0000783	x	x	
24	energy from biomass	Raw	MJ	0.0000425	0.0000425	0.0000000	x	x	0.0000425	x	x	
25	energy from coal (28,0 MJ/kg)	Raw	MJ	0.0034413	0.0034413	0.0000004	x	x	0.0034409	x	x	
26	energy from hydro power	Raw	MJ	26.1941588	26.1850000	25.5760000	0.0000000	0.0000781	0.0014035	0.5999700	0.0012943	
27	energy from hydrogen	Raw	MJ	0.0002102	0.0002102	0.0000000	x	x	0.0002102	x	x	
28	energy from lignite (15,0MJ/kg)	Raw	MJ	0.0001448	0.0001448	0.0000000	x	x	0.0001447	x	x	
29	energy from natural gas (38,8MJ/m3)	Raw	MJ	0.0334370	0.0334370	0.0000043	x	x	0.0334320	x	x	
30	energy from oil (45,0MJ/kg)	Raw	MJ	0.0693570	0.0693570	0.0000090	x	x	0.0693480	x	x	
31	energy from peat	Raw	MJ	0.0000033	0.0000033	0.0000000	x	x	0.0000033	x	x	
32	energy from sulphur (9,3MJ/kg)	Raw	MJ	0.0000042	0.0000042	0.0000000	x	x	0.0000042	x	x	
33	energy from U (451000MJ/kg)	Raw	MJ	0.0046649	0.0046649	0.0000006	x	x	0.0046643	x	x	
34	energy from wood	Raw	MJ	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
35	energy recovered	Raw	MJ	(0.0008892)	(0.0008892)	(0.0000001)	x	x	(0.0008891)	x	x	
36	feldspar	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
37	ferromanganese	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
38	float agent	Raw	kg	0.0000009	0.0000009	0.0000009	x	x	x	x	x	
39	fluorspar	Raw	kg	0.0000009	0.0000009	0.0000000	x	x	0.0000009	x	x	
40	gas (35MJ/m3); from oil production	Raw	m3	0.0745797	0.0742480	0.0664220	0.0002833	0.0000083	x	0.0000018	0.0000084	
41	granite	Raw	kg	0.0000009	0.0000009	0.0000000	x	x	0.0000009	x	x	
42	gravel	Raw	kg	0.1100000	0.1100000	0.0960610	0.0053176	0.0000248	0.0000000	x	x	
43	iron (in ore)	Raw	kg	0.0266108	0.0257870	0.0238870	0.0002285	0.0000062	0.0000003	0.0000821	0.0000933	
44	iron (ore)	Raw	kg	0.0163950	0.0163950	0.0108820	x	0.0055132	x	x	x	
45	iron (scrap)	Raw	kg	0.0014045	0.0014045	0.0009322	x	0.0004723	x	x	x	
46	kaolinite (chinaclay)	Raw	kg	0.0000017	0.0000017	0.0000017	x	x	x	x	x	
47	KCl	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
48	lead (in ore)	Raw	kg	0.0000643	0.0000642	0.0000513	0.0000087	0.0000000	0.0000000	0.0000000	0.0000000	
49	lignite (8.1 MJ/kg) ETH	Raw	kg	0.1343000	0.1343000	0.0576990	0.0003375	0.0000215	x	0.0000436	0.0001936	
50	limestone	Raw	kg	0.1599200	0.1599200	0.1583200	0.0002250	0.0006490	0.0000013	x	x	
51	manganese (in ore)	Raw	kg	0.0000345	0.0000339	0.0000321	0.0000003	0.0000000	x	0.0000004	0.0000001	
52	marl	Raw	kg	0.0691545	0.0669430	0.0641620	0.0000008	0.0000060	x	0.0004342	0.0001986	
53	material known, no data	Raw	kg	0.0178840	0.0178840	0.0178840	0.0000000	0.0000000	x	x	x	
54	material unknown	Raw	kg	0.0061509	0.0061509	0.0061476	0.0000024	0.0000000	x	x	x	
55	mercury (in ore)	Raw	kg	0.0002269	0.0002269	0.0002269	0.0000000	0.0000000	x	x	x	
56	mining gas (30,3 MJ/kg) ETH	Raw	kg	0.0133170	0.0133170	0.0128090	0.0000065	0.0000004	x	0.0000009	0.0000017	
57	molybdene (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000	0.0000000	
58	NaCl	Raw	kg	0.0000465	0.0000465	0.0000000	x	x	0.0000465	x	x	
59	natural gas (35,0 MJ/m3) ETH	Raw	m3	0.5165200	0.5165200	0.4601500	0.0048157	0.0006922	x	0.0000102	0.0002911	
60	natural gas (42 MJ/m3)	Raw	m3	0.0000123	0.0000123	0.0000123	x	x	x	x	x	
61	natural gas (vol)	Raw	m3	0.0000197	0.0000197	0.0000111	0.0000067	0.0000019	x	x	x	
62	nickel (in ore)	Raw	kg	0.0000487	0.0000483	0.0000433	0.0000006	0.0000000	0.0000000	0.0000001	0.0000032	
63	nitrogen	Raw	kg	0.0000916	0.0000916	0.0000000	x	x	0.0000916	x	x	
64	olivine	Raw	kg	0.0000000	0.0000000	0.0000000	x	x	0.0000000	x	x	
65	oxygen	Raw	kg	0.0000885	0.0000885	0.0000885	x	x	0.0000001	x	x	
66	palladium (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000	0.0000000	

Figure 2 - LCI Inventory of Data for 1kg of Aluminium (Cont'd)

LCI data (1 kg aluminium extrusion profile + anodising)

No	Substance	Compartment	Unit	ref. Total Amounts		LCI 1 Aluminium ingot primary		LCI 2 Wood spruce (70% (MCdry 12%)		LCI 3 Steel rolled (BOF)		LCI 4 HDPE A cold		LCI 5 Electr. hydro UCPTE		LCI 6 Electr. nuclear UCPTE	
						/ 30%											
67	phosphate (as P2O5)	Raw	kg	0.0000000	0.0000000	0.0000000	x		x		0.0000000	x			x		
68	platinum (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
69	quartz sand	Raw	kg	0.0140410	0.0140410	0.0140410	x		x		x		x		x		
70	rhenium (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
71	rhodium (in ore)	Raw	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
72	rock salt	Raw	kg	0.1102343	0.1101900	0.1099300		0.0000763		0.0000125	x			0.0000003		0.0000034	
73	rutile	Raw	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x		x		
74	salt	Raw	kg	0.0000013	0.0000013	0.0000013	x		x		x		x		x		
75	sand	Raw	kg	0.0058571	0.0058571	0.0051275		0.0001168		0.0000055		0.0000002	x		x		
76	sec wood	Raw	kg	(0.0148960)	(0.0148960)	x		(0.0148960)	x		x		x		x		
77	shale	Raw	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x		x		
78	silver (in ore)	Raw	kg	0.0000035	0.0000035	0.0000031		0.0000000		0.0000000	x			0.0000000		0.0000000	
79	sulphur	Raw	kg	0.0007170	0.0007170	0.0007170	x		x		x		x		x		
80	sulphur (bonded)	Raw	kg	0.0000002	0.0000002	0.0000000	x		x			0.0000002	x		x		
81	sulphur (elemental)	Raw	kg	0.0000005	0.0000005	0.0000000	x		x			0.0000005	x		x		
82	tin (in ore)	Raw	kg	0.0000020	0.0000020	0.0000017		0.0000000		0.0000000	x			0.0000000		0.0000000	
83	tin (ore, 0,965%)	Raw	kg	0.0000002	0.0000002	0.0000002	x		x		x		x		x		
84	turbine water ETH	Raw	m3	0.4578400	0.4578400	0.4086400		0.0089930		0.0000959	x		x		x		
85	uranium (in ore)	Raw	kg	0.0000618	0.0000612	0.0000551		0.0000000		0.0000000	x			0.0000000		0.0000059	
86	water	Raw	kg	221.8490000	179.2800000	165.6200000		0.1813100		0.0528410	x			0.0116060		1.8639000	
87	water (cooling)	Raw	kg	0.0480780	0.0480780	0.0000062	x		x			0.0480710	x		x		
88	water (drinking, for process.)	Raw	kg	0.0040643	0.0040643	0.0000005	x		x			0.0040638	x		x		
89	water (process)	Raw	kg	0.7292100	0.7292100	0.7288000		0.0000258		0.0000851		0.0002985	x		x		
90	water (sea)	Raw	kg	0.0262840	0.0262840	0.0174460	x			0.0088387	x		x		x		
91	water (sea, for cooling)	Raw	kg	0.0245820	0.0245820	0.0000032	x		x			0.0245790	x		x		
92	water (sea, for processing)	Raw	kg	0.0001452	0.0001452	0.0000000	x		x			0.0001452	x		x		
93	water (surface, for cooling)	Raw	kg	0.0002810	0.0002810	0.0000436		0.0000000		0.0000000		0.0002374	x		x		
94	water (surface, for process.)	Raw	kg	0.0000030	0.0000030	0.0000000	x		x			0.0000030	x		x		
95	water (well, for cooling)	Raw	kg	0.0000038	0.0000038	0.0000000	x		x			0.0000038	x		x		
96	water (well, for processing)	Raw	kg	0.0000001	0.0000001	0.0000000	x		x			0.0000001	x		x		
97	water barrage (vol)	Raw	m3	0.0019043	0.0019043	0.0016998		0.0000371		0.0000004	x		x		x		
98	water l	Raw	m3	0.0003841	0.0003841	0.0003835		0.0000000		0.0000006	x		x		x		
99	wood	Raw	kg	0.0332750	0.0323380	0.0315210		0.0000246		0.0000014	x			0.0000021		0.0000161	
100	wood (spruce european)	Raw	kg	0.0879240	0.0879240	0.0000120		0.0879120	x		x		x		x		
101	zeolite	Raw	kg	0.0000089	0.0000085	0.0000073		0.0000000		0.0000000	x			0.0000000		0.0000000	
102	zinc (in ore)	Raw	kg	0.0000026	0.0000026	0.0000023		0.0000001		0.0000000		0.0000000		0.0000000		0.0000000	
103	1,2-dichloroethane	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
104	acetaldehyde	Air	kg	0.0000010	0.0000010	0.0000008		0.0000000		0.0000000	x			0.0000000		0.0000000	
105	acetic acid	Air	kg	0.0000058	0.0000054	0.0000047		0.0000000		0.0000000	x			0.0000000		0.0000000	
106	acetone	Air	kg	0.0000010	0.0000010	0.0000008		0.0000000		0.0000000	x			0.0000000		0.0000000	
107	acrolein	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
108	aerosols	Air	kg	0.0000013	0.0000013	0.0000000		0.0000012		0.0000000	x		x		x		
109	Al	Air	kg	0.0001172	0.0001126	0.0001082		0.0000000		0.0000000	x			0.0000000		0.0000000	
110	aldehydes	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
111	alkanes	Air	kg	0.0000135	0.0000129	0.0000116		0.0000000		0.0000000	x			0.0000000		0.0000000	
112	alkenes	Air	kg	0.0000072	0.0000069	0.0000065		0.0000000		0.0000000	x			0.0000000		0.0000000	
113	aluminum oxide	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x		x		
114	ammonia	Air	kg	0.0000262	0.0000254	0.0000243		0.0000002		0.0000000		0.0000000		0.0000000		0.0000001	
115	As	Air	kg	0.0000003	0.0000003	0.0000003		0.0000000		0.0000000	x			0.0000000		0.0000000	
116	asbestos	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
117	B	Air	kg	0.0000299	0.0000295	0.0000265		0.0000000		0.0000000	x			0.0000000		0.0000000	
118	Ba	Air	kg	0.0000014	0.0000013	0.0000013		0.0000000		0.0000000	x			0.0000000		0.0000000	
119	Be	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
120	benzaldehyde	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
121	benzene	Air	kg	0.0000152	0.0000143	0.0000130		0.0000001		0.0000000	x			0.0000000		0.0000000	
122	benzo(a)pyrene	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
123	Br	Air	kg	0.0000045	0.0000043	0.0000041		0.0000000		0.0000000	x			0.0000000		0.0000000	
124	butane	Air	kg	0.0000990	0.0000965	0.0000867		0.0000005		0.0000000	x			0.0000000		0.0000000	
125	butene	Air	kg	0.0000029	0.0000029	0.0000025		0.0000000		0.0000000	x			0.0000000		0.0000000	
126	Ca	Air	kg	0.0000444	0.0000437	0.0000409		0.0000001		0.0000000	x			0.0000000		0.0000000	
127	calcium hydroxide	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x		x		
128	calcium oxide	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x		x		
129	Cd	Air	kg	0.0000001	0.0000001	0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
130	CF4	Air	kg	0.0002825	0.0002825	0.0002825		0.0000000		0.0000000	x		x		x		
131	CFC-11	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
132	CFC-114	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
133	CFC-116	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
134	CFC-12	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
135	CFC-13	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
136	CFC-14	Air	kg	0.0000002	0.0000002	0.0000002		0.0000000		0.0000000	x			0.0000000		0.0000000	
137	CFC-21	Air	kg	0.0000002	0.0000002	0.0000002		0.0000000		0.0000000	x		x		x		
138	CFC (hard)	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		
139	CFC (soft)	Air	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x		x		
140	Cl2	Air	kg	0.0000139	0.0000139	0.0000139		0.0000000		0.0000000		0.0000000	x		x		
141	CN (complex)	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x		x		

Figure 2 - LCI Inventory of Data for 1kg of Aluminium (Cont'd)

LCI data (1 kg aluminium extrusion profile + anodising)

No	Substance	Compartment	Unit	Total Amounts	ref.	LCI 1 Aluminium ingot (70% primary / 30%		LCI 2 Wood spruce (MCdry 12%)		LCI 3 Steel rolled (BOF)		LCI 4 cold HDPE A		LCI 5 Electr. UCPTE		LCI 6 hydro Electr. UCPTE	nuclear
142	CO	Air	kg	0.0445479	0.0444720	0.0443870		(0.0001318)		0.0000450		0.0000011		0.0000004		0.0000020	
143	CO2	Air	kg	0.2871945	0.0001845	0.0001844		0.0000000		0.0000000	x		x				x
144	CO2 (fossil)	Air	kg	8.5763000	8.5763000	7.8782000		0.0256700		0.0044201		0.0024513		0.0005184		0.0016793	
145	CO2 (non-fossil)	Air	kg	(0.0547740)	(0.0547740)	0.0010957		(0.0559760)		0.0000002		(0.0000048)	x				x
146	cobalt	Air	kg	0.0000003	0.0000003	0.0000003		0.0000000		0.0000000	x			0.0000000		0.0000000	
147	Cr	Air	kg	0.0000007	0.0000006	0.0000006		0.0000000		0.0000000	x			0.0000000		0.0000000	
148	CS2	Air	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x				x
149	Cu	Air	kg	0.0000015	0.0000014	0.0000013		0.0000000		0.0000000	x			0.0000000		0.0000000	
150	CxHy	Air	kg	0.0007132	0.0007132	0.0006311		(0.0000009)		0.0000007		0.0000083		0.0000000		0.0000000	
151	CxHy (non methane)	Air	kg	0.0088114	0.0088114	0.0078734		0.0000480		0.0000012	x			0.0000005		0.0000026	
152	CxHy (sulph)	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x				x
153	CxHy aromatic	Air	kg	0.0000003	0.0000003	0.0000001		0.0000000		0.0000000		0.0000002		0.0000000		0.0000000	
154	CxHy chloro	Air	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x				x
155	CxHy incineration_msw	Air	kg	0.0000026	0.0000026	0.0000001		0.0000025		0.0000000	x		x				x
156	dichloroethene	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
157	dichloromethane	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
158	dioxin (TEQ)	Air	kg	0.0000000	0.0000000	0.0000000		(0.0000000)		0.0000000	x			0.0000000		0.0000000	
159	dust	Air	kg	0.0240620	0.0240620	0.0238960		(0.0000220)		0.0000721		0.0000040	x				x
160	dust (coal)	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x				x
161	dust rough (s>10)	Air	kg	0.0084857	0.0084857	0.0080593		0.0000000		0.0000002	x			0.0000317		0.0000170	
162	ethane	Air	kg	0.0000902	0.0000815	0.0000737		0.0000009		0.0000000	x			0.0000000		0.0000001	
163	ethanol	Air	kg	0.0000020	0.0000020	0.0000017		0.0000000		0.0000000	x			0.0000000		0.0000000	
164	ethene	Air	kg	0.0000333	0.0000330	0.0000291		0.0000013		0.0000000	x			0.0000000		0.0000000	
165	ethylbenzene	Air	kg	0.0000092	0.0000089	0.0000083		0.0000000		0.0000000	x			0.0000000		0.0000000	
166	ethyne	Air	kg	0.0000001	0.0000001	0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
167	F2	Air	kg	0.0006781	0.0006781	0.0006781	x		x			0.0000000	x				x
168	Fe	Air	kg	0.0000569	0.0000549	0.0000525		0.0000000		0.0000000	x			0.0000000		0.0000000	
169	formaldehyde	Air	kg	0.0000159	0.0000138	0.0000127		0.0000001		0.0000000	x			0.0000000		0.0000000	
170	H2	Air	kg	0.0016533	0.0000333	0.0000331		0.0000000		0.0000001		0.0000001	x				x
171	H2S	Air	kg	0.0000100	0.0000089	0.0000084		0.0000001		0.0000001		0.0000000		0.0000000		0.0000000	
172	H2SO4	Air	kg	0.0000011	0.0000011	0.0000011	x		x			0.0000000	x				x
173	HALON-1301	Air	kg	0.0000001	0.0000001	0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
174	HCFC-22	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
175	HCl	Air	kg	0.0009570	0.0009190	0.0008743		0.0000003		0.0000000		0.0000001		0.0000000		0.0000001	
176	HCN	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
177	He	Air	kg	0.0000679	0.0000679	0.0000609		0.0000003		0.0000000	x		x				x
178	heat losses	Air	MJ	45.6420000	45.6420000	41.9730000	x			0.0007447	x			0.0168860		1.7374000	
179	heavy metals	Air	kg	-	-	x		-		x	x		x				x
180	heptane	Air	kg	0.0000203	0.0000201	0.0000180		0.0000001		0.0000000	x			0.0000000		0.0000000	
181	hexane	Air	kg	0.0000425	0.0000423	0.0000378		0.0000002		0.0000000	x			0.0000000		0.0000000	
182	HF	Air	kg	0.0001294	0.0001254	0.0001146		0.0000001		0.0000000		0.0000000		0.0000000		0.0000000	
183	Hg	Air	kg	0.0000002	0.0000002	0.0000002		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
184	I	Air	kg	0.0000015	0.0000015	0.0000014		0.0000000		0.0000000	x			0.0000000		0.0000000	
185	iron dust	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x				x
186	K	Air	kg	0.0000152	0.0000146	0.0000139		0.0000000		0.0000000	x			0.0000000		0.0000000	
187	La	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
188	mercaptans	Air	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x				x
189	metals	Air	kg	0.0000000	0.0000000	0.0000000	x		x			0.0000000	x				x
190	methane	Air	kg	0.0203646	0.0194560	0.0183220		0.0000436		0.0000043		0.0000080		0.0000011		0.0000042	
191	methanol	Air	kg	0.0000021	0.0000020	0.0000017		0.0000000		0.0000000	x			0.0000000		0.0000000	
192	methyl t-butyl ether	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
193	Mg	Air	kg	0.0000364	0.0000349	0.0000334		0.0000000		0.0000000	x			0.0000000		0.0000000	
194	Mn	Air	kg	0.0000014	0.0000014	0.0000012		0.0000000		0.0000001	x			0.0000000		0.0000000	
195	Mo	Air	kg	0.0000001	0.0000001	0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
196	N2	Air	kg	0.0007470	0.0007470	0.0007363		0.0000013		0.0000001	x		x				x
197	N2O	Air	kg	0.0003555	0.0003533	0.0002082		0.0000010		0.0000001		0.0000000		0.0000000		0.0000000	
198	Na	Air	kg	0.0000117	0.0000113	0.0000104		0.0000000		0.0000000	x			0.0000000		0.0000000	
199	Na2CO3	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x				x
200	Ni	Air	kg	0.0000044	0.0000043	0.0000038		0.0000000		0.0000000	x			0.0000000		0.0000000	
201	NO	Air	kg	0.0000031	0.0000031	0.0000003		0.0000027		0.0000000	x		x				x
202	NO2	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
203	NOx	Air	kg	0.0188912	0.0182390	0.0165070		0.0001508		0.0000115		0.0000139		0.0000020		0.0000067	
204	Olefins (unspec.)	Air	kg	0.0000010	0.0000010	0.0000010		0.0000000		0.0000000	x		x				x
205	P	Air	kg	0.0000013	0.0000012	0.0000012		0.0000000		0.0000000	x			0.0000000		0.0000000	
206	PAH's	Air	kg	0.0000359	0.0000359	0.0000358		0.0000000		0.0000001		0.0000000		0.0000000		0.0000000	
207	Pb	Air	kg	0.0000014	0.0000014	0.0000013		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
208	pentane	Air	kg	0.0001258	0.0001229	0.0001106		0.0000006		0.0000000	x			0.0000000		0.0000000	
209	phenol	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
210	potassium monoxide	Air	kg	0.0000000	0.0000000	0.0000000	x		x		x		x				x
211	propane	Air	kg	0.0001045	0.0001011	0.0000909		0.0000005		0.0000000	x			0.0000000		0.0000000	
212	propene	Air	kg	0.0000049	0.0000048	0.0000043		0.0000000		0.0000000	x			0.0000000		0.0000000	
213	propionaldehyde	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x		x				x
214	propionic acid	Air	kg	0.0000002	0.0000002	0.0000002		0.0000000		0.0000000	x			0.0000000		0.0000000	
215	Pt	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
216	Sb	Air	kg	0.0000000	0.0000000	0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	

Figure 2 - LCI Inventory of Data for 1kg of Aluminium (Cont'd)

LCI data (1 kg aluminium extrusion profile + anodising)

No	Substance	Compartment	Unit	Total Amounts	ref.		LCI 1 Aluminium ingot primary / 30%		LCI 2 Wood spruce (70% MCdry 12%)		LCI 3 Steel rolled (BOF)		LCI 4 cold HDPE A		LCI 5 Electr. hydro UCPTE		LCI 6 Electr. nuclear UCPTE	
217	Sc	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
218	Se	Air	kg	0.0000006	0.0000006		0.0000005		0.0000000		0.0000000	x			0.0000000		0.0000000	
219	Si	Air	kg	0.0000333	0.0000333		0.0000298		0.0000006		0.0000000	x		x		x		
220	silicates	Air	kg	0.0001749	0.0001679		0.0001579		0.0000000		0.0000000	x			0.0000000		0.0000000	
221	silicon carbide	Air	kg	0.0000001	0.0000001		0.0000001	x			x	x		x		x		
222	silicon dioxide	Air	kg	0.0000336	0.0000336		0.0000336	x			x	x		x		x		
223	Sn	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
224	SO2	Air	kg	0.0473569	0.0466390		0.0428620		0.0000355		0.0000076	x			0.0000014		0.0000127	
225	SOx (as SO2)	Air	kg	0.0029822	0.0029822		0.0026825		0.0000329		0.0000008		0.0000192	x		x		
226	Sr	Air	kg	0.0000017	0.0000016		0.0000015		0.0000000		0.0000000	x			0.0000000		0.0000000	
227	sulphur	Air	kg	0.0000001	0.0000001		0.0000000		0.0000001		0.0000000	x		x		x		
228	Te	Air	kg	-	-		-		-		-	x		x		x		
229	tetrachloromethane	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
230	Th	Air	kg	0.0000001	0.0000001		0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
231	Ti	Air	kg	0.0000052	0.0000050		0.0000048		0.0000000		0.0000000	x			0.0000000		0.0000000	
232	Tl	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
233	toluene	Air	kg	0.0000185	0.0000179		0.0000163		0.0000001		0.0000000	x			0.0000000		0.0000000	
234	trichloromethane	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
235	U	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
236	unspecified emission	Air	kg	0.0000000	0.0000000		0.0000000	x			x	x		x		x		
237	V	Air	kg	0.0000161	0.0000156		0.0000140		0.0000000		0.0000000	x			0.0000000		0.0000000	
238	vinyl chloride	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
239	water	Air	kg	0.0269130	0.0269130		0.0075212		0.0193920	x		x		x		x		
240	xylene	Air	kg	0.0000400	0.0000388		0.0000362		0.0000001		0.0000000	x			0.0000000		0.0000000	
241	Zn	Air	kg	0.0000040	0.0000039		0.0000035		0.0000002		0.0000000	x			0.0000000		0.0000000	
242	Zr	Air	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
243	1,1-dichloroethene	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
244	1,1,1-trichloroethane	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
245	acenafthylene	Water	kg	0.0000001	0.0000001		0.0000001		0.0000000		0.0000000	x		x		x		
246	Acid as H+	Water	kg	0.0002388	0.0002387		0.0002386		0.0000000		0.0000000		0.0000001		0.0000000		0.0000000	
247	acid organic (as C)	Water	kg	0.0002509	0.0002509		0.0002251		0.0000011		0.0000000	x		x		x		
248	Ag	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
249	Al	Water	kg	0.0031112	0.0029697		0.0028585		0.0000000		0.0000000		0.0000000		0.0000002		0.0000023	
250	alkenes	Water	kg	0.0000001	0.0000001		0.0000001		0.0000000		0.0000000	x			0.0000000		0.0000000	
251	AOCl	Water	kg	0.0000002	0.0000002		0.0000002		0.0000000		0.0000000	x		x		x		
252	AOX	Water	kg	0.0000002	0.0000002		0.0000002		0.0000000		0.0000000	x			0.0000000		0.0000000	
253	As	Water	kg	0.0000063	0.0000060		0.0000058		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
254	asbestos	Water	kg	0.0000009	0.0000009		0.0000009		0.0000000		0.0000000	x		x		x		
255	B	Water	kg	0.0000067	0.0000065		0.0000062		0.0000000		0.0000000	x			0.0000000		0.0000000	
256	Ba	Water	kg	0.0003888	0.0003766		0.0003529		0.0000005		0.0000000	x			0.0000000		0.0000001	
257	baryte	Water	kg	0.0011199	0.0010984		0.0009824		0.0000049		0.0000002	x			0.0000000		0.0000003	
258	Be	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
259	benzene	Water	kg	0.0000075	0.0000075		0.0000067		0.0000000		0.0000000	x			0.0000000		0.0000000	
260	BOD	Water	kg	0.0000087	0.0000086		0.0000076		0.0000001		0.0000000		0.0000002		0.0000000		0.0000000	
261	Br	Water	kg	0.0000134	0.0000134		0.0000134		0.0000000		0.0000000	x		x		x		
262	Ca	Water	kg	0.0045542	0.0045542		0.0042492		0.0000080		0.0000003		0.0000000		0.0000002		0.0000009	
263	calcium compounds	Water	kg	0.0001381	0.0000065		0.0000065		0.0000000		0.0000000	x		x		x		
264	carbonate	Water	kg	0.0000000	0.0000000		0.0000000	x			x		0.0000000	x		x		
265	Cd	Water	kg	0.0000002	0.0000002		0.0000002		0.0000000		0.0000000	x			0.0000000		0.0000000	
266	Ce	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
267	chlorate ion (ClO3-)	Water	kg	0.0001250	0.0001250		0.0001249		0.0000000		0.0000000	x		x		x		
268	chlorobenzene	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
269	chromate	Water	kg	0.0000000	0.0000000		0.0000000	x			x		0.0000000	x		x		
270	Cl-	Water	kg	0.0536106	0.0524960		0.0484720		0.0001570		0.0000039		0.0000005		0.0000022		0.0000312	
271	Cl2	Water	kg	0.0000473	0.0000473		0.0000473		0.0000000		0.0000000		0.0000000	x		x		
272	Co	Water	kg	0.0000062	0.0000059		0.0000057		0.0000000		0.0000000	x			0.0000000		0.0000000	
273	COD	Water	kg	0.0002158	0.0002150		0.0001950		0.0000008		0.0000010		0.0000003		0.0000000		0.0000000	
274	Cr	Water	kg	0.0000311	0.0000297		0.0000286		0.0000000		0.0000000	x			0.0000000		0.0000000	
275	Cr (III)	Water	kg	0.0000005	0.0000005		0.0000004		0.0000000		0.0000000	x		x		x		
276	Cr (VI)	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
277	Cs	Water	kg	0.0000001	0.0000001		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
278	Cu	Water	kg	0.0000156	0.0000149		0.0000144		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
279	CxHy	Water	kg	0.0001881	0.0001783		0.0001558		0.0000000		0.0000000		0.0000001		0.0000000		0.0000002	
280	CxHy aliphatic	Water	kg	0.0000009	0.0000009		0.0000008		0.0000000		0.0000000	x			0.0000000		0.0000000	
281	CxHy aromatic	Water	kg	0.0000345	0.0000343		0.0000306		0.0000001		0.0000000	x			0.0000000		0.0000000	
282	CxHy chloro	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
283	cyanide	Water	kg	0.0000006	0.0000006		0.0000006		0.0000000		0.0000000		0.0000000		0.0000000		0.0000000	
284	detergent/oil	Water	kg	0.0000001	0.0000001		0.0000000	x			x		0.0000001	x		x		
285	di(2-ethylhexyl)phthalate	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
286	dibutylphthalate	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
287	dichloroethane	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x			0.0000000		0.0000000	
288	dichloromethane	Water	kg	0.0000004	0.0000004		0.0000004		0.0000000		0.0000000	x			0.0000000		0.0000000	
289	dimethylphthalate	Water	kg	0.0000000	0.0000000		0.0000000		0.0000000		0.0000000	x		x		x		
290	dissolved organics	Water	kg	0.0000007	0.0000000		0.0000000	x			x		0.0000000	x		x		
291	dissolved substances	Water	kg	0.0014539	0.0013938		0.0013438		0.0000012		0.0000001		0.0000005		0.0000001		0.0000002	

Figure 2 - LCI Inventory of Data for 1kg of Aluminium (Cont'd)

LCI data (1 kg aluminium extrusion profile + anodising)

No	Substance	Compartment	Unit	Total Amounts	ref.	LCI 1 Aluminium ingot primary / 30%	LCI 2 Wood spruce (70% (MCdry 12%)	LCI 3 Steel rolled (BOF)	LCI 4 cold HDPE A	LCI 5 Electr. hydro UCPTE	LCI 6 Electr. nuclear UCPTE
292	DOC	Water	kg	0.0000076		0.0000076	0.0000068	0.0000001	0.0000000	x	0.0000000
293	ethyl benzene	Water	kg	0.0000014		0.0000014	0.0000012	0.0000000	0.0000000	x	0.0000000
294	Fe	Water	kg	0.0011653		0.0011206	0.0009633	0.0000006	0.0000000	0.0000000	0.0000001
295	fluoride ions	Water	kg	0.0000113		0.0000109	0.0000103	0.0000000	0.0000000	0.0000000	0.0000000
296	formaldehyde	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000
297	glutaraldehyde	Water	kg	0.0000001		0.0000001	0.0000001	0.0000000	0.0000000	x	0.0000000
298	H2S	Water	kg	0.0000001		0.0000001	0.0000001	0.0000000	0.0000000	x	0.0000000
299	heat losses	Water	MJ	(15.95300)		(15.95300)	(15.84800)	x	0.0000480	x	(0.4791900)
300	hexachloroethane	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
301	Hg	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
302	HOCL	Water	kg	0.0000139		0.0000134	0.0000124	0.0000000	0.0000000	x	0.0000000
303	hydroxy (ions)	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
304	I	Water	kg	0.0000057		0.0000056	0.0000050	0.0000000	0.0000000	x	0.0000000
305	K	Water	kg	0.0012084		0.0011643	0.0011019	0.0000010	0.0000000	0.0000000	0.0000001
306	Kjeldahl-N	Water	kg	0.0000179		0.0000179	0.0000160	0.0000001	0.0000001	x	x
307	metallic ions	Water	kg	0.0727205		0.0000005	0.0000005	0.0000000	0.0000000	0.0000001	x
308	Mg	Water	kg	0.0027167		0.0025973	0.0024945	0.0000005	0.0000000	0.0000000	0.0000002
309	Mn	Water	kg	0.0000704		0.0000674	0.0000645	0.0000000	0.0000000	x	0.0000000
310	Mo	Water	kg	0.0000089		0.0000086	0.0000082	0.0000000	0.0000000	x	0.0000000
311	MTBE	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
312	Na	Water	kg	0.0218629		0.0216270	0.0194850	0.0000966	0.0000022	0.0000005	0.0000008
313	NH3	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
314	NH4+	Water	kg	0.0000822		0.0000822	0.0000737	0.0000003	0.0000000	0.0000000	x
315	Ni	Water	kg	0.0000266		0.0000151	0.0000146	0.0000000	0.0000000	0.0000000	0.0000000
316	nitrate	Water	kg	0.0001192		0.0001160	0.0001085	0.0000005	0.0000000	0.0000000	0.0000000
317	nitrite	Water	kg	0.0000001		0.0000001	0.0000001	0.0000000	0.0000000	x	x
318	nitrogen	Water	kg	0.0001323		0.0001323	0.0001185	0.0000004	0.0000000	0.0000000	0.0000000
319	o-xylene	Water	kg	0.0000053		0.0000053	0.0000048	0.0000000	0.0000000	x	0.0000000
320	oil	Water	kg	0.0009178		0.0009178	0.0008231	0.0000040	0.0000001	x	0.0000000
321	oil (animal/vegetable)	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
322	olefines	Water	kg	0.0000006		0.0000006	0.0000005	0.0000000	0.0000000	x	x
323	other organics	Water	kg	0.0000176		0.0000176	0.0000158	0.0000001	0.0000000	0.0000000	x
324	P	Water	kg	0.0000005		0.0000005	0.0000004	0.0000000	0.0000000	x	0.0000000
325	P2O5	Water	kg	0.0000000		0.0000000	0.0000000	x	x	0.0000000	x
326	PAH's	Water	kg	0.0000149		0.0000149	0.0000148	0.0000000	0.0000000	x	0.0000000
327	Pb	Water	kg	0.0000171		0.0000164	0.0000157	0.0000000	0.0000000	0.0000000	0.0000000
328	phenol	Water	kg	0.0000076		0.0000076	0.0000068	0.0000000	0.0000000	0.0000000	0.0000000
329	phosphate	Water	kg	0.0001855		0.0001770	0.0001705	0.0000000	0.0000000	x	0.0000000
330	Ru	Water	kg	0.0000005		0.0000005	0.0000004	0.0000000	0.0000000	x	x
331	S	Water	kg	0.0000002		0.0000002	0.0000002	0.0000000	0.0000000	x	0.0000000
332	salt	Water	kg	0.0005292		0.0005195	0.0002488	0.0000013	0.0000001	x	0.0000002
333	Sb	Water	kg	0.0000001		0.0000001	0.0000000	0.0000000	0.0000000	x	0.0000000
334	Se	Water	kg	0.0000156		0.0000149	0.0000143	0.0000000	0.0000000	x	0.0000000
335	Si	Water	kg	0.0000002		0.0000002	0.0000002	0.0000000	0.0000000	x	0.0000000
336	Sn	Water	kg	0.0001080		0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000
337	SO3	Water	kg	0.0000001		0.0000000	0.0000000	0.0000000	0.0000000	x	x
338	Sr	Water	kg	0.0003812		0.0003775	0.0003398	0.0000013	0.0000000	x	0.0000000
339	sulphate	Water	kg	0.0569500		0.0202640	0.0189890	0.0000078	0.0000007	0.0000001	0.0000013
340	sulphide	Water	kg	0.0000030		0.0000030	0.0000028	0.0000000	0.0000000	0.0000000	0.0000000
341	suspended substances	Water	kg	0.0041938		0.0041245	0.0037437	0.0000154	0.0000017	0.0000029	0.0000001
342	Te	Water	kg	-		-	x	-	x	x	x
343	tetrachloroethene	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
344	tetrachloromethane	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
345	Ti	Water	kg	0.0001854		0.0001770	0.0001704	0.0000000	0.0000000	x	0.0000000
346	titanium(IV)oxide	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	x
347	TOC	Water	kg	0.0007650		0.0007153	0.0006464	0.0000023	0.0000001	x	0.0000000
348	toluene	Water	kg	0.0000063		0.0000062	0.0000056	0.0000000	0.0000000	x	0.0000000
349	tributyltin	Water	kg	0.0000001		0.0000001	0.0000001	0.0000000	0.0000000	x	0.0000000
350	trichloroethene	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000
351	trichloromethane	Water	kg	0.0000001		0.0000001	0.0000001	0.0000000	0.0000000	x	x
352	triethylene glycol	Water	kg	0.0000047		0.0000047	0.0000041	0.0000001	0.0000000	x	x
353	unspecified emission	Water	kg	0.0000142		0.0000142	0.0000142	x	x	x	x
354	V	Water	kg	0.0000160		0.0000153	0.0000147	0.0000000	0.0000000	x	0.0000000
355	vinyl chloride	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	x
356	W	Water	kg	0.0000000		0.0000000	0.0000000	0.0000000	0.0000000	x	0.0000000
357	Zn	Water	kg	0.0000320		0.0000305	0.0000294	0.0000000	0.0000000	0.0000000	0.0000000
358	Abfaelle-Inertst.dep	Solid	kg	0.0395650		0.0395650	0.0346740	0.0017480	0.0000095	x	x
359	Abfaelle-Reststst.dep	Solid	kg	0.0002927		0.0002927	0.0002618	0.0000084	0.0000002	x	x
360	asbestos	Solid	kg	0.0000020		0.0000020	0.0000020	0.0000000	0.0000000	x	x
361	Bauspgut-Inertst.dep	Solid	kg	0.0003161		0.0003161	0.0002735	0.0000047	0.0000004	x	x
362	Beton-Inertst.dep	Solid	kg	0.0012572		0.0012572	0.0011269	0.0000122	0.0000002	x	x
363	Bohrabfall-Landf	Solid	kg	0.0062469		0.0062469	0.0055929	0.0000334	0.0000011	x	x
364	Bohrabfall-Rstst.dep	Solid	kg	0.0104510		0.0104510	0.0093569	0.0000559	0.0000019	x	x
365	bottom ash (mswi)	Solid	kg	0.0007862		0.0007862	0.0002481	0.0005133	0.0000001	x	x
366	chemical waste (inert)	Solid	kg	0.0000008		0.0000008	0.0000000	x	x	0.0000008	x

Figure 3 - Regionalisation Process

The regionalisation process converts established European data into data based upon Hong Kong construction market conditions. Although there are many factors influencing the data only a few require direct adjustment.

The factors considered within the regionalisation process are therefore:

- Fuel Mix in the production location compared with European Database assumptions
- Transportation distances from production location to site
- Transportation mode from production location to site
- Manufacturing process adopted in production location compared with that in the European situation.

The above calculations are performed as follows:

- Fuel Mix adjustment using GEMIS database within Simapro
- Transportation distances from raw material extraction location to production facility in Guangdong and from Guangdong to a construction site in Hong Kong
- Transportation mode adjusted to road transportation from production facility to site
- Manufacturing process in the case of aluminium and glass found to be similar to European data assumptions therefore few revisions made.

Based upon the above adjustments a new set of LCI data is generated as illustrated in Figure 4 below.

Figure 4 - Regionalised LCI Data Set

Based upon the regionalisation process each of the chemicals and raw materials has an adjusted impact amount. Below is the LCI data set for Glass following the regionalisation process.

No	Substance	Compartment	Unit	Regionalised Amounts
1	bauxite	Raw	kg	0.00018591
2	chromium (in ore)	Raw	kg	0.00000920
3	Cl	Raw	kg	0.00000000
4	coal (18 MJ/kg) ETH	Raw	kg	0.02824403
5	coal (27.1 MJ/kg)	Raw	kg	0.00000000
6	coal (29.3 MJ/kg)	Raw	kg	0.01413800
7	coal ETH	Raw	kg	0.00190540
8	cobalt (in ore)	Raw	kg	0.00000000
9	copper (in ore)	Raw	kg	0.00002832
10	crude oil (41.9 MJ/kg)	Raw	kg	0.00000000
11	crude oil (42,6 MJ/kg) ETH	Raw	kg	0.10481000
12	crude oil ETH	Raw	kg	0.00773070
13	energy (undef.)	Raw	MJ	0.02130100
14	energy from hydro power	Raw	MJ	0.02169000
15	gas (35MJ/m3); from oil pro	Raw	m3	0.00715780
16	iron (in ore)	Raw	kg	0.00363610
17	lead (in ore)	Raw	kg	0.00004189
18	lignite (8.1 MJ/kg) ETH	Raw	kg	0.00459510
19	lignite ETH	Raw	kg	0.00109670
20	manganese (in ore)	Raw	kg	0.00000287
21	mining gas (30,3 MJ/kg) ETI	Raw	kg	0.00009561
22	molybdene (in ore)	Raw	kg	0.00000000
23	natural gas (35,0 MJ/m3) ET	Raw	m3	0.20015000
24	natural gas (vol)	Raw	m3	0.00000017
25	natural gas ETH	Raw	m3	0.00025806
26	nickel (in ore)	Raw	kg	0.00000561
27	palladium (in ore)	Raw	kg	0.00000000
28	petroleum gas ETH	Raw	m3	0.00052917
29	platinum (in ore)	Raw	kg	0.00000000
30	potential energy water ETH	Raw	MJ	0.00578280
31	rhenium (in ore)	Raw	kg	0.00000000
32	rhodium (in ore)	Raw	kg	0.00000000
33	silver (in ore)	Raw	kg	0.00000035
34	sulphur	Raw	kg	0.02467900
35	tin (in ore)	Raw	kg	0.00000020
36	turbine water ETH	Raw	m3	0.14174000
37	uranium (in ore)	Raw	kg	0.00000059
38	uranium (in ore) ETH	Raw	kg	0.00000008
39	water	Raw	kg	3.46800000
40	water l	Raw	m3	0.00396210
41	wood	Raw	kg	0.00026410
42	zinc (in ore)	Raw	kg	0.00000077
43	1,2-dichloroethane	Air	kg	0.00000000
44	acetaldehyde	Air	kg	0.00000003
45	acetic acid	Air	kg	0.00000059
46	acetone	Air	kg	0.00000003
47	acrolein	Air	kg	0.00000000
48	aldehydes	Air	kg	0.00000000
49	alkanes	Air	kg	0.00000021
50	alkenes	Air	kg	0.00000001
51	ammonia	Air	kg	0.00009142
52	As	Air	kg	0.00000002
53	Ba	Air	kg	0.00000001
54	Be	Air	kg	0.00000000
55	benzaldehyde	Air	kg	0.00000000
56	benzene	Air	kg	0.00000272
57	benzo(a)pyrene	Air	kg	0.00000000
58	butane	Air	kg	0.00001220
59	butene	Air	kg	0.00000063
60	Cd	Air	kg	0.00000001

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Regionalised Amounts
61	CFC-11	Air	kg	0.00000000
62	CFC-114	Air	kg	0.00000000
63	CFC-116	Air	kg	0.00000000
64	CFC-12	Air	kg	0.00000000
65	CFC-13	Air	kg	0.00000000
66	CFC-14	Air	kg	0.00000002
67	CFC (hard)	Air	kg	0.00000000
68	CO	Air	kg	0.00367190
69	CO2	Air	kg	0.02396800
70	CO2 (fossil)	Air	kg	1.25000000
71	cobalt	Air	kg	0.00000001
72	Cu	Air	kg	0.00000008
73	CxHy	Air	kg	0.00006389
74	CxHy aromatic	Air	kg	0.00000002
75	dichloromethane	Air	kg	0.00000000
76	dioxin (TEQ)	Air	kg	0.00000000
77	dust (PM10) mobile	Air	kg	0.00000926
78	dust (PM10) stationary	Air	kg	0.00000514
79	ethane	Air	kg	0.00002545
80	ethanol	Air	kg	0.00000006
81	ethene	Air	kg	0.00001418
82	ethylbenzene	Air	kg	0.00000031
83	ethyne	Air	kg	0.00000000
84	formaldehyde	Air	kg	0.00000095
85	H2S	Air	kg	0.00000149
86	HALON-1301	Air	kg	0.00000001
87	HCFC-22	Air	kg	0.00000000
88	HCl	Air	kg	0.00012163
89	heptane	Air	kg	0.00000202
90	hexachlorobenzene	Air	kg	0.00000000
91	hexane	Air	kg	0.00000423
92	HF	Air	kg	0.00004849
93	Hg	Air	kg	0.00000001
94	methane	Air	kg	0.00221210
95	methanol	Air	kg	0.00000006
96	methyl t-butyl ether	Air	kg	0.00000000
97	Mo	Air	kg	0.00000000
98	N2O	Air	kg	0.00001065
99	Ni	Air	kg	0.00000020
100	NO	Air	kg	0.00000007
101	non methane VOC	Air	kg	0.00009936
102	NOx	Air	kg	0.00731150
103	NOx (as NO2)	Air	kg	0.00021573
104	PAH's	Air	kg	0.00000006
105	Pb	Air	kg	0.00000018
106	pentachlorobenzene	Air	kg	0.00000000
107	pentachlorophenol	Air	kg	0.00000000
108	pentane	Air	kg	0.00001479
109	phenol	Air	kg	0.00000000
110	propane	Air	kg	0.00001411

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Regionalised Amounts
111	propene	Air	kg	0.00000048
112	propionaldehyde	Air	kg	0.00000000
113	propionic acid	Air	kg	0.00000006
114	Sb	Air	kg	0.00000000
115	Se	Air	kg	0.00000002
116	Sn	Air	kg	0.00000000
117	SO2	Air	kg	0.00531400
118	SOx (as SO2)	Air	kg	0.00058923
119	tetrachloromethane	Air	kg	0.00000000
120	Tl	Air	kg	0.00000000
121	toluene	Air	kg	0.00000194
122	trichloromethane	Air	kg	0.00000000
123	V	Air	kg	0.00000062
124	vinyl chloride	Air	kg	0.00000000
125	xylene	Air	kg	0.00000173
126	Zn	Air	kg	0.00000126
127	1,1,1-trichloroethane	Water	kg	0.00000000
128	As	Water	kg	0.00000001
129	Ba	Water	kg	0.00001437
130	Be	Water	kg	0.00000000
131	benzene	Water	kg	0.00000077
132	Cd	Water	kg	0.00000002
133	chlorobenzene	Water	kg	0.00000000
134	Co	Water	kg	0.00000001
135	Cr (III)	Water	kg	0.00000010
136	Cr (VI)	Water	kg	0.00000000
137	Cu	Water	kg	0.00000003
138	di(2-ethylhexyl)phthalate	Water	kg	0.00000000
139	dibutylphthalate	Water	kg	0.00000000
140	dichloromethane	Water	kg	0.00000006
141	dimethylphthalate	Water	kg	0.00000000
142	ethyl benzene	Water	kg	0.00000014
143	formaldehyde	Water	kg	0.00000000
144	Hg	Water	kg	0.00000000
145	metallic ions	Water	kg	0.00476290
146	Mo	Water	kg	0.00000003
147	Ni	Water	kg	0.00000004
148	o-xylene	Water	kg	0.00000051
149	PAH's	Water	kg	0.00000007
150	Pb	Water	kg	0.00000010
151	phenol	Water	kg	0.00000077
152	Sb	Water	kg	0.00000000
153	Se	Water	kg	0.00000002
154	Sn	Water	kg	0.00000000
155	tetrachloroethene	Water	kg	0.00000000
156	tetrachloromethane	Water	kg	0.00000000
157	toluene	Water	kg	0.00000063
158	tributyltin	Water	kg	0.00000001
159	trichloroethene	Water	kg	0.00000000
160	trichloromethane	Water	kg	0.00000000
161	V	Water	kg	0.00000003
162	vinyl chloride	Water	kg	0.00000000
163	Zn	Water	kg	0.00000016

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Regionalised Amounts
164	Abfaelle-Inertst.dep	Solid	kg	0.00776430
165	Abfaelle-Reststst.dep	Solid	kg	0.00009717
166	asbestos	Solid	kg	0.00000000
167	final waste (inert)	Solid	kg	0.00015018
168	fly ash	Solid	kg	0.00000508
169	produc. waste (not inert)	Solid	kg	0.00000514
170	solid waste	Solid	kg	0.06423800
171	toxic waste	Solid	kg	0.00059829
172	As (ind.)	Soil	kg	0.00000000
173	Cd (ind.)	Soil	kg	0.00000000
174	Co (ind.)	Soil	kg	0.00000000
175	Cr (ind.)	Soil	kg	0.00000000
176	Cu (ind.)	Soil	kg	0.00000000
177	Hg (ind.)	Soil	kg	0.00000000
178	Ni (ind.)	Soil	kg	0.00000000
179	Pb (ind.)	Soil	kg	0.00000000
180	Zn (ind.)	Soil	kg	0.00000001

Below is the LCI data set for aluminium following the regionalisation process.

No	Substance	Compartment	Unit	Amounts
1	bauxite	Raw	kg	3.7300000
2	chromium (in ore)	Raw	kg	0.0001170
3	Cl	Raw	kg	0.0000000
4	coal	Raw	kg	0.0000116
5	coal (18 MJ/kg) ETH	Raw	kg	3.2044000
6	coal (27.1 MJ/kg)	Raw	kg	0.0000000
7	coal (29.3 MJ/kg)	Raw	kg	0.0501490
8	coal ETH	Raw	kg	0.0056056
9	cobalt (in ore)	Raw	kg	0.0000000
10	copper (in ore)	Raw	kg	0.0002624
11	crude oil (41.9 MJ/kg)	Raw	kg	0.0000000
12	crude oil (42,6 MJ/kg) ETH	Raw	kg	1.5212000
13	crude oil (42,7 MJ/kg) IDEMAT	Raw (recovered)	kg	(0.0019100)
14	crude oil ETH	Raw	kg	0.0084420
15	crude oil IDEMAT	Raw	kg	0.1451900
16	energy (undef.)	Raw	MJ	0.4537000
17	energy from biomass	Raw	MJ	0.0000425
18	energy from coal	Raw	MJ	0.0000048
19	energy from coal (28,0 MJ/kg)	Raw	MJ	0.0034400
20	energy from hydro power	Raw	MJ	37.4470000

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Amounts
21	energy from hydrogen	Raw	MJ	0.0002102
22	energy from lignite	Raw	MJ	0.0000000
23	energy from lignite (15,0MJ/kg)	Raw	MJ	0.0001447
24	energy from natural gas	Raw	MJ	0.0000000
25	energy from natural gas (38,8MJ/m3)	Raw	MJ	0.0334320
26	energy from oil	Raw	MJ	0.0000191
27	energy from oil (45,0MJ/kg)	Raw	MJ	0.0693480
28	energy from peat	Raw	MJ	0.0000033
29	energy from sulphur (9,3MJ/kg)	Raw	MJ	0.0000042
30	energy from U (451000MJ/kg)	Raw	MJ	0.0046643
31	energy from uranium	Raw	MJ	0.0000000
32	energy from wood	Raw	MJ	0.0000000
33	energy recovered	Raw	MJ	(0.0008890)
34	gas (35MJ/m3); from oil production	Raw	m3	0.1006600
35	iron (in ore)	Raw	kg	0.0368000
36	iron (ore)	Raw	kg	0.0209000
37	lead (in ore)	Raw	kg	0.0000921
38	lignite (8.1 MJ/kg) ETH	Raw	kg	0.0674200
39	lignite ETH	Raw	kg	0.0012099
40	manganese (in ore)	Raw	kg	0.0000492
41	mercury (in ore)	Raw	kg	0.0003204
42	mining gas (30,3 MJ/kg) ETH	Raw	kg	0.0211480
43	molybdene (in ore)	Raw	kg	0.0000000
44	natural gas	Raw	kg	0.0640020
45	natural gas (35,0 MJ/m3) ETH	Raw	m3	0.5629800
46	natural gas (vol)	Raw	m3	0.0000152
47	natural gas ETH	Raw	m3	0.0021974
48	nickel (in ore)	Raw	kg	0.0000640
49	palladium (in ore)	Raw	kg	0.0000000
50	petroleum gas ETH	Raw	m3	0.0005590
51	platinum (in ore)	Raw	kg	0.0000000
52	potential energy water ETH	Raw	MJ	0.0061079
53	rhenium (in ore)	Raw	kg	0.0000000
54	rhodium (in ore)	Raw	kg	0.0000000
55	silver	Raw	kg	0.0000000
56	silver (in ore)	Raw	kg	0.0000048
57	sulphur (bonded)	Raw	kg	0.0000002
58	sulphur (elemental)	Raw	kg	0.0000005
59	tin (in ore)	Raw	kg	0.0000027
60	turbine water ETH	Raw	m3	0.6334700
61	uranium (in ore)	Raw	kg	0.0000778
62	uranium (in ore) ETH	Raw	kg	0.0000001
63	water	Raw	kg	296.0000000
64	water (cooling)	Raw	kg	0.0481000
65	water (drinking, for process.)	Raw	kg	0.0040600
66	water (process)	Raw	kg	1.0200000
67	water (sea, for cooling)	Raw	kg	0.0246000
68	water (sea, for processing)	Raw	kg	0.0001450
69	water (surface, for cooling)	Raw	kg	0.0002990
70	water (surface, for process.)	Raw	kg	0.0000030
71	water (well, for cooling)	Raw	kg	0.0000038
72	water (well, for processing)	Raw	kg	0.0000001
73	water barrage (vol)	Raw	m3	0.0025000
74	water l	Raw	m3	0.0004670
75	wood	Raw	kg	0.0325000

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Amounts
76	wood (spruce european)	Raw	kg	0.0879000
77	zinc (in ore)	Raw	kg	0.0000038
78	1,2-dichloroethane	Air	kg	0.0000000
79	acetaldehyde	Air	kg	0.0000012
80	acetic acid	Air	kg	0.0000065
81	acetone	Air	kg	0.0000012
82	acrolein	Air	kg	0.0000000
83	aldehydes	Air	kg	0.0000001
84	alkanes	Air	kg	0.0000183
85	alkenes	Air	kg	0.0000108
86	ammonia	Air	kg	0.0000276
87	As	Air	kg	0.0000004
88	Ba	Air	kg	0.0000021
89	Be	Air	kg	0.0000000
90	benzaldehyde	Air	kg	0.0000000
91	benzene	Air	kg	0.0000191
92	benzo(a)pyrene	Air	kg	0.0000000
93	butane	Air	kg	0.0001300
94	butene	Air	kg	0.0000040
95	Cd	Air	kg	0.0000001
96	CFC-11	Air	kg	0.0000000
97	CFC-114	Air	kg	0.0000000
98	CFC-116	Air	kg	0.0000000
99	CFC-12	Air	kg	0.0000000
100	CFC-13	Air	kg	0.0000000
101	CFC-14	Air	kg	0.0000003

102 CFC (hard)	Air	kg	0.0000000	
103 CFC (soft)	Air	kg	0.0000000	
104 CO	Air	kg	0.0642000	
105 CO2	Air	kg	0.5010000	
106 CO2 (fossil)	Air	kg		11.9000000
107 cobalt	Air	kg	0.0000004	
108 CS2	Air	kg	0.0000000	
109 Cu	Air	kg	0.0000020	
110 CxHy	Air	kg	0.0017700	
111 CxHy aromatic	Air	kg	0.0000003	
112 CxHy chloro	Air	kg	0.0000000	
113 dichloromethane	Air	kg	0.0000000	
114 dioxin (TEQ)	Air	kg	0.0000000	
115 dust (PM10) mobile	Air	kg	0.0000098	
116 dust (PM10) stationary	Air	kg	0.0000054	
117 ethane	Air	kg	0.0001020	
118 ethanol	Air	kg	0.0000023	
119 ethene	Air	kg	0.0000487	

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Amounts
120	ethylbenzene	Air	kg	0.0000135
121	ethyne	Air	kg	0.0000002
122	formaldehyde	Air	kg	0.0000174
123	H2S	Air	kg	0.0000079
124	HALON-1301	Air	kg	0.0000001
125	HCFC-22	Air	kg	0.0000000
126	HCl	Air	kg	0.0012400
127	heptane	Air	kg	0.0000274
128	hexachlorobenzene	Air	kg	0.0000000
129	hexane	Air	kg	0.0000575
130	HF	Air	kg	0.0001504
131	HFC-134a	Air	kg	0.0000000
132	Hg	Air	kg	0.0000002
133	metals	Air	kg	0.0000014
134	methane	Air	kg	0.0309000
135	methanol	Air	kg	0.0000024
136	methyl t-butyl ether	Air	kg	0.0000000
137	Mo	Air	kg	0.0000002
138	N2O	Air	kg	0.0002420
139	Ni	Air	kg	0.0000052
140	NO	Air	kg	0.0000032
141	NO2	Air	kg	0.0000000
142	non methane VOC	Air	kg	0.0001350
143	NOx	Air	kg	0.0353000
144	NOx (as NO2)	Air	kg	0.0002279
145	PAH's	Air	kg	0.0000399
146	Pb	Air	kg	0.0000017
147	PCB's	Air	kg	0.0000000
148	pentachlorobenzene	Air	kg	0.0000000
149	pentachlorophenol	Air	kg	0.0000000
150	pentane	Air	kg	0.0001660
151	phenol	Air	kg	0.0000000
152	propane	Air	kg	0.0001360
153	propene	Air	kg	0.0000067
154	propionaldehyde	Air	kg	0.0000000
155	propionic acid	Air	kg	0.0000002
156	Sb	Air	kg	0.0000000
157	Se	Air	kg	0.0000009
158	Sn	Air	kg	0.0000001
159	SO2	Air	kg	0.0754910
160	SOx	Air	kg	0.0000168
161	SOx (as SO2)	Air	kg	0.0038600
162	styrene	Air	kg	0.0000000
163	tetrachloromethane	Air	kg	0.0000000
164	Tl	Air	kg	0.0000000
165	toluene	Air	kg	0.0000249
166	trichloromethane	Air	kg	0.0000000
167	V	Air	kg	0.0000214
168	vinyl chloride	Air	kg	0.0000000
169	VOC	Air	kg	0.0000245
170	xylene	Air	kg	0.0000588

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Amounts
171	Zn	Air	kg	0.0000058
172	1,1,1-trichloroethane	Water	kg	0.0000000
173	As	Water	kg	0.0000097
174	Ba	Water	kg	0.0005702
175	Be	Water	kg	0.0000000
176	benzene	Water	kg	0.0000102
177	butylbenzylphthalate	Water	kg	0.0000000
178	Cd	Water	kg	0.0000004
179	chlorobenzene	Water	kg	0.0000000
180	Co	Water	kg	0.0000095
181	Cr (III)	Water	kg	0.0000007
182	Cr (VI)	Water	kg	0.0000000
183	Cu	Water	kg	0.0000239
184	di(2-ethylhexyl)phthalate	Water	kg	0.0000000
185	dibutylphthalate	Water	kg	0.0000000
186	dichloromethane	Water	kg	0.0000006
187	dimethylphthalate	Water	kg	0.0000000
188	ethyl benzene	Water	kg	0.0000019
189	formaldehyde	Water	kg	0.0000000
190	Hg	Water	kg	0.0000000
191	metallic ions	Water	kg	0.0727210
192	Mo	Water	kg	0.0000135
193	Ni	Water	kg	0.0000348
194	o-xylene	Water	kg	0.0000072
195	PAH's	Water	kg	0.0000212
196	Pb	Water	kg	0.0000258
197	phenol	Water	kg	0.0000102
198	Sb	Water	kg	0.0000001
199	Se	Water	kg	0.0000239
200	Sn	Water	kg	0.0001081
201	styrene	Water	kg	0.0000000
202	tetrachloroethene	Water	kg	0.0000000
203	tetrachloromethane	Water	kg	0.0000000
204	toluene	Water	kg	0.0000085
205	tributyltin	Water	kg	0.0000002
206	trichloroethene	Water	kg	0.0000000
207	trichloromethane	Water	kg	0.0000001
208	V	Water	kg	0.0000244
209	vinyl chloride	Water	kg	0.0000000
210	Zn	Water	kg	0.0000486
211	Abfaelle-Inertst.dep	Solid	kg	0.0465830
212	Abfaelle-Reststst.dep	Solid	kg	0.0003628
213	asbestos	Solid	kg	0.0000028
214	chemical waste (inert)	Solid	kg	0.0000008
215	chemical waste (regulated)	Solid	kg	0.0000109
216	construction waste	Solid	kg	0.0000004
217	dross	Solid	kg	0.0021189
218	dust - not specified	Solid	kg	0.0053600
219	final waste (inert)	Solid	kg	1.3156000
220	fly ash	Solid	kg	0.0000858
221	industrial waste	Solid	kg	0.0000041
222	inorganic general	Solid	kg	0.0000000
223	metal scrap	Solid	kg	0.0000000

Figure 4 - Regionalised LCI Data Set (Cont'd)

No	Substance	Compartment	Unit	Amounts
224	mineral waste	Solid	kg	0.0003003
225	oil	Solid	kg	0.0019451
226	paper/board packaging	Solid	kg	0.0000000
227	plastics packaging	Solid	kg	0.0000000
228	process waste	Solid	kg	0.0025064
229	prod. waste unspecified	Solid	kg	0.0007265
230	produc. waste (not inert)	Solid	kg	0.0560150
231	slag	Solid	kg	0.0000932
232	slags/ash	Solid	kg	0.0651730
233	sludge	Solid	kg	0.0000103
234	solid waste	Solid	kg	0.1442100
235	toxic waste	Solid	kg	1.0654000
236	unspecified	Solid	kg	0.0000016
237	waste in incineration	Solid	kg	0.0000000
238	waste to recycling	Solid	kg	0.0000000
239	wood packaging	Solid	kg	0.0000000
240	zinc	Solid	kg	0.0000000
241	As (ind.)	Soil	kg	0.0000000
242	Cd (ind.)	Soil	kg	0.0000000
243	Co (ind.)	Soil	kg	0.0000000
244	Cr (ind.)	Soil	kg	0.0000000
245	Cu (ind.)	Soil	kg	0.0000000
246	Hg (ind.)	Soil	kg	0.0000000
247	Ni (ind.)	Soil	kg	0.0000000
248	Pb (ind.)	Soil	kg	0.0000000
249	Zn (ind.)	Soil	kg	0.0000000

Figure 5 - Characterisation of Regionalised LCI Data Set

The Characterisation process comprises the allocation of each chemical / element within a material to the 10 environmental impacts. In the case of Glass there are 180 chemicals / elements and for aluminium there are 249. Below is an illustration of the allocation process the characterization factors are derived from data within Simapro depending upon the database being used for the individual impact.

Characterisation (Aluminium - anodised)

				Impact Category	Energy	Energy
				Characterisation method	IVAM (energy)	
				Characterisation units		MJ
				Totals		238.3
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
1	bauxite	Raw	kg	3.730000		
2	chromium (in ore)	Raw	kg	0.000117		
3	Cl	Raw	kg	0.000000		
4	coal	Raw	kg	0.000012	29.30	0.000340
5	coal (18 MJ/kg) ETH	Raw	kg	3.204400	18.00	57.679200
6	coal (27.1 MJ/kg)	Raw	kg	0.000000	27.10	0.000000
7	coal (29.3 MJ/kg)	Raw	kg	0.050149	29.30	1.469366
8	coal ETH	Raw	kg	0.005606	18.00	0.100901
9	cobalt (in ore)	Raw	kg	0.000000		
10	copper (in ore)	Raw	kg	0.000262		
11	crude oil (41.9 MJ/kg)	Raw	kg	0.000000	41.90	0.000000
12	crude oil (42,6 MJ/kg) ETH	Raw	kg	1.521200	42.60	64.803120
13	crude oil (42,7 MJ/kg) IDEMAT	Raw (recovered)	kg	(0.001910)	42.70	(0.081557)
14	crude oil ETH	Raw	kg	0.008442	42.60	0.359629
15	crude oil IDEMAT	Raw	kg	0.145190	42.70	6.199613
16	energy (undef.)	Raw	MJ	0.453700	1.00	0.453700
17	energy from biomass	Raw	MJ	0.000043	1.00	0.000043
18	energy from coal	Raw	MJ	0.000005	1.00	0.000005
19	energy from coal (28,0 MJ/kg)	Raw	MJ	0.003440	1.00	0.003440
20	energy from hydro power	Raw	MJ	37.447000	1.00	37.447000
21	energy from hydrogen	Raw	MJ	0.000210	1.00	0.000210
22	energy from lignite	Raw	MJ	0.000000	1.00	0.000000
23	energy from lignite (15,0MJ/kg)	Raw	MJ	0.000145	1.00	0.000145
24	energy from natural gas	Raw	MJ	0.000000	1.00	0.000000
25	energy from natural gas (38,8MJ/m3)	Raw	MJ	0.033432	1.00	0.033432
26	energy from oil	Raw	MJ	0.000019	1.00	0.000019
27	energy from oil (45,0MJ/kg)	Raw	MJ	0.069348	1.00	0.069348
28	energy from peat	Raw	MJ	0.000003	1.00	0.000003
29	energy from sulphur (9,3MJ/kg)	Raw	MJ	0.000004	1.00	0.000004
30	energy from U (451000MJ/kg)	Raw	MJ	0.004664	1.00	0.004664
31	energy from uranium	Raw	MJ	0.000000	1.00	0.000000
32	energy from wood	Raw	MJ	0.000000	1.00	0.000000
33	energy recovered	Raw	MJ	(0.000889)	1.00	(0.000889)
34	gas (35MJ/m3); from oil production	Raw	m3	0.100660	35.00	3.523100
35	iron (in ore)	Raw	kg	0.036800		
36	iron (ore)	Raw	kg	0.020900		
37	lead (in ore)	Raw	kg	0.000092		
38	lignite (8.1 MJ/kg) ETH	Raw	kg	0.067420	8.00	0.539360
39	lignite ETH	Raw	kg	0.001210	8.10	0.009800
40	manganese (in ore)	Raw	kg	0.000049		
41	mercury (in ore)	Raw	kg	0.000320		
42	mining gas (30,3 MJ/kg) ETH	Raw	kg	0.021148	30.30	0.640784
43	molybdene (in ore)	Raw	kg	0.000000		
44	natural gas	Raw	kg	0.064002	30.30	1.939261
45	natural gas (35,0 MJ/m3) ETH	Raw	m3	0.562980	35.00	19.704300
46	natural gas (vol)	Raw	m3	0.000015	35.00	0.000532
47	natural gas ETH	Raw	m3	0.002197	35.00	0.076909
48	nickel (in ore)	Raw	kg	0.000064		
49	palladium (in ore)	Raw	kg	0.000000		
50	petroleum gas ETH	Raw	m3	0.000559		
51	platinum (in ore)	Raw	kg	0.000000		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

No	Substance	Compartment	Unit	Impact Category	Energy	Energy
				Characterisation method	IVAM (energy)	
				Characterisation units		MJ
				Totals		238.3
				Amounts	Chacterisation factor	
52	potential energy water ETH	Raw	MJ	0.006108	1.00	0.006108
53	rhenium (in ore)	Raw	kg	0.000000		
54	rhodium (in ore)	Raw	kg	0.000000		
55	silver	Raw	kg	0.000000		
56	silver (in ore)	Raw	kg	0.000005		
57	sulphur (bonded)	Raw	kg	0.000000		
58	sulphur (elemental)	Raw	kg	0.000000		
59	tin (in ore)	Raw	kg	0.000003		
60	turbine water ETH	Raw	m3	0.633470	10.00	6.334700
61	uranium (in ore)	Raw	kg	0.000078	451,000.00	35.087800
62	uranium (in ore) ETH	Raw	kg	0.000000	451,000.00	0.036309
63	water	Raw	kg	296.000000		
64	water (cooling)	Raw	kg	0.048100		
65	water (drinking, for process.)	Raw	kg	0.004060		
66	water (process)	Raw	kg	1.020000		
67	water (sea, for cooling)	Raw	kg	0.024600		
68	water (sea, for processing)	Raw	kg	0.000145		
69	water (surface, for cooling)	Raw	kg	0.000299		
70	water (surface, for process.)	Raw	kg	0.000003		
71	water (well, for cooling)	Raw	kg	0.000004		
72	water (well, for processing)	Raw	kg	0.000000		
73	water barrage (vol)	Raw	m3	0.002500	10.00	0.025000
74	water l	Raw	m3	0.000467		
75	wood	Raw	kg	0.032500	15.00	0.487500
76	wood (spruce european)	Raw	kg	0.087900	15.00	1.318500
77	zinc (in ore)	Raw	kg	0.000004		
78	1,2-dichloroethane	Air	kg	0.000000		
79	acetaldehyde	Air	kg	0.000001		
80	acetic acid	Air	kg	0.000006		
81	acetone	Air	kg	0.000001		
82	acrolein	Air	kg	0.000000		
83	aldehydes	Air	kg	0.000000		
84	alkanes	Air	kg	0.000018		
85	alkenes	Air	kg	0.000011		
86	ammonia	Air	kg	0.000028		
87	As	Air	kg	0.000000		
88	Ba	Air	kg	0.000002		
89	Be	Air	kg	0.000000		
90	benzaldehyde	Air	kg	0.000000		
91	benzene	Air	kg	0.000019		
92	benzo(a)pyrene	Air	kg	0.000000		
93	butane	Air	kg	0.000130		
94	butene	Air	kg	0.000004		
95	Cd	Air	kg	0.000000		
96	CFC-11	Air	kg	0.000000		
97	CFC-114	Air	kg	0.000000		
98	CFC-116	Air	kg	0.000000		
99	CFC-12	Air	kg	0.000000		
100	CFC-13	Air	kg	0.000000		
101	CFC-14	Air	kg	0.000000		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

No	Substance	Compartment	Unit	Impact Category	Energy	Energy
				Characterisation method	IVAM (energy)	
				Characterisation units		MJ
				Totals		238.3
				Amounts	Chacterisation factor	
102	CFC (hard)	Air	kg	0.000000		
103	CFC (soft)	Air	kg	0.000000		
104	CO	Air	kg	0.064200		
105	CO2	Air	kg	0.501000		
106	CO2 (fossil)	Air	kg	11.900000		
107	cobalt	Air	kg	0.000000		
108	CS2	Air	kg	0.000000		
109	Cu	Air	kg	0.000002		
110	CxHy	Air	kg	0.001770		
111	CxHy aromatic	Air	kg	0.000000		
112	CxHy chloro	Air	kg	0.000000		
113	dichloromethane	Air	kg	0.000000		
114	dioxin (TEQ)	Air	kg	0.000000		
115	dust (PM10) mobile	Air	kg	0.000010		
116	dust (PM10) stationary	Air	kg	0.000005		
117	ethane	Air	kg	0.000102		
118	ethanol	Air	kg	0.000002		
119	ethene	Air	kg	0.000049		
120	ethylbenzene	Air	kg	0.000014		
121	ethyne	Air	kg	0.000000		
122	formaldehyde	Air	kg	0.000017		
123	H2S	Air	kg	0.000008		
124	HALON-1301	Air	kg	0.000000		
125	HCFC-22	Air	kg	0.000000		
126	HCl	Air	kg	0.001240		
127	heptane	Air	kg	0.000027		
128	hexachlorobenzene	Air	kg	0.000000		
129	hexane	Air	kg	0.000058		
130	HF	Air	kg	0.000150		
131	HFC-134a	Air	kg	0.000000		
132	Hg	Air	kg	0.000000		
133	metals	Air	kg	0.000001		
134	methane	Air	kg	0.030900		
135	methanol	Air	kg	0.000002		
136	methyl t-butyl ether	Air	kg	0.000000		
137	Mo	Air	kg	0.000000		
138	N2O	Air	kg	0.000242		
139	Ni	Air	kg	0.000005		
140	NO	Air	kg	0.000003		
141	NO2	Air	kg	0.000000		
142	non methane VOC	Air	kg	0.000135		
143	NOx	Air	kg	0.035300		
144	NOx (as NO2)	Air	kg	0.000228		
145	PAH's	Air	kg	0.000040		
146	Pb	Air	kg	0.000002		
147	PCB's	Air	kg	0.000000		
148	pentachlorobenzene	Air	kg	0.000000		
149	pentachlorophenol	Air	kg	0.000000		
150	pentane	Air	kg	0.000166		
151	phenol	Air	kg	0.000000		
152	propane	Air	kg	0.000136		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

No	Substance	Compartment	Unit	Impact Category	Energy	Energy
				Characterisation method	IVAM (energy)	
				Characterisation units		MJ
				Totals		238.3
				Amounts	Chacterisation factor	
153	propene	Air	kg	0.000007		
154	propionaldehyde	Air	kg	0.000000		
155	propionic acid	Air	kg	0.000000		
156	Sb	Air	kg	0.000000		
157	Se	Air	kg	0.000001		
158	Sn	Air	kg	0.000000		
159	SO2	Air	kg	0.075491		
160	SOx	Air	kg	0.000017		
161	SOx (as SO2)	Air	kg	0.003860		
162	styrene	Air	kg	0.000000		
163	tetrachloromethane	Air	kg	0.000000		
164	Tl	Air	kg	0.000000		
165	toluene	Air	kg	0.000025		
166	trichloromethane	Air	kg	0.000000		
167	V	Air	kg	0.000021		
168	vinyl chloride	Air	kg	0.000000		
169	VOC	Air	kg	0.000025		
170	xylene	Air	kg	0.000059		
171	Zn	Air	kg	0.000006		
172	1,1,1-trichloroethane	Water	kg	0.000000		
173	As	Water	kg	0.000010		
174	Ba	Water	kg	0.000570		
175	Be	Water	kg	0.000000		
176	benzene	Water	kg	0.000010		
177	butylbenzylphthalate	Water	kg	0.000000		
178	Cd	Water	kg	0.000000		
179	chlorobenzene	Water	kg	0.000000		
180	Co	Water	kg	0.000009		
181	Cr (III)	Water	kg	0.000001		
182	Cr (VI)	Water	kg	0.000000		
183	Cu	Water	kg	0.000024		
184	di(2-ethylhexyl)phthalate	Water	kg	0.000000		
185	dibutylphthalate	Water	kg	0.000000		
186	dichloromethane	Water	kg	0.000001		
187	dimethylphthalate	Water	kg	0.000000		
188	ethyl benzene	Water	kg	0.000002		
189	formaldehyde	Water	kg	0.000000		
190	Hg	Water	kg	0.000000		
191	metallic ions	Water	kg	0.072721		
192	Mo	Water	kg	0.000013		
193	Ni	Water	kg	0.000035		
194	o-xylene	Water	kg	0.000007		
195	PAH's	Water	kg	0.000021		
196	Pb	Water	kg	0.000026		
197	phenol	Water	kg	0.000010		
198	Sb	Water	kg	0.000000		
199	Se	Water	kg	0.000024		
200	Sn	Water	kg	0.000108		
201	styrene	Water	kg	0.000000		
202	tetrachloroethene	Water	kg	0.000000		
203	tetrachloromethane	Water	kg	0.000000		
204	toluene	Water	kg	0.000008		
205	tributyltin	Water	kg	0.000000		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

No	Substance	Compartment	Unit	Impact Category	Energy	Energy
				Characterisation method	IVAM (energy)	
				Characterisation units		MJ
				Totals		238.3
				Amounts	Chacterisation factor	
206	trichloroethene	Water	kg	0.000000		
207	trichloromethane	Water	kg	0.000000		
208	V	Water	kg	0.000024		
209	vinyl chloride	Water	kg	0.000000		
210	Zn	Water	kg	0.000049		
211	Abfaelle-Inertst.dep	Solid	kg	0.046583		
212	Abfaelle-Reststst.dep	Solid	kg	0.000363		
213	asbestos	Solid	kg	0.000003		
214	chemical waste (inert)	Solid	kg	0.000001		
215	chemical waste (regulated)	Solid	kg	0.000011		
216	construction waste	Solid	kg	0.000000		
217	dross	Solid	kg	0.002119		
218	dust - not specified	Solid	kg	0.005360		
219	final waste (inert)	Solid	kg	1.315600		
220	fly ash	Solid	kg	0.000086		
221	industrial waste	Solid	kg	0.000004		
222	inorganic general	Solid	kg	0.000000		
223	metal scrap	Solid	kg	0.000000		
224	mineral waste	Solid	kg	0.000300		
225	oil	Solid	kg	0.001945		
226	paper/board packaging	Solid	kg	0.000000		
227	plastics packaging	Solid	kg	0.000000		
228	process waste	Solid	kg	0.002506		
229	prod. waste unspecified	Solid	kg	0.000726		
230	produc. waste (not inert)	Solid	kg	0.056015		
231	slag	Solid	kg	0.000093		
232	slags/ash	Solid	kg	0.065173		
233	sludge	Solid	kg	0.000010		
234	solid waste	Solid	kg	0.144210		
235	toxic waste	Solid	kg	1.065400		
236	unspecified	Solid	kg	0.000002		
237	waste in incineration	Solid	kg	0.000000		
238	waste to recycling	Solid	kg	0.000000		
239	wood packaging	Solid	kg	0.000000		
240	zinc	Solid	kg	0.000000		
241	As (ind.)	Soil	kg	0.000000		
242	Cd (ind.)	Soil	kg	0.000000		
243	Co (ind.)	Soil	kg	0.000000		
244	Cr (ind.)	Soil	kg	0.000000		
245	Cu (ind.)	Soil	kg	0.000000		
246	Hg (ind.)	Soil	kg	0.000000		
247	Ni (ind.)	Soil	kg	0.000000		
248	Pb (ind.)	Soil	kg	0.000000		
249	Zn (ind.)	Soil	kg	0.000000		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

				Impact Category	Global warming	Global warming
				Characterisation method	CML 2 baseline 2000 (global warming)	
				Characterisation units		kg CO2 eq.
				Total		13.1
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
1	bauxite	Raw	kg	3.7300000		
2	chromium (in ore)	Raw	kg	0.0001170		
3	Cl	Raw	kg	0.0000000		
4	coal	Raw	kg	0.0000116		
5	coal (18 MJ/kg) ETH	Raw	kg	3.2044000		
6	coal (27.1 MJ/kg)	Raw	kg	0.0000000		
7	coal (29.3 MJ/kg)	Raw	kg	0.0501490		
8	coal ETH	Raw	kg	0.0056056		
9	cobalt (in ore)	Raw	kg	0.0000000		
10	copper (in ore)	Raw	kg	0.0002624		
11	crude oil (41.9 MJ/kg)	Raw	kg	0.0000000		
12	crude oil (42,6 MJ/kg) ETH	Raw	kg	1.5212000		
13	crude oil (42,7 MJ/kg) IDEMAT	Raw (recovered)	kg	(0.0019100)		
14	crude oil ETH	Raw	kg	0.0084420		
15	crude oil IDEMAT	Raw	kg	0.1451900		
16	energy (undef.)	Raw	MJ	0.4537000		
17	energy from biomass	Raw	MJ	0.0000425		
18	energy from coal	Raw	MJ	0.0000048		
19	energy from coal (28,0 MJ/kg)	Raw	MJ	0.0034400		
20	energy from hydro power	Raw	MJ	37.4470000		
21	energy from hydrogen	Raw	MJ	0.0002102		
22	energy from lignite	Raw	MJ	0.0000000		
23	energy from lignite (15,0MJ/kg)	Raw	MJ	0.0001447		
24	energy from natural gas	Raw	MJ	0.0000000		
25	energy from natural gas (38,8MJ/m3)	Raw	MJ	0.0334320		
26	energy from oil	Raw	MJ	0.0000191		
27	energy from oil (45,0MJ/kg)	Raw	MJ	0.0693480		
28	energy from peat	Raw	MJ	0.0000033		
29	energy from sulphur (9,3MJ/kg)	Raw	MJ	0.0000042		
30	energy from U (451000MJ/kg)	Raw	MJ	0.0046643		
31	energy from uranium	Raw	MJ	0.0000000		
32	energy from wood	Raw	MJ	0.0000000		
33	energy recovered	Raw	MJ	(0.0008890)		
34	gas (35MJ/m3); from oil production	Raw	m3	0.1006600		
35	iron (in ore)	Raw	kg	0.0368000		
36	iron (ore)	Raw	kg	0.0209000		
37	lead (in ore)	Raw	kg	0.0000921		
38	lignite (8.1 MJ/kg) ETH	Raw	kg	0.0674200		
39	lignite ETH	Raw	kg	0.0012099		
40	manganese (in ore)	Raw	kg	0.0000492		
41	mercury (in ore)	Raw	kg	0.0003204		
42	mining gas (30,3 MJ/kg) ETH	Raw	kg	0.0211480		
43	molybdene (in ore)	Raw	kg	0.0000000		
44	natural gas	Raw	kg	0.0640020		
45	natural gas (35,0 MJ/m3) ETH	Raw	m3	0.5629800		
46	natural gas (vol)	Raw	m3	0.0000152		
47	natural gas ETH	Raw	m3	0.0021974		
48	nickel (in ore)	Raw	kg	0.0000640		
49	palladium (in ore)	Raw	kg	0.0000000		
50	petroleum gas ETH	Raw	m3	0.0005590		
51	platinum (in ore)	Raw	kg	0.0000000		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

				Impact Category	Global warming	Global warming
				Characterisation method	CML 2 baseline 2000 (global warming)	
				Characterisation units		kg CO2 eq.
				Total		13.1
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
52	potential energy water ETH	Raw	MJ	0.0061079		
53	rhenium (in ore)	Raw	kg	0.0000000		
54	rhodium (in ore)	Raw	kg	0.0000000		
55	silver	Raw	kg	0.0000000		
56	silver (in ore)	Raw	kg	0.0000048		
57	sulphur (bonded)	Raw	kg	0.0000002		
58	sulphur (elemental)	Raw	kg	0.0000005		
59	tin (in ore)	Raw	kg	0.0000027		
60	turbine water ETH	Raw	m3	0.6334700		
61	uranium (in ore)	Raw	kg	0.0000778		
62	uranium (in ore) ETH	Raw	kg	0.0000001		
63	water	Raw	kg	296.0000000		
64	water (cooling)	Raw	kg	0.0481000		
65	water (drinking, for process.)	Raw	kg	0.0040600		
66	water (process)	Raw	kg	1.0200000		
67	water (sea, for cooling)	Raw	kg	0.0246000		
68	water (sea, for processing)	Raw	kg	0.0001450		
69	water (surface, for cooling)	Raw	kg	0.0002990		
70	water (surface, for process.)	Raw	kg	0.0000030		
71	water (well, for cooling)	Raw	kg	0.0000038		
72	water (well, for processing)	Raw	kg	0.0000001		
73	water barrage (vol)	Raw	m3	0.0025000		
74	water l	Raw	m3	0.0004670		
75	wood	Raw	kg	0.0325000		
76	wood (spruce european)	Raw	kg	0.0879000		
77	zinc (in ore)	Raw	kg	0.0000038		
78	1,2-dichloroethane	Air	kg	0.0000000		
79	acetaldehyde	Air	kg	0.0000012		
80	acetic acid	Air	kg	0.0000065		
81	acetone	Air	kg	0.0000012		
82	acrolein	Air	kg	0.0000000		
83	aldehydes	Air	kg	0.0000001		
84	alkanes	Air	kg	0.0000183		
85	alkenes	Air	kg	0.0000108		
86	ammonia	Air	kg	0.0000276		
87	As	Air	kg	0.0000004		
88	Ba	Air	kg	0.0000021		
89	Be	Air	kg	0.0000000		
90	benzaldehyde	Air	kg	0.0000000		
91	benzene	Air	kg	0.0000191		
92	benzo(a)pyrene	Air	kg	0.0000000		
93	butane	Air	kg	0.0001300		
94	butene	Air	kg	0.0000040		
95	Cd	Air	kg	0.0000001		
96	CFC-11	Air	kg	0.0000000	4,000.0000000	0.0000027
97	CFC-114	Air	kg	0.0000000	9,300.0000000	0.0001730
98	CFC-116	Air	kg	0.0000000	9,200.0000000	0.0003689
99	CFC-12	Air	kg	0.0000000	8,500.0000000	0.0000012
100	CFC-13	Air	kg	0.0000000	11,700.0000000	0.0000011
101	CFC-14	Air	kg	0.0000003	6,500.0000000	0.0021190

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

				Impact Category	Global warming	Global warming
				Characterisation method	CML 2 baseline 2000 (global warming)	
				Characterisation units		kg CO2 eq.
				Total		13.1
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
102	CFC (hard)	Air	kg	0.0000000		
103	CFC (soft)	Air	kg	0.0000000		
104	CO	Air	kg	0.0642000		
105	CO2	Air	kg	0.5010000	1.0000000	0.5010000
106	CO2 (fossil)	Air	kg	11.9000000	1.0000000	11.9000000
107	cobalt	Air	kg	0.0000004		
108	CS2	Air	kg	0.0000000		
109	Cu	Air	kg	0.0000020		
110	CxHy	Air	kg	0.0017700		
111	CxHy aromatic	Air	kg	0.0000003		
112	CxHy chloro	Air	kg	0.0000000		
113	dichloromethane	Air	kg	0.0000000	9.0000000	0.0000000
114	dioxin (TEQ)	Air	kg	0.0000000		
115	dust (PM10) mobile	Air	kg	0.0000098		
116	dust (PM10) stationary	Air	kg	0.0000054		
117	ethane	Air	kg	0.0001020		
118	ethanol	Air	kg	0.0000023		
119	ethene	Air	kg	0.0000487		
120	ethylbenzene	Air	kg	0.0000135		
121	ethyne	Air	kg	0.0000002		
122	formaldehyde	Air	kg	0.0000174		
123	H2S	Air	kg	0.0000079		
124	HALON-1301	Air	kg	0.0000001	5,600.0000000	0.0005466
125	HCFC-22	Air	kg	0.0000000	1,700.0000000	0.0000007
126	HCl	Air	kg	0.0012400		
127	heptane	Air	kg	0.0000274		
128	hexachlorobenzene	Air	kg	0.0000000		
129	hexane	Air	kg	0.0000575		
130	HF	Air	kg	0.0001504		
131	HFC-134a	Air	kg	0.0000000	1,300.0000000	0.0000000
132	Hg	Air	kg	0.0000002		
133	metals	Air	kg	0.0000014		
134	methane	Air	kg	0.0309000	21.0000000	0.6489000
135	methanol	Air	kg	0.0000024		
136	methyl t-butyl ether	Air	kg	0.0000000		
137	Mo	Air	kg	0.0000002		
138	N2O	Air	kg	0.0002420	310.0000000	0.0750200
139	Ni	Air	kg	0.0000052		
140	NO	Air	kg	0.0000032		
141	NO2	Air	kg	0.0000000		
142	non methane VOC	Air	kg	0.0001350		
143	NOx	Air	kg	0.0353000		
144	NOx (as NO2)	Air	kg	0.0002279		
145	PAH's	Air	kg	0.0000399		
146	Pb	Air	kg	0.0000017		
147	PCB's	Air	kg	0.0000000		
148	pentachlorobenzene	Air	kg	0.0000000		
149	pentachlorophenol	Air	kg	0.0000000		
150	pentane	Air	kg	0.0001660		
151	phenol	Air	kg	0.0000000		
152	propane	Air	kg	0.0001360		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

				Impact Category	Global warming	Global warming
				Characterisation method	CML 2 baseline 2000 (global warming)	
				Characterisation units		kg CO2 eq.
				Total		13.1
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
153	propene	Air	kg	0.0000067		
154	propionaldehyde	Air	kg	0.0000000		
155	propionic acid	Air	kg	0.0000002		
156	Sb	Air	kg	0.0000000		
157	Se	Air	kg	0.0000009		
158	Sn	Air	kg	0.0000001		
159	SO2	Air	kg	0.0754910		
160	SOx	Air	kg	0.0000168		
161	SOx (as SO2)	Air	kg	0.0038600		
162	styrene	Air	kg	0.0000000		
163	tetrachloromethane	Air	kg	0.0000000	1,400.0000000	0.0000021
164	Tl	Air	kg	0.0000000		
165	toluene	Air	kg	0.0000249		
166	trichloromethane	Air	kg	0.0000000	4.0000000	0.0000000
167	V	Air	kg	0.0000214		
168	vinyl chloride	Air	kg	0.0000000		
169	VOC	Air	kg	0.0000245		
170	xylene	Air	kg	0.0000588		
171	Zn	Air	kg	0.0000058		
172	1,1,1-trichloroethane	Water	kg	0.0000000		
173	As	Water	kg	0.0000097		
174	Ba	Water	kg	0.0005702		
175	Be	Water	kg	0.0000000		
176	benzene	Water	kg	0.0000102		
177	butylbenzylphthalate	Water	kg	0.0000000		
178	Cd	Water	kg	0.0000004		
179	chlorobenzene	Water	kg	0.0000000		
180	Co	Water	kg	0.0000095		
181	Cr (III)	Water	kg	0.0000007		
182	Cr (VI)	Water	kg	0.0000000		
183	Cu	Water	kg	0.0000239		
184	di(2-ethylhexyl)phthalate	Water	kg	0.0000000		
185	dibutylphthalate	Water	kg	0.0000000		
186	dichloromethane	Water	kg	0.0000006		
187	dimethylphthalate	Water	kg	0.0000000		
188	ethyl benzene	Water	kg	0.0000019		
189	formaldehyde	Water	kg	0.0000000		
190	Hg	Water	kg	0.0000000		
191	metallic ions	Water	kg	0.0727210		
192	Mo	Water	kg	0.0000135		
193	Ni	Water	kg	0.0000348		
194	o-xylene	Water	kg	0.0000072		
195	PAH's	Water	kg	0.0000212		
196	Pb	Water	kg	0.0000258		
197	phenol	Water	kg	0.0000102		
198	Sb	Water	kg	0.0000001		
199	Se	Water	kg	0.0000239		
200	Sn	Water	kg	0.0001081		
201	styrene	Water	kg	0.0000000		
202	tetrachloroethene	Water	kg	0.0000000		
203	tetrachloromethane	Water	kg	0.0000000		
204	toluene	Water	kg	0.0000085		
205	tributyltin	Water	kg	0.0000002		

Figure 5 - Characterisation of Regionalised LCI Data Set (Cont'd)

Characterisation (Aluminium - anodised)

				Impact Category	Global warming	Global warming
				Characterisation method	CML 2 baseline 2000 (global warming)	
				Characterisation units		kg CO2 eq.
				Total		13.1
No	Substance	Compartment	Unit	Amounts	Chacterisation factor	
206	trichloroethene	Water	kg	0.0000000		
207	trichloromethane	Water	kg	0.0000001		
208	V	Water	kg	0.0000244		
209	vinyl chloride	Water	kg	0.0000000		
210	Zn	Water	kg	0.0000486		
211	Abfaelle-Inertst.dep	Solid	kg	0.0465830		
212	Abfaelle-Reststst.dep	Solid	kg	0.0003628		
213	asbestos	Solid	kg	0.0000028		
214	chemical waste (inert)	Solid	kg	0.0000008		
215	chemical waste (regulated)	Solid	kg	0.0000109		
216	construction waste	Solid	kg	0.0000004		
217	dross	Solid	kg	0.0021189		
218	dust - not specified	Solid	kg	0.0053600		
219	final waste (inert)	Solid	kg	1.3156000		
220	fly ash	Solid	kg	0.0000858		
221	industrial waste	Solid	kg	0.0000041		
222	inorganic general	Solid	kg	0.0000000		
223	metal scrap	Solid	kg	0.0000000		
224	mineral waste	Solid	kg	0.0003003		
225	oil	Solid	kg	0.0019451		
226	paper/board packaging	Solid	kg	0.0000000		
227	plastics packaging	Solid	kg	0.0000000		
228	process waste	Solid	kg	0.0025064		
229	prod. waste unspecified	Solid	kg	0.0007265		
230	produc. waste (not inert)	Solid	kg	0.0560150		
231	slag	Solid	kg	0.0000932		
232	slags/ash	Solid	kg	0.0651730		
233	sludge	Solid	kg	0.0000103		
234	solid waste	Solid	kg	0.1442100		
235	toxic waste	Solid	kg	1.0654000		
236	unspecified	Solid	kg	0.0000016		
237	waste in incineration	Solid	kg	0.0000000		
238	waste to recycling	Solid	kg	0.0000000		
239	wood packaging	Solid	kg	0.0000000		
240	zinc	Solid	kg	0.0000000		
241	As (ind.)	Soil	kg	0.0000000		
242	Cd (ind.)	Soil	kg	0.0000000		
243	Co (ind.)	Soil	kg	0.0000000		
244	Cr (ind.)	Soil	kg	0.0000000		
245	Cu (ind.)	Soil	kg	0.0000000		
246	Hg (ind.)	Soil	kg	0.0000000		
247	Ni (ind.)	Soil	kg	0.0000000		
248	Pb (ind.)	Soil	kg	0.0000000		
249	Zn (ind.)	Soil	kg	0.0000000		

The above illustrations show the characterization process for energy and global warming for aluminium, the same process is carried out for all 10 impacts and for each material. Due to practical space constraints in this guide only the above are shown.

Figure 6 - Normalisation of LCI Data

Once the characterized data is established the impacts under each of the 10 environmental impacts are then totaled to give the overall impact value. Normalisation is the apportionment of these characterized totals in relation to the total impact of a Hong Kong Citizen in a year (Based upon information from the HK Census & Statistics Deparment). This process therefore takes two parts, firstly the normalization factors for Global, Regional and Local impacts are established, these are as set out in the table (Note: references to Climate Change and Global Warming throughout this guide should be read as the same).

	impacts	category	location	ref. Year	Total impacts	units	population	normalized impact values	Units	References for Impact figures
1	Energy	Local	HK	1999	762,337,092,000	MJ	6,610,000	115,330.88	MJ/person/year	references: World Bank - Hong Kong commercial energy use (17886 kt of oil equivalent)
2	Climate change	Local	HK	2000	39,503,000,000	kg	6,670,000	5,922.49	kg CO2 eq./person/year	Hong Kong Greenhouse Gas Emission Inventory, 2000,
3	Water Consumption	Local	HK	2000	924,130,000,000	litre	6,670,000	138,550.22	litre/person/year	Water Supplies Department, HK SAR Government, fresh water consumption, year 2000
4	Resource Depletion	Local	HK	1999	349,933,400	kg	6,610,000	52.94	kg/person/year	references: Census and Statistic Dept for oil, coal and natural gas consumption per capita figure 1999. For aluminium, lead, iron, copper, manganese, nikel, zinc and tin consumption per capita figure, refer to CML data.
5	Photochemical smog	Local	HK	2000	16,064,637	kg	6,670,000	2.41	kg ethene eq./person/year	Hong Kong Greenhouse Gas Emission Inventory, 2000, on NMVOC, CO and CH4 emission, normalized by CML 2 baseline characterisation method.
6	Ozone depletion	Local	HK	2000	165,000	kg	6,670,000	0.02	kg CFC-11 eq./person/year	Environmental Protection Department, HK SAR Government, CFC consumption and emission 2000
6	Acid rain	Local	HK	2000	129,935,400	kg	6,670,000	19.48	kg SO2 eq./person/year	Hong Kong Greenhouse Gas Emission Inventory, 2000, on SO2, ammonia and NOx emission, normalized by CML 2 baseline Characterisation Method.
7	Waste	Local	HK	2000	17,542,100,000	kg	6,670,000	2,630.00	tonnes/person/year	Environmental Protection Department, HK SAR Government 2000 waste figure.
9	Toxicity to humans	Local	HK	1999	299,522,862,045	kg	6,610,000	45,313.59	kg Tox./person/year	the Normalisation factors World, stated on the spreadsheet version (July 2002) proportion according to world against HK GDP
10	Toxicity to ecosystem	Local	HK	1999	2,697,851,109,231	kg	6,610,000	408,146.92	kg Tox./person/year	the Normalisation factors World, stated on the spreadsheet version (July 2002) proportion according to world against HK GDP

Figure 6 - Normalisation of LCI Data (Cont'd)

Using the above information relating to each of the environmental impacts the total characterized impact value is then divided by the established normalization factor. For example:

1kg of Glass is therefore converted as shown below:

Impact	Unit	Characterized Total	Normalized Impact Value	Normalization Value
Energy	MJ	14.8303	115,330.88	0.00013
Climate Change	Kg CO_2	1.3200	5,922.49	0.00022
Water Consumption	Litre	7.4301	138,550.22	0.00005
Resource Depletion	Kg Sb	0.0068	52.94	0.00013
Photochemical Smog	Kg C_2H_2	0.0005	2.41	0.00020
Ozone Depletion	KG CFC-11	0.0000	0.02	0.00001
Acid Rain	Kg SO_2	0.0110	19.48	0.00056
Waste	Kg Waste	0.0729	2,630.00	0.00003
Toxicity to Humans	Kg 1,4-DB	0.2520	45,313.59	0.00001
EcoToxicity	Kg 1,4-DB	2030.0260	408,146.92	0.00497

It should be noted that within the model the values are calculated to their full number of decimal places, but in this example the values have been rounded to aid presentation.

The same calculation process is used for the aluminium as illustrated below:

Impact	Unit	Characterized Total	Normalized Impact Value	Normalization Value
Energy	MJ	238.3000	115,330.88	0.00207
Climate Change	Kg CO_2	13.1000	5,922.49	0.00222
Water Consumption	Litre	298.0000	138,550.22	0.00215
Resource Depletion	Kg Sb	0.0924	52.94	0.00174
Photochemical Smog	Kg C_2H_2	0.0067	2.41	0.00278
Ozone Depletion	KG CFC-11	0.0000	0.02	0.00006
Acid Rain	Kg SO_2	0.1130	19.48	0.00580
Waste	Kg Waste	0.2710	2,630.00	0.00103
Toxicity to Humans	Kg 1,4-DB	31.8000	45,313.59	0.00070
EcoToxicity	Kg 1,4-DB	8221.5428	408,146.92	0.02014

Figure 7 - Weighting Process

Once the normalized values are established for each material, it is then necessary to weight them based upon their respective level of importance. Below is an illustration of the local weighting factors used in the model initially, following the series of workshops held in 2002.

The weighting process itself is relatively simple since it takes the individual value for each environmental impact and multiplies it by the weighting factor, for example:

Aluminium:

Impact	Normalized value	Weighting	Weighted Impact
Energy	0.00207	10.57	0.000218
Resource Depletion	0.00174	8.34	0.000146
Water Consumption	0.00215	10.39	0.000223
Waste	0.00103	14.91	0.000153
Climate Change	0.00222	8.02	0.000178
Acid Rain	0.00580	7.23	0.000420
Photochemical Smog	0.00278	13.68	0.000380
Ozone Depletion	0.00006	6.95	0.000004
Toxicity to Humans	0.00070	10.80	0.000076
EcoToxicity	0.02014	9.11	0.001835
		Total	0.003633

Figure 7 - Weighting Process (Cont'd)

The same process is repeated for glass. The resultant values are then added together to give the total number of HK E-Points for 1 kg of the material. This means that the HK E-Points for 1 kg of Aluminium is 0.0036 and for 1 kg of Glass is 0.0006. These values are then transferred and used in the other parts of the model.

Glass

Impact	Normalized value	Weighting	Weighted Impact
Energy	0.00013	10.57	0.000014
Resource Depletion	0.00013	8.34	0.000011
Water Consumption	0.00005	10.39	0.000006
Waste	0.00003	14.91	0.000004
Climate Change	0.00022	8.02	0.000018
Acid Rain	0.00056	7.23	0.000041
Photochemical Smog	0.00020	13.68	0.000027
Ozone Depletion	0.00001	6.95	0.000001
Toxicity to Humans	0.00001	10.80	0.000001
EcoToxicity	0.00497	9.11	0.000453
		Total	0.000575

Figure 8 - Quantities Derived From BQ and Drawings

The quantities included in the model are derived from two primary sources (Standard Bills of Quantities / Schedules of Rates and Standard Drawings), depending upon the nature of the functional unit. In the case of the aluminium windows the quantities are derived from both documents.

The functional unit comprises two elements, aluminium (for the frame) and glass (for the window), each material has to be separately quantified. The Standard Bills of Quantities only enumerates the windows therefore actual material quantities have to be derived from the standard drawings.

The calculation for one functional unit (i.e. 1m2) of the living room area is therefore as follows:

Quantity of aluminium frame material calculated by measuring from the standard block design drawings = 0.002617 m3

Quantity of aluminium burglar grilles calculated by measuring form the standard block design drawings = 0.000488 m3

Quantity of glass for windows based upon the window size = 0.58 m2 x thickness of glass (5mm) = 0.0029 m3

These total volumes are then carried forward to the next stage.

Figure 9 - Material Densities

The densities of all materials are established from a range of published sources including British Standard and are expressed as kg/m3 of a material. In this example the densities for both aluminium and glass are shown below:

Material	ID	Density
Aluminium - Powder Coated	16	2707
Aluminium - Anodised	17	2707
Glass - Clear Float	38	2787

These densities are then applied to the material quantities established previously, as follows:

Aluminium Frame 0.002617m3 x 2707 kg/m3 = 7.0842kg

Aluminium Burglar Grilles 0.000488m3 x 2707kg/m3 = 1.321kg

Glass 0.002886m3 x 2787kg/m3 = 8.0433kg

It should be noted that the actual values entered in the model are slightly different due to the arithmetical rounding of values to a greater number of decimal places.

These values represent the net mass of each material used in the building (i.e. the finished quantity).

Figure 10 - Wastage Allowances

Percentage wastage allowances are derived from ASD's technical circular 8 of 1982 as well as current industry practice. In the case of this functional unit there wastage allowances are based upon the following assessments:

Glass - ASD circular refers to minimum 2.5% maximum 7.5%, but this is based upon on site general glass usage, this element is standardized and glass is therefore considered to be more efficiently used, hence less cutting. Wastage allowance has therefore been assessed as being 2%.

Aluminium - There are no published data on this material, but since these are units installed within precast facades under controlled conditions the wastage would be lower than normal. Hence, the cutting of units would be small, but if damage and other factors are considered a percentage allowance of 1% has been assessed and included in the model. This value has also been confirmed verbally by aluminium window suppliers as being a reasonable allowance.

Figure 11 - Calculation of Gross Material Mass

The gross mass of each material is the amount of material necessary to produce the actual end product, therefore, this value is obtained by taking the net mass and applying the appropriate wastage factor.

In the case of this functional unit, the process is illustrated as follows:

Aluminium

Net Mass = 8.4051kg
Wastage Allowance = 1%

Total Wastage Quantity = 0.0841kg

Gross Mass = 8.4892kg

Glass

Net Mass = 8.0433kg
Wastage Allowance = 2%

Total Wastage Quantity = 0.1609kg

Gross Mass = 8.2042kg

The above gross mass figures are now used in the remainder of the model. The total generated wastage quantity of 0.245kg (0.0841 + 0.1609) is then transferred back into the characterization process under the environmental impact calculation as an addition to the wastage impact.

Figure 12 - Calculation of Initial Impact in HK E-Points

The initial impact of each material is now generated using the combination of the HK E-Points for each material (in terms of points / kg) along with the gross mass of each material.

Therefore in the case of this functional unit, the calculation would be:

Glass

Total HK E-Points = 0.000575

Gross Mass = 8.2042kg

Total HK E-Points for each Functional Unit = 0.00472

Aluminium

Total HK E-Points = 0.00363

Gross Mass = 8.4892kg

Total HK E-Points for each Functional Unit = 0.03082

Total HK E-Points = 0.00472+0.03082 = 0.03554

Using this total HK E-Point value the total number of functional units of a particular type are then used to derive the total initial impact used in the assessment of the complete building. Therefore, in the case of this functional unit there are 2,813.1975m2 of this functional unit, hence the total HK E-Points for 1m2 of this functional unit is 0.03554. This means that the total HK E-Points for this functional unit in the context of the whole building is 100.0446 (note slight difference due to rounding of numbers).

It should be noted that within the model the values are calculated to their full number of decimal places, but in this example the values have been rounded to aid presentation.

Figure 13 - Calculation of Vacant Flat Quantities

The calculation of the vacant flat quantities are derived from a series of frequencies and the total number of units within the complete building.

There are five classifications of vacant flat works included within the model:

Type 0 - No Vacant flat works
Type 1 - Repainting Only
Type 2 - Minor Refurbishment
Type 3 - Major Internal Refurbishment
Type 4 - Total Flat Renovation

The detailed definition of each type is contained within the main research report. It should be noted that within the model each subsequent type also includes the scope of work of the earlier types, therefore Type 3 would include the scope of work included in Types 1 and 2 as well as the work in Type 3.

The quantity of flats included within each category is derived from historical records of other estates and from this a profile of frequency is determined. The frequencies are then divided into batches of years, based upon profiles derived form historical records. These five frequencies reflect the aging of the building and the fact that older buildings require more repair and maintenance works.

In the case of this functional unit the windows would only be replaced as part of the total flat refurbishment (Type 4), therefore the percentage frequencies are:

Years 1 - 4 after construction - Nil
Years 5 - 12 after construction - Nil
Years 13 - 27 after construction - 0.75%
Years 28 - 37 after construction - 5.00%
Over 37 Years after construction - 14.00%

The above percentages apply to the number of flats within the building affected. Therefore in each of the year bands the percentage of the total number of flats is applied to the total material quantity within the functional unit.

In this functional unit for example:

Years 28 – 37 after construction 5.00% of all flats are affected, hence the quantity would be

Aluminium Gross Mass = 8.4892kg x 5.00% = 0.4245kg

Glass Gross Mass = 8.2042kg x 5.00% = 0.4102kg

The same process is repeated for all the year groupings, which means that an annual profile, in terms of gross mass is developed. The wastage values are also separated and fed back into the overall environmental impact calculation.

These quantities are carried through to the total repair and maintenance collection.

Figure 14 - Calculation of Preventative Maintenance Quantities

The preventative maintenance quantities are generated based upon a percentage allowance on a 7 year cycle (although this cycle frequency can be adjusted in the building data sheet within the model).

This section therefore calculates the percentage of a complete functional unit affected by the preventative maintenance, this percentage is derived from historical records and the scope of work included in typical CARE contracts.

Once the percentage of the total functional unit involved in the preventative maintenance is determined this percentage is applied to the gross mass of the functional unit with the total generated being carried forward to the collection of repair and maintenance quantities.

In the case of this functional unit there is no preventative maintenance works.

Figure 15 - Calculation of Emergency Quantities

The calculation of the quantities of material classified as emergency quantities is derived using a percentage included within the model. Not all functional units have an emergency quantity impact because they are either functional units which would not be damaged or are units which are repaired and maintained as part of a standard regime.

In general where functional units are subject to an emergency percentage the actual percentage included in the model is determined using a weighted risk calculation. This is based upon the following formula:

Likelihood of Damage Occurring (as a percentage)

x

Percentage of Total Functional Unit to be replaced

The above calculation is a standard risk assessment approach and reflects the potential impact and likelihood.

In the case of the aluminium window functional unit there is no emergency allowance since the windows are subject to a vacant flat refurbishment regime.

Figure 16 - Calculation of Design Life Quantities

Design life quantities are derived from historically published data from around the world on the estimated life span of different materials and building components. In the case of this model the number of years entered is controlled by two factors. Where the design life is specified as being 55 years, this is a value of convenience in that the duration is being set outside the designated study period. Therefore full replacement does not occur during the building life. It does not mean that the design life is 55 years it is just that this item is subject to a different replacement profile, the duration could be 100 years or anything, as long as it is outside the study period.

In all other cases the design life is set at the actual estimated duration of the functional unit. Therefore for the purposes of the model, once this point is reached the functional unit is replaced completely. The model does not take into account any extended life or reusability within the functional unit.

In the case of this functional unit this process does not apply.

Figure 17 - Calculation of Total Repair and Maintenance Costs for a Functional Unit

Repair and maintenance rates as derived in Figure 20 are brought forward into this section and compiled with all repair and maintenance quantities to establish the total annual repair and maintenance cost for each functional unit in the context of the whole building.

In the case of this functional unit, the only category is vacant flats. The model contains the all in rate for this item at HK$1,250.00 / m2 of functional unit.

This rate is applied to the quantities derived from the vacant flat calculation shown above as follows:

Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	0.75%
Years 28 - 37 after construction	-	5.00%
Over 37 Years after construction	-	14.00%

The generated rates are therefore:

Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	HK$26,373.73
Years 28 - 37 after construction	-	HK$175,824.84
Over 37 Years after construction	-	HK$492,309.56

These rates are annual rates and are used in the whole life profile.

Figure 18 - Calculation of Repair and Maintenance HK E-Points

The HK E-Points for each of the materials is derived in the same way as for the costs shown in Figure 17. The total quantities are generated then the HK E-Point values applied to each.

The HK E-Point value is applied to the quantities derived from the vacant flat calculation shown above as follows:

Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	0.75%
Years 28 - 37 after construction	-	5.00%
Over 37 Years after construction	-	14.00%

The generated HK E-Points are therefore:

Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	0.77
Years 28 - 37 after construction	-	5.13
Over 37 Years after construction	-	14.38

These rates are annual rates and are used in the whole life profile.

Figure 19 - Calculation of Whole Life HK E-Points

The whole life HK E-Point profile is the summary of the annual series of impacts produced using the information from all the other stages. The results are then presented in an annual summary starting from the initial impact and with all repair and maintenance impacts added. The initial impact has been divided over three years to reflect the fact that the initial construction work spans a number of years (refer to Figure 12). In each case the total given below is derived from the summation of all impacts across all the functional units.

In the case of this functional unit, the results in the context of the whole building are as follows:

Year 1	-	Nil
Year 2	-	33.49
Year 3	-	33.49
Year 4	-	33.49
Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	0.77
Years 28 - 37 after construction	-	5.13
Over 37 Years after construction	-	14.38

Figure 20 - Calculation of Repair and Maintenance Rates

The individual repair and maintenance rates in the context of the whole building are generated using the information obtained from recent district term contracts. These contract provide unit rates for each of the specific activities in the case of this functional unit the consolidated rates are as follows:

Complete replacement of external windows HK$1,950 / flat

Replace / Repair Burglar Grilles HK$850 / flat

Since each flat contains more than one window the total area of the windows in the flat has been calculated at 8.13m2 (average / flat). This area is then applied to the total combined rate from above to generate a rate / m2 of unit of HK$344.40/m2.

Applying this composite rate to the living room window area of 3.52m2 / window unit the cost is HK$1,212.30 / window unit. This rate therefore reflects the currently specified term contract rate, however based upon recent tenders these printed rates are usually adjusted upward by about 3% in this category to allow for tender price adjustments and preliminaries.

Therefore the rate of HK$1,212.30 / m2 of functional unit is increased by 3% to HK$1,248.67 / m2 of functional unit and rounded to HK$1,250 / m2 of functional unit for inclusion in the model.

Figure 21 - Calculation of Initial Costs for Material

The initial construction costs are calculated based upon rates obtained from recent construction tenders. The rates are then converted into rates / kg and adjusted by general allowances for preliminaries.

In the case of this functional unit the tendered rates for windows are derived from the individual rates for glass, burglar grilles and aluminium windows. This functional unit comprises two aluminium frame items window references PW3 and PW1. The recent tendered rates used in the model are based upon rates of HK$745.80/No and HK$769.50/No respectively. The other component of the aluminium frame is the burglar grille which is derived from the unit types E and F, which have unit rates of HK$68.40/No, HK$70.30/No, HK$33.30/No and HK$35.20/No depending upon the size.

In order to derive a consolidated rate these unit rates have to be converted into a rate / m3, therefore using the quantities in the contract the total cost is generated to be HK$713,043.30 for both the aluminium frame and the burglar grilles (using the rates above and quantities in the standard BQ). This total cost is then divided by the calculated total net mass for glass of the functional unit in this case 23,645.22kg to give a rate per kg of HK$30.16.

This rate represents the basic tender rate for this material component, however it is now necessary to adjust the rate to reflect the percentage amount of preliminaries included in the tenders. Using the same tenders and the same averaging process a consolidated preliminaries percentage has been derived as being 20.19%. This percentage is allowed on all initial construction costs to generate and all inclusive rate, so in the case of aluminium in the living room window this rate would become HK$36.25/kg and this rate is then entered into the model.

The above process is then repeated for the total net mass of glass, where the initial tender rate is HK$90.98/m2. The converted rate becomes HK$6.53/kg before preliminaries adjustment and HK$7.85/kg after adjustment.

Figure 22 - Calculation of Initial Costs for Functional Unit

Continuing the process from the above initial rate calculation the initial cost of the complete functional unit is derived by taking the initial rate and multiplying it by the total net mass for one functional unit, then multiplying this outcome by the total number of functional units of that type.

In the case of this functional unit the process is illustrated as follows:

Aluminium

Initial Rate HK$36.25/kg x 8.405kg = HK$304.68

Glass

Initial Rates HK$7.85/kg x 8.0433kg = HK$63.14

The total of the above values is HK$367.82 and represents the total initial cost of one functional unit. In this case there are 2,813.1975m2 of this functional unit therefore the total initial cost of this functional unit in the context of the whole building is:

HK$367.82 x 2,813.1975m2 = HK$1,034,750.30

Figure 23 - Calculation of Whole Life Costs

The whole life cost profile is the summary of the annual series of expenditure items produced using the information from all the other stages. The results are then presented in an annual summary starting from the initial cost and with all repair and maintenance costs added. The initial cost has been divided over three years to reflect the fact that the initial construction work spans a number of years.

In the case of this functional unit, the results are as follows:

Year 1	-	Nil
Year 2	-	HK$344,921.27
Year 3	-	HK$344,921.27
Year 4	-	HK$344,921.27
Years 1 - 4 after construction	-	Nil
Years 5 - 12 after construction	-	Nil
Years 13 - 27 after construction	-	HK$26,373.73
Years 28 - 37 after construction	-	HK$175,824.84
Over 37 Years after construction	-	HK$492,309.56

Discounting

Discounting within the model is provided, this is generated using the standard net present value (NPV) approach whereby the discount rate published by a relevant body (such as the Finance Bureau or HKHA's Finance Division) is included. The formula for calculating NPV is:

$$F = \frac{1}{(1 + d_r)^y}$$

Where

F = Net Present Value Factor
d_r = the real discount rate
y = the appropriate number of years

Figure 24 - Operational Energy Values

The calculation of all operational energy values is carried out outside the main LCConsole model, either through the use of a energy simulation software tool (in this case Visual DOE) or by using historical billing information.

The values for each unit or area are then derived in terms of kWh for electricity and gas and m3 water. Each of these are then converted to HK E-points by using standard factors of:

Electricity - 1 kWh = 0.000185 HKE-Points

Gas - 1 kWh = 0.0000148 HK E-Points

Water - 1 m3 = 0.00079 HK E-Points

Therefore for example, the total quantity of gas consumed is 1,523,807.87, multiplied by the above factor of 0.0000148 HK E-Points generates a total of 22.5524 HK E-Points after rounding.

The totals from this calculation are then included into the main whole life environmental profile. Exactly the same process is applied to the cost calculation.

It should be noted that this operational energy element of the model does not respond automatically to changes in material usage within the building. If revisions to materials are made it is necessary to re-run the simulation to establish new data sets.

APPENDIX D : FUNCTIONAL UNITS INITIAL COST RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:27:29
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Initial

Functional Unit	Total Cost
Piles	$ 20,937,727.85
RC Walls - Fairfaced	$ 16,677,048.37
RC Slabs - Fairfaced	$ 11,929,170.44
Small Power Installation - Flats	$ 5,232,325.00
Lift Equipment	$ 4,100,397.00
Panel Walls - Internal	$ 4,076,542.65
RC Walls - Generally	$ 4,053,921.81
RC Water Tanks	$ 3,621,329.44
Main Equipment - Switchboards	$ 3,613,400.00
Precast Facades Type 1	$ 3,465,120.00
Mains & Distribution	$ 3,264,625.70
Fresh Water System - Installation	$ 2,790,485.42
Lift Cars	$ 2,733,598.00
Wall Finishes - Corridors & Lobbies	$ 2,485,450.04
Gatesets	$ 2,280,928.47
FTNS & STDN System	$ 2,111,200.00
Sanitary Fittings - Flats	$ 2,036,611.05
Ground Floor Modifications	$ 1,950,568.58
Wall Finishes - Internal Flat Areas	$ 1,901,709.47
Lighting Installation - Public Areas	$ 1,852,715.03
Pile Caps	$ 1,851,955.20
RC Beams - Fairfaced	$ 1,601,500.94
Floor Finishes - Kitchens & Bathrooms	$ 1,525,395.08
Doorsets - Kitchen	$ 1,482,105.61
Aluminium Windows - Bedrooms	$ 1,478,635.67
Lighting Installation - Flats	$ 1,461,600.00
Doorsets - Flat Entrance	$ 1,460,081.29
Hot Water System	$ 1,226,888.47
Fresh Water System - Distribution	$ 1,166,068.59
Precast Facades Type 2	$ 1,163,136.00
Fire Hydrant & Hose Reel System	$ 1,136,253.93
Doorsets - Bathroom (1B /2B)	$ 1,130,182.02
Aluminium Windows - Living Area	$ 1,034,763.81
Sink Units	$ 948,970.84
Precast Stairs	$ 943,216.00
Floor Finishes - Corridors & Lobbies	$ 938,371.40
Soil and Waste - Distribution	$ 841,275.09
Panel Walls - Inter Flat	$ 817,455.72
Water Meter Doors	$ 646,950.40
Main Equipment - Generator	$ 632,015.13
External Wall Finishes - Facades	$ 631,892.80
Fire Alarm & Detection System	$ 606,294.01
Aluminium Windows - Kitchen	$ 584,788.61
Doorsets - Exit Staircases	$ 584,502.40
Cooking Benches	$ 520,264.70
RC Beams - Generally	$ 519,776.59
Typical Floor Block Walls	$ 502,715.50

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:27:29
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Initial

Functional Unit		Total Cost
Roof System - Paving	$	491,293.44
Metal Doors - Plantrooms	$	447,190.80
Mirrors	$	410,707.09
Fresh Water Pump System	$	388,780.53
Flush Water Pump System	$	388,780.53
Aluminium Windows - Bathroom	$	381,762.59
Soil and Waste - Installation	$	349,037.92
Flushing Water System - Installation	$	345,261.41
Floor Finishes - Staircases	$	334,532.83
Security System - Doorphone	$	333,072.25
Wall Finishes - Staircases	$	332,324.88
Doorsets - Plant Rooms	$	317,802.65
RC Columns - Generally	$	307,588.91
Doorsets - Bathroom (1/2P)	$	303,916.99
Substructure Tanking	$	295,410.50
Spun Concrete Refuse Chutes	$	293,242.40
Wall Finishes - Plant Rooms	$	285,382.89
External Wall Finishes - Generally	$	277,147.90
Handrail & Balustrade - Staircases	$	273,821.79
Drying Rails / Laundry Poles	$	238,908.99
Internal Waterproofing	$	233,965.48
Wall Finishes - Main Entrance Lobby	$	219,884.96
Roof System - Screed	$	211,786.50
Aluminium Windows - Corridor	$	198,173.02
Aluminium Windows - Lift Lobby	$	196,140.70
Hose Reel Doors - Hairline	$	191,665.80
Floor Finishes - Movement Joints, etc	$	179,646.68
Rainwater Pipes & Outlets	$	176,765.76
Wall Finishes - Refuse Room	$	170,421.80
Ground Floor Block Walls	$	162,658.55
Letter Boxes	$	155,287.54
Security System - CCTV System	$	144,485.25
Doors - Pipe ducts	$	143,143.20
A/C Drain Pipes	$	140,232.49
Small Power Installation - Public Areas	$	125,048.00
Wall Finishes - Movement Joints, etc	$	119,060.40
Precast Curbs	$	110,410.11
Flushing Water System - Distribution	$	109,327.17
Floor Washing System	$	104,714.00
Signage	$	104,426.12
Staircase Enclosure	$	98,518.76
Fire Fighting System	$	97,621.41
Sliding Shutters - Refuse Chutes	$	96,792.40
Minor RC Concrete Items	$	96,474.95
RC Columns - Fairfaced	$	95,472.73
External Ceiling Finishes	$	88,220.91
Floor Finishes - Plant Rooms	$	85,082.90

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:27:29
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Initial

Functional Unit		Total Cost
Bearing Pads - Tanks & M&E	$	85,058.75
Towel Rails	$	84,406.36
Curtain Rails	$	80,762.92
RC Stairs	$	79,355.20
Stainless Steel Doorset - Plant Rooms	$	79,176.67
RC Slabs - Generally	$	78,521.79
Aluminium Windows - Bedrooms Stainless Steel Grilles	$	76,459.71
Doorsets - Refuse Rooms	$	73,078.11
Floor Finishes - Refuse Room	$	71,169.65
Louvres - Stainless Steel	$	66,476.50
Seating Benches	$	61,076.67
Lightning & Earthing	$	60,268.34
Ceiling Finishes - Main Entrance Lobby	$	59,284.44
Air Duct Trunking	$	58,225.23
Aluminium Windows - Living Area Stainless Steel Grilles	$	54,515.24
Precast Lintols	$	50,288.24
Earthing and Bonding	$	48,283.55
Railings - Refuge Area	$	46,234.98
Ceiling Finishes - Plant Rooms	$	41,879.67
Louvres - GMS	$	40,887.89
Railings - Generally	$	40,207.68
Level 1 Canopy	$	39,034.10
Automatic Sprinker System	$	36,530.08
Security System - Door Monitoring	$	34,307.00
Precast Cills	$	31,118.70
Aluminium Windows - Kitchen Stainless Steel Grilles	$	30,849.31
Stainless Steel Window & Doors - Ground Floor	$	30,498.84
Gates - Refuge Area	$	28,578.03
Cat Ladders	$	24,962.31
Lightning Protection System	$	24,182.40
Movement Joints	$	22,413.64
Aluminium Windows - Plant Rooms	$	21,920.93
Stainless Steel Windows - Lobby	$	21,587.94
Earthworks	$	21,053.82
Aluminium Windows - Bathroom Stainless Steel Grilles	$	20,491.73
Aluminium Louvres - Plant Rooms	$	18,777.77
External Step Finishes	$	17,439.75
Doorsets - Ground Floor	$	16,096.14
Notice Board	$	15,244.24
Security Guard Counter	$	13,626.75
Drainage	$	13,345.44
Stainless Steel Door - Plant Rooms	$	12,245.23
Roof Block Walls	$	11,445.15
Glazed Door & Window - Entrance	$	11,393.17
Lift Vent Covers	$	8,429.58
Hose Reel Doors - Polished	$	7,984.62
Roller Shutters - MAC Room	$	5,947.16

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:27:29
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Initial

Functional Unit		Total Cost
Lift Car Finishes	$	5,594.70
Screens & Grilles	$	4,898.34
Glass Blocks - Ground Floor	$	4,722.28
Typhoon Guards	$	4,392.52
FS Inlet Doors	$	4,283.35
Bin Guards	$	4,032.57
Aluminium Door & Window - 1/F	$	3,311.87
Flashing - Refuse Chutes	$	3,234.64
Inspection Panels - Refuse Chutes	$	1,936.95
Louvres - Refuse Room	$	1,932.98
Angle Protectors - Ground Floor	$	1,407.06
Metal Cages	$	1,324.22
Floor Finishes - Main Entrance Lobby	$	1,085.01
Sanitary Fittings - Other Areas	$	404.22

APPENDIX E : ELEMENTARY BREAKDOWN OF THE INITIAL CAPITAL COSTS

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block
Block Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 11:54 AM
Generated by:	Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
CFA:	41,758
Base Price Level:	10/03

Capital Cost by Element Type

Elements		ELEMENT TOTAL (HK$)	ELEMENTAL COST (HK$/m2 CFA)	PERCENTAGE (%)
1. Foundation and Substructure				
1.1 Piling	$	22,789,683	545.76	16.15
1.2 Substructure	$	2,267,033	54.29	1.61
	$	**25,056,716**	**600.05**	**17.76**
2. Carcase				
2.1 Frame and slabs	$	16,065,252	384.72	11.38
2.2 External walls	$	21,305,304	510.21	15.10
2.3 Internal walls	$	9,629,462	230.60	6.82
2.4 Doors and shutters	$	9,368,160	224.34	6.64
2.5 Windows	$	4,273,368	102.34	3.03
2.6 Glazed screens				
2.7 Shop fronts				
2.8 Skylights	$	39,034	0.93	0.03
	$	**60,680,581**	**1,453.15**	**43.00**
3. Finishings				
3.1 Roof finishes	$	703,080	16.84	0.50
3.2 Floor finishes	$	3,369,249	80.69	2.39
3.3 Internal wall finishes	$	5,514,234	132.05	3.91
3.4 Ceiling finishes	$	101,164	2.42	0.07
3.5 External wall finishes	$	1,014,701	24.30	0.72
3.6 Décor, graphics and signage	$	104,426	2.50	0.07
	$	**10,806,855**	**258.80**	**7.66**
4. Furniture and Fittings				
4.1 Metal works and sundries	$	1,357,546	32.51	0.96
4.2 Built-in furniture	$	1,714,471	41.06	1.21
4.3 Kitchen appliances				
	$	**3,072,017**	**73.57**	**2.18**
5. Services				
5.1 Sanitary fittings	$	2,037,015	48.78	1.44
5.2 Plumbing and disposal	$	10,816,212	259.02	7.66
5.3 Fire services	$	2,654,260	63.56	1.88
5.4 Electrical	$	16,372,688	392.09	11.60
5.5 Security	$	511,865	12.26	0.36
5.6 MVAC	$	140,232	3.36	0.10
5.7 Lifts	$	6,848,019	163.99	4.85
5.8 Gas				
5.9 Communication	$	2,111,200	50.56	1.50
5.10 Gondola				
5.11 Building automation				
5.12 Sewage treatment				
5.13 Refuse disposal				
5.14 Builder's works, profit & attendance				
	$	**41,491,492**	**993.62**	**29.40**
6. Miscellaneous Works				
6.1 External works and landscaping				
6.2 Drainage	$	13,345	0.32	0.01
	$	**13,345**	**0.32**	**0.01**
Totals	**$**	**141,121,007**	**3,379.50**	**100.00**

APPENDIX F : FUNCTIONAL UNITS INITIAL ENVIRONMENTAL IMPACT RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:29:27
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Initial

Functional Unit	HK E-points
RC Walls - Fairfaced	1,005.6084
Precast Facades Type 1	877.7428
RC Slabs - Fairfaced	814.2855
RC Water Tanks	417.0637
RC Walls - Generally	398.6325
Piles	328.2574
Precast Facades Type 2	250.9976
Pile Caps	181.1108
RC Beams - Fairfaced	130.8042
Aluminium Windows - Bedrooms	124.0507
Precast Stairs	116.9420
Mains & Distribution	114.7354
Aluminium Windows - Living Area	100.4724
Ground Floor Modifications	67.2133
RC Beams - Generally	49.1488
Small Power Installation - Flats	48.7848
Roof System - Paving	40.9368
Precast Curbs	33.8806
Aluminium Windows - Kitchen	33.8245
Panel Walls - Internal	33.0363
Gatesets	32.4568
RC Columns - Generally	28.4198
Lighting Installation - Public Areas	26.7077
Internal Waterproofing	25.1844
Hot Water System	24.5090
Wall Finishes - Corridors & Lobbies	23.6445
Doorsets - Flat Entrance	21.1485
Doorsets - Bathroom (1B /2B)	20.4524
Doorsets - Kitchen	19.3761
Fresh Water System - Installation	19.1354
Floor Finishes - Kitchens & Bathrooms	18.8131
Wall Finishes - Internal Flat Areas	17.5745
Sink Units	15.2864
Floor Finishes - Corridors & Lobbies	15.2071
Main Equipment - Switchboards	13.3674
Typical Floor Block Walls	11.7468
Aluminium Windows - Bathroom	11.6251
Sanitary Fittings - Flats	11.4508
Movement Joints	11.3281
Soil and Waste - Installation	10.8883
Lift Equipment	10.4861
Doorsets - Exit Staircases	10.3775
Wall Finishes - Movement Joints, etc	9.3738
Fire Hydrant & Hose Reel System	9.2354
Lighting Installation - Flats	9.2144
Precast Lintols	9.0168
Aluminium Windows - Lift Lobby	8.7740

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:29:27
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Initial

Functional Unit	HK E-points
Water Meter Doors	8.7517
Minor RC Concrete Items	7.7374
RC Columns - Fairfaced	7.7117
Fresh Water System - Distribution	7.5779
Cooking Benches	7.5514
RC Stairs	7.3741
Floor Finishes - Movement Joints, etc	6.8326
Soil and Waste - Distribution	6.8322
Mirrors	6.7659
RC Slabs - Generally	6.7659
Aluminium Windows - Corridor	6.6275
External Wall Finishes - Facades	6.1559
Aluminium Windows - Bedrooms Stainless Steel Grilles	6.0384
Metal Doors - Plantrooms	5.9577
Handrail & Balustrade - Staircases	5.7586
Rainwater Pipes & Outlets	5.6958
Floor Finishes - Staircases	5.3736
Aluminium Windows - Living Area Stainless Steel Grilles	4.9630
Doorsets - Plant Rooms	4.7137
Spun Concrete Refuse Chutes	4.5241
Panel Walls - Inter Flat	4.4158
Small Power Installation - Public Areas	4.3659
Precast Cills	4.2636
Ground Floor Block Walls	3.9703
Main Equipment - Generator	3.9614
Lift Cars	3.8689
Ceiling Finishes - Main Entrance Lobby	3.4019
Drying Rails / Laundry Poles	3.3138
Flushing Water System - Installation	3.2615
Earthing and Bonding	3.0701
Substructure Tanking	2.7233
Wall Finishes - Staircases	2.6887
Doorsets - Bathroom (1/2P)	2.5174
Staircase Enclosure	2.4348
Aluminium Louvres - Plant Rooms	2.3466
Hose Reel Doors - Hairline	2.2768
Roof System - Screed	2.2342
FTNS & STDN System	2.1771
Doors - Pipe ducts	2.1542
External Wall Finishes - Generally	2.0847
Wall Finishes - Plant Rooms	1.8958
Fresh Water Pump System	1.7575
Floor Finishes - Plant Rooms	1.7527
Railings - Refuge Area	1.6049
Aluminium Windows - Kitchen Stainless Steel Grilles	1.5633
Letter Boxes	1.4803
Sliding Shutters - Refuse Chutes	1.3825

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:29:27
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Initial

Functional Unit	HK E-points
Fire Fighting System	1.2640
Railings - Generally	1.1840
Doorsets - Refuse Rooms	1.1655
Wall Finishes - Refuse Room	1.0912
Seating Benches	1.0427
Louvres - GMS	0.9995
Security System - Doorphone	0.9291
Louvres - Stainless Steel	0.8994
Fire Alarm & Detection System	0.8806
Stainless Steel Doorset - Plant Rooms	0.8584
Curtain Rails	0.8520
Air Duct Trunking	0.8426
Floor Washing System	0.7803
Flush Water Pump System	0.7301
Gates - Refuge Area	0.7136
Cat Ladders	0.6933
Aluminium Windows - Plant Rooms	0.6692
Aluminium Windows - Bathroom Stainless Steel Grilles	0.6084
Floor Finishes - Refuse Room	0.6042
A/C Drain Pipes	0.6029
External Ceiling Finishes	0.6017
Towel Rails	0.5017
Drainage	0.4284
Lightning Protection System	0.4094
Glazed Door & Window - Entrance	0.3802
Ceiling Finishes - Plant Rooms	0.3213
Level 1 Canopy	0.3000
Roof Block Walls	0.2879
Stainless Steel Windows - Lobby	0.2786
Flushing Water System - Distribution	0.2522
Signage	0.2292
Stainless Steel Window & Doors - Ground Floor	0.2086
Stainless Steel Door - Plant Rooms	0.2059
Security Guard Counter	0.1950
Bearing Pads - Tanks & M&E	0.1739
Glass Blocks - Ground Floor	0.1654
Automatic Sprinker System	0.1482
Wall Finishes - Main Entrance Lobby	0.1435
Notice Board	0.1416
Lightning & Earthing	0.1332
Typhoon Guards	0.1218
Security System - Door Monitoring	0.1205
Security System - CCTV System	0.1156
Bin Guards	0.1056
Lift Vent Covers	0.0991
Roller Shutters - MAC Room	0.0900
External Step Finishes	0.0891

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:29:27
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Initial

Functional Unit	HK E-points
Doorsets - Ground Floor	0.0878
Screens & Grilles	0.0871
Aluminium Door & Window - 1/F	0.0842
Flashing - Refuse Chutes	0.0584
Hose Reel Doors - Polished	0.0497
Angle Protectors - Ground Floor	0.0391
Metal Cages	0.0373
Inspection Panels - Refuse Chutes	0.0262
Louvres - Refuse Room	0.0162
Lift Car Finishes	0.0157
FS Inlet Doors	0.0104
Earthworks	0.0039
Sanitary Fittings - Other Areas	0.0031
Floor Finishes - Main Entrance Lobby	0.0012

APPENDIX G : ELEMENTARY BREAKDOWN OF THE INITIAL ENVIRONMENTAL IMPACTS

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block		
Block Edition:	6/00 Revision to 1/00 Edition		
Date:	13/10/04 3:28 PM		
Generated by:	Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0		
Weighting:	Local	Norm: Local	
CFA:	41,758	No. of Occupants:	3,196

Initial Impact by Element Type

Elements	HK E-points	/m2 CFA	/Person
1. Foundation and Substructure			
1.1 Piling	509.3682	0.0116	0.1509
1.2 Substructure	69.9405	0.0015	0.0202
	579.3087	**0.0131**	**0.1711**
2. Carcase			
2.1 Frame and slabs	1,187.4765	0.0270	0.3533
2.2 External walls	2,134.3488	0.0499	0.6513
2.3 Internal walls	452.2551	0.0101	0.1325
2.4 Doors and shutters	179.8670	0.0043	0.0559
2.5 Windows	304.4298	0.0073	0.0952
2.6 Glazed screens			
2.7 Shop fronts			
2.8 Skylights	0.3000	0.0000	0.0001
	4,258.6772	**0.0986**	**1.2883**
3. Finishings			
3.1 Roof finishes	43.1710	0.0010	0.0132
3.2 Floor finishes	73.7692	0.0016	0.0212
3.3 Internal wall finishes	56.4119	0.0013	0.0164
3.4 Ceiling finishes	3.7231	0.0001	0.0012
3.5 External wall finishes	8.9314	0.0002	0.0027
3.6 Décor, graphics and signage	0.2292	0.0000	0.0001
	186.2358	**0.0042**	**0.0547**
4. Furniture and Fittings			
4.1 Metal works and sundries	23.1912	0.0006	0.0072
4.2 Built-in furniture	25.6974	0.0006	0.0079
4.3 Kitchen appliances			
	48.8886	**0.0012**	**0.0151**
5. Services			
5.1 Sanitary fittings	11.4539	0.0003	0.0036
5.2 Plumbing and disposal	496.6489	0.0118	0.1539
5.3 Fire services	14.0159	0.0003	0.0044
5.4 Electrical	225.5924	0.0054	0.0705
5.5 Security	1.1652	0.0000	0.0004
5.6 MVAC	0.6029	0.0000	0.0002
5.7 Lifts	14.4719	0.0003	0.0045
5.8 Gas			
5.9 Communication	2.1771	0.0001	0.0007
5.10 Gondola			
5.11 Building automation			
5.12 Sewage treatment			
5.13 Refuse disposal			
5.14 Builder's works, profit & attendance			
	766.1282	**0.0182**	**0.2380**
6. Miscellaneous Works			
6.1 External works and landscaping			
6.2 Drainage	0.4284	0.0000	0.0001
	0.4284	**0.0000**	**0.0001**
Total HK E-points	**5,839.6668**	**0.1353**	**1.7674**

APPENDIX H : FUNCTIONAL UNITS WHOLE LIFE CYCLE COST RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:33:02
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Whole Life

Functional Unit	Total Cost
RC Slabs - Fairfaced	$ 35,521,955.20
RC Walls - Fairfaced	$ 34,668,694.08
Wall Finishes - Internal Flat Areas	$ 33,261,645.47
Floor Finishes - Kitchens & Bathrooms	$ 21,288,688.08
Piles	$ 20,937,727.85
Small Power Installation - Flats	$ 20,377,442.43
Panel Walls - Internal	$ 12,839,745.53
Fresh Water System - Distribution	$ 12,701,631.09
Lighting Installation - Flats	$ 11,934,829.48
Internal Waterproofing	$ 11,634,328.48
Wall Finishes - Corridors & Lobbies	$ 11,226,951.71
Sanitary Fittings - Flats	$ 10,438,096.05
Flushing Water System - Distribution	$ 9,722,295.92
Precast Facades Type 1	$ 9,692,320.00
Aluminium Windows - Living Area	$ 9,588,642.46
Lift Equipment	$ 8,200,794.00
Aluminium Windows - Bedrooms	$ 7,779,045.41
Main Equipment - Switchboards	$ 7,226,800.00
Hot Water System	$ 6,994,669.72
Gatesets	$ 6,945,490.47
Mains & Distribution	$ 6,529,251.40
Fresh Water System - Installation	$ 6,441,970.84
Doorsets - Kitchen	$ 6,288,589.98
RC Walls - Generally	$ 6,058,487.39
Precast Facades Type 2	$ 5,833,536.00
Sink Units	$ 5,755,455.22
Panel Walls - Inter Flat	$ 5,601,696.72
Lift Cars	$ 5,467,203.50
Doorsets - Flat Entrance	$ 5,347,216.29
Doorsets - Bathroom (1B /2B)	$ 4,980,182.02
FTNS & STDN System	$ 4,222,400.00
RC Water Tanks	$ 3,710,640.34
Cooking Benches	$ 3,404,155.32
Floor Finishes - Corridors & Lobbies	$ 2,977,612.80
Ground Floor Modifications	$ 2,756,968.58
Aluminium Windows - Kitchen	$ 2,447,157.43
Fire Hydrant & Hose Reel System	$ 2,272,507.86
Floor Finishes - Staircases	$ 2,252,731.98
Wall Finishes - Plant Rooms	$ 2,147,458.98
Lighting Installation - Public Areas	$ 1,980,925.37
External Wall Finishes - Facades	$ 1,944,885.60
Water Meter Doors	$ 1,940,851.20
Pile Caps	$ 1,851,955.20
Soil and Waste - Installation	$ 1,784,037.92
Doorsets - Exit Staircases	$ 1,729,004.80
Curtain Rails	$ 1,618,837.92
RC Beams - Fairfaced	$ 1,601,500.94

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:33:02
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Whole Life

Functional Unit	Total Cost
Towel Rails	$ 1,430,221.99
Roof System - Paving	$ 1,360,450.08
Main Equipment - Generator	$ 1,264,030.26
Doorsets - Bathroom (1/2P)	$ 1,260,401.36
Fire Alarm & Detection System	$ 1,212,588.02
Aluminium Windows - Bathroom	$ 1,020,649.22
Precast Stairs	$ 943,216.00
Doorsets - Plant Rooms	$ 927,855.30
Floor Finishes - Plant Rooms	$ 880,884.06
Soil and Waste - Distribution	$ 841,275.09
Handrail & Balustrade - Staircases	$ 821,465.37
Fresh Water Pump System	$ 792,261.06
Flush Water Pump System	$ 784,911.06
Rainwater Pipes & Outlets	$ 750,765.76
Drying Rails / Laundry Poles	$ 724,800.87
Floor Finishes - Movement Joints, etc	$ 718,586.72
Aluminium Windows - Bedrooms Stainless Steel Grilles	$ 672,844.91
Security System - Doorphone	$ 666,144.50
Wall Finishes - Staircases	$ 632,091.26
External Wall Finishes - Generally	$ 631,963.90
Aluminium Windows - Living Area Stainless Steel Grilles	$ 631,496.46
Hose Reel Doors - Hairline	$ 574,997.40
Roof System - Screed	$ 545,577.20
RC Beams - Generally	$ 519,776.59
Typical Floor Block Walls	$ 502,715.50
Metal Doors - Plantrooms	$ 489,190.80
Mirrors	$ 410,707.09
Doors - Pipe ducts	$ 409,486.40
Aluminium Windows - Corridor	$ 397,692.44
Aluminium Windows - Lift Lobby	$ 394,063.90
Wall Finishes - Movement Joints, etc	$ 357,181.20
Flushing Water System - Installation	$ 345,261.41
Letter Boxes	$ 310,575.08
RC Columns - Generally	$ 307,588.91
Staircase Enclosure	$ 295,556.28
Substructure Tanking	$ 295,410.50
Spun Concrete Refuse Chutes	$ 293,242.40
Sliding Shutters - Refuse Chutes	$ 290,377.20
Security System - CCTV System	$ 288,970.50
A/C Drain Pipes	$ 280,464.98
Bearing Pads - Tanks & M&E	$ 255,176.25
Wall Finishes - Refuse Room	$ 228,450.40
Ceiling Finishes - Plant Rooms	$ 223,100.01
Wall Finishes - Main Entrance Lobby	$ 220,000.96
Doorsets - Refuse Rooms	$ 216,156.22
Floor Washing System	$ 209,428.00
Signage	$ 209,009.08

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:33:02
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Whole Life

Functional Unit		Total Cost
Aluminium Windows - Kitchen Stainless Steel Grilles	$	185,775.24
Seating Benches	$	183,230.01
Ceiling Finishes - Main Entrance Lobby	$	177,853.32
Floor Finishes - Refuse Room	$	166,228.89
Ground Floor Block Walls	$	162,658.55
Railings - Refuge Area	$	138,704.94
External Ceiling Finishes	$	126,209.91
Small Power Installation - Public Areas	$	125,048.00
Louvres - GMS	$	122,663.67
Railings - Generally	$	120,623.04
Air Duct Trunking	$	116,450.46
Precast Curbs	$	110,410.11
Fire Fighting System	$	97,621.41
Minor RC Concrete Items	$	96,474.95
RC Columns - Fairfaced	$	95,472.73
Gates - Refuge Area	$	85,734.09
Aluminium Windows - Bathroom Stainless Steel Grilles	$	81,158.04
RC Stairs	$	79,355.20
Stainless Steel Doorset - Plant Rooms	$	79,275.11
RC Slabs - Generally	$	78,521.79
Cat Ladders	$	74,886.93
Automatic Sprinker System	$	73,060.16
Security System - Door Monitoring	$	68,614.00
Movement Joints	$	67,240.92
Louvres - Stainless Steel	$	66,476.50
Lightning & Earthing	$	60,268.34
Precast Lintols	$	50,288.24
Earthing and Bonding	$	48,283.55
Notice Board	$	45,732.72
Aluminium Windows - Plant Rooms	$	44,093.64
Security Guard Counter	$	40,880.25
Level 1 Canopy	$	39,034.10
Aluminium Louvres - Plant Rooms	$	37,678.39
Doorsets - Ground Floor	$	37,442.28
External Step Finishes	$	34,903.65
Precast Cills	$	31,118.70
Stainless Steel Window & Doors - Ground Floor	$	30,556.40
Lightning Protection System	$	24,182.40
Hose Reel Doors - Polished	$	23,953.86
Glazed Door & Window - Entrance	$	22,864.77
Stainless Steel Windows - Lobby	$	21,662.51
Earthworks	$	21,053.82
Roller Shutters - MAC Room	$	17,841.48
Screens & Grilles	$	14,695.02
FS Inlet Doors	$	14,600.04
Drainage	$	13,345.44
Typhoon Guards	$	13,177.56

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:33:02
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0

Functional Units Ranked by Total Cost - Whole Life

Functional Unit		Total Cost
Stainless Steel Door - Plant Rooms	$	12,245.23
Bin Guards	$	12,097.71
Roof Block Walls	$	11,445.15
Flashing - Refuse Chutes	$	9,703.92
Glass Blocks - Ground Floor	$	9,444.56
Lift Vent Covers	$	8,429.58
Aluminium Door & Window - 1/F	$	6,640.32
Inspection Panels - Refuse Chutes	$	5,810.85
Lift Car Finishes	$	5,597.70
Angle Protectors - Ground Floor	$	4,221.18
Metal Cages	$	3,972.66
Louvres - Refuse Room	$	3,710.66
Floor Finishes - Main Entrance Lobby	$	1,610.51
Sanitary Fittings - Other Areas	$	1,212.66

APPENDIX I : WHOLE LIFE CYCLE COST PROFILE – ELEMENTARY BREAKDOWN

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:00 PM
Orientation: Orientation1_NS
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Base Price Level: 10/03

Whole Life Cost Profile

Element	0	1	2	3	4	5	6	7	8	9	10	11	12
1. Foundation and Substructure													
1.1 Piling	-	22,789,683.05	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	-	2,267,032.90	-	-	-	-	-	-	-	-	-	115,200.00	-
2. Carcase													
2.1 Frame and slabs	-	-	5,355,084.12	5,355,084.12	5,355,084.12	34,758.66	34,758.66	34,758.66	34,758.66	70,212.48	70,212.48	1,363,234.45	70,212.48
2.2 External walls	-	-	7,101,768.12	7,101,768.12	7,101,768.12	27,081.17	27,081.17	27,081.17	27,081.17	54,703.96	54,703.96	1,006,413.63	54,703.96
2.3 Internal walls	-	-	3,209,820.55	3,209,820.55	3,209,820.55	-	-	-	-	-	-	286,366.51	-
2.4 Doors and shutters	-	-	3,122,720.16	3,122,720.16	3,122,720.16	1.97	1.97	1.97	1.97	9,989.47	9,989.47	148,739.47	9,989.47
2.5 Windows	-	-	1,424,456.09	1,424,456.09	1,424,456.09	74.74	74.74	74.74	74.74	74.74	74.74	327.79	74.74
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	13,011.37	13,011.37	13,011.37	-	-	-	-	-	-	-	-
3. Finishings													
3.1 Roof finishes	-	-	234,359.98	234,359.98	234,359.98	29.35	29.35	29.35	29.35	29.35	29.35	71,229.35	29.35
3.2 Floor finishes	-	-	1,123,083.01	1,123,083.01	1,123,083.01	90.45	90.45	90.45	90.45	55,660.45	55,660.45	531,383.93	55,660.45
3.3 Internal wall finishes	-	-	1,838,078.15	1,838,078.15	1,838,078.15	110.31	110.31	110.31	110.31	56,030.31	56,030.31	1,184,567.06	56,030.31
3.4 Ceiling finishes	-	-	33,721.37	33,721.37	33,721.37	-	-	-	-	-	-	13,923.00	-
3.5 External wall finishes	-	-	338,233.79	338,233.79	338,233.79	0.48	0.48	0.48	0.48	0.48	0.48	56,115.48	0.48
3.6 Décor, graphics and signage	-	-	34,808.71	34,808.71	34,808.71	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
4. Furniture and Fittings													
4.1 Metal works and sundries	-	-	452,515.44	452,515.44	452,515.44	-	-	-	-	2,996.25	2,996.25	20,596.25	2,996.25
4.2 Built-in furniture	-	-	571,490.25	571,490.25	571,490.25	-	-	-	-	7,990.00	7,990.00	7,990.00	7,990.00
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services													
5.1 Sanitary fittings	-	-	679,005.09	679,005.09	679,005.09	-	-	-	-	14,981.25	14,981.25	14,981.25	14,981.25
5.2 Plumbing and disposal	-	-	3,605,404.01	3,605,404.01	3,605,404.01	1.99	1.99	1.99	1.99	27,966.99	27,966.99	450,711.49	27,966.99
5.3 Fire services	-	-	884,753.50	884,753.50	884,753.50	-	-	-	-	-	-	3,150.00	-
5.4 Electrical	-	-	5,457,562.79	5,457,562.79	5,457,562.79	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21
5.5 Security	-	-	170,621.50	170,621.50	170,621.50	-	-	-	-	-	-	-	-
5.6 MVAC	-	-	46,744.16	46,744.16	46,744.16	-	-	-	-	-	-	-	-
5.7 Lifts	-	-	2,282,673.09	2,282,673.09	2,282,673.09	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	703,733.33	703,733.33	703,733.33	-	-	-	-	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works													
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	4,448.48	4,448.48	4,448.48	-	-	-	-	-	-	-	-
General Items													
Demolition													
Demolition Cost													
Demolition Credit													
Operational Costs													
Electricity						3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas						1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water						1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total cost in year	**-**	**25,056,715.95**	**38,688,097.05**	**38,688,097.05**	**38,688,097.05**	**6,285,750.09**	**6,285,750.09**	**6,285,750.09**	**6,285,750.09**	**6,524,236.71**	**6,524,236.71**	**11,498,530.64**	**6,524,236.71**
Total cost in study	**753,333,293.68**												
Interest rate	7.90%	Discount factor	1.00	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.68	0.65	0.62
Inflation rate	3.75%														
Discount rate	4.00%	Discounted total cost in year	-	24,092,996.12	35,769,320.56	34,393,577.49	33,070,747.62	5,166,428.40	4,967,719.62	4,776,653.49	4,592,936.05	4,583,842.21	4,407,540.59	7,469,226.31	4,075,019.04

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:00 PM
Orientation: Orientation1_NS
Generated by: Hong Kong Housing Authority with HKHA
Base Price Level: 10/03

Whole Life Cost Profile

Element	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Foundation and Substructure													
1.1 Piling	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	-	-	-	-	-	115,200.00	-	-	-	-	-	-	115,200.00
2. Carcase													
2.1 Frame and slabs	70,212.48	70,212.48	70,212.48	70,212.48	208,551.93	1,501,573.90	208,551.93	208,551.93	208,551.93	208,551.93	208,551.93	230,965.57	1,501,573.90
2.2 External walls	54,703.96	54,703.96	54,703.96	54,703.96	196,087.02	1,147,796.68	196,087.02	196,087.02	196,087.02	196,087.02	196,087.02	196,087.02	1,147,796.68
2.3 Internal walls	-	-	-	-	41,770.13	328,136.64	41,770.13	41,770.13	41,770.13	41,770.13	41,770.13	41,770.13	328,136.64
2.4 Doors and shutters	9,989.47	9,989.47	9,989.47	9,989.47	131,237.72	269,987.72	131,237.72	131,237.72	131,237.72	131,237.72	131,237.72	131,237.72	269,987.72
2.5 Windows	74.74	74.74	74.74	74.74	57,868.68	58,121.73	57,868.68	57,868.68	57,868.68	57,868.68	57,868.68	57,868.68	58,121.73
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings													
3.1 Roof finishes	29.35	29.35	29.35	29.35	29.35	71,229.35	29.35	29.35	29.35	29.35	29.35	29.35	71,229.35
3.2 Floor finishes	55,660.45	55,660.45	55,660.45	55,660.45	333,510.45	809,233.93	513,157.13	333,510.45	333,510.45	333,510.45	333,510.45	418,593.35	809,233.93
3.3 Internal wall finishes	56,030.31	56,030.31	56,030.31	56,030.31	335,630.31	1,464,167.06	335,630.31	335,630.31	335,630.31	335,630.31	335,630.31	621,013.21	1,464,167.06
3.4 Ceiling finishes	-	-	-	-	-	13,923.00	-	-	-	-	-	-	13,923.00
3.5 External wall finishes	0.48	0.48	0.48	0.48	2,100.48	58,215.48	2,100.48	2,100.48	2,100.48	2,100.48	2,100.48	2,100.48	58,215.48
3.6 Décor, graphics and signage	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
4. Furniture and Fittings													
4.1 Metal works and sundries	2,996.25	2,996.25	2,996.25	2,996.25	32,958.75	50,558.75	32,958.75	32,958.75	32,958.75	32,958.75	32,958.75	36,193.39	50,558.75
4.2 Built-in furniture	7,990.00	7,990.00	7,990.00	7,990.00	83,895.00	83,895.00	83,895.00	83,895.00	83,895.00	83,895.00	83,895.00	158,598.42	83,895.00
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services													
5.1 Sanitary fittings	14,981.25	14,981.25	14,981.25	14,981.25	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50
5.2 Plumbing and disposal	27,966.99	27,966.99	27,966.99	27,966.99	293,634.49	716,378.99	293,634.49	293,634.49	293,634.49	293,634.49	293,634.49	293,634.49	716,378.99
5.3 Fire services	-	-	-	-	-	3,150.00	-	-	-	-	-	-	3,150.00
5.4 Electrical	2,564.21	2,564.21	2,564.21	2,564.21	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89
5.5 Security	-	-	-	-	-	-	-	-	-	-	-	-	-
5.6 MVAC	-	-	-	-	-	-	-	-	-	-	-	-	-
5.7 Lifts	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works													
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	-	-	-	-	-	-	-	-	-	-	-
General Items													
Demolition													
Demolition Cost													
Demolition Credit													
Operational Costs													
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total cost in year	**6,524,236.71**	**6,524,236.71**	**6,524,236.71**	**6,524,236.71**	**8,089,111.46**	**13,063,405.39**	**8,268,758.14**	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**	**8,559,928.95**	**13,063,405.39**
Total cost in study **753,333,293.68**													
Interest rate 7.90% Discount factor	0.60	0.58	0.56	0.53	0.51	0.49	0.47	0.46	0.44	0.42	0.41	0.39	0.38
Inflation rate 3.75%													
Discount rate 4.00% Discounted total cost in year	3,918,287.54	3,767,584.18	3,622,677.10	3,483,343.37	4,152,733.47	6,448,464.36	3,924,703.47	3,691,764.94	3,549,773.98	3,413,244.22	3,281,965.60	3,339,412.17	4,900,302.96

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:00 PM
Orientation: Orientation1_NS
Generated by: Hong Kong Housing Authority with HKHA
Base Price Level: 10/03

Whole Life Cost Profile

Element	26	27	28	29	30	31	32	33	34	35	36	37	38
1. Foundation and Substructure													
1.1 Piling	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	-	-	-	-	-	-	115,200.00	-	-	-	-	-	-
2. Carcase													
2.1 Frame and slabs	208,551.93	208,551.93	208,551.93	307,070.69	208,551.93	208,551.93	1,641,303.70	348,281.72	348,281.72	348,281.72	348,281.72	348,281.72	348,281.72
2.2 External walls	196,087.02	196,087.02	196,087.02	196,087.02	196,087.02	196,087.02	1,447,062.99	495,353.32	495,353.32	495,353.32	495,353.32	495,353.32	495,353.32
2.3 Internal walls	41,770.13	41,770.13	41,770.13	41,770.13	41,770.13	41,770.13	564,834.01	278,467.50	278,467.50	278,467.50	278,467.50	278,467.50	278,467.50
2.4 Doors and shutters	131,237.72	131,237.72	131,237.72	1,120,274.77	131,237.72	131,237.72	539,250.72	400,500.72	400,500.72	400,500.72	400,500.72	400,500.72	400,500.72
2.5 Windows	57,868.68	57,868.68	57,868.68	98,756.57	57,868.68	57,868.68	385,620.75	385,367.70	400,072.74	385,367.70	385,367.70	385,367.70	385,367.70
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings													
3.1 Roof finishes	29.35	29.35	29.35	29.35	29.35	29.35	71,229.35	29.35	29.35	29.35	29.35	29.35	29.35
3.2 Floor finishes	333,510.45	333,510.45	333,510.45	333,510.45	333,510.45	333,510.45	1,198,223.93	722,500.45	902,147.13	722,500.45	722,500.45	722,500.45	722,500.45
3.3 Internal wall finishes	335,630.31	335,630.31	335,630.31	454,690.71	335,630.31	335,630.31	1,855,607.06	727,070.31	727,070.31	727,070.31	727,070.31	727,070.31	727,070.31
3.4 Ceiling finishes	-	-	-	101,164.11	-	-	13,923.00	-	-	-	-	-	-
3.5 External wall finishes	2,100.48	2,100.48	2,100.48	2,100.48	2,100.48	2,100.48	70,115.48	14,000.48	14,000.48	14,000.48	14,000.48	14,000.48	14,000.48
3.6 Décor, graphics and signage	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
4. Furniture and Fittings													
4.1 Metal works and sundries	32,958.75	32,958.75	32,958.75	429,341.88	32,958.75	32,958.75	95,003.13	77,403.13	77,403.13	77,403.13	77,403.13	77,403.13	77,403.13
4.2 Built-in furniture	83,895.00	83,895.00	83,895.00	99,139.24	83,895.00	83,895.00	179,775.00	179,775.00	335,062.54	179,775.00	179,775.00	179,775.00	179,775.00
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services													
5.1 Sanitary fittings	89,887.50	89,887.50	89,887.50	90,291.72	89,887.50	89,887.50	194,756.25	194,756.25	194,756.25	194,756.25	194,756.25	194,756.25	194,756.25
5.2 Plumbing and disposal	293,634.49	293,634.49	293,634.49	378,693.24	293,634.49	293,634.49	1,051,958.99	629,214.49	629,214.49	629,214.49	629,214.49	629,214.49	629,214.49
5.3 Fire services	-	-	-	-	-	-	3,150.00	-	2,556,639.08	-	-	-	-
5.4 Electrical	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	60,912.89	391,555.41	391,555.41	14,595,521.24	391,555.41	391,555.41	391,555.41	391,555.41
5.5 Security	-	-	-	-	-	-	-	-	511,864.50	-	-	-	-
5.6 MVAC	-	-	-	-	-	-	-	-	140,232.49	-	-	-	-
5.7 Lifts	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	2,733,598.21	0.21	0.21	0.21	0.21
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	-	-	-	-	-	-	2,111,200.00	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works													
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	-	-	-	-	-	-	-	-	-	-	-
General Items													
Demolition													
Demolition Cost													
Demolition Credit													
Operational Costs													
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total cost in year	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**	**9,934,870.00**	**8,089,111.46**	**8,089,111.46**	**16,039,606.52**	**11,065,312.59**	**33,672,451.75**	**11,065,312.59**	**11,065,312.59**	**11,065,312.59**	**11,065,312.59**
Total cost in study **753,333,293.68**													
Interest rate 7.90% Discount factor	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.27	0.26	0.25	0.24	0.23	0.23
Inflation rate 3.75%													
Discount rate 4.00% Discounted total cost in year	2,917,655.47	2,805,437.96	2,697,536.50	3,185,630.20	2,494,024.13	2,398,100.13	4,572,217.32	3,032,937.79	8,874,445.28	2,804,121.48	2,696,270.66	2,592,567.94	2,492,853.79

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:00 PM
Orientation: Orientation1_NS
Generated by: Hong Kong Housing Authority with HKHA
Base Price Level: 10/03

Whole Life Cost Profile

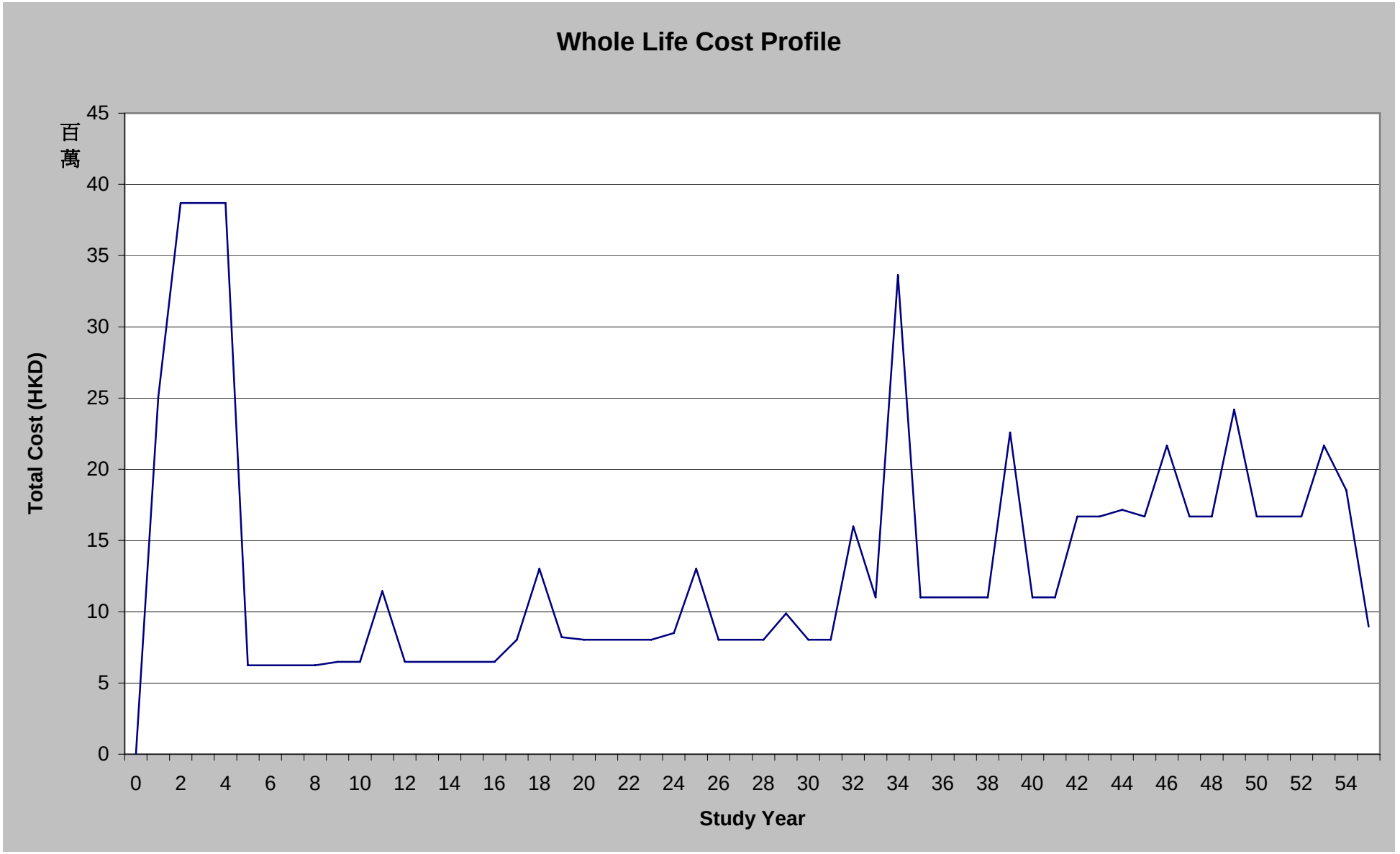
Element	39	40	41	42	43	44	45	46	47	48	49	50
1. Foundation and Substructure												
1.1 Piling	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	115,200.00	-	-	-	-	-	-	115,200.00	-	-	-	-
2. Carcase												
2.1 Frame and slabs	1,641,303.70	348,281.72	348,281.72	556,138.48	556,138.48	578,552.12	556,138.48	1,849,160.45	556,138.48	556,138.48	556,138.48	556,138.48
2.2 External walls	1,447,062.99	495,353.32	495,353.32	1,060,498.71	1,060,498.71	1,060,498.71	1,060,498.71	2,012,208.38	1,060,498.71	1,060,498.71	1,060,498.71	1,060,498.71
2.3 Internal walls	569,556.29	278,467.50	278,467.50	779,709.00	779,709.00	779,709.00	779,709.00	1,066,075.51	779,709.00	779,709.00	779,709.00	779,709.00
2.4 Doors and shutters	1,530,730.02	400,500.72	400,500.72	931,635.97	931,635.97	931,635.97	931,635.97	1,070,385.97	931,635.97	931,635.97	931,635.97	931,635.97
2.5 Windows	385,620.75	385,367.70	385,367.70	1,078,895.03	1,078,895.03	1,078,895.03	1,078,895.03	1,079,148.08	1,078,895.03	1,078,895.03	1,513,907.45	1,078,895.03
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings												
3.1 Roof finishes	774,309.29	29.35	29.35	29.35	29.35	29.35	29.35	71,229.35	29.35	29.35	29.35	29.35
3.2 Floor finishes	2,542,297.80	722,500.45	722,500.45	1,422,682.45	1,422,682.45	1,507,765.35	1,422,682.45	1,898,405.93	1,422,682.45	1,422,682.45	1,602,329.13	1,422,682.45
3.3 Internal wall finishes	4,341,057.10	727,070.31	727,070.31	1,431,662.31	1,431,662.31	1,717,045.21	1,431,662.31	2,560,199.06	1,431,662.31	1,431,662.31	1,431,662.31	1,431,662.31
3.4 Ceiling finishes	13,923.00	-	-	-	-	-	-	13,923.00	-	-	-	-
3.5 External wall finishes	719,448.03	14,000.48	14,000.48	39,200.48	39,200.48	39,200.48	39,200.48	95,315.48	39,200.48	39,200.48	39,200.48	39,200.48
3.6 Décor, graphics and signage	104,429.26	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
4. Furniture and Fittings												
4.1 Metal works and sundries	238,146.33	77,403.13	77,403.13	159,800.00	159,800.00	163,034.64	159,800.00	177,400.00	159,800.00	159,800.00	159,800.00	159,800.00
4.2 Built-in furniture	179,775.00	179,775.00	179,775.00	351,560.00	351,560.00	426,263.42	351,560.00	351,560.00	351,560.00	351,560.00	351,560.00	351,560.00
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-
5. Services												
5.1 Sanitary fittings	194,756.25	194,756.25	194,756.25	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00
5.2 Plumbing and disposal	1,156,672.99	629,214.49	629,214.49	1,230,461.99	1,230,461.99	1,230,461.99	1,230,461.99	1,653,206.49	1,230,461.99	1,230,461.99	4,020,947.41	1,230,461.99
5.3 Fire services	3,150.00	-	-	-	-	-	-	3,150.00	-	-	-	-
5.4 Electrical	449,780.64	391,555.41	391,555.41	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57
5.5 Security	-	-	-	-	-	-	-	-	-	-	-	-
5.6 MVAC	-	-	-	-	-	-	-	-	-	-	-	-
5.7 Lifts	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	4,100,397.21	0.21
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	-	-	-	-	-	-	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works												
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	-	-	-	-	-	-	-	-	-	-
General Items												
Demolition												
Demolition Cost												
Demolition Credit												
Operational Costs												
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total cost in year	**22,628,253.05**	**11,065,312.59**	**11,065,312.59**	**16,738,570.10**	**16,738,570.10**	**17,209,387.60**	**16,738,570.10**	**21,712,864.03**	**16,738,570.10**	**16,738,570.10**	**24,244,111.62**	**16,738,570.10**
Total cost in study **753,333,293.68**												
Interest rate 7.90% Discount factor	0.22	0.21	0.20	0.19	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14
Inflation rate 3.75%												
Discount rate 4.00% Discounted total cost in year	4,901,746.06	2,304,783.47	2,216,137.95	3,223,429.09	3,099,451.05	3,064,068.73	2,865,616.73	3,574,238.45	2,649,423.76	2,547,522.84	3,547,910.60	2,355,328.08

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block
Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 12:00 PM
Orientation:	Orientation1_NS
Generated by:	Hong Kong Housing Authority with HKHA
Base Price Level:	10/03

Whole Life Cost Profile

Element	51	52	53	54	55
1. Foundation and Substructure					
1.1 Piling	-	-	-	-	-
1.2 Substructure	-	-	115,200.00	-	-
2. Carcase					
2.1 Frame and slabs	556,138.48	556,138.48	1,849,160.45	654,657.24	-
2.2 External walls	1,060,498.71	1,060,498.71	2,012,208.38	1,060,498.71	-
2.3 Internal walls	779,709.00	779,709.00	1,066,075.51	779,709.00	-
2.4 Doors and shutters	931,635.97	931,635.97	1,070,385.97	1,920,673.02	-
2.5 Windows	1,078,895.03	1,078,895.03	1,079,148.08	1,119,782.92	-
2.6 Glazed screens	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-
2.8 Skylights	-	-	-	-	-
3. Finishings					
3.1 Roof finishes	29.35	29.35	71,229.35	29.35	-
3.2 Floor finishes	1,422,682.45	1,422,682.45	1,898,405.93	1,422,682.45	-
3.3 Internal wall finishes	1,431,662.31	1,431,662.31	2,560,199.06	1,550,722.71	-
3.4 Ceiling finishes	-	-	13,923.00	101,164.11	-
3.5 External wall finishes	39,200.48	39,200.48	95,315.48	39,200.48	-
3.6 Décor, graphics and signage	3.14	3.14	3.14	3.14	-
4. Furniture and Fittings					
4.1 Metal works and sundries	159,800.00	159,800.00	177,400.00	556,183.13	-
4.2 Built-in furniture	351,560.00	351,560.00	351,560.00	366,804.24	-
4.3 Kitchen appliances	-	-	-	-	-
5. Services					
5.1 Sanitary fittings	383,520.00	383,520.00	383,520.00	383,924.22	-
5.2 Plumbing and disposal	1,230,461.99	1,230,461.99	1,653,206.49	1,315,520.74	-
5.3 Fire services	-	-	3,150.00	-	-
5.4 Electrical	1,091,739.57	1,091,739.57	1,091,739.57	1,091,739.57	-
5.5 Security	-	-	-	-	-
5.6 MVAC	-	-	-	-	-
5.7 Lifts	0.21	0.21	0.21	0.21	-
5.8 Gas	-	-	-	-	-
5.9 Communication	-	-	-	-	-
5.10 Gondola	-	-	-	-	-
5.11 Building automation	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-
6. Miscellaneous Works					
6.1 External works and landscaping	-	-	-	-	-
6.2 Drainage	-	-	-	-	-
General Items					
Demolition					
Demolition Cost					9,200,000.00
Demolition Credit					- 250,000.00
Operational Costs					
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	
Total cost in year	**16,738,570.10**	**16,738,570.10**	**21,712,864.03**	**18,584,328.65**	**8,950,000.00**
Total cost in study	**753,333,293.68**				
Interest rate 7.90% — Discount factor	0.14	0.13	0.13	0.12	0.12
Inflation rate 3.75%					
Discount rate 4.00% — Discounted total cost in year	2,264,738.54	2,177,633.21	2,716,127.48	2,235,355.37	1,035,116.89


Whole Life Cost Profile
百萬
Total Cost (HKD)
45
40
35
30
25
20
15
10
5
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Study Year

APPENDIX J : WHOLE LIFE CYCLE COST PROFILE –FUNCTIONAL UNIT BREAKDOWN

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block
Block Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 12:16 PM
Orientation:	Orientation1_NS
Generated by:	Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Base Price Level:	10/03

Whole Life Cost Profile by Functional Unit

Functional Units	0	1	2	3	4	5	6	7	8	9	10	11
A/C Drain Pipes	-	-	46,744.16	46,744.16	46,744.16	-	-	-	-	-	-	-
Air Duct Trunking	-	-	19,408.41	19,408.41	19,408.41	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	-	-	1,103.96	1,103.96	1,103.96	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Aluminium Louvres - Plant Rooms	-	-	6,259.26	6,259.26	6,259.26	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Aluminium Windows - Bathroom	-	-	127,254.20	127,254.20	127,254.20	-	-	-	-	-	-	-
Aluminium Windows - Bathroom Stainless Steel Grilles	-	-	6,830.58	6,830.58	6,830.58	-	-	-	-	-	-	-
Aluminium Windows - Bedrooms	-	-	492,878.56	492,878.56	492,878.56	-	-	-	-	-	-	-
Aluminium Windows - Bedrooms Stainless Steel Grilles	-	-	25,486.57	25,486.57	25,486.57	-	-	-	-	-	-	-
Aluminium Windows - Corridor	-	-	66,057.67	66,057.67	66,057.67	26.93	26.93	26.93	26.93	26.93	26.93	26.93
Aluminium Windows - Kitchen	-	-	194,929.54	194,929.54	194,929.54	-	-	-	-	-	-	-
Aluminium Windows - Kitchen Stainless Steel Grilles	-	-	10,283.10	10,283.10	10,283.10	-	-	-	-	-	-	-
Aluminium Windows - Lift Lobby	-	-	65,380.23	65,380.23	65,380.23	35.65	35.65	35.65	35.65	35.65	35.65	35.65
Aluminium Windows - Living Area	-	-	344,921.27	344,921.27	344,921.27	-	-	-	-	-	-	-
Aluminium Windows - Living Area Stainless Steel Grilles	-	-	18,171.75	18,171.75	18,171.75	-	-	-	-	-	-	-
Aluminium Windows - Plant Rooms	-	-	7,306.98	7,306.98	7,306.98	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Angle Protectors - Ground Floor	-	-	469.02	469.02	469.02	-	-	-	-	-	-	-
Automatic Sprinker System	-	-	12,176.69	12,176.69	12,176.69	-	-	-	-	-	-	-
Bearing Pads - Tanks & M&E	-	-	28,352.92	28,352.92	28,352.92	-	-	-	-	-	-	-
Bin Guards	-	-	1,344.19	1,344.19	1,344.19	-	-	-	-	-	-	-
Cat Ladders	-	-	8,320.77	8,320.77	8,320.77	-	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	19,761.48	19,761.48	19,761.48	-	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	-	-	13,959.89	13,959.89	13,959.89	-	-	-	-	-	-	13,923.00
Cooking Benches	-	-	173,421.57	173,421.57	173,421.57	-	-	-	-	2,996.25	2,996.25	2,996.25
Curtain Rails	-	-	26,920.97	26,920.97	26,920.97	-	-	-	-	1,598.00	1,598.00	1,598.00
Doors - Pipe ducts	-	-	47,714.40	47,714.40	47,714.40	-	-	-	-	-	-	17,600.00
Doorsets - Bathroom (1/2P)	-	-	101,305.66	101,305.66	101,305.66	-	-	-	-	993.75	993.75	993.75
Doorsets - Bathroom (1B /2B)	-	-	376,727.34	376,727.34	376,727.34	-	-	-	-	4,000.00	4,000.00	4,000.00
Doorsets - Exit Staircases	-	-	194,834.13	194,834.13	194,834.13	-	-	-	-	-	-	80,000.00
Doorsets - Flat Entrance	-	-	486,693.76	486,693.76	486,693.76	-	-	-	-	-	-	-
Doorsets - Ground Floor	-	-	5,365.38	5,365.38	5,365.38	-	-	-	-	-	-	750.00
Doorsets - Kitchen	-	-	494,035.20	494,035.20	494,035.20	-	-	-	-	4,993.75	4,993.75	4,993.75
Doorsets - Refuse Rooms	-	-	24,359.37	24,359.37	24,359.37	-	-	-	-	-	-	10,000.00
Doorsets - Plant Rooms	-	-	105,934.22	105,934.22	105,934.22	-	-	-	-	-	-	41,750.00
Drainage	-	-	4,448.48	4,448.48	4,448.48	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	-	-	79,636.33	79,636.33	79,636.33	-	-	-	-	-	-	-
Earthing and Bonding	-	-	16,094.52	16,094.52	16,094.52	-	-	-	-	-	-	-
Earthworks	-	21,053.82	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	-	-	29,406.97	29,406.97	29,406.97	-	-	-	-	-	-	5,427.00
External Step Finishes	-	-	5,813.25	5,813.25	5,813.25	0.48	0.48	0.48	0.48	0.48	0.48	0.48
External Wall Finishes - Facades	-	-	210,630.93	210,630.93	210,630.93	-	-	-	-	-	-	-
External Wall Finishes - Generally	-	-	92,382.63	92,382.63	92,382.63	-	-	-	-	-	-	50,688.00
Fire Alarm & Detection System	-	-	202,098.00	202,098.00	202,098.00	-	-	-	-	-	-	-
Fire Fighting System	-	-	32,540.47	32,540.47	32,540.47	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	378,751.31	378,751.31	378,751.31	-	-	-	-	-	-	-
Flashing - Refuse Chutes	-	-	1,078.21	1,078.21	1,078.21	-	-	-	-	-	-	-
Floor Finishes - Corridors & Lobbies	-	-	312,790.47	312,790.47	312,790.47	28.30	28.30	28.30	28.30	28.30	28.30	157,093.30
Floor Finishes - Kitchens & Bathrooms	-	-	508,465.03	508,465.03	508,465.03	-	-	-	-	35,241.25	35,241.25	35,241.25
Floor Finishes - Main Entrance Lobby	-	-	361.67	361.67	361.67	0.01	0.01	0.01	0.01	0.01	0.01	75.01
Floor Finishes - Movement Joints, etc	-	-	59,882.23	59,882.23	59,882.23	-	-	-	-	-	-	-
Floor Finishes - Plant Rooms	-	-	28,360.97	28,360.97	28,360.97	-	-	-	-	-	-	89,376.48
Floor Finishes - Refuse Room	-	-	23,723.22	23,723.22	23,723.22	2.21	2.21	2.21	2.21	2.21	2.21	3,399.21
Floor Finishes - Staircases	-	-	111,510.94	111,510.94	111,510.94	59.93	59.93	59.93	59.93	59.93	59.93	225,869.93
Floor Washing System	-	-	34,904.67	34,904.67	34,904.67	-	-	-	-	-	-	-
Flush Water Pump System	-	-	129,593.51	129,593.51	129,593.51	-	-	-	-	-	-	1,050.00
Flushing Water System - Distribution	-	-	36,442.39	36,442.39	36,442.39	-	-	-	-	9,987.50	9,987.50	9,987.50
Flushing Water System - Installation	-	-	115,087.14	115,087.14	115,087.14	-	-	-	-	-	-	-
Fresh Water Pump System	-	-	129,593.51	129,593.51	129,593.51	-	-	-	-	-	-	2,100.00
Fresh Water System - Distribution	-	-	388,689.53	388,689.53	388,689.53	-	-	-	-	11,985.00	11,985.00	11,985.00
Fresh Water System - Installation	-	-	930,161.81	930,161.81	930,161.81	-	-	-	-	-	-	123,000.00
FS Inlet Doors	-	-	1,427.78	1,427.78	1,427.78	-	-	-	-	-	-	250.00
FTNS & STDN System	-	-	703,733.33	703,733.33	703,733.33	-	-	-	-	-	-	-
Gates - Refuge Area	-	-	9,526.01	9,526.01	9,526.01	-	-	-	-	-	-	-
Gatesets	-	-	760,309.49	760,309.49	760,309.49	-	-	-	-	-	-	-
Glass Blocks - Ground Floor	-	-	1,574.09	1,574.09	1,574.09	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	-	-	3,797.72	3,797.72	3,797.72	1.57	1.57	1.57	1.57	1.57	1.57	1.57
Ground Floor Block Walls	-	-	54,219.52	54,219.52	54,219.52	-	-	-	-	-	-	-
Ground Floor Modifications	-	1,950,568.58	-	-	-	-	-	-	-	-	-	115,200.00
Handrail & Balustrade - Staircases	-	-	91,273.93	91,273.93	91,273.93	-	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	63,888.60	63,888.60	63,888.60	-	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	2,661.54	2,661.54	2,661.54	-	-	-	-	-	-	-
Hot Water System	-	-	408,962.82	408,962.82	408,962.82	-	-	-	-	5,992.50	5,992.50	5,992.50
Inspection Panels - Refuse Chutes	-	-	645.65	645.65	645.65	-	-	-	-	-	-	-
Internal Waterproofing	-	-	77,988.49	77,988.49	77,988.49	-	-	-	-	20,328.75	20,328.75	20,328.75
Letter Boxes	-	-	51,762.51	51,762.51	51,762.51	-	-	-	-	-	-	-
Level 1 Canopy	-	-	13,011.37	13,011.37	13,011.37	-	-	-	-	-	-	-
Lift Car Finishes	-	-	1,864.90	1,864.90	1,864.90	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Lift Cars	-	-	911,199.33	911,199.33	911,199.33	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lift Equipment	-	-	1,366,799.00	1,366,799.00	1,366,799.00	-	-	-	-	-	-	-
Lift Vent Covers	-	-	2,809.86	2,809.86	2,809.86	-	-	-	-	-	-	-
Lighting Installation - Flats	-	-	487,200.00	487,200.00	487,200.00	-	-	-	-	-	-	-
Lighting Installation - Public Areas	-	-	617,571.68	617,571.68	617,571.68	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21
Lightning & Earthing	-	-	20,089.45	20,089.45	20,089.45	-	-	-	-	-	-	-
Lightning Protection System	-	-	8,060.80	8,060.80	8,060.80	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	22,158.83	22,158.83	22,158.83	-	-	-	-	-	-	-
Louvres - GMS	-	-	13,629.30	13,629.30	13,629.30	-	-	-	-	-	-	-
Louvres - Refuse Room	-	-	644.33	644.33	644.33	0.13	0.13	0.13	0.13	0.13	0.13	253.18
Main Equipment - Generator	-	-	210,671.71	210,671.71	210,671.71	-	-	-	-	-	-	-
Main Equipment - Switchboards	-	-	1,204,466.67	1,204,466.67	1,204,466.67	-	-	-	-	-	-	-
Mains & Distribution	-	-	1,088,208.57	1,088,208.57	1,088,208.57	-	-	-	-	-	-	-
Metal Cages	-	-	441.41	441.41	441.41	-	-	-	-	-	-	-
Metal Doors - Plantrooms	-	-	149,063.60	149,063.60	149,063.60	-	-	-	-	-	-	6,000.00
Minor RC Concrete Items	-	-	32,158.32	32,158.32	32,158.32	-	-	-	-	-	-	-
Mirrors	-	-	136,902.36	136,902.36	136,902.36	-	-	-	-	-	-	-
Movement Joints	-	-	7,471.21	7,471.21	7,471.21	-	-	-	-	-	-	-
Notice Board	-	-	5,081.41	5,081.41	5,081.41	-	-	-	-	-	-	-
Panel Walls - Inter Flat	-	-	272,485.24	272,485.24	272,485.24	-	-	-	-	-	-	-
Panel Walls - Internal	-	-	1,358,847.55	1,358,847.55	1,358,847.55	-	-	-	-	-	-	-
Pile Caps	-	1,851,955.20	-	-	-	-	-	-	-	-	-	-
Piles	-	20,937,727.85	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	10,372.90	10,372.90	10,372.90	-	-	-	-	-	-	-
Precast Curbs	-	-	36,803.37	36,803.37	36,803.37	-	-	-	-	-	-	-
Precast Facades Type 1	-	-	1,155,040.00	1,155,040.00	1,155,040.00	-	-	-	-	-	-	-
Precast Facades Type 2	-	-	387,712.00	387,712.00	387,712.00	-	-	-	-	-	-	-
Precast Lintols	-	-	16,762.75	16,762.75	16,762.75	-	-	-	-	-	-	-
Precast Stairs	-	-	314,405.33	314,405.33	314,405.33	-	-	-	-	-	-	-
Railings - Generally	-	-	13,402.56	13,402.56	13,402.56	-	-	-	-	-	-	-
Railings - Refuge Area	-	-	15,411.66	15,411.66	15,411.66	-	-	-	-	-	-	-
Rainwater Pipes & Outlets	-	-	58,921.92	58,921.92	58,921.92	-	-	-	-	-	-	82,000.00
RC Beams - Fairfaced	-	-	533,833.65	533,833.65	533,833.65	-	-	-	-	-	-	-
RC Beams - Generally	-	-	173,258.86	173,258.86	173,258.86	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	31,824.24	31,824.24	31,824.24	-	-	-	-	-	-	-
RC Columns - Generally	-	-	102,529.64	102,529.64	102,529.64	-	-	-	-	-	-	-
RC Slabs - Fairfaced	-	-	3,976,390.15	3,976,390.15	3,976,390.15	34,758.66	34,758.66	34,758.66	34,758.66	70,212.48	70,212.48	1,363,234.45
RC Slabs - Generally	-	-	26,173.93	26,173.93	26,173.93	-	-	-	-	-	-	-
RC Stairs	-	-	26,451.73	26,451.73	26,451.73	-	-	-	-	-	-	-
RC Walls - Fairfaced	-	-	5,559,016.12	5,559,016.12	5,559,016.12	27,081.17	27,081.17	27,081.17	27,081.17	54,703.96	54,703.96	1,006,413.63
RC Walls - Generally	-	-	1,351,307.27	1,351,307.27	1,351,307.27	-	-	-	-	-	-	286,366.51
RC Water Tanks	-	-	1,207,109.81	1,207,109.81	1,207,109.81	1.99	1.99	1.99	1.99	1.99	1.99	12,746.49
Roller Shutters - MAC Room	-	-	1,982.39	1,982.39	1,982.39	-	-	-	-	-	-	-
Roof Block Walls	-	-	3,815.05	3,815.05	3,815.05	-	-	-	-	-	-	-
Roof System - Paving	-	-	163,764.48	163,764.48	163,764.48	17.42	17.42	17.42	17.42	17.42	17.42	53,873.42
Roof System - Screed	-	-	70,595.50	70,595.50	70,595.50	11.92	11.92	11.92	11.92	11.92	11.92	17,355.92
Sanitary Fittings - Flats	-	-	678,870.35	678,870.35	678,870.35	-	-	-	-	14,981.25	14,981.25	14,981.25
Sanitary Fittings - Other Areas	-	-	134.74	134.74	134.74	-	-	-	-	-	-	-
Screens & Grilles	-	-	1,632.78	1,632.78	1,632.78	-	-	-	-	-	-	-
Seating Benches	-	-	20,358.89	20,358.89	20,358.89	-	-	-	-	-	-	-
Security Guard Counter	-	-	4,542.25	4,542.25	4,542.25	-	-	-	-	-	-	-
Security System - CCTV System	-	-	48,161.75	48,161.75	48,161.75	-	-	-	-	-	-	-
Security System - Door Monitoring	-	-	11,435.67	11,435.67	11,435.67	-	-	-	-	-	-	-
Security System - Doorphone	-	-	111,024.08	111,024.08	111,024.08	-	-	-	-	-	-	-
Signage	-	-	34,808.71	34,808.71	34,808.71	3.14	3.14	3.14	3.14	3.14	3.14	3.14
Sink Units	-	-	316,323.61	316,323.61	316,323.61	-	-	-	-	4,993.75	4,993.75	4,993.75
Sliding Shutters - Refuse Chutes	-	-	32,264.13	32,264.13	32,264.13	-	-	-	-	-	-	-
Small Power Installation - Flats	-	-	1,744,108.33	1,744,108.33	1,744,108.33	-	-	-	-	-	-	-
Small Power Installation - Public Areas	-	-	41,682.67	41,682.67	41,682.67	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	280,425.03	280,425.03	280,425.03	-	-	-	-	-	-	-
Soil and Waste - Installation	-	-	116,345.97	116,345.97	116,345.97	-	-	-	-	-	-	205,000.00
Spun Concrete Refuse Chutes	-	-	97,747.47	97,747.47	97,747.47	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	4,081.74	4,081.74	4,081.74	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	-	-	26,392.22	26,392.22	26,392.22	1.97	1.97	1.97	1.97	1.97	1.97	1.97
Stainless Steel Window & Doors - Ground Floor	-	-	10,166.28	10,166.28	10,166.28	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Stainless Steel Windows - Lobby	-	-	7,195.98	7,195.98	7,195.98	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Staircase Enclosure	-	-	32,839.59	32,839.59	32,839.59	-	-	-	-	-	-	-
Substructure Tanking	-	295,410.50	-	-	-	-	-	-	-	-	-	-
Towel Rails	-	-	28,135.45	28,135.45	28,135.45	-	-	-	-	1,398.25	1,398.25	1,398.25
Typhoon Guards	-	-	1,464.17	1,464.17	1,464.17	-	-	-	-	-	-	-
Typical Floor Block Walls	-	-	167,571.83	167,571.83	167,571.83	-	-	-	-	-	-	-
Wall Finishes - Corridors & Lobbies	-	-	828,483.35	828,483.35	828,483.35	74.43	74.43	74.43	74.43	74.43	74.43	893,264.43
Wall Finishes - Internal Flat Areas	-	-	633,903.16	633,903.16	633,903.16	-	-	-	-	55,920.00	55,920.00	55,920.00
Wall Finishes - Main Entrance Lobby	-	-	73,294.99	73,294.99	73,294.99	2.32	2.32	2.32	2.32	2.32	2.32	2.32
Wall Finishes - Movement Joints, etc	-	-	39,686.80	39,686.80	39,686.80	-	-	-	-	-	-	-
Wall Finishes - Plant Rooms	-	-	95,127.63	95,127.63	95,127.63	17.21	17.21	17.21	17.21	17.21	17.21	184,367.21
Wall Finishes - Refuse Room	-	-	56,807.27	56,807.27	56,807.27	6.41	6.41	6.41	6.41	6.41	6.41	8,250.41
Wall Finishes - Staircases	-	-	110,774.96	110,774.96	110,774.96	9.94	9.94	9.94	9.94	9.94	9.94	42,762.69
Water Meter Doors	-	-	215,650.13	215,650.13	215,650.13	-	-	-	-	-	-	-
General Items												
Demolition												
Demolition Cost												
Demolition Credit												
Operational Costs												
Electricity						3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas						1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water						1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total Cost in Year	**-**		**25,056,715.95**	**38,688,097.05**	**38,688,097.05**	**6,285,750.09**	**6,285,750.09**	**6,285,750.09**	**6,285,750.09**	**6,524,236.71**	**6,524,236.71**	**11,498,530.64**
Capital Period	**141,121,007.10**											
Operational Period	**603,262,286.58**											
End of Life	**8,950,000.00**											
Study Period	**753,333,293.68**											
Interest rate	7.90%	Discount factor	1.00	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.68	0.65
Inflation rate	3.75%													
Discount rate	4.00%	Discounted total cost in year	-	24,092,996.12	35,769,320.56	34,393,577.49	33,070,747.62	5,166,428.40	4,967,719.62	4,776,653.49	4,592,936.05	4,583,842.21	4,407,540.59	7,469,226.31

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block
Block Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 12:16 PM
Orientation:	Orientation1_NS
Generated by:	Hong Kong Housing Authority with HKHA Life C
Base Price Level:	10/03

Whole Life Cost Profile by Functional Unit

Functional Units	12	13	14	15	16	17	18	19	20	21	22	23
A/C Drain Pipes	-	-	-	-	-	-	-	-	-	-	-	-
Air Duct Trunking	-	-	-	-	-	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Aluminium Louvres - Plant Rooms	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Aluminium Windows - Bathroom	-	-	-	-	-	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85
Aluminium Windows - Bathroom Stainless Steel Grilles	-	-	-	-	-	187.05	187.05	187.05	187.05	187.05	187.05	187.05
Aluminium Windows - Bedrooms	-	-	-	-	-	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72
Aluminium Windows - Bedrooms Stainless Steel Grilles	-	-	-	-	-	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80
Aluminium Windows - Corridor	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93
Aluminium Windows - Kitchen	-	-	-	-	-	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14
Aluminium Windows - Kitchen Stainless Steel Grilles	-	-	-	-	-	477.68	477.68	477.68	477.68	477.68	477.68	477.68
Aluminium Windows - Lift Lobby	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65
Aluminium Windows - Living Area	-	-	-	-	-	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73
Aluminium Windows - Living Area Stainless Steel Grilles	-	-	-	-	-	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98
Aluminium Windows - Plant Rooms	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Angle Protectors - Ground Floor	-	-	-	-	-	-	-	-	-	-	-	-
Automatic Sprinker System	-	-	-	-	-	-	-	-	-	-	-	-
Bearing Pads - Tanks & M&E	-	-	-	-	-	-	-	-	-	-	-	-
Bin Guards	-	-	-	-	-	-	-	-	-	-	-	-
Cat Ladders	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	-	-	-	-	-	-	13,923.00	-	-	-	-	-
Cooking Benches	2,996.25	2,996.25	2,996.25	2,996.25	2,996.25	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63
Curtain Rails	1,598.00	1,598.00	1,598.00	1,598.00	1,598.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00
Doors - Pipe ducts	-	-	-	-	-	-	17,600.00	-	-	-	-	-
Doorsets - Bathroom (1/2P)	993.75	993.75	993.75	993.75	993.75	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38
Doorsets - Bathroom (1B /2B)	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00
Doorsets - Exit Staircases	-	-	-	-	-	-	80,000.00	-	-	-	-	-
Doorsets - Flat Entrance	-	-	-	-	-	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00
Doorsets - Ground Floor	-	-	-	-	-	-	750.00	-	-	-	-	-
Doorsets - Kitchen	4,993.75	4,993.75	4,993.75	4,993.75	4,993.75	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38
Doorsets - Refuse Rooms	-	-	-	-	-	-	10,000.00	-	-	-	-	-
Doorsets - Plant Rooms	-	-	-	-	-	-	41,750.00	-	-	-	-	-
Drainage	-	-	-	-	-	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	-	-	-	-	-	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13
Earthing and Bonding	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks	-	-	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	-	-	-	-	-	-	5,427.00	-	-	-	-	-
External Step Finishes	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
External Wall Finishes - Facades	-	-	-	-	-	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00
External Wall Finishes - Generally	-	-	-	-	-	-	50,688.00	-	-	-	-	-
Fire Alarm & Detection System	-	-	-	-	-	-	-	-	-	-	-	-
Fire Fighting System	-	-	-	-	-	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-	-	-	-	-
Flashing - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-
Floor Finishes - Corridors & Lobbies	28.30	28.30	28.30	28.30	28.30	28.30	157,093.30	28.30	28.30	28.30	28.30	28.30
Floor Finishes - Kitchens & Bathrooms	35,241.25	35,241.25	35,241.25	35,241.25	35,241.25	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50
Floor Finishes - Main Entrance Lobby	0.01	0.01	0.01	0.01	0.01	0.01	75.01	0.01	0.01	0.01	0.01	0.01
Floor Finishes - Movement Joints, etc	-	-	-	-	-	-	-	179,646.68	-	-	-	-
Floor Finishes - Plant Rooms	-	-	-	-	-	-	89,376.48	-	-	-	-	-
Floor Finishes - Refuse Room	2.21	2.21	2.21	2.21	2.21	2.21	3,399.21	2.21	2.21	2.21	2.21	2.21
Floor Finishes - Staircases	59.93	59.93	59.93	59.93	59.93	59.93	225,869.93	59.93	59.93	59.93	59.93	59.93
Floor Washing System	-	-	-	-	-	-	-	-	-	-	-	-
Flush Water Pump System	-	-	-	-	-	-	1,050.00	-	-	-	-	-
Flushing Water System - Distribution	9,987.50	9,987.50	9,987.50	9,987.50	9,987.50	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75
Flushing Water System - Installation	-	-	-	-	-	-	-	-	-	-	-	-
Fresh Water Pump System	-	-	-	-	-	-	2,100.00	-	-	-	-	-
Fresh Water System - Distribution	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50
Fresh Water System - Installation	-	-	-	-	-	-	123,000.00	-	-	-	-	-
FS Inlet Doors	-	-	-	-	-	-	250.00	-	-	-	-	-
FTNS & STDN System	-	-	-	-	-	-	-	-	-	-	-	-
Gates - Refuge Area	-	-	-	-	-	-	-	-	-	-	-	-
Gatesets	-	-	-	-	-	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00
Glass Blocks - Ground Floor	-	-	-	-	-	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
Ground Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Ground Floor Modifications	-	-	-	-	-	-	115,200.00	-	-	-	-	-
Handrail & Balustrade - Staircases	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water System	5,992.50	5,992.50	5,992.50	5,992.50	5,992.50	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25
Inspection Panels - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-
Internal Waterproofing	20,328.75	20,328.75	20,328.75	20,328.75	20,328.75	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50
Letter Boxes	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 Canopy	-	-	-	-	-	-	-	-	-	-	-	-
Lift Car Finishes	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Lift Cars	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lift Equipment	-	-	-	-	-	-	-	-	-	-	-	-
Lift Vent Covers	-	-	-	-	-	-	-	-	-	-	-	-
Lighting Installation - Flats	-	-	-	-	-	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09
Lighting Installation - Public Areas	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21
Lightning & Earthing	-	-	-	-	-	-	-	-	-	-	-	-
Lightning Protection System	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - GMS	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Refuse Room	0.13	0.13	0.13	0.13	0.13	0.13	253.18	0.13	0.13	0.13	0.13	0.13
Main Equipment - Generator	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment - Switchboards	-	-	-	-	-	-	-	-	-	-	-	-
Mains & Distribution	-	-	-	-	-	-	-	-	-	-	-	-
Metal Cages	-	-	-	-	-	-	-	-	-	-	-	-
Metal Doors - Plantrooms	-	-	-	-	-	-	6,000.00	-	-	-	-	-
Minor RC Concrete Items	-	-	-	-	-	-	-	-	-	-	-	-
Mirrors	-	-	-	-	-	-	-	-	-	-	-	-
Movement Joints	-	-	-	-	-	-	-	-	-	-	-	-
Notice Board	-	-	-	-	-	-	-	-	-	-	-	-
Panel Walls - Inter Flat	-	-	-	-	-	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00
Panel Walls - Internal	-	-	-	-	-	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13
Pile Caps	-	-	-	-	-	-	-	-	-	-	-	-
Piles	-	-	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	-	-	-	-	-	-	-	-	-	-
Precast Curbs	-	-	-	-	-	-	-	-	-	-	-	-
Precast Facades Type 1	-	-	-	-	-	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00
Precast Facades Type 2	-	-	-	-	-	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00
Precast Lintols	-	-	-	-	-	-	-	-	-	-	-	-
Precast Stairs	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Generally	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Refuge Area	-	-	-	-	-	-	-	-	-	-	-	-
Rainwater Pipes & Outlets	-	-	-	-	-	-	82,000.00	-	-	-	-	-
RC Beams - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-
RC Beams - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Slabs - Fairfaced	70,212.48	70,212.48	70,212.48	70,212.48	70,212.48	208,551.93	1,501,573.90	208,551.93	208,551.93	208,551.93	208,551.93	208,551.93
RC Slabs - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Stairs	-	-	-	-	-	-	-	-	-	-	-	-
RC Walls - Fairfaced	54,703.96	54,703.96	54,703.96	54,703.96	54,703.96	162,487.02	1,114,196.68	162,487.02	162,487.02	162,487.02	162,487.02	162,487.02
RC Walls - Generally	-	-	-	-	-	-	286,366.51	-	-	-	-	-
RC Water Tanks	1.99	1.99	1.99	1.99	1.99	1.99	12,746.49	1.99	1.99	1.99	1.99	1.99
Roller Shutters - MAC Room	-	-	-	-	-	-	-	-	-	-	-	-
Roof Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Roof System - Paving	17.42	17.42	17.42	17.42	17.42	17.42	53,873.42	17.42	17.42	17.42	17.42	17.42
Roof System - Screed	11.92	11.92	11.92	11.92	11.92	11.92	17,355.92	11.92	11.92	11.92	11.92	11.92
Sanitary Fittings - Flats	14,981.25	14,981.25	14,981.25	14,981.25	14,981.25	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50
Sanitary Fittings - Other Areas	-	-	-	-	-	-	-	-	-	-	-	-
Screens & Grilles	-	-	-	-	-	-	-	-	-	-	-	-
Seating Benches	-	-	-	-	-	-	-	-	-	-	-	-
Security Guard Counter	-	-	-	-	-	-	-	-	-	-	-	-
Security System - CCTV System	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Door Monitoring	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Doorphone	-	-	-	-	-	-	-	-	-	-	-	-
Signage	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
Sink Units	4,993.75	4,993.75	4,993.75	4,993.75	4,993.75	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38
Sliding Shutters - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-
Small Power Installation - Flats	-	-	-	-	-	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Installation	-	-	-	-	-	-	205,000.00	-	-	-	-	-
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
Stainless Steel Window & Doors - Ground Floor	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Stainless Steel Windows - Lobby	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Staircase Enclosure	-	-	-	-	-	-	-	-	-	-	-	-
Substructure Tanking	-	-	-	-	-	-	-	-	-	-	-	-
Towel Rails	1,398.25	1,398.25	1,398.25	1,398.25	1,398.25	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63
Typhoon Guards	-	-	-	-	-	-	-	-	-	-	-	-
Typical Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Corridors & Lobbies	74.43	74.43	74.43	74.43	74.43	74.43	893,264.43	74.43	74.43	74.43	74.43	74.43
Wall Finishes - Internal Flat Areas	55,920.00	55,920.00	55,920.00	55,920.00	55,920.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00
Wall Finishes - Main Entrance Lobby	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
Wall Finishes - Movement Joints, etc	-	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Plant Rooms	17.21	17.21	17.21	17.21	17.21	17.21	184,367.21	17.21	17.21	17.21	17.21	17.21
Wall Finishes - Refuse Room	6.41	6.41	6.41	6.41	6.41	6.41	8,250.41	6.41	6.41	6.41	6.41	6.41
Wall Finishes - Staircases	9.94	9.94	9.94	9.94	9.94	9.94	42,762.69	9.94	9.94	9.94	9.94	9.94
Water Meter Doors	-	-	-	-	-	-	-	-	-	-	-	-
General Items												
Demolition												
Demolition Cost												
Demolition Credit												
Operational Costs												
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total Cost in Year	**6,524,236.71**	**6,524,236.71**	**6,524,236.71**	**6,524,236.71**	**6,524,236.71**	**8,089,111.46**	**13,063,405.39**	**8,268,758.14**	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**
Capital Period 141,121,007.10												
Operational Period 603,262,286.58												
End of Life 8,950,000.00												
Study Period 753,333,293.68												
Interest rate 7.90% Discount factor	0.62	0.60	0.58	0.56	0.53	0.51	0.49	0.47	0.46	0.44	0.42	0.41
Inflation rate 3.75%												
Discount rate 4.00% Discounted total cost in year	4,075,019.04	3,918,287.54	3,767,584.18	3,622,677.10	3,483,343.37	4,152,733.47	6,448,464.36	3,924,703.47	3,691,764.94	3,549,773.98	3,413,244.22	3,281,965.60

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:16 PM
Orientation: Orientation1_NS
Generated by: Hong Kong Housing Authority with HKHA Life C
Base Price Level: 10/03

Whole Life Cost Profile by Functional Unit

Functional Units	24	25	26	27	28	29	30	31	32	33	34	35
A/C Drain Pipes	-	-	-	-	-	-	-	-	-	-	140,232.49	-
Air Duct Trunking	-	-	-	-	-	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	3,312.20	0.33
Aluminium Louvres - Plant Rooms	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Aluminium Windows - Bathroom	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	1,969.85	13,132.31	13,132.31	13,132.31	13,132.31
Aluminium Windows - Bathroom Stainless Steel Grilles	187.05	187.05	187.05	187.05	187.05	187.05	187.05	187.05	1,247.00	1,247.00	1,247.00	1,247.00
Aluminium Windows - Bedrooms	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	19,425.72	129,504.83	129,504.83	129,504.83	129,504.83
Aluminium Windows - Bedrooms Stainless Steel Grilles	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	1,838.80	12,258.69	12,258.69	12,258.69	12,258.69
Aluminium Windows - Corridor	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93
Aluminium Windows - Kitchen	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	5,742.14	38,280.96	38,280.96	38,280.96	38,280.96
Aluminium Windows - Kitchen Stainless Steel Grilles	477.68	477.68	477.68	477.68	477.68	477.68	477.68	477.68	3,184.50	3,184.50	3,184.50	3,184.50
Aluminium Windows - Lift Lobby	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65
Aluminium Windows - Living Area	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	26,373.73	175,824.84	175,824.84	175,824.84	175,824.84
Aluminium Windows - Living Area Stainless Steel Grilles	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	1,778.98	11,859.84	11,859.84	11,859.84	11,859.84
Aluminium Windows - Plant Rooms	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Angle Protectors - Ground Floor	-	-	-	-	-	1,407.06	-	-	-	-	-	-
Automatic Sprinker System	-	-	-	-	-	-	-	-	-	-	36,530.08	-
Bearing Pads - Tanks & M&E	-	-	-	-	-	85,058.75	-	-	-	-	-	-
Bin Guards	-	-	-	-	-	4,032.57	-	-	-	-	-	-
Cat Ladders	-	-	-	-	-	24,962.31	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	-	59,284.44	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	-	13,923.00	-	-	-	41,879.67	-	-	13,923.00	-	-	-
Cooking Benches	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	67,415.63	67,415.63	67,415.63	67,415.63
Curtain Rails	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	16,779.00	35,955.00	35,955.00	35,955.00	35,955.00
Doors - Pipe ducts	-	17,600.00	-	-	-	-	-	-	17,600.00	-	-	-
Doorsets - Bathroom (1/2P)	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	10,434.38	22,359.38	22,359.38	22,359.38	22,359.38
Doorsets - Bathroom (1B /2B)	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	42,000.00	90,000.00	90,000.00	90,000.00	90,000.00
Doorsets - Exit Staircases	-	80,000.00	-	-	-	-	-	-	80,000.00	-	-	-
Doorsets - Flat Entrance	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	11,985.00	79,900.00	79,900.00	79,900.00	79,900.00
Doorsets - Ground Floor	-	750.00	-	-	-	-	-	-	750.00	-	-	-
Doorsets - Kitchen	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	112,359.38	112,359.38	112,359.38	112,359.38
Doorsets - Refuse Rooms	-	10,000.00	-	-	-	-	-	-	10,000.00	-	-	-
Doorsets - Plant Rooms	-	41,750.00	-	-	-	-	-	-	41,750.00	-	-	-
Drainage	-	-	-	-	-	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	1,498.13	9,987.50	9,987.50	9,987.50	9,987.50
Earthing and Bonding	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks	-	-	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	-	5,427.00	-	-	-	-	-	-	5,427.00	-	-	-
External Step Finishes	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
External Wall Finishes - Facades	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	14,000.00	14,000.00	14,000.00	14,000.00
External Wall Finishes - Generally	-	50,688.00	-	-	-	-	-	-	50,688.00	-	-	-
Fire Alarm & Detection System	-	-	-	-	-	-	-	-	-	-	606,294.01	-
Fire Fighting System	-	-	-	-	-	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-	-	-	1,136,253.93	-
Flashing - Refuse Chutes	3,234.64	-	-	-	-	-	-	-	-	-	-	-
Floor Finishes - Corridors & Lobbies	28.30	157,093.30	28.30	28.30	28.30	28.30	28.30	28.30	157,093.30	28.30	28.30	28.30
Floor Finishes - Kitchens & Bathrooms	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	211,447.50	458,136.25	458,136.25	458,136.25	458,136.25
Floor Finishes - Main Entrance Lobby	0.01	75.01	0.01	0.01	0.01	0.01	0.01	0.01	75.01	0.01	0.01	0.01
Floor Finishes - Movement Joints, etc	-	-	-	-	-	-	-	-	-	-	179,646.68	-
Floor Finishes - Plant Rooms	85,082.90	89,376.48	-	-	-	-	-	-	89,376.48	-	-	-
Floor Finishes - Refuse Room	2.21	3,399.21	2.21	2.21	2.21	2.21	2.21	2.21	3,399.21	2.21	2.21	2.21
Floor Finishes - Staircases	59.93	225,869.93	59.93	59.93	59.93	59.93	59.93	59.93	225,869.93	59.93	59.93	59.93
Floor Washing System	-	-	-	-	-	-	-	-	-	-	-	-
Flush Water Pump System	-	1,050.00	-	-	-	-	-	-	1,050.00	-	388,780.53	-
Flushing Water System - Distribution	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	104,868.75	224,718.75	224,718.75	224,718.75	224,718.75
Flushing Water System - Installation	-	-	-	-	-	-	-	-	-	-	-	-
Fresh Water Pump System	-	2,100.00	-	-	-	-	-	-	2,100.00	-	388,780.53	-
Fresh Water System - Distribution	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	125,842.50	269,662.50	269,662.50	269,662.50	269,662.50
Fresh Water System - Installation	-	123,000.00	-	-	-	-	-	-	123,000.00	-	-	-
FS Inlet Doors	-	250.00	-	-	-	4,283.35	-	-	250.00	-	-	-
FTNS & STDN System	-	-	-	-	-	-	-	-	-	-	2,111,200.00	-
Gates - Refuge Area	-	-	-	-	-	28,578.03	-	-	-	-	-	-
Gatesets	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	14,382.00	95,880.00	95,880.00	95,880.00	95,880.00
Glass Blocks - Ground Floor	-	-	-	-	-	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	11,394.74	1.57
Ground Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Ground Floor Modifications	-	115,200.00	-	-	-	-	-	-	115,200.00	-	-	-
Handrail & Balustrade - Staircases	-	-	-	-	-	273,821.79	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	-	-	-	191,665.80	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	-	-	-	7,984.62	-	-	-	-	-	-
Hot Water System	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	62,921.25	134,831.25	134,831.25	134,831.25	134,831.25
Inspection Panels - Refuse Chutes	-	-	-	-	-	1,936.95	-	-	-	-	-	-
Internal Waterproofing	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	121,972.50	264,273.75	264,273.75	264,273.75	264,273.75
Letter Boxes	-	-	-	-	-	-	-	-	-	-	155,287.54	-
Level 1 Canopy	-	-	-	-	-	-	-	-	-	-	-	-
Lift Car Finishes	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Lift Cars	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	2,733,598.15	0.15
Lift Equipment	-	-	-	-	-	-	-	-	-	-	-	-
Lift Vent Covers	-	-	-	-	-	-	-	-	-	-	-	-
Lighting Installation - Flats	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	27,785.09	185,233.91	185,233.91	1,646,833.91	185,233.91
Lighting Installation - Public Areas	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21
Lightning & Earthing	-	-	-	-	-	-	-	-	-	-	-	-
Lightning Protection System	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - GMS	-	-	-	-	-	40,887.89	-	-	-	-	-	-
Louvres - Refuse Room	0.13	253.18	0.13	0.13	0.13	0.13	0.13	0.13	253.18	0.13	0.13	0.13
Main Equipment - Generator	-	-	-	-	-	-	-	-	-	-	632,015.13	-
Main Equipment - Switchboards	-	-	-	-	-	-	-	-	-	-	3,613,400.00	-
Mains & Distribution	-	-	-	-	-	-	-	-	-	-	3,264,625.70	-
Metal Cages	-	-	-	-	-	1,324.22	-	-	-	-	-	-
Metal Doors - Plantrooms	-	6,000.00	-	-	-	-	-	-	6,000.00	-	-	-
Minor RC Concrete Items	-	-	-	-	-	-	-	-	-	-	-	-
Mirrors	-	-	-	-	-	-	-	-	-	-	-	-
Movement Joints	22,413.64	-	-	-	-	-	-	-	-	-	-	-
Notice Board	-	-	-	-	-	15,244.24	-	-	-	-	-	-
Panel Walls - Inter Flat	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	14,751.00	98,340.00	98,340.00	98,340.00	98,340.00
Panel Walls - Internal	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	27,019.13	180,127.50	180,127.50	180,127.50	180,127.50
Pile Caps	-	-	-	-	-	-	-	-	-	-	-	-
Piles	-	-	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	-	-	-	-	-	-	-	-	-	-
Precast Curbs	-	-	-	-	-	-	-	-	-	-	-	-
Precast Facades Type 1	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	19,200.00	128,000.00	128,000.00	128,000.00	128,000.00
Precast Facades Type 2	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	96,000.00	96,000.00	96,000.00	96,000.00
Precast Lintols	-	-	-	-	-	-	-	-	-	-	-	-
Precast Stairs	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Generally	-	-	-	-	-	40,207.68	-	-	-	-	-	-
Railings - Refuge Area	-	-	-	-	-	46,234.98	-	-	-	-	-	-
Rainwater Pipes & Outlets	-	82,000.00	-	-	-	-	-	-	82,000.00	-	-	-
RC Beams - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-
RC Beams - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Slabs - Fairfaced	208,551.93	1,501,573.90	208,551.93	208,551.93	208,551.93	208,551.93	208,551.93	208,551.93	1,641,303.70	348,281.72	348,281.72	348,281.72
RC Slabs - Generally	-	-	-	-	-	-	-	-	-	-	-	-
RC Stairs	-	-	-	-	-	-	-	-	-	-	-	-
RC Walls - Fairfaced	162,487.02	1,114,196.68	162,487.02	162,487.02	162,487.02	162,487.02	162,487.02	162,487.02	1,223,062.99	271,353.32	271,353.32	271,353.32
RC Walls - Generally	-	286,366.51	-	-	-	-	-	-	286,366.51	-	-	-
RC Water Tanks	1.99	12,746.49	1.99	1.99	1.99	1.99	1.99	1.99	12,746.49	1.99	1.99	1.99
Roller Shutters - MAC Room	-	-	-	-	-	5,947.16	-	-	-	-	-	-
Roof Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Roof System - Paving	17.42	53,873.42	17.42	17.42	17.42	17.42	17.42	17.42	53,873.42	17.42	17.42	17.42
Roof System - Screed	11.92	17,355.92	11.92	11.92	11.92	11.92	11.92	11.92	17,355.92	11.92	11.92	11.92
Sanitary Fittings - Flats	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	89,887.50	194,756.25	194,756.25	194,756.25	194,756.25
Sanitary Fittings - Other Areas	-	-	-	-	-	404.22	-	-	-	-	-	-
Screens & Grilles	-	-	-	-	-	4,898.34	-	-	-	-	-	-
Seating Benches	61,076.67	-	-	-	-	-	-	-	-	-	-	-
Security Guard Counter	13,626.75	-	-	-	-	-	-	-	-	-	-	-
Security System - CCTV System	-	-	-	-	-	-	-	-	-	-	144,485.25	-
Security System - Door Monitoring	-	-	-	-	-	-	-	-	-	-	34,307.00	-
Security System - Doorphone	-	-	-	-	-	-	-	-	-	-	333,072.25	-
Signage	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
Sink Units	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	52,434.38	112,359.38	112,359.38	112,359.38	112,359.38
Sliding Shutters - Refuse Chutes	-	-	-	-	-	96,792.40	-	-	-	-	-	-
Small Power Installation - Flats	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	30,563.59	203,757.30	203,757.30	5,436,082.30	203,757.30
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Installation	-	205,000.00	-	-	-	-	-	-	205,000.00	-	-	-
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
Stainless Steel Window & Doors - Ground Floor	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Stainless Steel Windows - Lobby	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Staircase Enclosure	-	-	-	-	-	98,518.76	-	-	-	-	-	-
Substructure Tanking	-	-	-	-	-	-	-	-	-	-	-	-
Towel Rails	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	14,681.63	31,460.63	31,460.63	31,460.63	31,460.63
Typhoon Guards	-	-	-	-	-	4,392.52	-	-	-	-	-	-
Typical Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Corridors & Lobbies	74.43	893,264.43	74.43	74.43	74.43	74.43	74.43	74.43	893,264.43	74.43	74.43	74.43
Wall Finishes - Internal Flat Areas	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	335,520.00	726,960.00	726,960.00	726,960.00	726,960.00
Wall Finishes - Main Entrance Lobby	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
Wall Finishes - Movement Joints, etc	-	-	-	-	-	119,060.40	-	-	-	-	-	-
Wall Finishes - Plant Rooms	285,400.10	184,367.21	17.21	17.21	17.21	17.21	17.21	17.21	184,367.21	17.21	17.21	17.21
Wall Finishes - Refuse Room	6.41	8,250.41	6.41	6.41	6.41	6.41	6.41	6.41	8,250.41	6.41	6.41	6.41
Wall Finishes - Staircases	9.94	42,762.69	9.94	9.94	9.94	9.94	9.94	9.94	42,762.69	9.94	9.94	9.94
Water Meter Doors	-	-	-	-	-	646,950.40	-	-	-	-	-	-
General Items												
Demolition												
Demolition Cost												
Demolition Credit												
Operational Costs												
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total Cost in Year	**8,559,928.95**	**13,063,405.39**	**8,089,111.46**	**8,089,111.46**	**8,089,111.46**	**9,934,870.00**	**8,089,111.46**	**8,089,111.46**	**16,039,606.52**	**11,065,312.59**	**33,672,451.75**	**11,065,312.59**
Capital Period 141,121,007.10												
Operational Period 603,262,286.58												
End of Life 8,950,000.00												
Study Period 753,333,293.68												
Interest rate 7.90% Discount factor	0.39	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.27	0.26	0.25
Inflation rate 3.75%												
Discount rate 4.00% Discounted total cost in year	3,339,412.17	4,900,302.96	2,917,655.47	2,805,437.96	2,697,536.50	3,185,630.20	2,494,024.13	2,398,100.13	4,572,217.32	3,032,937.79	8,874,445.28	2,804,121.48

Project Details

Name:	Standard New Harmony 1 (Opt 2) Block
Block Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 12:16 PM
Orientation:	Orientation1_NS
Generated by:	Hong Kong Housing Authority with HKHA Life C
Base Price Level:	10/03

Whole Life Cost Profile by Functional Unit

Functional Units	36	37	38	39	40	41	42	43	44	45	46
A/C Drain Pipes	-	-	-	-	-	-	-	-	-	-	-
Air Duct Trunking	-	-	-	58,225.23	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Aluminium Louvres - Plant Rooms	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Aluminium Windows - Bathroom	13,132.31	13,132.31	13,132.31	13,132.31	13,132.31	13,132.31	36,770.45	36,770.45	36,770.45	36,770.45	36,770.45
Aluminium Windows - Bathroom Stainless Steel Grilles	1,247.00	1,247.00	1,247.00	1,247.00	1,247.00	1,247.00	3,491.59	3,491.59	3,491.59	3,491.59	3,491.59
Aluminium Windows - Bedrooms	129,504.83	129,504.83	129,504.83	129,504.83	129,504.83	129,504.83	362,613.51	362,613.51	362,613.51	362,613.51	362,613.51
Aluminium Windows - Bedrooms Stainless Steel Grilles	12,258.69	12,258.69	12,258.69	12,258.69	12,258.69	12,258.69	34,324.33	34,324.33	34,324.33	34,324.33	34,324.33
Aluminium Windows - Corridor	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93	26.93
Aluminium Windows - Kitchen	38,280.96	38,280.96	38,280.96	38,280.96	38,280.96	38,280.96	107,186.70	107,186.70	107,186.70	107,186.70	107,186.70
Aluminium Windows - Kitchen Stainless Steel Grilles	3,184.50	3,184.50	3,184.50	3,184.50	3,184.50	3,184.50	8,916.60	8,916.60	8,916.60	8,916.60	8,916.60
Aluminium Windows - Lift Lobby	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65	35.65
Aluminium Windows - Living Area	175,824.84	175,824.84	175,824.84	175,824.84	175,824.84	175,824.84	492,309.56	492,309.56	492,309.56	492,309.56	492,309.56
Aluminium Windows - Living Area Stainless Steel Grilles	11,859.84	11,859.84	11,859.84	11,859.84	11,859.84	11,859.84	33,207.55	33,207.55	33,207.55	33,207.55	33,207.55
Aluminium Windows - Plant Rooms	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Angle Protectors - Ground Floor	-	-	-	-	-	-	-	-	-	-	-
Automatic Sprinker System	-	-	-	-	-	-	-	-	-	-	-
Bearing Pads - Tanks & M&E	-	-	-	-	-	-	-	-	-	-	-
Bin Guards	-	-	-	-	-	-	-	-	-	-	-
Cat Ladders	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	-	-	-	13,923.00	-	-	-	-	-	-	13,923.00
Cooking Benches	67,415.63	67,415.63	67,415.63	67,415.63	67,415.63	67,415.63	131,835.00	131,835.00	131,835.00	131,835.00	131,835.00
Curtain Rails	35,955.00	35,955.00	35,955.00	35,955.00	35,955.00	35,955.00	70,312.00	70,312.00	70,312.00	70,312.00	70,312.00
Doors - Pipe ducts	-	-	-	160,743.20	-	-	-	-	-	-	17,600.00
Doorsets - Bathroom (1/2P)	22,359.38	22,359.38	22,359.38	22,359.38	22,359.38	22,359.38	43,725.00	43,725.00	43,725.00	43,725.00	43,725.00
Doorsets - Bathroom (1B /2B)	90,000.00	90,000.00	90,000.00	90,000.00	90,000.00	90,000.00	176,000.00	176,000.00	176,000.00	176,000.00	176,000.00
Doorsets - Exit Staircases	-	-	-	664,502.40	-	-	-	-	-	-	80,000.00
Doorsets - Flat Entrance	79,900.00	79,900.00	79,900.00	79,900.00	79,900.00	79,900.00	223,720.00	223,720.00	223,720.00	223,720.00	223,720.00
Doorsets - Ground Floor	-	-	-	16,846.14	-	-	-	-	-	-	750.00
Doorsets - Kitchen	112,359.38	112,359.38	112,359.38	112,359.38	112,359.38	112,359.38	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00
Doorsets - Refuse Rooms	-	-	-	83,078.11	-	-	-	-	-	-	10,000.00
Doorsets - Plant Rooms	-	-	-	359,552.65	-	-	-	-	-	-	41,750.00
Drainage	-	-	-	-	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	9,987.50	9,987.50	9,987.50	9,987.50	9,987.50	9,987.50	27,965.00	27,965.00	27,965.00	27,965.00	27,965.00
Earthing and Bonding	-	-	-	-	-	-	-	-	-	-	-
Earthworks	-	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	-	-	-	5,427.00	-	-	-	-	-	-	5,427.00
External Step Finishes	0.48	0.48	0.48	17,440.23	0.48	0.48	0.48	0.48	0.48	0.48	0.48
External Wall Finishes - Facades	14,000.00	14,000.00	14,000.00	645,892.80	14,000.00	14,000.00	39,200.00	39,200.00	39,200.00	39,200.00	39,200.00
External Wall Finishes - Generally	-	-	-	50,688.00	-	-	-	-	-	-	50,688.00
Fire Alarm & Detection System	-	-	-	-	-	-	-	-	-	-	-
Fire Fighting System	-	-	-	-	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-	-	-	-
Flashing - Refuse Chutes	-	-	-	-	-	-	-	-	3,234.64	-	-
Floor Finishes - Corridors & Lobbies	28.30	28.30	28.30	1,095,464.70	28.30	28.30	28.30	28.30	28.30	28.30	157,093.30
Floor Finishes - Kitchens & Bathrooms	458,136.25	458,136.25	458,136.25	458,136.25	458,136.25	458,136.25	902,176.00	902,176.00	902,176.00	902,176.00	902,176.00
Floor Finishes - Main Entrance Lobby	0.01	0.01	0.01	75.01	0.01	0.01	0.01	0.01	0.01	0.01	75.01
Floor Finishes - Movement Joints, etc	-	-	-	-	-	-	-	-	-	-	-
Floor Finishes - Plant Rooms	-	-	-	89,376.48	-	-	-	-	85,082.90	-	89,376.48
Floor Finishes - Refuse Room	2.21	2.21	2.21	74,568.86	2.21	2.21	2.21	2.21	2.21	2.21	3,399.21
Floor Finishes - Staircases	59.93	59.93	59.93	560,402.75	59.93	59.93	59.93	59.93	59.93	59.93	225,869.93
Floor Washing System	-	-	-	104,714.00	-	-	-	-	-	-	-
Flush Water Pump System	-	-	-	1,050.00	-	-	-	-	-	-	1,050.00
Flushing Water System - Distribution	224,718.75	224,718.75	224,718.75	224,718.75	224,718.75	224,718.75	439,450.00	439,450.00	439,450.00	439,450.00	439,450.00
Flushing Water System - Installation	-	-	-	-	-	-	-	-	-	-	-
Fresh Water Pump System	-	-	-	2,100.00	-	-	-	-	-	-	2,100.00
Fresh Water System - Distribution	269,662.50	269,662.50	269,662.50	269,662.50	269,662.50	269,662.50	527,340.00	527,340.00	527,340.00	527,340.00	527,340.00
Fresh Water System - Installation	-	-	-	123,000.00	-	-	-	-	-	-	123,000.00
FS Inlet Doors	-	-	-	250.00	-	-	-	-	-	-	250.00
FTNS & STDN System	-	-	-	-	-	-	-	-	-	-	-
Gates - Refuge Area	-	-	-	-	-	-	-	-	-	-	-
Gatesets	95,880.00	95,880.00	95,880.00	95,880.00	95,880.00	95,880.00	268,464.00	268,464.00	268,464.00	268,464.00	268,464.00
Glass Blocks - Ground Floor	-	-	-	4,722.28	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
Ground Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-
Ground Floor Modifications	-	-	-	115,200.00	-	-	-	-	-	-	115,200.00
Handrail & Balustrade - Staircases	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	-	-	-	-	-	-	-	-	-
Hot Water System	134,831.25	134,831.25	134,831.25	134,831.25	134,831.25	134,831.25	263,670.00	263,670.00	263,670.00	263,670.00	263,670.00
Inspection Panels - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-
Internal Waterproofing	264,273.75	264,273.75	264,273.75	264,273.75	264,273.75	264,273.75	520,416.00	520,416.00	520,416.00	520,416.00	520,416.00
Letter Boxes	-	-	-	-	-	-	-	-	-	-	-
Level 1 Canopy	-	-	-	-	-	-	-	-	-	-	-
Lift Car Finishes	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Lift Cars	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Lift Equipment	-	-	-	-	-	-	-	-	-	-	-
Lift Vent Covers	-	-	-	-	-	-	-	-	-	-	-
Lighting Installation - Flats	185,233.91	185,233.91	185,233.91	185,233.91	185,233.91	185,233.91	518,654.93	518,654.93	518,654.93	518,654.93	518,654.93
Lighting Installation - Public Areas	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21
Lightning & Earthing	-	-	-	-	-	-	-	-	-	-	-
Lightning Protection System	-	-	-	-	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	-	-	-	-	-	-	-	-	-
Louvres - GMS	-	-	-	-	-	-	-	-	-	-	-
Louvres - Refuse Room	0.13	0.13	0.13	253.18	0.13	0.13	0.13	0.13	0.13	0.13	253.18
Main Equipment - Generator	-	-	-	-	-	-	-	-	-	-	-
Main Equipment - Switchboards	-	-	-	-	-	-	-	-	-	-	-
Mains & Distribution	-	-	-	-	-	-	-	-	-	-	-
Metal Cages	-	-	-	-	-	-	-	-	-	-	-
Metal Doors - Plantrooms	-	-	-	6,000.00	-	-	-	-	-	-	6,000.00
Minor RC Concrete Items	-	-	-	-	-	-	-	-	-	-	-
Mirrors	-	-	-	-	-	-	-	-	-	-	-
Movement Joints	-	-	-	-	-	-	-	-	22,413.64	-	-
Notice Board	-	-	-	-	-	-	-	-	-	-	-
Panel Walls - Inter Flat	98,340.00	98,340.00	98,340.00	98,340.00	98,340.00	98,340.00	275,352.00	275,352.00	275,352.00	275,352.00	275,352.00
Panel Walls - Internal	180,127.50	180,127.50	180,127.50	180,127.50	180,127.50	180,127.50	504,357.00	504,357.00	504,357.00	504,357.00	504,357.00
Pile Caps	-	-	-	-	-	-	-	-	-	-	-
Piles	-	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	-	-	-	-	-	-	-	-	-
Precast Curbs	-	-	-	-	-	-	-	-	-	-	-
Precast Facades Type 1	128,000.00	128,000.00	128,000.00	128,000.00	128,000.00	128,000.00	358,400.00	358,400.00	358,400.00	358,400.00	358,400.00
Precast Facades Type 2	96,000.00	96,000.00	96,000.00	96,000.00	96,000.00	96,000.00	268,800.00	268,800.00	268,800.00	268,800.00	268,800.00
Precast Lintols	-	-	-	-	-	-	-	-	-	-	-
Precast Stairs	-	-	-	-	-	-	-	-	-	-	-
Railings - Generally	-	-	-	-	-	-	-	-	-	-	-
Railings - Refuge Area	-	-	-	-	-	-	-	-	-	-	-
Rainwater Pipes & Outlets	-	-	-	82,000.00	-	-	-	-	-	-	82,000.00
RC Beams - Fairfaced	-	-	-	-	-	-	-	-	-	-	-
RC Beams - Generally	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Generally	-	-	-	-	-	-	-	-	-	-	-
RC Slabs - Fairfaced	348,281.72	348,281.72	348,281.72	1,641,303.70	348,281.72	348,281.72	556,138.48	556,138.48	556,138.48	556,138.48	1,849,160.45
RC Slabs - Generally	-	-	-	-	-	-	-	-	-	-	-
RC Stairs	-	-	-	-	-	-	-	-	-	-	-
RC Walls - Fairfaced	271,353.32	271,353.32	271,353.32	1,223,062.99	271,353.32	271,353.32	433,298.71	433,298.71	433,298.71	433,298.71	1,385,008.38
RC Walls - Generally	-	-	-	286,366.51	-	-	-	-	-	-	286,366.51
RC Water Tanks	1.99	1.99	1.99	12,746.49	1.99	1.99	1.99	1.99	1.99	1.99	12,746.49
Roller Shutters - MAC Room	-	-	-	-	-	-	-	-	-	-	-
Roof Block Walls	-	-	-	-	-	-	-	-	-	-	-
Roof System - Paving	17.42	17.42	17.42	545,166.86	17.42	17.42	17.42	17.42	17.42	17.42	53,873.42
Roof System - Screed	11.92	11.92	11.92	229,142.42	11.92	11.92	11.92	11.92	11.92	11.92	17,355.92
Sanitary Fittings - Flats	194,756.25	194,756.25	194,756.25	194,756.25	194,756.25	194,756.25	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00
Sanitary Fittings - Other Areas	-	-	-	-	-	-	-	-	-	-	-
Screens & Grilles	-	-	-	-	-	-	-	-	-	-	-
Seating Benches	-	-	-	-	-	-	-	-	61,076.67	-	-
Security Guard Counter	-	-	-	-	-	-	-	-	13,626.75	-	-
Security System - CCTV System	-	-	-	-	-	-	-	-	-	-	-
Security System - Door Monitoring	-	-	-	-	-	-	-	-	-	-	-
Security System - Doorphone	-	-	-	-	-	-	-	-	-	-	-
Signage	3.14	3.14	3.14	104,429.26	3.14	3.14	3.14	3.14	3.14	3.14	3.14
Sink Units	112,359.38	112,359.38	112,359.38	112,359.38	112,359.38	112,359.38	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00
Sliding Shutters - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-
Small Power Installation - Flats	203,757.30	203,757.30	203,757.30	203,757.30	203,757.30	203,757.30	570,520.43	570,520.43	570,520.43	570,520.43	570,520.43
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Installation	-	-	-	205,000.00	-	-	-	-	-	-	205,000.00
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
Stainless Steel Window & Doors - Ground Floor	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Stainless Steel Windows - Lobby	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Staircase Enclosure	-	-	-	-	-	-	-	-	-	-	-
Substructure Tanking	-	-	-	-	-	-	-	-	-	-	-
Towel Rails	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	31,460.63	61,523.00	61,523.00	61,523.00	61,523.00	61,523.00
Typhoon Guards	-	-	-	-	-	-	-	-	-	-	-
Typical Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Corridors & Lobbies	74.43	74.43	74.43	3,378,714.47	74.43	74.43	74.43	74.43	74.43	74.43	893,264.43
Wall Finishes - Internal Flat Areas	726,960.00	726,960.00	726,960.00	726,960.00	726,960.00	726,960.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00
Wall Finishes - Main Entrance Lobby	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
Wall Finishes - Movement Joints, etc	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Plant Rooms	17.21	17.21	17.21	184,367.21	17.21	17.21	17.21	17.21	285,400.10	17.21	184,367.21
Wall Finishes - Refuse Room	6.41	6.41	6.41	8,250.41	6.41	6.41	6.41	6.41	6.41	6.41	8,250.41
Wall Finishes - Staircases	9.94	9.94	9.94	42,762.69	9.94	9.94	9.94	9.94	9.94	9.94	42,762.69
Water Meter Doors	-	-	-	-	-	-	-	-	-	-	-
General Items											
Demolition											
Demolition Cost											
Demolition Credit											
Operational Costs											
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80
Total Cost in Year	**11,065,312.59**	**11,065,312.59**	**11,065,312.59**	**22,628,253.05**	**11,065,312.59**	**11,065,312.59**	**16,738,570.10**	**16,738,570.10**	**17,209,387.60**	**16,738,570.10**	**21,712,864.03**
Capital Period 141,121,007.10											
Operational Period 603,262,286.58											
End of Life 8,950,000.00											
Study Period 753,333,293.68											
Interest rate 7.90% Discount factor	0.24	0.23	0.23	0.22	0.21	0.20	0.19	0.19	0.18	0.17	0.16
Inflation rate 3.75%											
Discount rate 4.00% Discounted total cost in year	2,696,270.66	2,592,567.94	2,492,853.79	4,901,746.06	2,304,783.47	2,216,137.95	3,223,429.09	3,099,451.05	3,064,068.73	2,865,616.73	3,574,238.45

Project Details

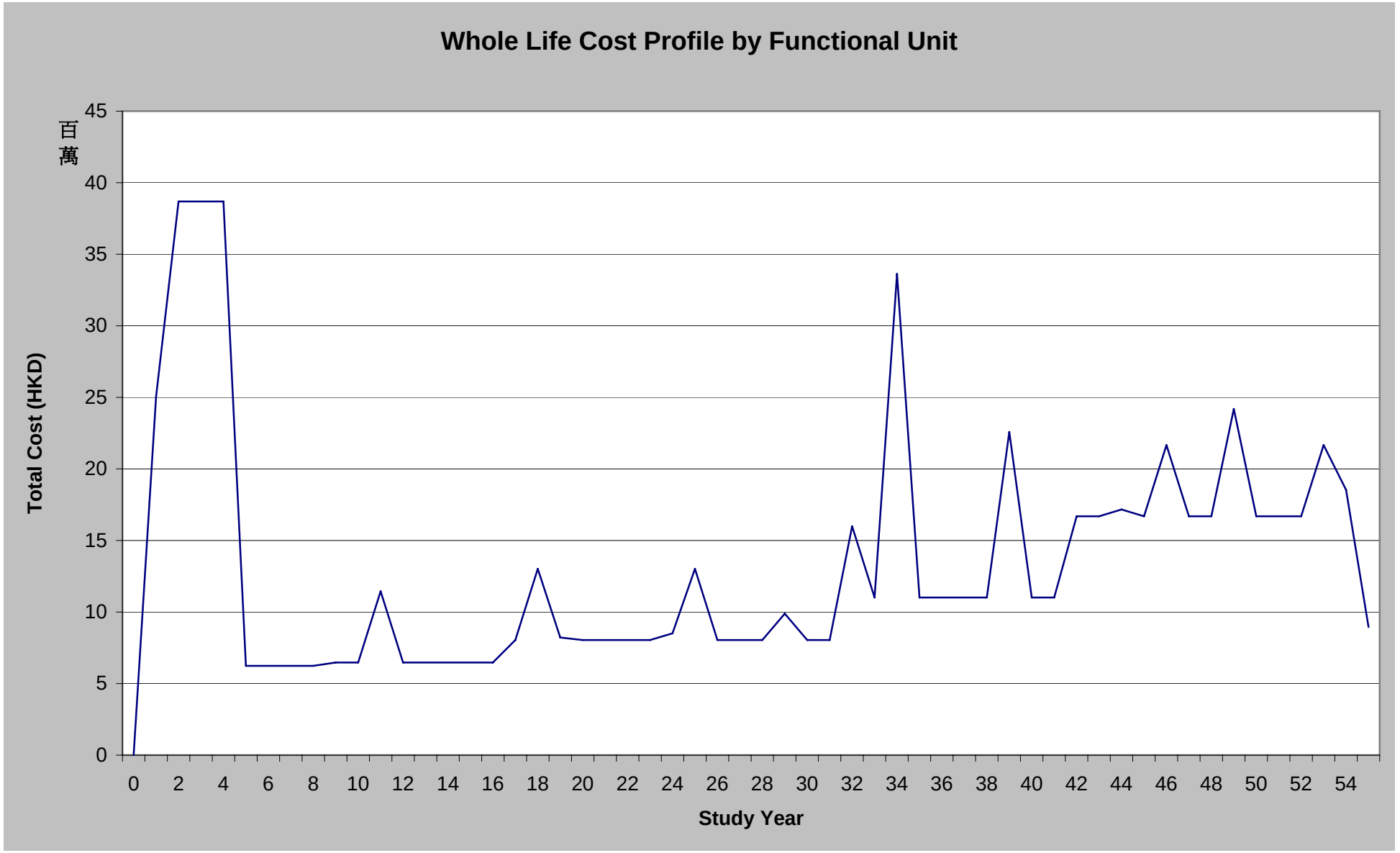
Name:	Standard New Harmony 1 (Opt 2) Block
Block Edition:	6/00 Revision to 1/00 Edition
Date:	09/06/05 12:16 PM
Orientation:	Orientation1_NS
Generated by:	Hong Kong Housing Authority with HKHA Life C
Base Price Level:	10/03

Whole Life Cost Profile by Functional Unit

Functional Units	47	48	49	50	51	52	53	54	55	Total
A/C Drain Pipes	-	-	-	-	-	-	-	-		280,464.98
Air Duct Trunking	-	-	-	-	-	-	-	-		116,450.46
Aluminium Door & Window - 1/F	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33		6,640.32
Aluminium Louvres - Plant Rooms	2.46	2.46	18,780.23	2.46	2.46	2.46	2.46	2.46		37,678.39
Aluminium Windows - Bathroom	36,770.45	36,770.45	36,770.45	36,770.45	36,770.45	36,770.45	36,770.45	36,770.45		1,020,649.22
Aluminium Windows - Bathroom Stainless Steel Grilles	3,491.59	3,491.59	3,491.59	3,491.59	3,491.59	3,491.59	3,491.59	3,491.59		81,158.04
Aluminium Windows - Bedrooms	362,613.51	362,613.51	362,613.51	362,613.51	362,613.51	362,613.51	362,613.51	362,613.51		7,779,045.41
Aluminium Windows - Bedrooms Stainless Steel Grilles	34,324.33	34,324.33	34,324.33	34,324.33	34,324.33	34,324.33	34,324.33	34,324.33		672,844.91
Aluminium Windows - Corridor	26.93	26.93	198,199.95	26.93	26.93	26.93	26.93	26.93		397,692.44
Aluminium Windows - Kitchen	107,186.70	107,186.70	107,186.70	107,186.70	107,186.70	107,186.70	107,186.70	107,186.70		2,447,157.43
Aluminium Windows - Kitchen Stainless Steel Grilles	8,916.60	8,916.60	8,916.60	8,916.60	8,916.60	8,916.60	8,916.60	8,916.60		185,775.24
Aluminium Windows - Lift Lobby	35.65	35.65	196,176.35	35.65	35.65	35.65	35.65	35.65		394,063.90
Aluminium Windows - Living Area	492,309.56	492,309.56	492,309.56	492,309.56	492,309.56	492,309.56	492,309.56	492,309.56		9,588,642.46
Aluminium Windows - Living Area Stainless Steel Grilles	33,207.55	33,207.55	33,207.55	33,207.55	33,207.55	33,207.55	33,207.55	33,207.55		631,496.46
Aluminium Windows - Plant Rooms	5.04	5.04	21,925.97	5.04	5.04	5.04	5.04	5.04		44,093.64
Angle Protectors - Ground Floor	-	-	-	-	-	-	-	1,407.06		4,221.18
Automatic Sprinker System	-	-	-	-	-	-	-	-		73,060.16
Bearing Pads - Tanks & M&E	-	-	-	-	-	-	-	85,058.75		255,176.25
Bin Guards	-	-	-	-	-	-	-	4,032.57		12,097.71
Cat Ladders	-	-	-	-	-	-	-	24,962.31		74,886.93
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	-	-	-	59,284.44		177,853.32
Ceiling Finishes - Plant Rooms	-	-	-	-	-	-	13,923.00	41,879.67		223,100.01
Cooking Benches	131,835.00	131,835.00	131,835.00	131,835.00	131,835.00	131,835.00	131,835.00	131,835.00		3,404,155.32
Curtain Rails	70,312.00	70,312.00	70,312.00	70,312.00	70,312.00	70,312.00	70,312.00	70,312.00		1,618,837.92
Doors - Pipe ducts	-	-	-	-	-	-	17,600.00	-		409,486.40
Doorsets - Bathroom (1/2P)	43,725.00	43,725.00	43,725.00	43,725.00	43,725.00	43,725.00	43,725.00	43,725.00		1,260,401.36
Doorsets - Bathroom (1B /2B)	176,000.00	176,000.00	176,000.00	176,000.00	176,000.00	176,000.00	176,000.00	176,000.00		4,980,182.02
Doorsets - Exit Staircases	-	-	-	-	-	-	80,000.00	-		1,729,004.80
Doorsets - Flat Entrance	223,720.00	223,720.00	223,720.00	223,720.00	223,720.00	223,720.00	223,720.00	223,720.00		5,347,216.29
Doorsets - Ground Floor	-	-	-	-	-	-	750.00	-		37,442.28
Doorsets - Kitchen	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00		6,288,589.98
Doorsets - Refuse Rooms	-	-	-	-	-	-	10,000.00	-		216,156.22
Doorsets - Plant Rooms	-	-	-	-	-	-	41,750.00	-		927,855.30
Drainage	-	-	-	-	-	-	-	-		13,345.44
Drying Rails / Laundry Poles	27,965.00	27,965.00	27,965.00	27,965.00	27,965.00	27,965.00	27,965.00	27,965.00		724,800.87
Earthing and Bonding	-	-	-	-	-	-	-	-		48,283.55
Earthworks	-	-	-	-	-	-	-	-		21,053.82
External Ceiling Finishes	-	-	-	-	-	-	5,427.00	-		126,209.91
External Step Finishes	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48		34,903.65
External Wall Finishes - Facades	39,200.00	39,200.00	39,200.00	39,200.00	39,200.00	39,200.00	39,200.00	39,200.00		1,944,885.60
External Wall Finishes - Generally	-	-	-	-	-	-	50,688.00	-		631,963.90
Fire Alarm & Detection System	-	-	-	-	-	-	-	-		1,212,588.02
Fire Fighting System	-	-	-	-	-	-	-	-		97,621.41
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-		2,272,507.86
Flashing - Refuse Chutes	-	-	-	-	-	-	-	-		9,703.92
Floor Finishes - Corridors & Lobbies	28.30	28.30	28.30	28.30	28.30	28.30	157,093.30	28.30		2,977,612.80
Floor Finishes - Kitchens & Bathrooms	902,176.00	902,176.00	902,176.00	902,176.00	902,176.00	902,176.00	902,176.00	902,176.00		21,288,688.08
Floor Finishes - Main Entrance Lobby	0.01	0.01	0.01	0.01	0.01	0.01	75.01	0.01		1,610.51
Floor Finishes - Movement Joints, etc	-	-	179,646.68	-	-	-	-	-		718,586.72
Floor Finishes - Plant Rooms	-	-	-	-	-	-	89,376.48	-		880,884.06
Floor Finishes - Refuse Room	2.21	2.21	2.21	2.21	2.21	2.21	3,399.21	2.21		166,228.89
Floor Finishes - Staircases	59.93	59.93	59.93	59.93	59.93	59.93	225,869.93	59.93		2,252,731.98
Floor Washing System	-	-	-	-	-	-	-	-		209,428.00
Flush Water Pump System	-	-	-	-	-	-	1,050.00	-		784,911.06
Flushing Water System - Distribution	439,450.00	439,450.00	439,450.00	439,450.00	439,450.00	439,450.00	439,450.00	439,450.00		9,722,295.92
Flushing Water System - Installation	-	-	-	-	-	-	-	-		345,261.41
Fresh Water Pump System	-	-	-	-	-	-	2,100.00	-		792,261.06
Fresh Water System - Distribution	527,340.00	527,340.00	527,340.00	527,340.00	527,340.00	527,340.00	527,340.00	527,340.00		12,701,631.09
Fresh Water System - Installation	-	-	2,790,485.42	-	-	-	123,000.00	-		6,441,970.84
FS Inlet Doors	-	-	-	-	-	-	250.00	4,283.35		14,600.04
FTNS & STDN System	-	-	-	-	-	-	-	-		4,222,400.00
Gates - Refuge Area	-	-	-	-	-	-	-	28,578.03		85,734.09
Gatesets	268,464.00	268,464.00	268,464.00	268,464.00	268,464.00	268,464.00	268,464.00	268,464.00		6,945,490.47
Glass Blocks - Ground Floor	-	-	-	-	-	-	-	-		9,444.56
Glazed Door & Window - Entrance	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57		22,864.77
Ground Floor Block Walls	-	-	-	-	-	-	-	-		162,658.55
Ground Floor Modifications	-	-	-	-	-	-	115,200.00	-		2,756,968.58
Handrail & Balustrade - Staircases	-	-	-	-	-	-	-	273,821.79		821,465.37
Hose Reel Doors - Hairline	-	-	-	-	-	-	-	191,665.80		574,997.40
Hose Reel Doors - Polished	-	-	-	-	-	-	-	7,984.62		23,953.86
Hot Water System	263,670.00	263,670.00	263,670.00	263,670.00	263,670.00	263,670.00	263,670.00	263,670.00		6,994,669.72
Inspection Panels - Refuse Chutes	-	-	-	-	-	-	-	1,936.95		5,810.85
Internal Waterproofing	520,416.00	520,416.00	520,416.00	520,416.00	520,416.00	520,416.00	520,416.00	520,416.00		11,634,328.48
Letter Boxes	-	-	-	-	-	-	-	-		310,575.08
Level 1 Canopy	-	-	-	-	-	-	-	-		39,034.10
Lift Car Finishes	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06		5,597.70
Lift Cars	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15		5,467,203.50
Lift Equipment	-	-	4,100,397.00	-	-	-	-	-		8,200,794.00
Lift Vent Covers	-	-	-	-	-	-	-	-		8,429.58
Lighting Installation - Flats	518,654.93	518,654.93	518,654.93	518,654.93	518,654.93	518,654.93	518,654.93	518,654.93		11,934,829.48
Lighting Installation - Public Areas	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21	2,564.21		1,980,925.37
Lightning & Earthing	-	-	-	-	-	-	-	-		60,268.34
Lightning Protection System	-	-	-	-	-	-	-	-		24,182.40
Louvres - Stainless Steel	-	-	-	-	-	-	-	-		66,476.50
Louvres - GMS	-	-	-	-	-	-	-	40,887.89		122,663.67
Louvres - Refuse Room	0.13	0.13	0.13	0.13	0.13	0.13	253.18	0.13		3,710.66
Main Equipment - Generator	-	-	-	-	-	-	-	-		1,264,030.26
Main Equipment - Switchboards	-	-	-	-	-	-	-	-		7,226,800.00
Mains & Distribution	-	-	-	-	-	-	-	-		6,529,251.40
Metal Cages	-	-	-	-	-	-	-	1,324.22		3,972.66
Metal Doors - Plantrooms	-	-	-	-	-	-	6,000.00	-		489,190.80
Minor RC Concrete Items	-	-	-	-	-	-	-	-		96,474.95
Mirrors	-	-	-	-	-	-	-	-		410,707.09
Movement Joints	-	-	-	-	-	-	-	-		67,240.92
Notice Board	-	-	-	-	-	-	-	15,244.24		45,732.72
Panel Walls - Inter Flat	275,352.00	275,352.00	275,352.00	275,352.00	275,352.00	275,352.00	275,352.00	275,352.00		5,601,696.72
Panel Walls - Internal	504,357.00	504,357.00	504,357.00	504,357.00	504,357.00	504,357.00	504,357.00	504,357.00		12,839,745.53
Pile Caps	-	-	-	-	-	-	-	-		1,851,955.20
Piles	-	-	-	-	-	-	-	-		20,937,727.85
Precast Cills	-	-	-	-	-	-	-	-		31,118.70
Precast Curbs	-	-	-	-	-	-	-	-		110,410.11
Precast Facades Type 1	358,400.00	358,400.00	358,400.00	358,400.00	358,400.00	358,400.00	358,400.00	358,400.00		9,692,320.00
Precast Facades Type 2	268,800.00	268,800.00	268,800.00	268,800.00	268,800.00	268,800.00	268,800.00	268,800.00		5,833,536.00
Precast Lintols	-	-	-	-	-	-	-	-		50,288.24
Precast Stairs	-	-	-	-	-	-	-	-		943,216.00
Railings - Generally	-	-	-	-	-	-	-	40,207.68		120,623.04
Railings - Refuge Area	-	-	-	-	-	-	-	46,234.98		138,704.94
Rainwater Pipes & Outlets	-	-	-	-	-	-	82,000.00	-		750,765.76
RC Beams - Fairfaced	-	-	-	-	-	-	-	-		1,601,500.94
RC Beams - Generally	-	-	-	-	-	-	-	-		519,776.59
RC Columns - Fairfaced	-	-	-	-	-	-	-	-		95,472.73
RC Columns - Generally	-	-	-	-	-	-	-	-		307,588.91
RC Slabs - Fairfaced	556,138.48	556,138.48	556,138.48	556,138.48	556,138.48	556,138.48	1,849,160.45	556,138.48		35,521,955.20
RC Slabs - Generally	-	-	-	-	-	-	-	-		78,521.79
RC Stairs	-	-	-	-	-	-	-	-		79,355.20
RC Walls - Fairfaced	433,298.71	433,298.71	433,298.71	433,298.71	433,298.71	433,298.71	1,385,008.38	433,298.71		34,668,694.08
RC Walls - Generally	-	-	-	-	-	-	286,366.51	-		6,058,487.39
RC Water Tanks	1.99	1.99	1.99	1.99	1.99	1.99	12,746.49	1.99		3,710,640.34
Roller Shutters - MAC Room	-	-	-	-	-	-	-	5,947.16		17,841.48
Roof Block Walls	-	-	-	-	-	-	-	-		11,445.15
Roof System - Paving	17.42	17.42	17.42	17.42	17.42	17.42	53,873.42	17.42		1,360,450.08
Roof System - Screed	11.92	11.92	11.92	11.92	11.92	11.92	17,355.92	11.92		545,577.20
Sanitary Fittings - Flats	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00	383,520.00		10,438,096.05
Sanitary Fittings - Other Areas	-	-	-	-	-	-	-	404.22		1,212.66
Screens & Grilles	-	-	-	-	-	-	-	4,898.34		14,695.02
Seating Benches	-	-	-	-	-	-	-	-		183,230.01
Security Guard Counter	-	-	-	-	-	-	-	-		40,880.25
Security System - CCTV System	-	-	-	-	-	-	-	-		288,970.50
Security System - Door Monitoring	-	-	-	-	-	-	-	-		68,614.00
Security System - Doorphone	-	-	-	-	-	-	-	-		666,144.50
Signage	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14		209,009.08
Sink Units	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00	219,725.00		5,755,455.22
Sliding Shutters - Refuse Chutes	-	-	-	-	-	-	-	96,792.40		290,377.20
Small Power Installation - Flats	570,520.43	570,520.43	570,520.43	570,520.43	570,520.43	570,520.43	570,520.43	570,520.43		20,377,442.43
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-		125,048.00
Soil and Waste - Distribution	-	-	-	-	-	-	-	-		841,275.09
Soil and Waste - Installation	-	-	-	-	-	-	205,000.00	-		1,784,037.92
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-		293,242.40
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-		12,245.23
Stainless Steel Doorset - Plant Rooms	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97		79,275.11
Stainless Steel Window & Doors - Ground Floor	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15		30,556.40
Stainless Steel Windows - Lobby	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49		21,662.51
Staircase Enclosure	-	-	-	-	-	-	-	98,518.76		295,556.28
Substructure Tanking	-	-	-	-	-	-	-	-		295,410.50
Towel Rails	61,523.00	61,523.00	61,523.00	61,523.00	61,523.00	61,523.00	61,523.00	61,523.00		1,430,221.99
Typhoon Guards	-	-	-	-	-	-	-	4,392.52		13,177.56
Typical Floor Block Walls	-	-	-	-	-	-	-	-		502,715.50
Wall Finishes - Corridors & Lobbies	74.43	74.43	74.43	74.43	74.43	74.43	893,264.43	74.43		11,226,951.71
Wall Finishes - Internal Flat Areas	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00	1,431,552.00		33,261,645.47
Wall Finishes - Main Entrance Lobby	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32		220,000.96
Wall Finishes - Movement Joints, etc	-	-	-	-	-	-	-	119,060.40		357,181.20
Wall Finishes - Plant Rooms	17.21	17.21	17.21	17.21	17.21	17.21	184,367.21	17.21		2,147,458.98
Wall Finishes - Refuse Room	6.41	6.41	6.41	6.41	6.41	6.41	8,250.41	6.41		228,450.40
Wall Finishes - Staircases	9.94	9.94	9.94	9.94	9.94	9.94	42,762.69	9.94		632,091.26
Water Meter Doors	-	-	-	-	-	-	-	646,950.40		1,940,851.20
General Items										
Demolition										
Demolition Cost										9,200,000.00
Demolition Credit									-	250,000.00
Operational Costs										
Electricity	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83	3,957,249.83		
Gas	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79	1,145,904.79		
Water	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80	1,117,878.80		
Total Cost in Year	**16,738,570.10**	**16,738,570.10**	**24,244,111.62**	**16,738,570.10**	**16,738,570.10**	**16,738,570.10**	**21,712,864.03**	**18,584,328.65**	**8,950,000.00**	

Capital Period	**141,121,007.10**
Operational Period	**603,262,286.58**
End of Life	**8,950,000.00**
Study Period	**753,333,293.68**

Interest rate	7.90%	Discount factor	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12
Inflation rate	3.75%										
Discount rate	4.00%	Discounted total cost in year	2,649,423.76	2,547,522.84	3,547,910.60	2,355,328.08	2,264,738.54	2,177,633.21	2,716,127.48	2,235,355.37	1,035,116.89


Whole Life Cost Profile by Functional Unit
百萬
Total Cost (HKD)
45
40
35
30
25
20
15
10
5
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Study Year

APPENDIX K : FUNCTIONAL UNITS WHOLE LIFE CYCLE ENVIRONMENTAL IMPACT RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:31:00
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Whole Life

Functional Unit	HK E-points
Precast Facades Type 1	3,115.4428
RC Walls - Fairfaced	1,086.5337
Precast Facades Type 2	890.8841
RC Slabs - Fairfaced	884.2519
RC Water Tanks	456.3537
Aluminium Windows - Bedrooms	432.4637
RC Walls - Generally	412.1952
Aluminium Windows - Living Area	350.2683
Piles	328.2574
Mains & Distribution	229.4707
Small Power Installation - Flats	229.4094
Internal Waterproofing	201.0881
Pile Caps	181.1108
Floor Finishes - Kitchens & Bathrooms	156.9636
Hot Water System	150.5328
Roof System - Paving	149.6507
Wall Finishes - Internal Flat Areas	145.9944
RC Beams - Fairfaced	130.8042
Doorsets - Bathroom (1B /2B)	125.7264
Doorsets - Kitchen	121.9307
Panel Walls - Internal	118.3761
Aluminium Windows - Kitchen	117.8901
Gatesets	116.9835
Precast Stairs	116.9420
Sink Units	93.5697
Sanitary Fittings - Flats	93.1817
Doorsets - Flat Entrance	77.8186
Ground Floor Modifications	71.9026
Wall Finishes - Corridors & Lobbies	68.1653
RC Beams - Generally	49.1488
Fresh Water System - Distribution	47.2878
Floor Finishes - Corridors & Lobbies	47.2789
Cooking Benches	47.2683
Lighting Installation - Flats	43.5887
Aluminium Windows - Bathroom	40.5229
Fresh Water System - Installation	38.3067
Movement Joints	33.9844
Precast Curbs	33.8806
External Wall Finishes - Facades	28.4580
RC Columns - Generally	28.4198
Wall Finishes - Movement Joints, etc	28.1215
Floor Finishes - Movement Joints, etc	27.3304
Lighting Installation - Public Areas	26.7936
Main Equipment - Switchboards	26.7347
Water Meter Doors	26.2550
Doorsets - Exit Staircases	23.7251
Aluminium Windows - Bedrooms Stainless Steel Grilles	21.2039
Lift Equipment	20.9723
Fire Hydrant & Hose Reel System	18.4709

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:31:00
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Whole Life

Functional Unit	HK E-points
Aluminium Windows - Lift Lobby	17.9003
Aluminium Windows - Living Area Stainless Steel Grilles	17.4280
Handrail & Balustrade - Staircases	17.2759
Panel Walls - Inter Flat	15.9719
Doorsets - Bathroom (1/2P)	15.5011
Doorsets - Plant Rooms	13.9349
Aluminium Windows - Corridor	13.5211
Floor Finishes - Staircases	12.5098
Drying Rails / Laundry Poles	11.8329
Typical Floor Block Walls	11.7468
Soil and Waste - Installation	11.1192
Ceiling Finishes - Main Entrance Lobby	10.2056
Precast Lintols	9.0168
Main Equipment - Generator	7.9228
Lift Cars	7.8904
Roof System - Screed	7.8236
Minor RC Concrete Items	7.7374
RC Columns - Fairfaced	7.7117
Wall Finishes - Plant Rooms	7.6077
RC Stairs	7.3741
Staircase Enclosure	7.3044
Soil and Waste - Distribution	6.8322
Hose Reel Doors - Hairline	6.8304
Mirrors	6.7659
RC Slabs - Generally	6.7659
Metal Doors - Plantrooms	6.0541
Doors - Pipe ducts	5.9695
Rainwater Pipes & Outlets	5.7920
Floor Finishes - Plant Rooms	5.5022
Aluminium Windows - Kitchen Stainless Steel Grilles	5.4915
Curtain Rails	5.0565
Railings - Refuge Area	4.8148
Aluminium Louvres - Plant Rooms	4.7359
Spun Concrete Refuse Chutes	4.5241
Small Power Installation - Public Areas	4.3659
FTNS & STDN System	4.3542
Precast Cills	4.2636
Sliding Shutters - Refuse Chutes	4.1474
Wall Finishes - Staircases	4.0080
Ground Floor Block Walls	3.9703
Fresh Water Pump System	3.5870
Railings - Generally	3.5521
Doorsets - Refuse Rooms	3.4025
Flushing Water System - Installation	3.2615
External Wall Finishes - Generally	3.1983
Seating Benches	3.1282
Earthing and Bonding	3.0701
Louvres - GMS	2.9985
Towel Rails	2.9723

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:31:00
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Whole Life

Functional Unit	HK E-points
Letter Boxes	2.9605
Substructure Tanking	2.7233
Gates - Refuge Area	2.1407
Aluminium Windows - Bathroom Stainless Steel Grilles	2.1375
Cat Ladders	2.0798
Security System - Doorphone	1.8582
Fire Alarm & Detection System	1.7612
Air Duct Trunking	1.6852
Floor Washing System	1.5605
Flushing Water System - Distribution	1.5097
Flush Water Pump System	1.4912
Wall Finishes - Refuse Room	1.3787
Aluminium Windows - Plant Rooms	1.3636
Ceiling Finishes - Plant Rooms	1.3392
Floor Finishes - Refuse Room	1.2888
Fire Fighting System	1.2640
A/C Drain Pipes	1.2058
External Ceiling Finishes	1.0313
Louvres - Stainless Steel	0.8994
Stainless Steel Doorset - Plant Rooms	0.8608
Glazed Door & Window - Entrance	0.7744
Security Guard Counter	0.5850
Signage	0.5752
Bearing Pads - Tanks & M&E	0.5217
Drainage	0.4284
Notice Board	0.4247
Lightning Protection System	0.4094
Typhoon Guards	0.3654
Glass Blocks - Ground Floor	0.3309
Bin Guards	0.3168
Stainless Steel Windows - Lobby	0.3083
Level 1 Canopy	0.3000
Automatic Sprinker System	0.2964
Roof Block Walls	0.2879
Roller Shutters - MAC Room	0.2700
Screens & Grilles	0.2614
Security System - Door Monitoring	0.2410
Security System - CCTV System	0.2312
Stainless Steel Window & Doors - Ground Floor	0.2183
Stainless Steel Door - Plant Rooms	0.2059
Doorsets - Ground Floor	0.2016
External Step Finishes	0.1808
Flashing - Refuse Chutes	0.1753
Aluminium Door & Window - 1/F	0.1723
Wall Finishes - Main Entrance Lobby	0.1505
Hose Reel Doors - Polished	0.1497
Lightning & Earthing	0.1332
Angle Protectors - Ground Floor	0.1180
Metal Cages	0.1126

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:31:00
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point - Whole Life

Functional Unit	HK E-points
Lift Vent Covers	0.0991
Inspection Panels - Refuse Chutes	0.0789
FS Inlet Doors	0.0390
Louvres - Refuse Room	0.0361
Lift Car Finishes	0.0183
Sanitary Fittings - Other Areas	0.0093
Earthworks	0.0039
Floor Finishes - Main Entrance Lobby	0.0018

APPENDIX L: WHOLE LIFE CYCLE ENVIRONMENTAL IMPACTS PROFILE – ELEMENTARY BREAKDOWN

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 11:56 AM
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile

Elements	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Foundation and Substructure																					
1.1 Piling	-	509.3682	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	-	69.9405	-	-	-	-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699	-	-
2. Carcase																					
2.1 Frame and slabs	-	-	395.8255	395.8255	395.8255	0.0787	0.0787	0.0787	0.0787	0.1589	0.1589	5.4533	0.1589	0.1589	0.1589	0.1589	0.1589	0.4719	5.7663	0.4719	0.4719
2.2 External walls	-	-	711.4496	711.4496	711.4496	0.0953	0.0953	0.0953	0.0953	0.1925	0.1925	6.0588	0.1925	0.1925	0.1925	0.1925	0.1925	9.4440	15.3103	9.4440	9.4440
2.3 Internal walls	-	-	150.7517	150.7517	150.7517	-	-	-	-	-	-	1.9375	-	-	-	-	-	0.2988	2.2363	0.2988	0.2988
2.4 Doors and shutters	-	-	59.9557	59.9557	59.9557	0.0000	0.0000	0.0000	0.0000	0.2295	0.2295	1.4694	0.2295	0.2295	0.2295	0.2295	0.2295	2.8443	4.0842	2.8443	2.8443
2.5 Windows	-	-	101.4766	101.4766	101.4766	0.0149	0.0149	0.0149	0.0149	0.0149	0.0149	0.0174	0.0149	0.0149	0.0149	0.0149	0.0149	2.1863	2.1888	2.1863	2.1863
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	0.1000	0.1000	0.1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings																					
3.1 Roof finishes	-	-	14.3903	14.3903	14.3903	0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	0.0277
3.2 Floor finishes	-	-	24.5897	24.5897	24.5897	0.0081	0.0081	0.0081	0.0081	0.5681	0.5681	3.2178	0.5681	0.5681	0.5681	0.5681	0.5681	3.3682	6.0178	10.2008	3.3682
3.3 Internal wall finishes	-	-	18.8040	18.8040	18.8040	0.0190	0.0190	0.0190	0.0190	0.2480	0.2480	3.5996	0.2480	0.2480	0.2480	0.2480	0.2480	1.3930	4.7445	1.3930	1.3930
3.4 Ceiling finishes	-	-	1.2410	1.2410	1.2410	-	-	-	-	-	-	0.0536	-	-	-	-	-	-	0.0536	-	-
3.5 External wall finishes	-	-	2.9771	2.9771	2.9771	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.2205	0.0001	0.0001	0.0001	0.0001	0.0001	0.0498	0.2703	0.0498	0.0498
3.6 Décor, graphics and signage	-	-	0.0764	0.0764	0.0764	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
4. Furniture and Fittings																					
4.1 Metal works and sundries	-	-	7.7304	7.7304	7.7304	-	-	-	-	0.0069	0.0069	0.2442	0.0069	0.0069	0.0069	0.0069	0.0069	0.0991	0.3364	0.0991	0.0991
4.2 Built-in furniture	-	-	8.5658	8.5658	8.5658	-	-	-	-	0.1226	0.1226	0.1226	0.1226	0.1226	0.1226	0.1226	0.1226	1.2873	1.2873	1.2873	1.2873
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services																					
5.1 Sanitary fittings	-	-	3.8180	3.8180	3.8180	-	-	-	-	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.8744	0.8744	0.8744	0.8744
5.2 Plumbing and disposal	-	-	165.3901	165.3901	165.3901	0.0003	0.0003	0.0003	0.0003	0.1738	0.1738	5.8364	0.1738	0.1738	0.1738	0.1738	0.1738	1.8220	7.4846	1.8220	1.8220
5.3 Fire services	-	-	4.6720	4.6720	4.6720	-	-	-	-	-	-	0.0147	-	-	-	-	-	-	0.0147	-	-
5.4 Electrical	-	-	75.1975	75.1975	75.1975	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.4858	0.4858	0.4858	0.4858
5.5 Security	-	-	0.3884	0.3884	0.3884	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.6 MVAC	-	-	0.2010	0.2010	0.2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.7 Lifts	-	-	4.8240	4.8240	4.8240	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	0.7257	0.7257	0.7257	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works																					
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	0.1428	0.1428	0.1428	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demolition																					
Demolition Impact																					
Transportaion Impact																					
Operational Energy																					
Electricity						772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143
Gas						22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444
Water						148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025
Total HK E-points in Year	**-**	**579.3087**	**1,753.2931**	**1,753.2931**	**1,753.2931**	**943.6124**	**943.6124**	**943.6124**	**943.6124**	**945.2570**	**945.2570**	**982.4215**	**945.2570**	**945.2570**	**945.2570**	**945.2570**	**945.2570**	**968.0191**	**########**	**974.8517**	**968.0191**

Total HK E-points in Study **64,323.5878**

Project Details

Name: Standard New Harmony 1 (Opt 2) Blc
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 11:56 AM
Generated by: Hong Kong Housing Authority with H
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile

Elements	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1. Foundation and Substructure																			
1.1 Piling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699
2. Carcase																			
2.1 Frame and slabs	0.4719	0.4719	0.4719	11.8001	5.7663	0.4719	0.4719	0.4719	2.9067	0.4719	0.4719	6.0825	0.7881	0.7881	0.7881	0.7881	0.7881	0.7881	6.0825
2.2 External walls	9.4440	9.4440	9.4440	9.4440	15.3103	9.4440	9.4440	9.4440	9.4440	9.4440	9.4440	65.9698	60.1034	60.1034	60.1034	60.1034	60.1034	60.1034	65.9698
2.3 Internal walls	0.2988	0.2988	0.2988	0.2988	2.2363	0.2988	0.2988	0.2988	0.2988	0.2988	0.2988	3.9292	1.9917	1.9917	1.9917	1.9917	1.9917	1.9917	4.0947
2.4 Doors and shutters	2.8443	2.8443	2.8443	2.8443	4.0842	2.8443	2.8443	2.8443	16.2325	2.8443	2.8443	9.3041	8.0642	8.0642	8.0642	8.0642	8.0642	8.0642	25.6486
2.5 Windows	2.1863	2.1863	2.1863	2.1863	2.1888	2.1863	2.1863	2.1863	3.1858	2.1863	2.1863	14.4935	14.4910	14.9553	14.4910	14.4910	14.4910	14.4910	14.4935
2.6 Glazed screens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings																			
3.1 Roof finishes	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	53.1627
3.2 Floor finishes	3.3682	3.3682	3.3682	5.1209	6.0178	3.3682	3.3682	3.3682	3.3682	3.3682	3.3682	9.9379	7.2882	14.1208	7.2882	7.2882	7.2882	7.2882	31.1228
3.3 Internal wall finishes	1.3930	1.3930	1.3930	3.2887	4.7445	1.3930	1.3930	1.3930	10.7668	1.3930	1.3930	6.3475	2.9959	2.9959	2.9959	2.9959	2.9959	2.9959	29.9920
3.4 Ceiling finishes	-	-	-	-	0.0536	-	-	-	3.7231	-	-	0.0536	-	-	-	-	-	-	0.0536
3.5 External wall finishes	0.0498	0.0498	0.0498	0.0498	0.2703	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.5524	0.3319	0.3319	0.3319	0.3319	0.3319	0.3319	6.7974
3.6 Décor, graphics and signage	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.2315
4. Furniture and Fittings																			
4.1 Metal works and sundries	0.0991	0.0991	0.0991	0.1575	0.3364	0.0991	0.0991	0.0991	9.6442	0.0991	0.0991	0.5684	0.3312	0.3312	0.3312	0.3312	0.3312	0.3312	2.7227
4.2 Built-in furniture	1.2873	1.2873	1.2873	2.5250	1.2873	1.2873	1.2873	1.2873	1.4288	1.2873	1.2873	2.7584	2.7584	4.2387	2.7584	2.7584	2.7584	2.7584	2.7584
4.3 Kitchen appliances	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services																			
5.1 Sanitary fittings	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8775	0.8744	0.8744	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946
5.2 Plumbing and disposal	1.8220	1.8220	1.8220	1.8220	7.4846	1.8220	1.8220	1.8220	1.9959	1.8220	1.8220	9.5666	3.9040	3.9040	3.9040	3.9040	3.9040	3.9040	10.3468
5.3 Fire services	-	-	-	-	0.0147	-	-	-	-	-	-	0.0147	-	12.7519	-	-	-	-	0.0147
5.4 Electrical	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	0.4858	3.2288	3.2288	193.2922	3.2288	3.2288	3.2288	3.2288	4.0714
5.5 Security	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1652	-	-	-	-	-
5.6 MVAC	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6029	-	-	-	-	-
5.7 Lifts	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	3.8720	0.0031	0.0031	0.0031	0.0031	0.0031
5.8 Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1771	-	-	-	-	-
5.10 Gondola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works																			
6.1 External works and landscaping	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demolition																			
Demolition Impact																			
Transportaion Impact																			
Operational Energy																			
Electricity	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143
Gas	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444
Water	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025
Total HK E-points in Year	**968.0191**	**968.0191**	**968.0191**	**984.2919**	**########**	**968.0191**	**968.0191**	**968.0191**	**########**	**968.0191**	**968.0191**	**1,088.7304**	**1,051.5659**	**1,270.9725**	**1,051.5659**	**1,051.5659**	**1,051.5659**	**1,051.5659**	**1,203.4920**

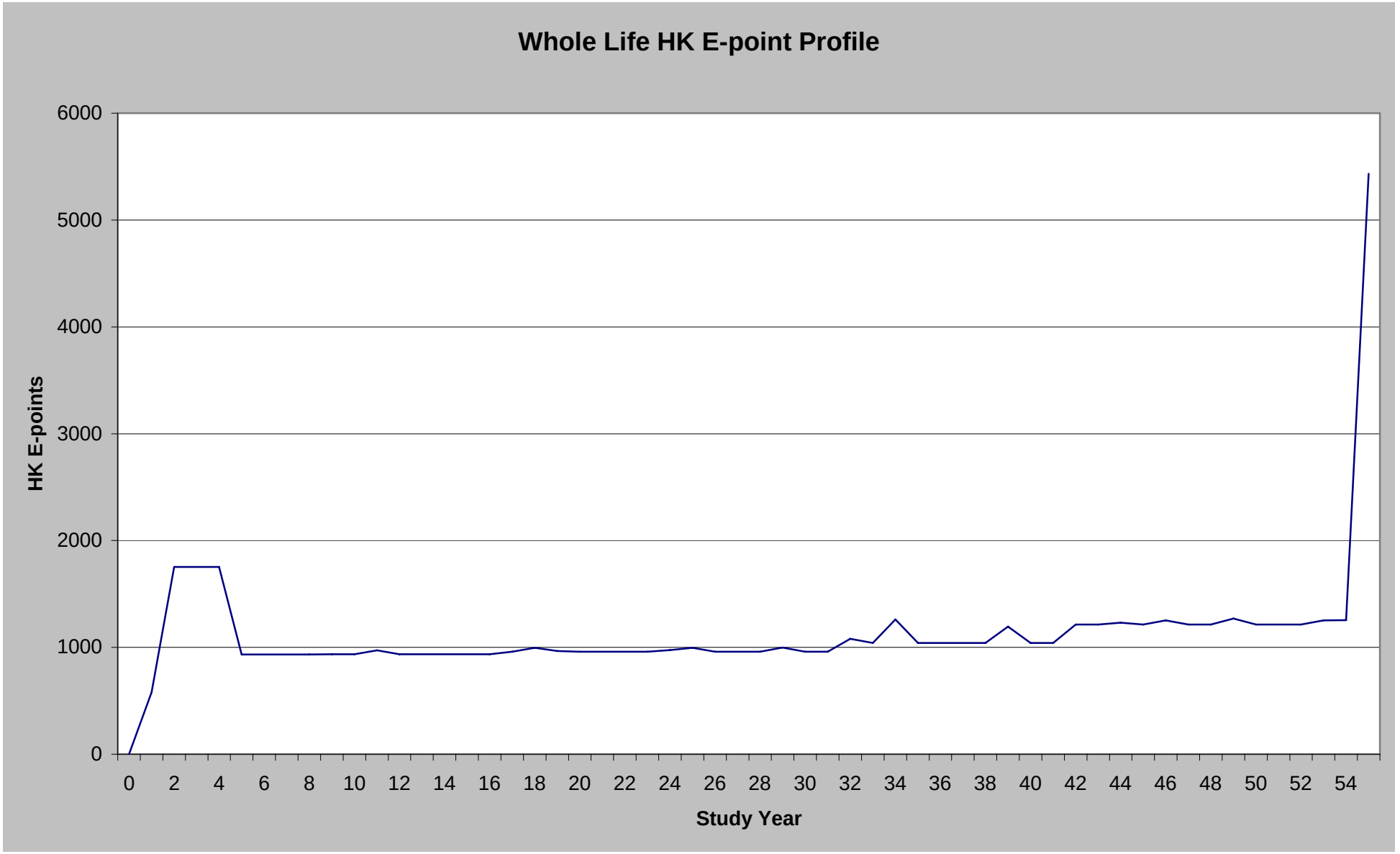
Total HK E-points in Study **64,323.5878**

Project Details

Name: Standard New Harmony 1 (Opt 2) Blc
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 11:56 AM
Generated by: Hong Kong Housing Authority with H
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile

Elements		40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1. Foundation and Substructure																	
1.1 Piling		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.2 Substructure		-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699	-	-
2. Carcase																	
2.1 Frame and slabs		0.7881	0.7881	1.2585	1.2585	12.5866	1.2585	6.5528	1.2585	1.2585	1.2585	1.2585	1.2585	1.2585	6.5528	3.6933	-
2.2 External walls		60.1034	60.1034	167.1409	167.1409	167.1409	167.1409	173.0073	167.1409	167.1409	167.1409	167.1409	167.1409	167.1409	173.0073	167.1409	-
2.3 Internal walls		1.9917	1.9917	5.5767	5.5767	5.5767	5.5767	7.5143	5.5767	5.5767	5.5767	5.5767	5.5767	5.5767	7.5143	5.5767	-
2.4 Doors and shutters		8.0642	8.0642	18.2208	18.2208	18.2208	18.2208	19.4607	18.2208	18.2208	18.2208	18.2208	18.2208	18.2208	19.4607	31.6090	-
2.5 Windows		14.4910	14.4910	40.5479	40.5479	40.5479	40.5479	40.5504	40.5479	40.5479	58.9651	40.5479	40.5479	40.5479	40.5504	41.5474	-
2.6 Glazed screens		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7 Shop fronts		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8 Skylights		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Finishings																	
3.1 Roof finishes		0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	0.0277	0.0277	0.0277	0.0277	0.0277	9.9917	0.0277	-
3.2 Floor finishes		7.2882	7.2882	14.3444	14.3444	16.0971	14.3444	16.9940	14.3444	14.3444	21.1770	14.3444	14.3444	14.3444	16.9940	14.3444	-
3.3 Internal wall finishes		2.9959	2.9959	5.8812	5.8812	7.7770	5.8812	9.2328	5.8812	5.8812	5.8812	5.8812	5.8812	5.8812	9.2328	15.2551	-
3.4 Ceiling finishes		-	-	-	-	-	-	0.0536	-	-	-	-	-	-	0.0536	3.7231	-
3.5 External wall finishes		0.3319	0.3319	0.9293	0.9293	0.9293	0.9293	1.1498	0.9293	0.9293	0.9293	0.9293	0.9293	0.9293	1.1498	0.9293	-
3.6 Décor, graphics and signage		0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	-
4. Furniture and Fittings																	
4.1 Metal works and sundries		0.3312	0.3312	0.7955	0.7955	0.8539	0.7955	1.0327	0.7955	0.7955	0.7955	0.7955	0.7955	0.7955	1.0327	10.3406	-
4.2 Built-in furniture		2.7584	2.7584	5.3943	5.3943	6.6320	5.3943	5.3943	5.3943	5.3943	5.3943	5.3943	5.3943	5.3943	5.3943	5.5359	-
4.3 Kitchen appliances		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Services																	
5.1 Sanitary fittings		1.8946	1.8946	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7340	-
5.2 Plumbing and disposal		3.9040	3.9040	7.6342	7.6342	7.6342	7.6342	13.2968	7.6342	7.6342	26.7695	7.6342	7.6342	7.6342	13.2968	7.8081	-
5.3 Fire services		-	-	-	-	-	-	0.0147	-	-	-	-	-	-	0.0147	-	-
5.4 Electrical		3.2288	3.2288	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	9.0377	-
5.5 Security		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.6 MVAC		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.7 Lifts		0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	10.4892	0.0031	0.0031	0.0031	0.0031	0.0031	-
5.8 Gas		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.9 Communication		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.10 Gondola		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.11 Building automation		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.12 Sewage treatment		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.13 Refuse diposal		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.14 Builder's works, profit & attendance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Miscellaneous Works																	
6.1 External works and landscaping		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.2 Drainage		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demolition																	
Demolition Impact																	4,380.3020
Transportaion Impact																	1,052.9855
Operational Energy																	
Electricity		772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	
Gas		22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	
Water		148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	
Total HK E-points in Year		**1,051.5659**	**1,051.5659**	**1,223.8866**	**1,223.8866**	**1,240.1594**	**1,223.8866**	**1,261.0511**	**1,223.8866**	**1,223.8866**	**1,278.7579**	**1,223.8866**	**1,223.8866**	**1,223.8866**	**1,261.0511**	**1,263.6698**	**5,433.2875**
Total HK E-points in Study	**64,323.5878**																


Whole Life HK E-point Profile
HK E-points
6000
5000
4000
3000
2000
1000
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Study Year

APPENDIX M: WHOLE LIFE CYCLE ENVIRONMENTAL IMPACTS PROFILE – FUNCTIONAL UNIT BREAKDOWN

Project Details

Name: Standard New Harmony 1 (Qpt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:13 PM
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile by Functional Unit

Functional Units	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A/C Drain Pipes	-	-	0.2010	0.2010	0.2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Duct Trunking	-	-	0.2809	0.2809	0.2809	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	-	-	0.0281	0.0281	0.0281	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Aluminium Louvres - Plant Rooms	-	-	0.7822	0.7822	0.7822	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Aluminium Windows - Bathroom	-	-	3.8750	3.8750	3.8750	-	-	-	-	-	-	-	-	-	-	-	-	0.0891	0.0891	0.0891	0.0891	0.0891	0.0891	0.0891	0.0891
Aluminium Windows - Bathroom Stainless Steel Grilles	-	-	0.2028	0.2028	0.2028	-	-	-	-	-	-	-	-	-	-	-	-	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
Aluminium Windows - Bedrooms	-	-	41.3502	41.3502	41.3502	-	-	-	-	-	-	-	-	-	-	-	-	0.9509	0.9509	0.9509	0.9509	0.9509	0.9509	0.9509	0.9509
Aluminium Windows - Bedrooms Stainless Steel Grilles	-	-	2.0128	2.0128	2.0128	-	-	-	-	-	-	-	-	-	-	-	-	0.0468	0.0468	0.0468	0.0468	0.0468	0.0468	0.0468	0.0468
Aluminium Windows - Corridor	-	-	2.2092	2.2092	2.2092	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053
Aluminium Windows - Kitchen	-	-	11.2748	11.2748	11.2748	-	-	-	-	-	-	-	-	-	-	-	-	0.2592	0.2592	0.2592	0.2592	0.2592	0.2592	0.2592	0.2592
Aluminium Windows - Kitchen Stainless Steel Grilles	-	-	0.5211	0.5211	0.5211	-	-	-	-	-	-	-	-	-	-	-	-	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
Aluminium Windows - Lift Lobby	-	-	2.9247	2.9247	2.9247	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
Aluminium Windows - Living Area	-	-	33.4908	33.4908	33.4908	-	-	-	-	-	-	-	-	-	-	-	-	0.7702	0.7702	0.7702	0.7702	0.7702	0.7702	0.7702	0.7702
Aluminium Windows - Living Area Stainless Steel Grilles	-	-	1.6543	1.6543	1.6543	-	-	-	-	-	-	-	-	-	-	-	-	0.0384	0.0384	0.0384	0.0384	0.0384	0.0384	0.0384	0.0384
Aluminium Windows - Plant Rooms	-	-	0.2231	0.2231	0.2231	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Angle Protectors - Ground Floor	-	-	0.0131	0.0131	0.0131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Automatic Sprinker System	-	-	0.0494	0.0494	0.0494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bearing Pads - Tanks & M&E	-	-	0.0580	0.0580	0.0580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bin Guards	-	-	0.0352	0.0352	0.0352	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cat Ladders	-	-	0.2311	0.2311	0.2311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	1.1340	1.1340	1.1340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	-	-	0.1071	0.1071	0.1071	-	-	-	-	-	-	0.0536	-	-	-	-	-	-	0.0536	-	-	-	-	-	-
Cooking Benches	-	-	2.5171	2.5171	2.5171	-	-	-	-	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.4333	0.4333	0.4333	0.4333	0.4333	0.4333	0.4333	0.4333
Curtain Rails	-	-	0.2840	0.2840	0.2840	-	-	-	-	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0459	0.0459	0.0459	0.0459	0.0459	0.0459	0.0459	0.0459
Doors - Pipe ducts	-	-	0.7181	0.7181	0.7181	-	-	-	-	-	-	0.2373	-	-	-	-	-	-	0.2373	-	-	-	-	-	-
Doorsets - Bathroom (1/2P)	-	-	0.8391	0.8391	0.8391	-	-	-	-	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.1416	0.1416	0.1416	0.1416	0.1416	0.1416	0.1416	0.1416
Doorsets - Bathroom (1B /2B)	-	-	6.8175	6.8175	6.8175	-	-	-	-	0.1094	0.1094	0.1094	0.1094	0.1094	0.1094	0.1094	0.1094	0.1484	0.1484	0.1484	0.1484	0.1484	0.1484	0.1484	0.1484
Doorsets - Exit Staircases	-	-	3.4592	3.4592	3.4592	-	-	-	-	-	-	0.4243	-	-	-	-	-	-	0.4243	-	-	-	-	-	-
Doorsets - Flat Entrance	-	-	7.0495	7.0495	7.0495	-	-	-	-	-	-	-	-	-	-	-	-	0.1747	0.1747	0.1747	0.1747	0.1747	0.1747	0.1747	0.1747
Doorsets - Ground Floor	-	-	0.0293	0.0293	0.0293	-	-	-	-	-	-	0.0037	-	-	-	-	-	-	0.0037	-	-	-	-	-	-
Doorsets - Kitchen	-	-	6.4587	6.4587	6.4587	-	-	-	-	0.1066	0.1066	0.1066	0.1066	0.1066	0.1066	0.1066	0.1066	0.1188	0.1188	0.1188	0.1188	0.1188	0.1188	0.1188	0.1188
Doorsets - Refuse Rooms	-	-	0.3885	0.3885	0.3885	-	-	-	-	-	-	0.1531	-	-	-	-	-	-	0.1531	-	-	-	-	-	-
Doorsets - Plant Rooms	-	-	1.5712	1.5712	1.5712	-	-	-	-	-	-	0.6439	-	-	-	-	-	-	0.6439	-	-	-	-	-	-
Drainage	-	-	0.1428	0.1428	0.1428	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	-	-	1.1046	1.1046	1.1046	-	-	-	-	-	-	-	-	-	-	-	-	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263
Earthing and Bonding	-	-	1.0234	1.0234	1.0234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks	0.0039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	-	-	0.2006	0.2006	0.2006	-	-	-	-	-	-	0.0614	-	-	-	-	-	-	0.0614	-	-	-	-	-	-
External Step Finishes	-	-	0.0297	0.0297	0.0297	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
External Wall Finishes - Facades	-	-	2.0520	2.0520	2.0520	-	-	-	-	-	-	-	-	-	-	-	-	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498
External Wall Finishes - Generally	-	-	0.6949	0.6949	0.6949	-	-	-	-	-	-	0.1591	-	-	-	-	-	-	0.1591	-	-	-	-	-	-
Fire Alarm & Detection System	-	-	0.2935	0.2935	0.2935	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire Fighting System	-	-	0.4213	0.4213	0.4213	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	3.0785	3.0785	3.0785	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flashing - Refuse Chutes	-	-	0.0195	0.0195	0.0195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0584
Floor Finishes - Corridors & Lobbies	-	-	5.0690	5.0690	5.0690	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	2.3718	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	2.3718	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061
Floor Finishes - Kitchens & Bathrooms	-	-	6.2710	6.2710	6.2710	-	-	-	-	0.2463	0.2463	0.2463	0.2463	0.2463	0.2463	0.2463	0.2463	1.4781	1.4781	1.4781	1.4781	1.4781	1.4781	1.4781	1.4781
Floor Finishes - Main Entrance Lobby	-	-	0.0005	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Floor Finishes - Movement Joints, etc	-	-	2.2775	2.2775	2.2775	-	-	-	-	-	-	-	-	-	-	-	-	-	6.8326	-	-	-	-	-	-
Floor Finishes - Plant Rooms	-	-	0.5842	0.5842	0.5842	-	-	-	-	-	-	0.0348	-	-	-	-	-	-	0.0348	-	-	-	-	-	1.7527
Floor Finishes - Refuse Room	-	-	0.2014	0.2014	0.2014	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0103	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0103	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Floor Finishes - Staircases	-	-	1.7912	1.7912	1.7912	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.2408	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.2408	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Floor Washing System	-	-	0.2601	0.2601	0.2601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flush Water Pump System	-	-	0.2434	0.2434	0.2434	-	-	-	-	-	-	0.0044	-	-	-	-	-	-	0.0044	-	-	-	-	-	-
Flushing Water System - Distribution	-	-	0.0841	0.0841	0.0841	-	-	-	-	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137
Flushing Water System - Installation	-	-	1.0872	1.0872	1.0872	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fresh Water Pump System	-	-	0.5858	0.5858	0.5858	-	-	-	-	-	-	0.0103	-	-	-	-	-	-	0.0103	-	-	-	-	-	-
Fresh Water System - Distribution	-	-	2.5260	2.5260	2.5260	-	-	-	-	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.4332	0.4332	0.4332	0.4332	0.4332	0.4332	0.4332	0.4332
Fresh Water System - Installation	-	-	6.3785	6.3785	6.3785	-	-	-	-	-	-	0.0051	-	-	-	-	-	-	0.0051	-	-	-	-	-	-
FS Inlet Doors	-	-	0.0035	0.0035	0.0035	-	-	-	-	-	-	0.0011	-	-	-	-	-	-	0.0011	-	-	-	-	-	-
FTNS & STDN System	-	-	0.7257	0.7257	0.7257	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gates - Refuge Area	-	-	0.2379	0.2379	0.2379	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gatesets	-	-	10.8189	10.8189	10.8189	-	-	-	-	-	-	-	-	-	-	-	-	0.2606	0.2606	0.2606	0.2606	0.2606	0.2606	0.2606	0.2606
Glass Blocks - Ground Floor	-	-	0.0551	0.0551	0.0551	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	-	-	0.1267	0.1267	0.1267	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Ground Floor Block Walls	-	-	1.3234	1.3234	1.3234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Floor Modifications	67.2133	-	-	-	-	-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699	-	-	-	-	-	-
Handrail & Balustrade - Staircases	-	-	1.9195	1.9195	1.9195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	0.7589	0.7589	0.7589	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	0.0166	0.0166	0.0166	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water System	-	-	8.1697	8.1697	8.1697	-	-	-	-	0.1309	0.1309	0.1309	0.1309	0.1309	0.1309	0.1309	0.1309	1.3748	1.3748	1.3748	1.3748	1.3748	1.3748	1.3748	1.3748
Inspection Panels - Refuse Chutes	-	-	0.0088	0.0088	0.0088	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Internal Waterproofing	-	-	8.3948	8.3948	8.3948	-	-	-	-	0.3137	0.3137	0.3137	0.3137	0.3137	0.3137	0.3137	0.3137	1.8820	1.8820	1.8820	1.8820	1.8820	1.8820	1.8820	1.8820
Letter Boxes	-	-	0.4934	0.4934	0.4934	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 Canopy	-	-	0.1000	0.1000	0.1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lift Car Finishes	-	-	0.0059	0.0059	0.0059	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lift Cars	-	-	1.2896	1.2896	1.2896	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
Lift Equipment	-	-	3.4954	3.4954	3.4954	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lift Vent Covers	-	-	0.0330	0.0330	0.0330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lighting Installation - Flats	-	-	3.0715	3.0715	3.0715	-	-	-	-	-	-	-	-	-	-	-	-	0.0776	0.0776	0.0776	0.0776	0.0776	0.0776	0.0776	0.0776
Lighting Installation - Public Areas	-	-	8.9026	8.9026	8.9026	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Lightning & Earthing	-	-	0.0444	0.0444	0.0444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lightning Protection System	-	-	0.1365	0.1365	0.1365	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	0.2998	0.2998	0.2998	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - GMS	-	-	0.3332	0.3332	0.3332	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Refuse Room	-	-	0.0054	0.0054	0.0054	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Main Equipment - Generator	-	-	1.3205	1.3205	1.3205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment - Switchboards	-	-	4.4558	4.4558	4.4558	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mains & Distribution	-	-	38.2451	38.2451	38.2451	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metal Cages	-	-	0.0125	0.0125	0.0125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metal Doors - Plantrooms	-	-	1.9859	1.9859	1.9859	-	-	-	-	-	-	0.0138	-	-	-	-	-	-	0.0138	-	-	-	-	-	-
Minor RC Concrete Items	-	-	2.5791	2.5791	2.5791	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mirrors	-	-	2.2553	2.2553	2.2553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Movement Joints	-	-	3.7760	3.7760	3.7760	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3281
Notice Board	-	-	0.0472	0.0472	0.0472	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panel Walls - Inter Flat	-	-	1.4719	1.4719	1.4719	-	-	-	-	-	-	-	-	-	-	-	-	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356
Panel Walls - Internal	-	-	11.0121	11.0121	11.0121	-	-	-	-	-	-	-	-	-	-	-	-	0.2631	0.2631	0.2631	0.2631	0.2631	0.2631	0.2631	0.2631
Pile Caps	181.1108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piles	328.2574	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	1.4212	1.4212	1.4212	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Curbs	-	-	11.2935	11.2935	11.2935	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Facades Type 1	-	-	292.5809	292.5809	292.5809	-	-	-	-	-	-	-	-	-	-	-	-	6.8994	6.8994	6.8994	6.8994	6.8994	6.8994	6.8994	6.8994
Precast Facades Type 2	-	-	83.6659	83.6659	83.6659	-	-	-	-	-	-	-	-	-	-	-	-	1.9729	1.9729	1.9729	1.9729	1.9729	1.9729	1.9729	1.9729
Precast Lintols	-	-	3.0056	3.0056	3.0056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Stairs	-	-	38.9807	38.9807	38.9807	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Generally	-	-	0.3947	0.3947	0.3947	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Refuge Area	-	-	0.5350	0.5350	0.5350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rainwater Pipes & Outlets	-	-	1.8986	1.8986	1.8986	-	-	-	-	-	-	0.0137	-	-	-	-	-	-	0.0137	-	-	-	-	-	-
RC Beams - Fairfaced	-	-	43.6014	43.6014	43.6014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Beams - Generally	-	-	16.3829	16.3829	16.3829	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	2.5706	2.5706	2.5706	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Generally	-	-	9.4733	9.4733	9.4733	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Slabs - Fairfaced	-	-	271.4285	271.4285	271.4285	0.0787	0.0787	0.0787	0.0787	0.1589	0.1589	5.4533	0.1589	0.1589	0.1589	0.1589	0.1589	0.4719	5.7663	0.4719	0.4719	0.4719	0.4719	0.4719	0.4719
RC Slabs - Generally	-	-	2.2553	2.2553	2.2553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Stairs	-	-	2.4580	2.4580	2.4580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Walls - Fairfaced	-	-	335.2028	335.2028	335.2028	0.0953	0.0953	0.0953	0.0953	0.1925	0.1925	6.0588	0.1925	0.1925	0.1925	0.1925	0.1925	0.5717	6.4380	0.5717	0.5717	0.5717	0.5717	0.5717	0.5717
RC Walls - Generally	-	-	132.8775	132.8775	132.8775	-	-	-	-	-	-	1.9375	-	-	-	-	-	-	1.9375	-	-	-	-	-	-
RC Water Tanks	-	-	139.0212	139.0212	139.0212	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Roller Shutters - MAC Room	-	-	0.0300	0.0300	0.0300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Block Walls	-	-	0.0960	0.0960	0.0960	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof System - Paving	-	-	13.6456	13.6456	13.6456	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	9.5266	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	9.5266	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254
Roof System - Screed	-	-	0.7447	0.7447	0.7447	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.4651	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.4651	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Sanitary Fittings - Flats	-	-	3.8169	3.8169	3.8169	-	-	-	-	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.1457	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744
Sanitary Fittings - Other Areas	-	-	0.0010	0.0010	0.0010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Screens & Grilles	-	-	0.0290	0.0290	0.0290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seating Benches	-	-	0.3476	0.3476	0.3476	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0427
Security Guard Counter	-	-	0.0650	0.0650	0.0650	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1950
Security System - CCTV System	-	-	0.0385	0.0385	0.0385	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Door Monitoring	-	-	0.0402	0.0402	0.0402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Doorphone	-	-	0.3097	0.3097	0.3097	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Signage	-	-	0.0764	0.0764	0.0764	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Sink Units	-	-	5.0955	5.0955	5.0955	-	-	-	-	0.0813	0.0813	0.0813	0.0813	0.0813	0.0813	0.0813	0.0813	0.8540	0.8540	0.8540	0.8540	0.8540	0.8540	0.8540	0.8540
Sliding Shutters - Refuse Chutes	-	-	0.4608	0.4608	0.4608	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small Power Installation - Flats	-	-	16.2616	16.2616	16.2616	-	-	-	-	-	-	-	-	-	-	-	-	0.4065	0.4065	0.4065	0.4065	0.4065	0.4065	0.4065	0.4065
Small Power Installation - Public Areas	-	-	1.4553	1.4553	1.4553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	2.2774	2.2774	2.2774	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Installation	-	-	3.6294	3.6294	3.6294	-	-	-	-	-	-	0.0330	-	-	-	-	-	-	0.0330	-	-	-	-	-	-
Spun Concrete Refuse Chutes	-	-	1.5080	1.5080	1.5080	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	0.0686	0.0686	0.0686	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	-	-	0.2861	0.2861	0.2861	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Stainless Steel Window & Doors - Ground Floor	-	-	0.0695	0.0695	0.0695	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Stainless Steel Windows - Lobby	-	-	0.0929	0.0929	0.0929	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Staircase Enclosure	-	-	0.8116	0.8116	0.8116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Substructure Tanking	2.7233	-

Project Details

Name: Standard New Harmony 1 (Opt 2) Blc
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:13 PM
Generated by: Hong Kong Housing Authority with HI
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile by Functio

Functional Units	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
A/C Drain Pipes	-	-	-	-	-	-	-	-	-	0.6029	-	-	-	-	-	-	-	-	-	-	-	-
Air Duct Trunking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8426	-	-	-	-	-	-	-
Aluminium Door & Window - 1/F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0842	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Aluminium Louvres - Plant Rooms	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Aluminium Windows - Bathroom	0.0891	0.0891	0.0891	0.0891	0.0891	0.0891	0.0891	0.5940	0.5940	0.5940	0.5940	0.5940	0.5940	0.5940	0.5940	0.5940	0.5940	1.6632	1.6632	1.6632	1.6632	1.6632
Aluminium Windows - Bathroom Stainless Steel Grilles	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0314	0.0314	0.0314	0.0314	0.0314	0.0314	0.0314	0.0314	0.0314	0.0314	0.0880	0.0880	0.0880	0.0880	0.0880
Aluminium Windows - Bedrooms	0.9509	0.9509	0.9509	0.9509	0.9509	0.9509	0.9509	6.3394	6.3394	6.3394	6.3394	6.3394	6.3394	6.3394	6.3394	6.3394	6.3394	17.7504	17.7504	17.7504	17.7504	17.7504
Aluminium Windows - Bedrooms Stainless Steel Grilles	0.0468	0.0468	0.0468	0.0468	0.0468	0.0468	0.0468	0.3117	0.3117	0.3117	0.3117	0.3117	0.3117	0.3117	0.3117	0.3117	0.3117	0.8728	0.8728	0.8728	0.8728	0.8728
Aluminium Windows - Corridor	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053
Aluminium Windows - Kitchen	0.2592	0.2592	0.2592	0.2592	0.2592	0.2592	0.2592	1.7280	1.7280	1.7280	1.7280	1.7280	1.7280	1.7280	1.7280	1.7280	1.7280	4.8383	4.8383	4.8383	4.8383	4.8383
Aluminium Windows - Kitchen Stainless Steel Grilles	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121	0.0807	0.0807	0.0807	0.0807	0.0807	0.0807	0.0807	0.0807	0.0807	0.0807	0.2261	0.2261	0.2261	0.2261	0.2261
Aluminium Windows - Lift Lobby	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
Aluminium Windows - Living Area	0.7702	0.7702	0.7702	0.7702	0.7702	0.7702	0.7702	5.1346	5.1346	5.1346	5.1346	5.1346	5.1346	5.1346	5.1346	5.1346	5.1346	14.3767	14.3767	14.3767	14.3767	14.3767
Aluminium Windows - Living Area Stainless Steel Grilles	0.0384	0.0384	0.0384	0.0384	0.0384	0.0384	0.0384	0.2562	0.2562	0.2562	0.2562	0.2562	0.2562	0.2562	0.2562	0.2562	0.2562	0.7174	0.7174	0.7174	0.7174	0.7174
Aluminium Windows - Plant Rooms	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Angle Protectors - Ground Floor	-	-	-	-	0.0393	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Automatic Sprinkler System	-	-	-	-	-	-	-	-	-	0.1482	-	-	-	-	-	-	-	-	-	-	-	-
Bearing Pads - Tanks & M&E	-	-	-	-	0.1739	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bin Guards	-	-	-	-	0.1056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cat Ladders	-	-	-	-	0.6933	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	3.4019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceiling Finishes - Plant Rooms	0.0536	-	-	-	0.3213	-	-	0.0536	-	-	-	-	-	-	0.0536	-	-	-	-	-	-	0.0536
Cooking Benches	0.4333	0.4333	0.4333	0.4333	0.4333	0.4333	0.4333	0.9284	0.9284	0.9284	0.9284	0.9284	0.9284	0.9284	0.9284	0.9284	0.9284	1.8156	1.8156	1.8156	1.8156	1.8156
Curtain Rails	0.0459	0.0459	0.0459	0.0459	0.0459	0.0459	0.0459	0.0983	0.0983	0.0983	0.0983	0.0983	0.0983	0.0983	0.0983	0.0983	0.0983	0.1922	0.1922	0.1922	0.1922	0.1922
Doors - Pipe ducts	0.2373	-	-	-	-	-	-	0.2373	-	-	-	-	-	-	2.3915	-	-	-	-	-	-	0.2373
Doorsets - Bathroom (1/2P)	0.1416	0.1416	0.1416	0.1416	0.1416	0.1416	0.1416	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.3035	0.5935	0.5935	0.5935	0.5935	0.5935
Doorsets - Bathroom (1B /2B)	1.1484	1.1484	1.1484	1.1484	1.1484	1.1484	1.1484	2.4610	2.4610	2.4610	2.4610	2.4610	2.4610	2.4610	2.4610	2.4610	2.4610	4.8125	4.8125	4.8125	4.8125	4.8125
Doorsets - Exit Staircases	0.4243	-	-	-	-	-	-	0.4243	-	-	-	-	-	-	10.8018	-	-	-	-	-	-	0.4243
Doorsets - Flat Entrance	0.1747	0.1747	0.1747	0.1747	0.1747	0.1747	0.1747	1.1649	1.1649	1.1649	1.1649	1.1649	1.1649	1.1649	1.1649	1.1649	1.1649	3.2616	3.2616	3.2616	3.2616	3.2616
Doorsets - Ground Floor	0.0037	-	-	-	-	-	-	0.0037	-	-	-	-	-	-	0.0915	-	-	-	-	-	-	0.0037
Doorsets - Kitchen	1.1188	1.1188	1.1188	1.1188	1.1188	1.1188	1.1188	2.3974	2.3974	2.3974	2.3974	2.3974	2.3974	2.3974	2.3974	2.3974	2.3974	4.6882	4.6882	4.6882	4.6882	4.6882
Doorsets - Refuse Rooms	0.1531	-	-	-	-	-	-	0.1531	-	-	-	-	-	-	1.3185	-	-	-	-	-	-	0.1531
Doorsets - Plant Rooms	0.6439	-	-	-	-	-	-	0.6439	-	-	-	-	-	-	5.3576	-	-	-	-	-	-	0.6439
Drainage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drying Rails / Laundry Poles	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.0263	0.1751	0.1751	0.1751	0.1751	0.1751	0.1751	0.1751	0.1751	0.1751	0.1751	0.4903	0.4903	0.4903	0.4903	0.4903
Earthing and Bonding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
External Ceiling Finishes	0.0614	-	-	-	-	-	-	0.0614	-	-	-	-	-	-	0.0614	-	-	-	-	-	-	0.0614
External Step Finishes	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0892	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
External Wall Finishes - Facades	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.3319	0.3319	0.3319	0.3319	0.3319	0.3319	0.3319	6.4878	0.3319	0.3319	0.9293	0.9293	0.9293	0.9293	0.9293
External Wall Finishes - Generally	0.1591	-	-	-	-	-	-	0.1591	-	-	-	-	-	-	0.1591	-	-	-	-	-	-	0.1591
Fire Alarm & Detection System	-	-	-	-	-	-	-	-	-	0.8806	-	-	-	-	-	-	-	-	-	-	-	-
Fire Fighting System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-	-	9.2354	-	-	-	-	-	-	-	-	-	-	-	-
Flashing - Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0584	-	-
Floor Finishes - Corridors & Lobbies	2.3718	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	2.3718	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	17.5789	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	2.3718
Floor Finishes - Kitchens & Bathrooms	1.4781	1.4781	1.4781	1.4781	1.4781	1.4781	1.4781	3.2025	3.2025	3.2025	3.2025	3.2025	3.2025	3.2025	3.2025	3.2025	3.2025	6.3064	6.3064	6.3064	6.3064	6.3064
Floor Finishes - Main Entrance Lobby	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Floor Finishes - Movement Joints, etc	-	-	-	-	-	-	-	-	-	6.8326	-	-	-	-	-	-	-	-	-	-	-	-
Floor Finishes - Plant Rooms	0.0348	-	-	-	-	-	-	0.0348	-	-	-	-	-	-	0.0348	-	-	-	-	1.7527	-	0.0348
Floor Finishes - Refuse Room	0.0103	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0103	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.6144	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0103
Floor Finishes - Staircases	0.2408	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.2408	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	5.6145	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.2408
Floor Washing System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7803	-	-	-	-	-	-	-
Flush Water Pump System	0.0044	-	-	-	-	-	-	0.0044	-	0.7301	-	-	-	-	0.0044	-	-	-	-	-	-	0.0044
Flushing Water System - Distribution	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0294	0.0575	0.0575	0.0575	0.0575	0.0575
Flushing Water System - Installation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fresh Water Pump System	0.0103	-	-	-	-	-	-	0.0103	-	1.7575	-	-	-	-	0.0103	-	-	-	-	-	-	0.0103
Fresh Water System - Distribution	0.4332	0.4332	0.4332	0.4332	0.4332	0.4332	0.4332	0.9283	0.9283	0.9283	0.9283	0.9283	0.9283	0.9283	0.9283	0.9283	0.9283	1.8153	1.8153	1.8153	1.8153	1.8153
Fresh Water System - Installation	0.0051	-	-	-	-	-	-	0.0051	-	-	-	-	-	-	0.0051	-	-	-	-	-	-	0.0051
FS Inlet Doors	0.0011	-	-	-	0.0104	-	-	0.0011	-	-	-	-	-	-	0.0011	-	-	-	-	-	-	0.0011
FTNS & STDN System	-	-	-	-	-	-	-	-	-	2.1771	-	-	-	-	-	-	-	-	-	-	-	-
Gates - Refuge Area	-	-	-	-	0.7136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gatesets	0.2606	0.2606	0.2606	0.2606	0.2606	0.2606	0.2606	1.7374	1.7374	1.7374	1.7374	1.7374	1.7374	1.7374	1.7374	1.7374	1.7374	4.8648	4.8648	4.8648	4.8648	4.8648
Glass Blocks - Ground Floor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1654	-	-	-	-	-	-	-
Glazed Door & Window - Entrance	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.3805	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Ground Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ground Floor Modifications	0.6699	-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699	-	-	-	-	-	-	0.6699
Handrail & Balustrade - Staircases	-	-	-	-	5.7586	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Hairline	-	-	-	-	2.2768	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hose Reel Doors - Polished	-	-	-	-	0.0499	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water System	1.3748	1.3748	1.3748	1.3748	1.3748	1.3748	1.3748	2.9460	2.9460	2.9460	2.9460	2.9460	2.9460	2.9460	2.9460	2.9460	2.9460	5.7611	5.7611	5.7611	5.7611	5.7611
Inspection Panels - Refuse Chutes	-	-	-	-	0.0263	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Internal Waterproofing	1.8820	1.8820	1.8820	1.8820	1.8820	1.8820	1.8820	4.0777	4.0777	4.0777	4.0777	4.0777	4.0777	4.0777	4.0777	4.0777	4.0777	8.0298	8.0298	8.0298	8.0298	8.0298
Letter Boxes	-	-	-	-	-	-	-	-	-	1.4803	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 Canopy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lift Car Finishes	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lift Cars	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	3.8720	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
Lift Equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lift Vent Covers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lighting Installation - Flats	0.0776	0.0776	0.0776	0.0776	0.0776	0.0776	0.0776	0.5172	0.5172	9.7316	0.5172	0.5172	0.5172	0.5172	0.5172	0.5172	0.5172	1.4480	1.4480	1.4480	1.4480	1.4480
Lighting Installation - Public Areas	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Lightning & Earthing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lightning Protection System	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Stainless Steel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - GMS	-	-	-	-	0.9995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Louvres - Refuse Room	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026
Main Equipment - Generator	-	-	-	-	-	-	-	-	-	3.9614	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment - Switchboards	-	-	-	-	-	-	-	-	-	13.3674	-	-	-	-	-	-	-	-	-	-	-	-
Mains & Distribution	-	-	-	-	-	-	-	-	-	114.7354	-	-	-	-	-	-	-	-	-	-	-	-
Metal Cages	-	-	-	-	0.0375	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metal Doors - Plantrooms	0.0138	-	-	-	-	-	-	0.0138	-	-	-	-	-	-	0.0138	-	-	-	-	-	-	0.0138
Minor RC Concrete Items	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mirrors	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Movement Joints	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3281	-	-
Notice Board	-	-	-	-	0.1416	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panel Walls - Inter Flat	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.2375	0.2375	0.2375	0.2375	0.2375	0.2375	0.2375	0.2375	0.2375	0.2375	0.6651	0.6651	0.6651	0.6651	0.6651
Panel Walls - Internal	0.2631	0.2631	0.2631	0.2631	0.2631	0.2631	0.2631	1.7542	1.7542	1.7542	1.7542	1.7542	1.7542	1.7542	1.7542	1.7542	1.7542	4.9116	4.9116	4.9116	4.9116	4.9116
Pile Caps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Cills	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Curbs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Facades Type 1	6.8994	6.8994	6.8994	6.8994	6.8994	6.8994	6.8994	45.9959	45.9959	45.9959	45.9959	45.9959	45.9959	45.9959	45.9959	45.9959	45.9959	128.7885	128.7885	128.7885	128.7885	128.7885
Precast Facades Type 2	1.9729	1.9729	1.9729	1.9729	1.9729	1.9729	1.9729	13.1529	13.1529	13.1529	13.1529	13.1529	13.1529	13.1529	13.1529	13.1529	13.1529	36.8280	36.8280	36.8280	36.8280	36.8280
Precast Lintols	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Precast Stairs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Generally	-	-	-	-	1.1840	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Railings - Refuge Area	-	-	-	-	1.6049	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rainwater Pipes & Outlets	0.0137	-	-	-	-	-	-	0.0137	-	-	-	-	-	-	0.0137	-	-	-	-	-	-	0.0137
RC Beams - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Beams - Generally	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Fairfaced	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Columns - Generally	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Slabs - Fairfaced	5.7663	0.4719	0.4719	0.4719	0.4719	0.4719	0.4719	6.0825	0.7881	0.7881	0.7881	0.7881	0.7881	0.7881	6.0825	0.7881	0.7881	1.2585	1.2585	1.2585	1.2585	6.5528
RC Slabs - Generally	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Stairs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RC Walls - Fairfaced	6.4380	0.5717	0.5717	0.5717	0.5717	0.5717	0.5717	6.8211	0.9547	0.9547	0.9547	0.9547	0.9547	0.9547	6.8211	0.9547	0.9547	1.5245	1.5245	1.5245	1.5245	7.3908
RC Walls - Generally	1.9375	-	-	-	-	-	-	1.9375	-	-	-	-	-	-	1.9375	-	-	-	-	-	-	1.9375
RC Water Tanks	5.6110	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110
Roller Shutters - MAC Room	-	-	-	-	0.0900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof Block Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roof System - Paving	9.5266	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	9.5266	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	50.4634	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	9.5266
Roof System - Screed	0.4651	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.4651	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	2.6993	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.4651
Sanitary Fittings - Flats	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	0.8744	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	1.8946	3.7309	3.7309	3.7309	3.7309	3.7309
Sanitary Fittings - Other Areas	-	-	-	-	0.0031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Screens & Grilles	-	-	-	-	0.0871	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seating Benches	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0427	-	-
Security Guard Counter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1950	-	-
Security System - CCTV System	-	-	-	-	-	-	-	-	-	0.1156	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Door Monitoring	-	-	-	-	-	-	-	-	-	0.1205	-	-	-	-	-	-	-	-	-	-	-	-
Security System - Doorphone	-	-	-	-	-	-	-	-	-	0.9291	-	-	-	-	-	-	-	-	-	-	-	-
Signage	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.2315	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Sink Units	0.8540	0.8540	0.8540	0.8540	0.8540	0.8540	0.8540	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	1.8300	3.5787	3.5787	3.5787	3.5787	3.5787
Sliding Shutters - Refuse Chutes	-	-	-	-	1.3825	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small Power Installation - Flats	0.4065	0.4065	0.4065	0.4065	0.4065	0.4065	0.4065	2.7100	2.7100	51.4948	2.7100	2.7100	2.7100	2.7100	2.7100	2.7100	2.7100	7.5879	7.5879	7.5879	7.5879	7.5879
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Distribution	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil and Waste - Installation	0.0330	-	-	-	-	-	-	0.0330	-	-	-	-	-	-	0.0330	-	-	-	-	-	-	0.0330
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stainless Steel Doorset - Plant Rooms	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Stainless Steel Window & Doors - Ground Floor	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Stainless Steel Windows - Lobby	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Staircase Enclosure	-	-	-	-	2.4348	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Substructure Tanking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Towel Rails	0.0270	0.0270	0.0270	0.0270	0.0270	0.0270	0.0270	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.1129	0.1129	0.1129	0.1129	0.1129
Typhoon Guards	-	-	-	-	0.1218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Typical Floor Block Walls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wall Finishes - Corridors & Lobbies	2.8719	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	2.8719	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	26.5164	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	2.8719
Wall Finishes - Internal Flat Areas	1.3740	1.3740	1.3740	1.3740	1.3740	1.3740	1.3740	2.9769	2.9769	2.9769	2.9769	2.9769	2.9769	2.9769	2.9769	2.9769	2.9769	5.8623	5.8623	5.8623	5.8623	5.8623
Wall Finishes - Main Entrance Lobby	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

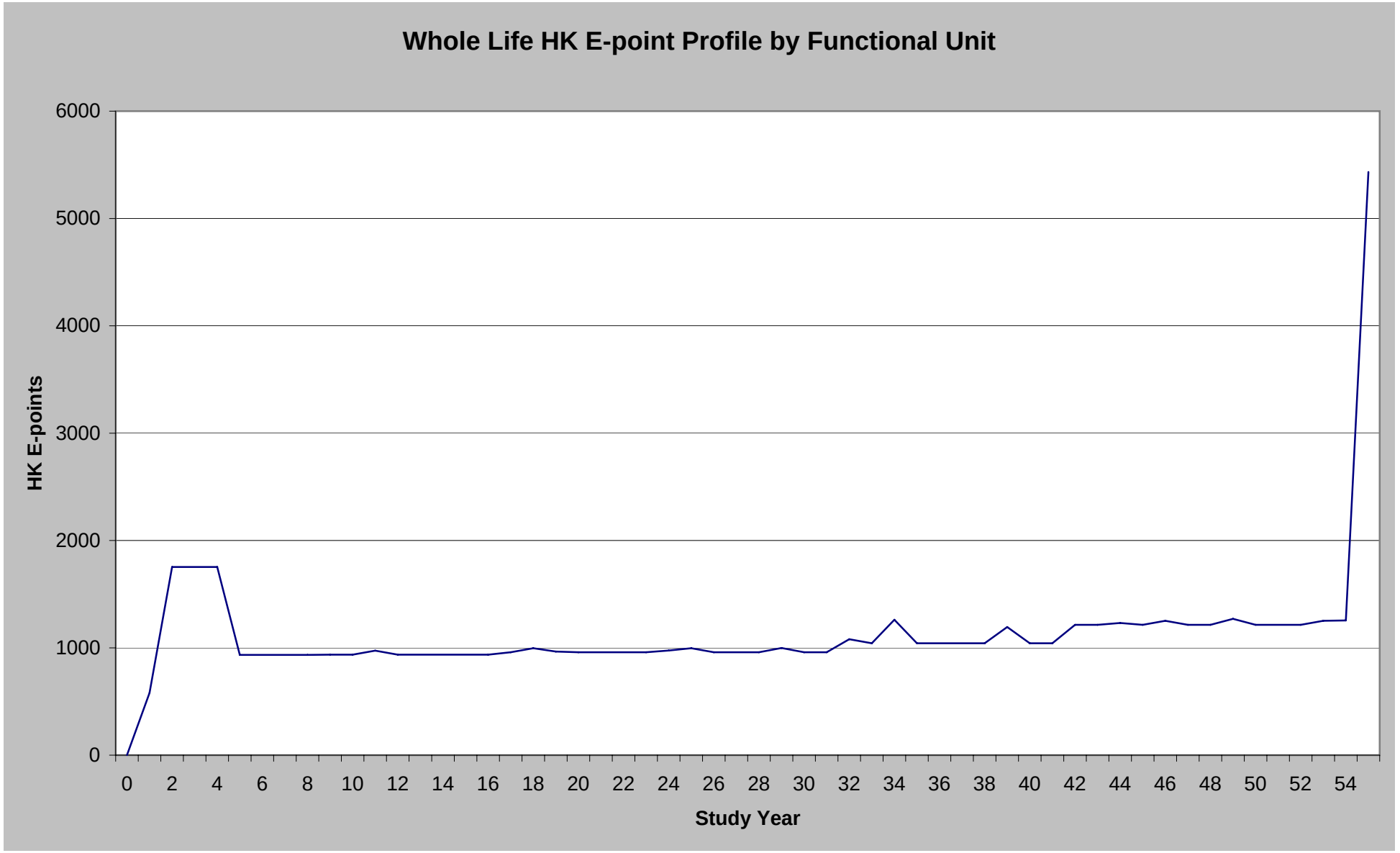
Project Details

Name: Standard New Harmony 1 (Opt 2) Blc
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/06/05 12:13 PM
Generated by: Hong Kong Housing Authority with HI
Orientation: Orientation1_NS
Weighting: Local Norm: Local

Whole Life HK E-point Profile by Functio

Functional Units	47	48	49	50	51	52	53	54	55	Total
A/C Drain Pipes	-	-	-	-	-	-	-	-		1.2058
Air Duct Trunking	-	-	-	-	-	-	-	-		1.6852
Aluminium Door & Window - 1/F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.1723
Aluminium Louvres - Plant Rooms	0.0009	0.0009	2.3474	0.0009	0.0009	0.0009	0.0009	0.0009		4.7359
Aluminium Windows - Bathroom	1.6632	1.6632	1.6632	1.6632	1.6632	1.6632	1.6632	1.6632		40.5229
Aluminium Windows - Bathroom Stainless Steel Grilles	0.0880	0.0880	0.0880	0.0880	0.0880	0.0880	0.0880	0.0880		2.1375
Aluminium Windows - Bedrooms	17.7504	17.7504	17.7504	17.7504	17.7504	17.7504	17.7504	17.7504		432.4637
Aluminium Windows - Bedrooms Stainless Steel Grilles	0.8728	0.8728	0.8728	0.8728	0.8728	0.8728	0.8728	0.8728		21.2039
Aluminium Windows - Corridor	0.0053	0.0053	6.6328	0.0053	0.0053	0.0053	0.0053	0.0053		13.5211
Aluminium Windows - Kitchen	4.8383	4.8383	4.8383	4.8383	4.8383	4.8383	4.8383	4.8383		117.8901
Aluminium Windows - Kitchen Stainless Steel Grilles	0.2261	0.2261	0.2261	0.2261	0.2261	0.2261	0.2261	0.2261		5.4915
Aluminium Windows - Lift Lobby	0.0070	0.0070	8.7811	0.0070	0.0070	0.0070	0.0070	0.0070		17.9003
Aluminium Windows - Living Area	14.3767	14.3767	14.3767	14.3767	14.3767	14.3767	14.3767	14.3767		350.2683
Aluminium Windows - Living Area Stainless Steel Grilles	0.7174	0.7174	0.7174	0.7174	0.7174	0.7174	0.7174	0.7174		17.4280
Aluminium Windows - Plant Rooms	0.0005	0.0005	0.6697	0.0005	0.0005	0.0005	0.0005	0.0005		1.3636
Angle Protectors - Ground Floor	-	-	-	-	-	-	-	0.0393		0.1180
Automatic Sprinker System	-	-	-	-	-	-	-	-		0.2964
Bearing Pads - Tanks & M&E	-	-	-	-	-	-	-	0.1739		0.5217
Bin Guards	-	-	-	-	-	-	-	0.1056		0.3168
Cat Ladders	-	-	-	-	-	-	-	0.6933		2.0798
Ceiling Finishes - Main Entrance Lobby	-	-	-	-	-	-	-	3.4019		10.2056
Ceiling Finishes - Plant Rooms	-	-	-	-	-	-	0.0536	0.3213		1.3392
Cooking Benches	1.8156	1.8156	1.8156	1.8156	1.8156	1.8156	1.8156	1.8156		47.2683
Curtain Rails	0.1922	0.1922	0.1922	0.1922	0.1922	0.1922	0.1922	0.1922		5.0565
Doors - Pipe ducts	-	-	-	-	-	-	0.2373	-		5.9695
Doorsets - Bathroom (1/2P)	0.5935	0.5935	0.5935	0.5935	0.5935	0.5935	0.5935	0.5935		15.5011
Doorsets - Bathroom (1B /2B)	4.8125	4.8125	4.8125	4.8125	4.8125	4.8125	4.8125	4.8125		125.7264
Doorsets - Exit Staircases	-	-	-	-	-	-	0.4243	-		23.7251
Doorsets - Flat Entrance	3.2616	3.2616	3.2616	3.2616	3.2616	3.2616	3.2616	3.2616		77.8186
Doorsets - Ground Floor	-	-	-	-	-	-	0.0037	-		0.2016
Doorsets - Kitchen	4.6882	4.6882	4.6882	4.6882	4.6882	4.6882	4.6882	4.6882		121.9307
Doorsets - Refuse Rooms	-	-	-	-	-	-	0.1531	-		3.4025
Doorsets - Plant Rooms	-	-	-	-	-	-	0.6439	-		13.9349
Drainage	-	-	-	-	-	-	-	-		0.4284
Drying Rails / Laundry Poles	0.4903	0.4903	0.4903	0.4903	0.4903	0.4903	0.4903	0.4903		11.8329
Earthing and Bonding	-	-	-	-	-	-	-	-		3.0701
Earthworks	-	-	-	-	-	-	-	-		0.0039
External Ceiling Finishes	-	-	-	-	-	-	0.0614	-		1.0313
External Step Finishes	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.1808
External Wall Finishes - Facades	0.9293	0.9293	0.9293	0.9293	0.9293	0.9293	0.9293	0.9293		28.4580
External Wall Finishes - Generally	-	-	-	-	-	-	0.1591	-		3.1983
Fire Alarm & Detection System	-	-	-	-	-	-	-	-		1.7612
Fire Fighting System	-	-	-	-	-	-	-	-		1.2640
Fire Hydrant & Hose Reel System	-	-	-	-	-	-	-	-		18.4709
Flashing - Refuse Chutes	-	-	-	-	-	-	-	-		0.1753
Floor Finishes - Corridors & Lobbies	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	2.3718	0.0061		47.2789
Floor Finishes - Kitchens & Bathrooms	6.3064	6.3064	6.3064	6.3064	6.3064	6.3064	6.3064	6.3064		156.9636
Floor Finishes - Main Entrance Lobby	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0018
Floor Finishes - Movement Joints, etc	-	-	6.8326	-	-	-	-	-		27.3304
Floor Finishes - Plant Rooms	-	-	-	-	-	-	0.0348	-		5.5022
Floor Finishes - Refuse Room	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0103	0.0002		1.2898
Floor Finishes - Staircases	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.2408	0.0018		12.5098
Floor Washing System	-	-	-	-	-	-	-	-		1.5605
Flush Water Pump System	-	-	-	-	-	-	0.0044	-		1.4912
Flushing Water System - Distribution	0.0575	0.0575	0.0575	0.0575	0.0575	0.0575	0.0575	0.0575		1.5097
Flushing Water System - Installation	-	-	-	-	-	-	-	-		3.2615
Fresh Water Pump System	-	-	-	-	-	-	0.0103	-		3.5870
Fresh Water System - Distribution	1.8153	1.8153	1.8153	1.8153	1.8153	1.8153	1.8153	1.8153		47.2878
Fresh Water System - Installation	-	-	19.1354	-	-	-	0.0051	-		38.3067
FS Inlet Doors	-	-	-	-	-	-	0.0011	0.0104		0.0390
FTNS & STDN System	-	-	-	-	-	-	-	-		4.3542
Gates - Refuge Area	-	-	-	-	-	-	-	0.7136		2.1407
Gatesets	4.8648	4.8648	4.8648	4.8648	4.8648	4.8648	4.8648	4.8648		116.9835
Glass Blocks - Ground Floor	-	-	-	-	-	-	-	-		0.3309
Glazed Door & Window - Entrance	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003		0.7744
Ground Floor Block Walls	-	-	-	-	-	-	-	-		3.9703
Ground Floor Modifications	-	-	-	-	-	-	0.6699	-		71.9026
Handrail & Balustrade - Staircases	-	-	-	-	-	-	-	5.7586		17.2759
Hose Reel Doors - Hairline	-	-	-	-	-	-	-	2.2768		6.8304
Hose Reel Doors - Polished	-	-	-	-	-	-	-	0.0499		0.1497
Hot Water System	5.7611	5.7611	5.7611	5.7611	5.7611	5.7611	5.7611	5.7611		150.5328
Inspection Panels - Refuse Chutes	-	-	-	-	-	-	-	0.0263		0.0789
Internal Waterproofing	8.0298	8.0298	8.0298	8.0298	8.0298	8.0298	8.0298	8.0298		201.0881
Letter Boxes	-	-	-	-	-	-	-	-		2.9605
Level 1 Canopy	-	-	-	-	-	-	-	-		0.3000
Lift Car Finishes	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0183
Lift Cars	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031		7.8904
Lift Equipment	-	-	10.4861	-	-	-	-	-		20.9723
Lift Vent Covers	-	-	-	-	-	-	-	-		0.0991
Lighting Installation - Flats	1.4480	1.4480	1.4480	1.4480	1.4480	1.4480	1.4480	1.4480		43.5887
Lighting Installation - Public Areas	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017		26.7936
Lightning & Earthing	-	-	-	-	-	-	-	-		0.1332
Lightning Protection System	-	-	-	-	-	-	-	-		0.4094
Louvres - Stainless Steel	-	-	-	-	-	-	-	-		0.8994
Louvres - GMS	-	-	-	-	-	-	-	0.9995		2.9985
Louvres - Refuse Room	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000		0.0361
Main Equipment - Generator	-	-	-	-	-	-	-	-		7.9228
Main Equipment - Switchboards	-	-	-	-	-	-	-	-		26.7347
Mains & Distribution	-	-	-	-	-	-	-	-		229.4707
Metal Cages	-	-	-	-	-	-	-	0.0375		0.1126
Metal Doors - Plantrooms	-	-	-	-	-	-	0.0138	-		6.0541
Minor RC Concrete Items	-	-	-	-	-	-	-	-		7.7374
Mirrors	-	-	-	-	-	-	-	-		6.7659
Movement Joints	-	-	-	-	-	-	-	-		33.9844
Notice Board	-	-	-	-	-	-	-	0.1416		0.4247
Panel Walls - Inter Flat	0.6651	0.6651	0.6651	0.6651	0.6651	0.6651	0.6651	0.6651		15.9719
Panel Walls - Internal	4.9116	4.9116	4.9116	4.9116	4.9116	4.9116	4.9116	4.9116		118.3761
Pile Caps	-	-	-	-	-	-	-	-		181.1108
Piles	-	-	-	-	-	-	-	-		328.2574
Precast Cills	-	-	-	-	-	-	-	-		4.2636
Precast Curbs	-	-	-	-	-	-	-	-		33.8806
Precast Facades Type 1	128.7885	128.7885	128.7885	128.7885	128.7885	128.7885	128.7885	128.7885		3,115.4428
Precast Facades Type 2	36.8280	36.8280	36.8280	36.8280	36.8280	36.8280	36.8280	36.8280		890.8841
Precast Lintols	-	-	-	-	-	-	-	-		9.0168
Precast Stairs	-	-	-	-	-	-	-	-		116.9420
Railings - Generally	-	-	-	-	-	-	-	1.1840		3.5521
Railings - Refuge Area	-	-	-	-	-	-	-	1.6049		4.8148
Rainwater Pipes & Outlets	-	-	-	-	-	-	0.0137	-		5.7920
RC Beams - Fairfaced	-	-	-	-	-	-	-	-		130.8042
RC Beams - Generally	-	-	-	-	-	-	-	-		49.1488
RC Columns - Fairfaced	-	-	-	-	-	-	-	-		7.7117
RC Columns - Generally	-	-	-	-	-	-	-	-		28.4198
RC Slabs - Fairfaced	1.2585	1.2585	1.2585	1.2585	1.2585	1.2585	6.5528	1.2585		884.2519
RC Slabs - Generally	-	-	-	-	-	-	-	-		6.7659
RC Stairs	-	-	-	-	-	-	-	-		7.3741
RC Walls - Fairfaced	1.5245	1.5245	1.5245	1.5245	1.5245	1.5245	7.3908	1.5245		1,086.5337
RC Walls - Generally	-	-	-	-	-	-	1.9375	-		412.1952
RC Water Tanks	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	5.6110	0.0003		456.3537
Roller Shutters - MAC Room	-	-	-	-	-	-	-	0.0900		0.2700
Roof Block Walls	-	-	-	-	-	-	-	-		0.2879
Roof System - Paving	0.0254	0.0254	0.0254	0.0254	0.0254	0.0254	9.5266	0.0254		149.6507
Roof System - Screed	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.4651	0.0023		7.8236
Sanitary Fittings - Flats	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309	3.7309		93.1817
Sanitary Fittings - Other Areas	-	-	-	-	-	-	-	0.0031		0.0093
Screens & Grilles	-	-	-	-	-	-	-	0.0871		0.2614
Seating Benches	-	-	-	-	-	-	-	-		3.1282
Security Guard Counter	-	-	-	-	-	-	-	-		0.5850
Security System - CCTV System	-	-	-	-	-	-	-	-		0.2312
Security System - Door Monitoring	-	-	-	-	-	-	-	-		0.2410
Security System - Doorphone	-	-	-	-	-	-	-	-		1.8582
Signage	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023		0.5752
Sink Units	3.5787	3.5787	3.5787	3.5787	3.5787	3.5787	3.5787	3.5787		93.5697
Sliding Shutters - Refuse Chutes	-	-	-	-	-	-	-	1.3825		4.1474
Small Power Installation - Flats	7.5879	7.5879	7.5879	7.5879	7.5879	7.5879	7.5879	7.5879		229.4094
Small Power Installation - Public Areas	-	-	-	-	-	-	-	-		4.3659
Soil and Waste - Distribution	-	-	-	-	-	-	-	-		6.8322
Soil and Waste - Installation	-	-	-	-	-	-	0.0330	-		11.1192
Spun Concrete Refuse Chutes	-	-	-	-	-	-	-	-		4.5241
Stainless Steel Door - Plant Rooms	-	-	-	-	-	-	-	-		0.2059
Stainless Steel Doorset - Plant Rooms	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.8608
Stainless Steel Window & Doors - Ground Floor	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002		0.2183
Stainless Steel Windows - Lobby	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006		0.3083
Staircase Enclosure	-	-	-	-	-	-	-	2.4348		7.3044
Substructure Tanking	-	-	-	-	-	-	-	-		2.7233
Towel Rails	0.1129	0.1129	0.1129	0.1129	0.1129	0.1129	0.1129	0.1129		2.9723
Typhoon Guards	-	-	-	-	-	-	-	0.1218		0.3654
Typical Floor Block Walls	-	-	-	-	-	-	-	-		11.7468
Wall Finishes - Corridors & Lobbies	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	2.8719	0.0180		68.1653
Wall Finishes - Internal Flat Areas	5.8623	5.8623	5.8623	5.8623	5.8623	5.8623	5.8623	5.8623		145.9944
Wall Finishes - Main Entrance Lobby	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.1505
Wall Finishes - Movement Joints, etc	-	-	-	-	-	-	-	9.3738		28.1215
Wall Finishes - Plant Rooms	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.2736	0.0001		7.6077
Wall Finishes - Refuse Room	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0367	0.0007		1.3787
Wall Finishes - Staircases	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1883	0.0000		4.0080
Water Meter Doors	-	-	-	-	-	-	-	8.7517		26.2550
Demolition										
Demolition Impact									4,380.3020	
Transportaion Impact									1,052.9855	
Operational Energy										
Electricity	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143	772.0143		
Gas	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444	22.6444		
Water	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025	148.7025		
Total HK E-points in Year	**1,223.8866**	**1,223.8866**	**1,278.7579**	**1,223.8866**	**1,223.8866**	**1,223.8866**	**1,261.0511**	**1,263.6698**	**5,433.2875**	

Capital Period	**5,839.1881**
Operational Period	**53,051.1122**
End of Life	**5,433.2875**
Study Period	**64,323.5878**


Whole Life HK E-point Profile by Functional Unit
HK E-points
6000
5000
4000
3000
2000
1000
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Study Year

APPENDIX N: FUNCTIONAL UNITS COMBINED INITIAL ENVIRONMENTAL AND COST RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:21:49
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Initial

Functional Unit	HK E-points		Total Cost
RC Walls - Fairfaced	1,005.6084	$	16,677,048.37
RC Slabs - Fairfaced	814.2855	$	11,929,170.44
Piles	328.2574	$	20,937,727.85
Precast Facades Type 1	877.7428	$	3,465,120.00
RC Water Tanks	417.0637	$	3,621,329.44
RC Walls - Generally	398.6325	$	4,053,921.81
Precast Facades Type 2	250.9976	$	1,163,136.00
Small Power Installation - Flats	48.7848	$	5,232,325.00
Pile Caps	181.1108	$	1,851,955.20
Mains & Distribution	114.7354	$	3,264,625.70
Panel Walls - Internal	33.0363	$	4,076,542.65
RC Beams - Fairfaced	130.8042	$	1,601,500.94
Aluminium Windows - Bedrooms	124.0507	$	1,478,635.67
Lift Equipment	10.4861	$	4,100,397.00
Main Equipment - Switchboards	13.3674	$	3,613,400.00
Precast Stairs	116.9420	$	943,216.00
Ground Floor Modifications	67.2133	$	1,950,568.58
Aluminium Windows - Living Area	100.4724	$	1,034,763.81
Fresh Water System - Installation	19.1354	$	2,790,485.42
Gatesets	32.4568	$	2,280,928.47
Wall Finishes - Corridors & Lobbies	23.6445	$	2,485,450.04
Lift Cars	3.8689	$	2,733,598.00
Lighting Installation - Public Areas	26.7077	$	1,852,715.03
Wall Finishes - Internal Flat Areas	17.5745	$	1,901,709.47
Sanitary Fittings - Flats	11.4508	$	2,036,611.05
FTNS & STDN System	2.1771	$	2,111,200.00
Floor Finishes - Kitchens & Bathrooms	18.8131	$	1,525,395.08
Doorsets - Flat Entrance	21.1485	$	1,460,081.29
Doorsets - Kitchen	19.3761	$	1,482,105.61
Hot Water System	24.5090	$	1,226,888.47
RC Beams - Generally	49.1488	$	519,776.59
Lighting Installation - Flats	9.2144	$	1,461,600.00
Doorsets - Bathroom (1B /2B)	20.4524	$	1,130,182.02
Roof System - Paving	40.9368	$	491,293.44
Aluminium Windows - Kitchen	33.8245	$	584,788.61
Fire Hydrant & Hose Reel System	9.2354	$	1,136,253.93
Fresh Water System - Distribution	7.5779	$	1,166,068.59
Sink Units	15.2864	$	948,970.84
Floor Finishes - Corridors & Lobbies	15.2071	$	938,371.40
Soil and Waste - Distribution	6.8322	$	841,275.09
RC Columns - Generally	28.4198	$	307,588.91
Precast Curbs	33.8806	$	110,410.11
Panel Walls - Inter Flat	4.4158	$	817,455.72
Water Meter Doors	8.7517	$	646,950.40
Internal Waterproofing	25.1844	$	233,965.48

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:21:49
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Initial

Functional Unit	HK E-points		Total Cost
Doorsets - Exit Staircases	10.3775	$	584,502.40
Typical Floor Block Walls	11.7468	$	502,715.50
External Wall Finishes - Facades	6.1559	$	631,892.80
Main Equipment - Generator	3.9614	$	632,015.13
Cooking Benches	7.5514	$	520,264.70
Aluminium Windows - Bathroom	11.6251	$	381,762.59
Fire Alarm & Detection System	0.8806	$	606,294.01
Soil and Waste - Installation	10.8883	$	349,037.92
Metal Doors - Plantrooms	5.9577	$	447,190.80
Mirrors	6.7659	$	410,707.09
Floor Finishes - Staircases	5.3736	$	334,532.83
Doorsets - Plant Rooms	4.7137	$	317,802.65
Fresh Water Pump System	1.7575	$	388,780.53
Flushing Water System - Installation	3.2615	$	345,261.41
Handrail & Balustrade - Staircases	5.7586	$	273,821.79
Aluminium Windows - Lift Lobby	8.7740	$	196,140.70
Flush Water Pump System	0.7301	$	388,780.53
Spun Concrete Refuse Chutes	4.5241	$	293,242.40
Wall Finishes - Staircases	2.6887	$	332,324.88
Doorsets - Bathroom (1/2P)	2.5174	$	303,916.99
Substructure Tanking	2.7233	$	295,410.50
Aluminium Windows - Corridor	6.6275	$	198,173.02
Security System - Doorphone	0.9291	$	333,072.25
Wall Finishes - Movement Joints, etc	9.3738	$	119,060.40
Floor Finishes - Movement Joints, etc	6.8326	$	179,646.68
Wall Finishes - Plant Rooms	1.8958	$	285,382.89
External Wall Finishes - Generally	2.0847	$	277,147.90
Drying Rails / Laundry Poles	3.3138	$	238,908.99
Rainwater Pipes & Outlets	5.6958	$	176,765.76
Movement Joints	11.3281	$	22,413.64
Minor RC Concrete Items	7.7374	$	96,474.95
RC Columns - Fairfaced	7.7117	$	95,472.73
Precast Lintols	9.0168	$	50,288.24
Roof System - Screed	2.2342	$	211,786.50
Ground Floor Block Walls	3.9703	$	162,658.55
RC Stairs	7.3741	$	79,355.20
Hose Reel Doors - Hairline	2.2768	$	191,665.80
RC Slabs - Generally	6.7659	$	78,521.79
Small Power Installation - Public Areas	4.3659	$	125,048.00
Wall Finishes - Main Entrance Lobby	0.1435	$	219,884.96
Aluminium Windows - Bedrooms Stainless Steel Grilles	6.0384	$	76,459.71
Wall Finishes - Refuse Room	1.0912	$	170,421.80
Doors - Pipe ducts	2.1542	$	143,143.20
Letter Boxes	1.4803	$	155,287.54
Aluminium Windows - Living Area Stainless Steel Grilles	4.9630	$	54,515.24

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:21:49
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Initial

Functional Unit	HK E-points		Total Cost
Staircase Enclosure	2.4348	$	98,518.76
A/C Drain Pipes	0.6029	$	140,232.49
Security System - CCTV System	0.1156	$	144,485.25
Ceiling Finishes - Main Entrance Lobby	3.4019	$	59,284.44
Precast Cills	4.2636	$	31,118.70
Sliding Shutters - Refuse Chutes	1.3825	$	96,792.40
Fire Fighting System	1.2640	$	97,621.41
Floor Finishes - Plant Rooms	1.7527	$	85,082.90
Floor Washing System	0.7803	$	104,714.00
Earthing and Bonding	3.0701	$	48,283.55
Flushing Water System - Distribution	0.2522	$	109,327.17
Signage	0.2292	$	104,426.12
External Ceiling Finishes	0.6017	$	88,220.91
Curtain Rails	0.8520	$	80,762.92
Doorsets - Refuse Rooms	1.1655	$	73,078.11
Stainless Steel Doorset - Plant Rooms	0.8584	$	79,176.67
Towel Rails	0.5017	$	84,406.36
Bearing Pads - Tanks & M&E	0.1739	$	85,058.75
Louvres - Stainless Steel	0.8994	$	66,476.50
Seating Benches	1.0427	$	61,076.67
Floor Finishes - Refuse Room	0.6042	$	71,169.65
Railings - Refuge Area	1.6049	$	46,234.98
Air Duct Trunking	0.8426	$	58,225.23
Aluminium Louvres - Plant Rooms	2.3466	$	18,777.77
Railings - Generally	1.1840	$	40,207.68
Aluminium Windows - Kitchen Stainless Steel Grilles	1.5633	$	30,849.31
Louvres - GMS	0.9995	$	40,887.89
Lightning & Earthing	0.1332	$	60,268.34
Ceiling Finishes - Plant Rooms	0.3213	$	41,879.67
Level 1 Canopy	0.3000	$	39,034.10
Gates - Refuge Area	0.7136	$	28,578.03
Cat Ladders	0.6933	$	24,962.31
Automatic Sprinker System	0.1482	$	36,530.08
Aluminium Windows - Plant Rooms	0.6692	$	21,920.93
Security System - Door Monitoring	0.1205	$	34,307.00
Stainless Steel Window & Doors - Ground Floor	0.2086	$	30,498.84
Aluminium Windows - Bathroom Stainless Steel Grilles	0.6084	$	20,491.73
Lightning Protection System	0.4094	$	24,182.40
Stainless Steel Windows - Lobby	0.2786	$	21,587.94
Drainage	0.4284	$	13,345.44
Earthworks	0.0039	$	21,053.82
Glazed Door & Window - Entrance	0.3802	$	11,393.17
External Step Finishes	0.0891	$	17,439.75
Notice Board	0.1416	$	15,244.24
Roof Block Walls	0.2879	$	11,445.15

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:21:49
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Initial

Functional Unit	HK E-points		Total Cost
Security Guard Counter	0.1950	$	13,626.75
Doorsets - Ground Floor	0.0878	$	16,096.14
Stainless Steel Door - Plant Rooms	0.2059	$	12,245.23
Lift Vent Covers	0.0991	$	8,429.58
Hose Reel Doors - Polished	0.0497	$	7,984.62
Glass Blocks - Ground Floor	0.1654	$	4,722.28
Roller Shutters - MAC Room	0.0900	$	5,947.16
Typhoon Guards	0.1218	$	4,392.52
Screens & Grilles	0.0871	$	4,898.34
Bin Guards	0.1056	$	4,032.57
Lift Car Finishes	0.0157	$	5,594.70
Aluminium Door & Window - 1/F	0.0842	$	3,311.87
Flashing - Refuse Chutes	0.0584	$	3,234.64
FS Inlet Doors	0.0104	$	4,283.35
Inspection Panels - Refuse Chutes	0.0262	$	1,936.95
Angle Protectors - Ground Floor	0.0391	$	1,407.06
Louvres - Refuse Room	0.0162	$	1,932.98
Metal Cages	0.0373	$	1,324.22
Floor Finishes - Main Entrance Lobby	0.0012	$	1,085.01
Sanitary Fittings - Other Areas	0.0031	$	404.22

APPENDIX O : FUNCTIONAL UNITS WHOLE LIFE CYCLE COMBINED ENVIRONMENTAL AND COST RANKING

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:24:24
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Whole Life

Functional Unit	HK E-points		Total Cost	Combined Index **
Precast Facades Type 1	3,115.4428	$	9,692,320.00	14.4069%
RC Walls - Fairfaced	1,086.5337	$	34,668,694.08	8.6347%
RC Slabs - Fairfaced	884.2519	$	35,521,955.20	7.8704%
Precast Facades Type 2	890.8841	$	5,833,536.00	4.4731%
Wall Finishes - Internal Flat Areas	145.9944	$	33,261,645.47	4.4606%
Piles	328.2574	$	20,937,727.85	3.8160%
Small Power Installation - Flats	229.4094	$	20,377,442.43	3.3298%
Floor Finishes - Kitchens & Bathrooms	156.9636	$	21,288,688.08	3.1259%
Aluminium Windows - Bedrooms	432.4637	$	7,779,045.41	2.7422%
Aluminium Windows - Living Area	350.2683	$	9,588,642.46	2.6004%
RC Walls - Generally	412.1952	$	6,058,487.39	2.4572%
RC Water Tanks	456.3537	$	3,710,640.34	2.3747%
Internal Waterproofing	201.0881	$	11,634,328.48	2.2001%
Panel Walls - Internal	118.3761	$	12,839,745.53	1.9864%
Mains & Distribution	229.4707	$	6,529,251.40	1.7322%
Fresh Water System - Distribution	47.2878	$	12,701,631.09	1.6673%
Sanitary Fittings - Flats	93.1817	$	10,438,096.05	1.6019%
Wall Finishes - Corridors & Lobbies	68.1653	$	11,226,951.71	1.5862%
Lighting Installation - Flats	43.5887	$	11,934,829.48	1.5630%
Hot Water System	150.5328	$	6,994,669.72	1.4492%
Gatesets	116.9835	$	6,945,490.47	1.3004%
Doorsets - Kitchen	121.9307	$	6,288,589.98	1.2457%
Flushing Water System - Distribution	1.5097	$	9,722,295.92	1.1282%
Doorsets - Bathroom (1B /2B)	125.7264	$	4,980,182.02	1.1109%
Sink Units	93.5697	$	5,755,455.22	1.0632%
Lift Equipment	20.9723	$	8,200,794.00	1.0357%
Pile Caps	181.1108	$	1,851,955.20	0.9862%
Doorsets - Flat Entrance	77.8186	$	5,347,216.29	0.9489%
Main Equipment - Switchboards	26.7347	$	7,226,800.00	0.9479%
Fresh Water System - Installation	38.3067	$	6,441,970.84	0.9067%
Roof System - Paving	149.6507	$	1,360,450.08	0.7953%
Aluminium Windows - Kitchen	117.8901	$	2,447,157.43	0.7852%
RC Beams - Fairfaced	130.8042	$	1,601,500.94	0.7427%
Panel Walls - Inter Flat	15.9719	$	5,601,696.72	0.7145%
Lift Cars	7.8904	$	5,467,203.50	0.6645%
Ground Floor Modifications	71.9026	$	2,756,968.58	0.6248%
Precast Stairs	116.9420	$	943,216.00	0.6076%
Cooking Benches	47.2683	$	3,404,155.32	0.5944%
Floor Finishes - Corridors & Lobbies	47.2789	$	2,977,612.80	0.5452%
FTNS & STDN System	4.3542	$	4,222,400.00	0.5058%
External Wall Finishes - Facades	28.4580	$	1,944,885.60	0.3458%
Lighting Installation - Public Areas	26.7936	$	1,980,925.37	0.3429%
Fire Hydrant & Hose Reel System	18.4709	$	2,272,507.86	0.3410%
Water Meter Doors	26.2550	$	1,940,851.20	0.3359%
Floor Finishes - Staircases	12.5098	$	2,252,731.98	0.3133%
Doorsets - Exit Staircases	23.7251	$	1,729,004.80	0.3007%
Aluminium Windows - Bathroom	40.5229	$	1,020,649.22	0.2906%
Wall Finishes - Plant Rooms	7.6077	$	2,147,458.98	0.2802%
RC Beams - Generally	49.1488	$	519,776.59	0.2696%
Soil and Waste - Installation	11.1192	$	1,784,037.92	0.2533%
Doorsets - Bathroom (1/2P)	15.5011	$	1,260,401.36	0.2115%
Curtain Rails	5.0565	$	1,618,837.92	0.2084%
Floor Finishes - Movement Joints, etc	27.3304	$	718,586.72	0.1995%
Main Equipment - Generator	7.9228	$	1,264,030.26	0.1796%
Towel Rails	2.9723	$	1,430,221.99	0.1777%
Handrail & Balustrade - Staircases	17.2759	$	821,465.37	0.1685%
Aluminium Windows - Bedrooms Stainless Steel Grilles	21.2039	$	672,844.91	0.1681%
Doorsets - Plant Rooms	13.9349	$	927,855.30	0.1665%
Wall Finishes - Movement Joints, etc	28.1215	$	357,181.20	0.1612%
Precast Curbs	33.8806	$	110,410.11	0.1573%
RC Columns - Generally	28.4198	$	307,588.91	0.1567%

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:24:24
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Whole Life

Functional Unit	HK E-points		Total Cost	Combined Index **
Movement Joints	33.9844	$	67,240.92	0.1527%
Fire Alarm & Detection System	1.7612	$	1,212,588.02	0.1474%
Aluminium Windows - Living Area Stainless Steel Grilles	17.4280	$	631,496.46	0.1472%
Drying Rails / Laundry Poles	11.8329	$	724,800.87	0.1341%
Soil and Waste - Distribution	6.8322	$	841,275.09	0.1262%
Floor Finishes - Plant Rooms	5.5022	$	880,884.06	0.1251%
Aluminium Windows - Lift Lobby	17.9003	$	394,063.90	0.1218%
Rainwater Pipes & Outlets	5.7920	$	750,765.76	0.1113%
Typical Floor Block Walls	11.7468	$	502,715.50	0.1081%
Fresh Water Pump System	3.5870	$	792,261.06	0.1067%
Aluminium Windows - Corridor	13.5211	$	397,692.44	0.1036%
Flush Water Pump System	1.4912	$	784,911.06	0.0969%
Roof System - Screed	7.8236	$	545,577.20	0.0963%
Hose Reel Doors - Hairline	6.8304	$	574,997.40	0.0955%
Wall Finishes - Staircases	4.0080	$	632,091.26	0.0900%
External Wall Finishes - Generally	3.1983	$	631,963.90	0.0866%
Security System - Doorphone	1.8582	$	666,144.50	0.0848%
Metal Doors - Plantrooms	6.0541	$	489,190.80	0.0823%
Mirrors	6.7659	$	410,707.09	0.0762%
Doors - Pipe ducts	5.9695	$	409,486.40	0.0727%
Staircase Enclosure	7.3044	$	295,556.28	0.0653%
Ceiling Finishes - Main Entrance Lobby	10.2056	$	177,853.32	0.0641%
Flushing Water System - Installation	3.2615	$	345,261.41	0.0537%
Spun Concrete Refuse Chutes	4.5241	$	293,242.40	0.0531%
Sliding Shutters - Refuse Chutes	4.1474	$	290,377.20	0.0512%
Letter Boxes	2.9605	$	310,575.08	0.0485%
Substructure Tanking	2.7233	$	295,410.50	0.0457%
Aluminium Windows - Kitchen Stainless Steel Grilles	5.4915	$	185,775.24	0.0449%
Precast Lintols	9.0168	$	50,288.24	0.0443%
Minor RC Concrete Items	7.7374	$	96,474.95	0.0441%
RC Columns - Fairfaced	7.7117	$	95,472.73	0.0439%
RC Stairs	7.3741	$	79,355.20	0.0406%
Doorsets - Refuse Rooms	3.4025	$	216,156.22	0.0395%
RC Slabs - Generally	6.7659	$	78,521.79	0.0379%
A/C Drain Pipes	1.2058	$	280,464.98	0.0375%
Railings - Refuge Area	4.8148	$	138,704.94	0.0365%
Ground Floor Block Walls	3.9703	$	162,658.55	0.0357%
Seating Benches	3.1282	$	183,230.01	0.0345%
Security System - CCTV System	0.2312	$	288,970.50	0.0343%
Small Power Installation - Public Areas	4.3659	$	125,048.00	0.0331%
Wall Finishes - Refuse Room	1.3787	$	228,450.40	0.0322%
Bearing Pads - Tanks & M&E	0.5217	$	255,176.25	0.0317%
Ceiling Finishes - Plant Rooms	1.3392	$	223,100.01	0.0315%
Floor Washing System	1.5605	$	209,428.00	0.0308%
Railings - Generally	3.5521	$	120,623.04	0.0291%
Louvres - GMS	2.9985	$	122,663.67	0.0269%
Signage	0.5752	$	209,009.08	0.0266%
Wall Finishes - Main Entrance Lobby	0.1505	$	220,000.96	0.0260%
Floor Finishes - Refuse Room	1.2888	$	166,228.89	0.0247%
Aluminium Louvres - Plant Rooms	4.7359	$	37,678.39	0.0245%
Precast Cills	4.2636	$	31,118.70	0.0218%
Air Duct Trunking	1.6852	$	116,450.46	0.0206%
Gates - Refuge Area	2.1407	$	85,734.09	0.0190%
External Ceiling Finishes	1.0313	$	126,209.91	0.0190%
Earthing and Bonding	3.0701	$	48,283.55	0.0187%
Aluminium Windows - Bathroom Stainless Steel Grilles	2.1375	$	81,158.04	0.0185%
Cat Ladders	2.0798	$	74,886.93	0.0175%
Fire Fighting System	1.2640	$	97,621.41	0.0167%
Stainless Steel Doorset - Plant Rooms	0.8608	$	79,275.11	0.0128%
Louvres - Stainless Steel	0.8994	$	66,476.50	0.0115%
Aluminium Windows - Plant Rooms	1.3636	$	44,093.64	0.0109%

Project Details

Name: Standard New Harmony 1 (Opt 2) Block
Block Edition: 6/00 Revision to 1/00 Edition
Date: 09/Jun/2005 12:24:24
Generated by: Hong Kong Housing Authority with HKHA Life Cycle Console 1.4.0
Weighting: Local
Norm: Local

Functional Units Ranked by HK E-point and Total Cost - Whole Life

Functional Unit	HK E-points		Total Cost	Combined Index **
Automatic Sprinker System	0.2964	$	73,060.16	0.0097%
Security System - Door Monitoring	0.2410	$	68,614.00	0.0089%
Lightning & Earthing	0.1332	$	60,268.34	0.0075%
Security Guard Counter	0.5850	$	40,880.25	0.0072%
Notice Board	0.4247	$	45,732.72	0.0071%
Glazed Door & Window - Entrance	0.7744	$	22,864.77	0.0059%
Level 1 Canopy	0.3000	$	39,034.10	0.0058%
Doorsets - Ground Floor	0.2016	$	37,442.28	0.0052%
External Step Finishes	0.1808	$	34,903.65	0.0048%
Lightning Protection System	0.4094	$	24,182.40	0.0045%
Stainless Steel Window & Doors - Ground Floor	0.2183	$	30,556.40	0.0045%
Stainless Steel Windows - Lobby	0.3083	$	21,662.51	0.0038%
Hose Reel Doors - Polished	0.1497	$	23,953.86	0.0034%
Drainage	0.4284	$	13,345.44	0.0034%
Roller Shutters - MAC Room	0.2700	$	17,841.48	0.0032%
Typhoon Guards	0.3654	$	13,177.56	0.0031%
Screens & Grilles	0.2614	$	14,695.02	0.0028%
Bin Guards	0.3168	$	12,097.71	0.0027%
Roof Block Walls	0.2879	$	11,445.15	0.0025%
Glass Blocks - Ground Floor	0.3309	$	9,444.56	0.0025%
Earthworks	0.0039	$	21,053.82	0.0024%
Stainless Steel Door - Plant Rooms	0.2059	$	12,245.23	0.0023%
Flashing - Refuse Chutes	0.1753	$	9,703.92	0.0019%
FS Inlet Doors	0.0390	$	14,600.04	0.0019%
Aluminium Door & Window - 1/F	0.1723	$	6,640.32	0.0015%
Lift Vent Covers	0.0991	$	8,429.58	0.0014%
Inspection Panels - Refuse Chutes	0.0789	$	5,810.85	0.0010%
Angle Protectors - Ground Floor	0.1180	$	4,221.18	0.0010%
Metal Cages	0.1126	$	3,972.66	0.0009%
Lift Car Finishes	0.0183	$	5,597.70	0.0007%
Louvres - Refuse Room	0.0361	$	3,710.66	0.0006%
Floor Finishes - Main Entrance Lobby	0.0018	$	1,610.51	0.0002%
Sanitary Fittings - Other Areas	0.0093	$	1,212.66	0.0002%
	11,722.24	$	433,331,622.74	

** Remark

The combined LCA/LCC ranking of the functional units is based upon summing LCA and LCC ratios (to the whole building) as given by the formula below :

Combined LCA/LCC indices = {(LCA of functional unit)/(LCA of whole building) + (LCC of functional unit)/(LCC of whole building)}/ 2 X 100%

APPENDIX P : CONSTRUCTION DETAILS AND SAMPLE SPECIFICATIONS FOR ALTERNATIVES PROPOSED

APPENDIX P1 : Specification for Proposed Sustainable Timber Doorsets to replace Hardwood Doors for Flat Entrance

APPENDIX P2 : Specification for Pesticides, Preservatives and Paintings

APPENDIX P3 : Sample Flooring Details – King's Park

APPENDIX P1 : Specification for Proposed Sustainable Timber Doorsets to replace Hardwood Doors for Flat Entrance

COM17 DOORSETS FOR STANDARD DOMESTIC FLAT ENTRANCE AND KITCHEN

MATERIALS

DOORSETS GENERALLY

COM17.M010.4 TIMBER QUALITY

To comply with the following:

1. Class and exposure to BS 1186:Part 1:1991, as follows:

Component	Door type as shown on Drawings	BS 1186:Part 1:1991	
		Class	Exposure
Door frame	1, 2 & 3	2	Exposed
Door leaf			
Stiles and rails	1, 2 & 3	2	Concealed
Eggcrate ribs	2	2	Concealed
Core laminations	1 & 3	3	Concealed
Lipping	1, 2 & 3	2	Exposed

2. Grading of defect limits to BS 1186:Part 1:1991 for knot size and distribution limits as follows:

Component	Maximum face width (mm)	Maximum ratio of knot size to face width (%)
Door frame	90	25
Door leaf		
Stiles and rails	35	50
	100	45
Eggcrate ribs	35	50
Core laminations	40	50
Lipping	15	40
	50	30

   a. The grading limits for knots and their distribution to be no closer than 150 mm on average measured over the length of the component in accordance with clause 9.2.2 of BS 1186:Part 1:1991.

COM17.M011.4 SUPPLY

To comply with the following :

1. The softwood used in doorsets for flat entrance and kitchen shall be Douglas Fir, Larch, Hemlock, Red Cedar, Spruce, Yellow Cypress or other softwood certified by local timber associations. Copy of an authenticated certificate showing species of wood and place of origin shall be attached to the wood delivered to site.
2. Except as varied by the above, the materials used in doorsets for flat entrance and kitchen shall comply with the following clauses:
    1. As per COM 8.M010A
    2. As per COM 8.M010B
    3. As per COM 8.M020A
    4. As per COM 8.M020B
    5. As per COM 8.M030A
    6. As per COM 8.M030B
    7. As per COM 8.M040
    8. As per COM 8.M050

COM17.M020.4 AVERAGE PERMISSIBLE MOISTURE CONTENT

For timber incorporated into the work:

1. Internal timber for use in Air Conditioned space 12%
2. Internal timber generally 16%
3. Timber with one face to the exterior of the building and one face to the interior 18%
4. External timber 20%

Calculate moisture content at the time of fabrication by the following formula:

$$\frac{\text{Wet (or supplied) Mass} - \text{Dry Mass}}{\text{Dry Mass}} \times 100 = \text{Moisture Content (\%)}$$

The dry mass shall be determined by drying in an oven at a temperature of 103^0C $\pm 2^0$C until the weight is constant.

COM 17.M021.4 LOAD RESISTANCE, STRENGTH, FIRE RESISTANCE AND BEHAVIOUR UNDER HUMIDITY VARIATIONS

The materials used for flat entrance and kitchen shall comply with the following clauses:

1. As per COM 8.M110
2. As per COM 8.M120
3. As per COM 8.M130
4. As per COM 8.M131
5. As per COM 8.M140

COM17.M030.4 SOFTWOOD

The density of softwood used in doorsets for flat entrance and kitchen shall be as follows:

1. Douglas Fir 530 kg/m^3.
2. Larch 590 kg/m^3.
3. Hemlock 500 kg/m^3.
4. Red Cedar 370 kg/^{m3}.
5. Spruce 430 kg/m^3.
6. Yellow Cypress 450 kg/m^3.

COM17.M040.4 REQUIREMENTS

1. Submission Requirements:
    a. At sample submission and approval stage, submit a sample of the proposed wooden doorsets for CM's approval together with all the following substantiation for CM's information:
        i. Job reference;
        ii. Name, address and contact person of the local supplier;
        iii. Name, address and contact person of the manufacturer;
        iv. Where applicable, either the document from the manufacturer showing his authorization for the supplier as the agent/distributor in Hong Kong or document from the supplier showing the appointment of the manufacturer and manufacturer's agreement for the production of the proposed product;
        v. Original or certified true copy (issued or certified by the laboratory that complies with PRE.B9.570) of the test reports showing full compliance with the requirements of sub-clause (2)(c) to (2)(e). The date of the test shall be generally within three years (except fire certificates) prior to the date of commencement of the Contract or at an earlier date for domestic blocks subject to CM's consideration on the track records as maintained by the Housing Department.
        vi. Fire certificates:
            - A certified true copy of the fire test certificate or assessment reports for the doorsets of fire rated construction;
            - Tested in accordance with BS 476:Part 20:1987 and BS 476:Part 22:1987 and certified as being capable of resisting the action of fire for the specified periods by a laboratory which must be accredited for the specific test by the Hong Kong Accreditation Service (HKAS) under the Hong Kong Laboratory Accreditation Scheme (HOKLAS), or an equivalent organization which has signed a mutual recognition agreement with HOKLAS with appropriate qualifications and experience in fire resisting construction;
            - The date of the test certificates and assessment reports shall be generally within five years prior to the date of commencement of the Contract;
            - The test certificates and assessment report must also record the detail specification together with drawings and photographs sufficient to completely describe the doorset's construction, materials and fittings used.

vii. Shop drawings for Approval showing the exact dimensions of all doorset components, fixing, joint details, the internal arrangements of the rail and battens, and particularly routing of the cavity reserved for the wiring of the electrical locksets;

viii. Samples of wooden veneer faced plywood and door frame if timber veneer finished doorsets are shown on Drawings.

ix. When the doorsets are supplied for domestic blocks, except for the ancillary facilities at lower floors, also include the followings in the submission:

- Two identical sample boards similar to the one maintained by the Housing Department showing the quality and timber species for the doorsets;
- One sample each for kitchen, bathroom, flat entrance and exit staircase doorsets in Standard Domestic on Site for the purposes of inspection and Approval. The Approved samples shall be kept on Site until completion of the doorset installation work;
- Original or certified true copy (certified by the certification body) of the ISO 9000 series Certification, or similar quality management system, for the manufacturing plant for CM's inspection. The certification body shall be either accredited by the Hong Kong Accreditation Service (HKAS) or considered as having equivalent standard by the Environment, Transport and Works Bureau.
- A test report showing compliance with sub-clause (3)(a)(iii) for doorsets produced by the proposed doorset manufacturer to demonstrate the effectiveness of the insecticidal control on the production of doorsets.

2. Quality Requirements:

a. Doorsets must be capable of withstanding incidental static and dynamic loads imposed during use, including forced opening and closing and impacts from human bodies and hard objects. The loads must not result in significant damage or deformation to the doorsets, nor dislodge or shatter any composite parts in a dangerous manner.

b. Doorsets of ½ hour fire resistance:

i. A fire resisting period of ½ hour, 30/30 (30 minutes integrity, 30 minutes insulation) shall be provided when tested to BS 476 : Part 22: 1987;

ii. Should be closely fitted around the edges to impede the passage of smoke and flame. Bottom gap should not exceed 4 mm;

iii. Must be hung on butt hinges made of metals or other suitable materials with melting points of not less than 800°C.

c. Doorsets of 1 hour fire resistance:

i. A fire resisting period of 1 hour when tested to BS 476: Part 22:1987;

ii. Proprietary timber doorsets including frame, hinges, door closers and any other hardware shall be as specified in BS 476 : Part 22:1987: Appendix A.2.3.

d. Satisfy the requirements of the following tests. After each test, the doorset must function properly and any damage or deformations are to be within the limits prescribed in sub-clauses (2)(f) to (2)(p). Two brand new samples are required for the tests below. Test number 1 to 3 to be carried out on Sample A in any order, and evaluation of result need not be terminated because of failure of one test. Test number 4 to 11 to be carried out on Sample B in sequence.

Test No.	Test Items	Test Methods	Acceptance Standards
1	Dimensional Accuracy, Squareness	Refer sub-clause (2)(f)	BS 5278:1976
2	General Flatness, Evenness	Refer sub-clause (2)(g)	BS 5277:1976
3	Behaviour Under Humidity Variations	Refer sub-clause (2)(h)	BS 5369:1987 (Test No. 3)
4	Resistance to Impact, Hard Body	Refer sub-clause (2)(i)	Same as Test No. 8 and in addition, the maximum residual deformation at any point must not exceed 1.25mm.
5	Resistance to Torsion	Refer sub-clause (2)(j)	Same as Test No. 8 and in addition, the residual deformation must not exceed 3mm.
6	Strength in the Plane of the Door Leaf	Refer sub-clause (2)(k)	Same as Test No. 8 and in addition, the residual deformation must not exceed 1mm.
7	Slamming Open	Refer sub-clause (2)(l)	Same as Test No. 8.
8	Slamming Closed	Refer sub-clause (2)(m)	No damage or deformation including loosening of fixings or joints which would render the doorsets unfit for use, No dislodgement or dangerous shattering of their composite parts.
9	Resistance to Jarring and Vibration	Refer sub-clause (2)(n)	Same as Test No. 8.
10	Resistance to Impact - At 20 Nm for kitchen and bathroom doorsets, and at 40 Nm for flat entrance and exit staircase doorsets - At 20 Nm for kitchen and bathroom doorsets, and at 80 Nm for flat entrance and exit staircase doorsets	Refer sub-clause (2)(o)	Same as Test No. 8 and in addition, the maximum residual deformation at any point must not exceed 2mm.

11	Resistance to Closing Against an Obstruction	Refer sub-clause (2)(p)	Same as Test No. 8.

e. Record the following information in the test reports:

   i. Description of product: a detailed specification and any necessary drawings or photographs, sufficient to completely identify the product and its fittings;

   ii. Test results:

      - Numerical test results expressed in the units prescribed for the appropriate test;
      - Any other specified criteria, e.g. “no damage occurred” etc;
      - A graph of performance against increasing stress wherever applicable;
      - Diagrams or photographs to show points of failure where appropriate.

   iii. Test conditions: details of atmosphere i.e. conditions prior to and during testing where appropriate.

f. Test No. 1 - dimensional accuracy, squareness

   i. Specified linear dimensions and squareness will be measured in accordance with BS 5278:1976, except that the height and width of doors will be measured with a maximum uncertainty of ±1.0 mm;

g. Test No. 2 - general flatness, evenness

   i. The defects of general flatness of a door leaf will be measured in accordance with BS 5277:1976;

   ii. Evenness of surfaces will be measured by metal straight edges, one each of 50 ± 2 mm and 200 ± 2 mm and a set of feeler gauges which enables measurement of 0.2 to 1.0 mm in increments of 0.1 mm;

   iii. Each door will be examined along four horizontal lines and two vertical lines, equally spaced, on each face of the doors, for any deviation in position exceeding the specified limits;

   iv. Each continuous gap will be measured once at the point of maximum deviation;

   v. The position of the point measured together with the magnitude of deviation will be recorded and reported.

h. Test No. 3 - behaviours under humidity variations

   i. Tests will be conducted in accordance with BS 5369:1987;

   ii. Measurements of bending and twist will be taken within 6 hours of removal from the chamber;

   iii. Doors that cannot be measured within the above specified period will be stored in the relevant climate or sealed in plastic wrapping;

   iv. Have a maximum deviation due to bending of 7.5 mm, measured vertically;

   v. The range between maximum deviation, due to twisting of any corner of the door in relation to the other three corners under the three climatic conditions, must not exceed 10 mm.

i. Test No. 4 - resistance to impact, hard body

   i. Test apparatus

- The impactor will be a solid steel ball of diameter 50 ± 2.5 mm, which can be dropped down the inside of a release tower of 100 mm internal diameter, with a flat base and weighing about 5 kg, excluding the steel ball. The tower will incorporate a means of releasing the ball quickly and freely.

ii. Test method

- The test doorset will be laid horizontally on a solid base, supported along three edges (top and both sides). Impacts will be applied to fifteen points on the surface as specified below.

iii. Object of impact pattern

- The object of the impact pattern is to control the spread of test points so that an undue concentration on places of high or low resistance is avoided;
- Figure 4(a) in Appendix COM5/I to this Worksection illustrates the principles by which a pattern is constructed, and shows one-half of the specimen;
- Aiming points are chosen from the centres of those sub-areas marked X;
- One point is selected from each of the fifteen rows, so that aiming points are spread in consecutive columns as shown in figure 4(a).

iv. Standard impact patterns

- Figure 4(b) in Appendix COM5/I to this Worksection indicates four different sets of aiming patterns developed in this way;
- Some door constructions may require different aiming points from the remaining sub-areas marked Y but alternatives will not give such a balanced pattern;
- Any of the four patterns shown may be used for a test but the location which is expected to be most vulnerable will be included;
- The development of alternative patterns is not essential.

v. Repeat testing template

- Where repeated testing is expected, such as for door leaves of standard size, a template may be used to avoid the need to mark out the face of a door leaf.

vi. Measurement of indents

- The depth of indent caused by an impact will be measured by a dial gauge mounted on a reference bar;
- The contact between the reference bar and the door leaf surface is by a flattened knife edge at one end and a single rounded point contact at the other;
- The knife edge will be positioned at right angles to the length of the bar and set at a separation of 200 mm from the point of contact;
- The dial gauge will be positioned centrally between the knife edge and the point of contact;
- The extent of damage caused by an impact will be assessed by a transparent sheet on which a circle of 15 mm diameter has been inscribed.

vii. Test method sequence

The sequence of the test method will be carried out as follows:

- An aiming point will be selected;

- A dial gauge reading will be taken at this point with the bar in a known orientation relative to the door edges;
- The tower will be positioned with its central axis over the aiming point;
- The ball will be dropped from a height where the distance from its underside to the door leaf surface corresponds to the specified impact energy;
- The tower will be removed and the depth of indent measured (by the difference of readings) with the bar and dial gauge in the previous position and orientation;
- Any consequent cracking of the material of the door together with any other damage caused by the impact will be assessed;
- This procedure will be repeated for the remainder of the specified aiming points.

j. Test No. 5 - resistance to torsion

i. Test apparatus

- The doorset will be mounted vertically and fixed in accordance with the manufacturer's recommendations;
- Arrangements will be made whereby the door leaf can be held open at 90 degrees by means of a clamp to top lockside corner;
- A means of applying force normal to the plane of the door leaf will be provided acting at its mid height;
- The force will act at the lockside edge of the door leaf;
- Deflection normal to the plane of the door leaf will be measured at the lower lockside corner.

ii. Initial loading

- Slack in the hinges will be taken up initially by preloading;
- Preloading will be carried out by carefully applying a force of 200N to the attachment point in increments not exceeding 100N, the force acting at right angles to the door leaf;
- The force will be removed in the same incremental stages as in the loading procedure;
- The position of the lockside lower corner will be noted as a datum for deflection measurements.

iii. Test loading

- A force of 400N will be applied in increments not exceeding 100N, the force acting at right angles to the door leaf;
- The deflection will be measured after the door leaf has stabilised at each increment, the movement of the dial gauge being less than 0.02 mm per minute;
- After the recording of the deflection under maximum force the reverse procedure will be adopted to remove the load. The final residual deflection at least 1 hour after all force has been removed will be recorded;
- Refer to Figure 5 - Torsion in Appendix COM5/I to this Worksection.

k. Test No. 6 - strength in the plane of the door leaf

i. Test specimen

- Doorset with factory-finish or finished as specified.

ii. Test method

As Test No. 5 - resistance to torsion test:

- The doorset will remain in the rig position described;
- In the resistance to torsion test, the force will be applied, acting downwards in the plane of the door leaf, to a point at about mid-height of the door leaf near the lockset in a vertical direction;
- The point of measurement will be on the centre line of the bottom edge of the door leaf and 10 mm in from the locking edge.

iii. Test reading

- The initial and final reading of the dial gauge will be taken with no force whatsoever applied to the door leaf (including the weight of the rope):

iv. Loading door

- A downward vertical force of 500N will be applied in increments of 50N;
- The final force will be maintained for 5 minutes when the maximum deformation is recorded;
- The reverse procedure will be adopted and the residual deformation measured one hour after all downward forces have been released.

v. Test criteria

- The maximum and residual deformation must not exceed 1.00 mm.

l. Test No. 7 - slamming open

i. Mount for test

- The doorset, including any architraves, trims, door stop, check or similar as specified, will be mounted, positioned and supported as in intended operational use, with the door leaf fully opened.

ii. Test method

- The door leaf will be moved towards the closed position through an angle of 30 degrees and allowed to open freely under the influence of the specified weight applied to the middle of the edge opposite the hinges at right angles to the plane of the fully open door;
- The procedure will be repeated 10 times at a rate not exceeding 15 times per minute;
- Double swing doors will be slammed open 10 times in each direction;
- If no closer or stop is specified, a floor mounted door stop will be provided at the 90 degrees open position;
- Refer to Figure 2 - slamming open, in Appendix COM5/I to this Worksection.

m. Test No. 8 - slamming closed

i. Test apparatus

- The doorset will be placed vertically in a rigid rig, fixed by a method recommended by the manufacturer;
- A light strong line will be arranged, that allows the door leaf to be closed from 60 degrees open by the descent of a weight of mass of 15kg;

- The line will be attached to the leaf at the lockset or if this is more than 150 mm from the lockside edge at some point within 150 mm of that edge at the level of the lockset;
- The line will be passed horizontally from the door leaf and then over a 25 mm diameter, horizontal bar of smooth steel arranged with its axis parallel to the plane of the door frame;
- The bar will be positioned 400 mm from the door leaf face when the door leaf is closed and spanning the width of the doorset;
- The line will descend vertically from the bar and carry the weight at its lower extremity so arranged that, at the point of closure, the weight strikes a platform removing further tension from the line.

ii. Test method

- The door leaf will be opened to 60 degrees and released, the door will be slammed shut by the action of the falling weight;
- Carry out test 20 times;
- Refer to Figure 1. - slamming closed, in Appendix COM5/I to this Worksection.

n. Test No. 9 - resistance to jarring and vibration

i. Mount for test

- The doorset will be mounted vertically in a rigid rig and fixed in accordance with the manufacturer's recommendations.

ii. Test apparatus

- A spheroconical bag to BS EN 594:1996 Clause 6.2 will be hung from an independent support at about the same height as the top of the door leaf as a pendulum capable of striking the door's closing face;
- The bag will be hung so that, at rest, with the door open at 45 degrees, it just contacts the surface of the door leaf with its centre of gravity at the level of the lockset, and at mid-width of the door frame;
- The lockset will be removed where this would be struck.

iii. Test method

- The door leaf will be opened from the closed position through an angle of 45°;
- If any closing device is fitted, the door leaf will be restrained slightly against closing, but not against opening; otherwise the door leaf will be unrestrained;
- If no closer or stop is specified, a floor mounted door stop at the 90° open position will be provided;
- The test body will be drawn away from the door leaf in a vertical plane normal to the door frame through an arc of 250 mm vertical height then released to strike the door leaf;
- Carry out test 100 times;
- Refer to Figure 7 - jarring, in Appendix COM5/I to this Worksection.

o. Test No. 10 - resistance to impact; heavy body

i. Test apparatus

- A spheroconical bag to BS EN 596:1995 Clause 6.2 will be hung as a pendulum capable of striking the door leaf;

- The bag will be placed so that, at rest, it just contacts the surface of the door leaf with its centre of gravity at the level of the lockset, such that when swung in a vertical plane normal to the door leaf it will impact the door leaf at mid-width of the door leaf.

ii. Mount for test

- The doorset will be mounted vertically and fixed in accordance with the manufacturer's recommendations. The door leaf, will be closed and locked.

iii. Test method

- With the door leaf closed and locked, the test body will be swung against the door leaf three times to the closing face, with an impact energy of:
  - 20 Nm each time for kitchen and bathroom doorsets and;
  - 40 Nm each time for flat entrance and exit staircase doorsets;

  The doorset will then be examined for any damage or deformation; then
- With the door leaf closed and locked and clamped at the position of the lockset the test will be repeated against both sides of the door leaf, three times, commencing with the opening face and with an impact energy of:
  - 40 Nm each time for kitchen and bathroom doorsets and;
  - 80 Nm each time for flat entrance and exit staircase doorsets;

  The doorset will then be examined for any breakage;
- Refer to Figure 3 - heavy body, in Appendix COM5/I to this Worksection.

p. Test No. 11 - resistance to closing against an obstruction

i. Mount for test

- The doorset will be mounted vertically in a rigid rig, and fixed in accordance with the manufacturer's recommendations. A dry hardwood slip, 50 mm x 50 mm x 10 mm and of mass between 15g and 20g will be provided for the test.

ii. Test method

- The door will be opened and the hardwood slip placed in the gap between the door leaf and the bottom of the hinge side jamb of the frame in order to hold the door ajar. The slip will be inserted from the closing face with its grain horizontal and its plane vertical and parallel to the plane of the door frame as shown in Figure 6 - "Arrangement of Hardwood slip for obstruction test", in Appendix COM5/I to this Worksection;
- A force will be applied, acting at right angles to the plane of the frame, increasing in 50N increments to the lockside edge, at the handle height until it reaches 200N.

q. When the wooden doorsets are supplied for domestic blocks, standard of visual quality of doorsets shall be comparable with the benchmark samples maintained by the Housing Department.

3. On Site Delivery Verification

a. At delivery stage, submit to the CM the followings:

i. Written confirmation that the material delivered to Site conforms with the Approved sample submitted under sub-clause (1)(a);

ii. Original or certified true copy of the Certificate of Origin for every batch of delivery. A batch being the accumulative total of 1500 doorsets or part thereof delivered to Site;

iii. Delivery notes for all material delivered to Site.

b. Carry out X-ray scanning test as follows:

i. In an Approved laboratory within two weeks from the delivery day of every batch of doorsets on Site to prove that the doorsets delivered is free from live insects and larvae infestation;

ii. Select two specimens in one sample of doorsets from each batch of delivery for the test;

iii Testing method in sequence shown below:

- Apply X-ray scanning to the whole door leaf;
- Select 10 spots from the X-ray scanning films;
- Remove the facing on one side of the door leaf for general inspection;
- Study in detail on the 10 selected spots including microscopic inspection (multiplication X20).
- Record the findings of the 10 selected spots including photographs of the whole leaf and individual selected spots.

iv. Remove the whole batch of doorsets off Site if the test results fail to meet the requirement stated in (b)(i).

c. Carry out the following verifications for wooden doorsets upon delivery on Site and in the presence of CM's representatives:

i. Method:

Verification Items	Method	Acceptance Standards
Dimension Check	By measurement	COM5.M210
Surface Quality	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency, painting same as CM's Approved sample.
Ironmongery Check	Visual	Same as CM's Approved sample.
Moisture Content	By moisture meters	13% to 17% (±2%)

ii. Frequency:

Items	Sampling Frequency	Representative Batch
Dimension Check	1 sample for every 200 pieces or part thereof	Same batch of material delivered to Site
Surface Quality	1 sample for every 200 pieces or part thereof	Same batch of material delivered to Site
Ironmongery Check	1 sample for every 200 pieces or part thereof	Same batch of material delivered to Site

Moisture Content	1 sample for every 200 pieces or part thereof	Same batch of material delivered to Site

d. When any of the verifications fail to meet the acceptance standards, either:

   i. Remove the representative batch off Site; or

   ii. When agreed by the CM, repeat all verification items on three separate samples selected by the CM. In case of failure of any verification to any one sample, remove the representative batch off Site, bear all associated costs, and no extension of time will be allowed.

COM17.M050.4 DOORSET TYPE (PAINT FINISH)

Doorset to comprise of the followings:

1. Solid core or skeleton flush door with paint finish complete with ironmongeries and hinged to door frame;
2. Hardwood door frame;
3. Glazing beads, fixing screws for glazing beads; and
4. Plastic pellets.

COM17.M060.4 DOORSET TYPE (TIMBER VENEER FINISH)

Doorsts to comprise of the followings:

1. Solid core or skeleton flush door in timber veneer faced plywood finish sprayed with semi-gloss clear polyurethane paint or clear lacquer paint complete with ironmongeries and hinged to door frame.;
2. Hardwood door frame to comprise a frame sprayed with semi-gloss clear polyurethane painted or clear lacquer;
3. Glazing beads, fixing screws for glazing beads and matching wooden fillet.

COM17.M070.4 IDENTIFICATION

Supply with a unique serial number marked in an inconspicuous position on each doorset and its detached parts. Identify and record the date of manufacture.

DIMENSIONAL ACCURACY

COM17.M210.4 DOORSETS, DOOR LEAVES AND FRAMES GENERALLY

Comply with BS 4787:Part 1:1980 unless otherwise specified in Appendix H "Schedule of Tolerances" to this Specification.

PREFORMING AND DRILLING

COM17.M310.4 DOORSETS

Preform with:

1. Holes or recesses to receive ironmongery as scheduled with the exception of overhead door closers and door stops and pre-drill screw fixing holes:

   a. For the purpose of fixing the door frames on to the sub-frames/linings or drywall partitions;

   b. On the door frames at 150 mm above finished floor level and at 450 mm centres;

c. Ensuring position of the ironmongery does not obstruct the predrilled fixing holes.

2. A cavity, where necessary, for the installation of wiring for the electrical locksets.

DOORSET FINISHES

COM17.M410.4 SURFACE FINISH

Ensure all timber doorsets, including top panels where applicable, frames and their parts are supplied in the following condition:

1. Door leaf surfaces: flat, true, smooth and jointless with no visible defects;
2. Inside of bathroom door leaf surfaces: finished with 1.3 mm plastic laminate;
3. For doorsets with paint finish:
   a. Primed, undercoated and sprayed with cellulose lacquer paint (except sub-clause (2) above);
   b. With backs of hardwood door frames treated with two coats of wood preservative.
4. For doorsets with timber veneer finish:
   a. Sprayed with semi-gloss clear polyurethane paint or clear lacquer paint (except sub-clause (2) above);
   b. With backs of hardwood door frames and veneer faced plywood treated with two coats of wood preservative.

COM17.M420.4 PLYWOOD FOR DOOR FACINGS

1. To BS 6566, Grade 2 veneer, 5 mm thick;
2. Plywood facings to be close grained and filled.

COM17.M430.4 LAMINATED PLASTIC SHEET FOR BATHROOM DOOR FACINGS

To BS EN 438:Part 1 & 2 :1991:

1. Class: VG (Vertical - General Purpose);
2. Colour/sheen: matt texture with colour to Approval;
3. Thickness: 1.0 mm;
4. Submit samples for Approval.

IRONMONGERY AND ANCILLARY MATERIALS

COM17.M510.4 IRONMONGERY

Doorsets to be supplied with the following items of ironmongery:

1. Ironmongery supplied fitted:
   a. 'Magic Eye' where scheduled:
   b. Hinges;
   c. Kicker plates where scheduled;
   d. Others as shown on the Drawings or scheduled.
2. Ironmongery supplied loose:
   a. Door closer where scheduled;

b. Locks and latches where scheduled;

c. Push plates and pull handles where scheduled.

COM17.M520.4 WOOD SCREWS

Use for fixing solid core top panels where applicable, glazing beads and architraves.

COM17.M530.4 PLASTIC PELLETS AND WOOD FILLER

The materials used for flat entrance and kitchen shall comply with the following clauses:

1. As per COM 8.M530
2. As per COM 8.M535

WORKMANSHIP

GENERALLY

COM17.W010.4 FRAME ASSEMBLY

1. Construct doorsets for flat entrance as follows :
    a. Core: 33 x 20mm butt jointed softwood lamels weighing 430kg/m3 to 600kg/m^3.
    b. Stiles: For doors exceed 2300mm high, a 100mm mid-rail constructed from softwood lamels and 1 no. 42 x 33mm softwood stile (either side) shall be required. Top and bottom rails must remain full width.
    c. Rails: 33 x 100mm softwood (constructed from minimum 20mm and maximum 30mm lamels). The rail dimension can be increased to a maximum dimension of 135mm where necessary.
    d. Sub-face: 6mm M.D.F. for paint, 6mm chipboard for veneer (internal) or 6mm W.B.P. plywood (external). MDF type shall be moisture resistant grade (MDFMR) with density in excess of 600kg/m^3 to BS 1142.
    e. Lipping: 6mm hardwood complete with 3mm radius to vertical edges.
    f. Frame: Hardwood as defined in TIM 1.M070.
    g, Tolerance: Width ±1.5mm, thickness ±1mm, height ±1.5mm.
    h. Fire rating: 1/2 hour fire resisting period for integrity for each side separately (including frame and fixing). All doors including frames should be tested or assessed in accordance with BS476 : Part 22.
2. Construct doorsets for kitchen as follows :
    a. Core: 33 x 20mm butt jointed softwood lamels weighing 430kg/m^3 to 600kg/m^3.
    b. Stiles: For doors exceed 2 300mm high, a 100mm mid-rail constructed from softwood lamels and 1 no. 42 x 33mm softwood stile (either side) shall be required. Top and bottom rails must remain full width.
    c. Rails: 33 x 100mm softwood (constructed from minimum 20mm and maximum 30mm lamels). The rail dimension can be increased to a maximum dimension of 135mm where necessary.
    d. Sub-face: 6mm M.D.F. for paint, 6mm chipboard for veneer (internal) or 6mm W.B.P. plywood (external). MDF type shall be moisture resistant grade (MDFMR) with density in excess of 600kg/m^3 to BS 1142.
    e. Lipping: 6mm hardwood complete with 3mm radius to vertical edges.
    f. Frame: Hardwood as defined in TIM 1.M070.
    g, Tolerance: Width ±1.5mm, thickness ±1mm, height ±1.5mm.
    h. Fire rating: 1/2 hour fire resisting period for integrity for each side separately (including frame and fixing). The maximum area of uninsulated glazing used in doors which are not required to be insulated shall not exceed 25% of the area of the door leaf. All doors including frames should be tested or assessed in accordance with BS 476 : Part 22.

COM17.W020.4 HEAD FIXING

Mid-span fix at the head.

COM17.W030.4 PELLETING

Plug pre-drilled fixing holes with nylon pellets.

COM17.W040.4 SPLAY EDGES

Provide splay edges to the lipping to enhance the operation of door leaves.

COM17.W050.4 JOINTS

1. For doorsets with paint finish:
    a. Provide 'V' joints at mitre joints of frames and of glazing beads, and at 'T' joint for transoms and frames to control the possible cracks of the paint finishes.
2. For doorsets with timber veneer finish:
    a. Provide 'V' joints at mitre joints of frames and of glazing beads, and at 'T' joint for transoms and frames. Provide the joints of the veneered faced plywood as shown in the standard drawings.

COM17.W060.4 SPREAD OF ADHESIVE

1. For doorsets with paint finish

    Provide sufficient and even spread of adhesive for gluing the plywood faces. This is indicated by a consistent bead of adhesive squeeze from the timber to plywood joint all around the perimeter of door leaves.
2. For doorsets with timber veneer finish

    Provide sufficient and even spread of adhesive for gluing the veneer and plywood faces. This is indicated by a consistent bead of adhesive squeeze from the plywood to veneer and from timber to plywood joint all around the perimeter of door leaves.

FIXING SEQUENCE

COM17.W110.4 INSTALLATION

Fix doorsets in formed openings in accordance with the manufacturer's recommendations and in the following sequence:

1. Install sub-frames/linings for fixing of door frames. Provide 5 mm thick plywood packs at every fixing position of door frame/sides panels. Provide means of attaching the door frames to sub-frames/linings or to panel partitions;
2. Fix door frames after the completion of all wet trade in the adjacent areas and plug holes with plastic pellets for paint finished doorsets or matching wood filler for timber veneer finished doorsets. Apply low modulus silicone sealant at joints between panel partitions/sub-frames and back of door frames;
3. Fix solid core top panels where applicable, glazing beads and plug holes in plastic pellets for paint finished doorsets or matching wood filler for timber veneer finished doorsets;
4. Install ironmongery to the predrilled holes or recesses on the doorsets;
5. Ease and oil knobsets and other ironmongery;
6. Install 6 mm thick polished wired glass and secure by gaskets and mastic at the vision panels, overpanels and side panels as specified in Worksection COM4.

TESTING

SURVEILLANCE TESTS FOR WOODEN DOORSETS

COM17.T1605.4 SURVEILLANCE TEST

When instructed:

1. Test Arrangements:
    a. Provide attendance on the Site;
    b. Provide, deliver and collect samples etc. as directed by CM or as specified;
2. Testing Samples:
    a. Provide one test sample from the batch of material delivered to Site (inclusive of door leaves, frames, ironmongery and other accessories sufficient for assembling doorsets from components) or as instructed by CM;
    b. One set of test sample will consist of two doorset specimens. Samples will be the complete component as to be installed, including glazing, all fixed parts, leaf, fastenings and fixings necessary to ensure normal operation. Bear all cost for any replacement of samples.
3. Testing Methods:

    As per COM5.M040 (2)(d).
4. Non-compliance:
    a. In the event that the test fails to meet the testing requirements:
        i. Remove the representative batch off Site; or
        ii. Carry out re-test in accordance with sub-clause (3)(a) on three separate samples selected by the CM in a laboratory that complies with the requirements stated in PRE 9.570. In case of any one sample fails the re-test, remove the representative batch off Site and bear all associated costs for the re-tests. No extension of time will be allowed.

APPENDIX COM17/I

COM17.APPEND1.4TESTS FOR TIMBER DOORSETS

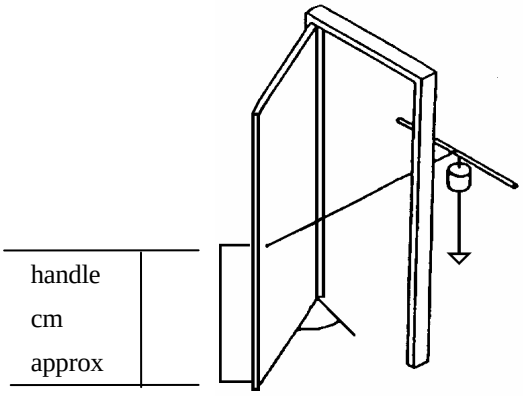


Fig. 1 - Slamming closed

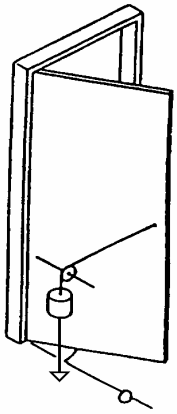


Fig. 2 - Slamming Open

APPENDIX P2 : Specification for Pesticides, Preservatives and Paintings

FIN7.M020.4 UNIFORM SUPPLY

1. Where possible, obtain all the materials in a coating system from the same manufacturer;
2. Furnish the CM with two copies of the manufacturer's data sheets for the proposed paints.

PESTICIDES AND PRESERVATIVES

FIN7.M110.4 RUST INHIBITOR

An Approved proprietary chemical agent which converts rust to iron phosphate.

FIN7.M120.4 ANTI-MOULD LIQUID

An Approved fungicidal solution.

FIN7.M130.4 PESTICIDAL COATING

Containing an Approved pesticide:

1. Registered under Pesticides Ordinance;
2. Safe to use for its purpose without causing hazards;
3. Effective in killing all stages of insect infestation and protecting timber from subsequent insect attack;
4. Colourless or coloured;
5. It shall be suitable for overpainting where treated surfaces are likely to be exposed or in contact with a painted finish.

FIN7.M140.4 WOOD PRESERVATIVE

1. An Approved proprietary brand to BS 1282:1999;
2. Safe to use for its purpose without causing hazards;
3. Colourless or coloured;
4. It shall be suitable for overpainting where treated surfaces are likely to be exposed or in contact with a painted finish.

FIN7.M150.4 WATER REPELLENT LIQUID

Silicone based or other Approved water repellent.

PRIMING PAINTS AND SEALERS

FIN7.M210.4 WOOD PRIMERS

Aluminium primer to BS 47561998: Type 1.

FIN7.M220.4 METAL PRIMERS

One of the following as recommended by the manufacturer of the finishing paint system:

1. Zinc phosphate primer;
2. Metallic, zinc rich primer to BS 4652:1995: Type 2.

3. Minimum two finishing coats.

PAINTING TO KITCHEN, BATHROOM, FLAT ENTRANCE AND EXIT STAIRCASE DOORSETS IN DOMESTIC

FIN7.W2110.4 GENERAL

Carry out spray painting in the supplier's workshop prior to delivery to Site and in accordance with the paint manufacturer's recommendations and the requirements as specified below.

FIN7.W2120.4 SAMPLES OF FINISHED WORK

1. Prior to the order of the paints, submit a sample, for Approval, consisting of two sets of the upper half of the finished doorsets indicating materials used for the filler, undercoat and finishing coats proposed and the standard of workmanship on the paint application;
2. The Approved sample will be used as an acceptance standard for the workmanship of the spray paint finish application.

FIN7.W2130.4 COLOURS

The colour of the finishing coats of the whole doorset will be selected from the 'NCS' colour range or to master colour chart by paint manufacturer as seleted by the CM.

FIN7.W2140.4 SURFACE PREPARATION

1. Fill all surface irregularities with filler or stopper as recommended by the paint manufacturer;
2. Leave to dry and sand down until smooth;
3. Ensure all surfaces to be painted are smooth, clean, dry and free from oil or grease and other contaminants.

FIN7.W2150.4 AMBIENT CONDITIONS

Do not commence painting in weather conditions with relative humidity above the limit specified by the paint manufacturer.

FIN7.W2160.4 APPLICATION OF PAINT

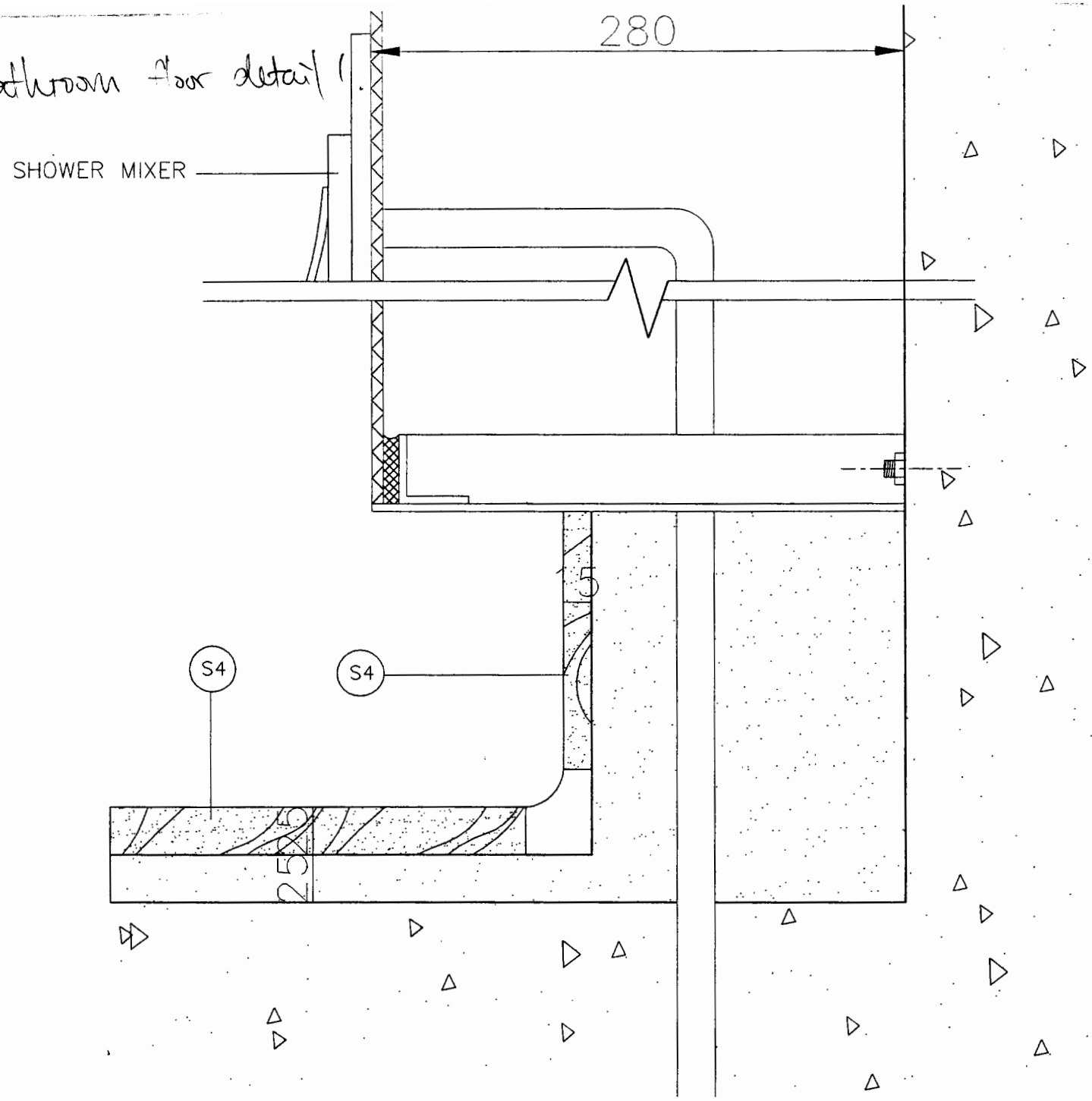
1. Apply one coat of undercoat by spray or by brush. Sand down and dust off;
2. Carry out thinning in accordance with the manufacturer's recommendation;
3. Allow sufficient time for the undercoat to dry before sanding and overcoating as recommended by the manufacturer;
4. Apply a minimum of three finishing coats by spray until the finished surfaces are smooth and free from wood grain. Ensure the working pressure of the pump, the nozzle size, the thinning process and the minimum recoating time satisfies the manufacturer's recommendations.

FIN7.W2170.4 DRYING AND PACKAGING

After application, leave to dry for a period of time before packing as recommended by the paint manufacturer. Wrap doorsets with uncoated white paper or equivalent material as recommended by the paint manufacturer. Do not use plastic coated materials or coloured paper for wrapping.

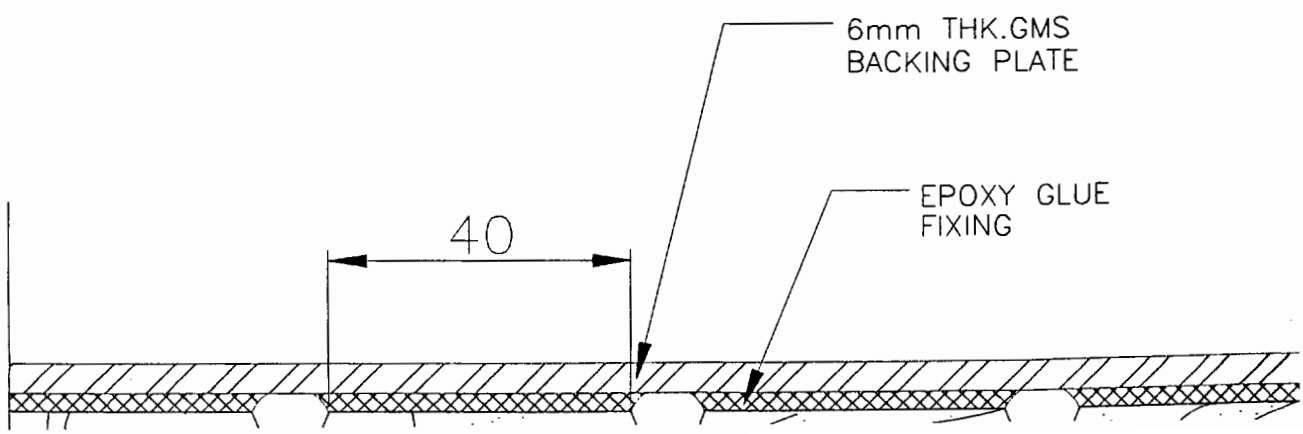
APPENDIX P3 : Sample Flooring Details – King's Park

Bathroom floor detail (

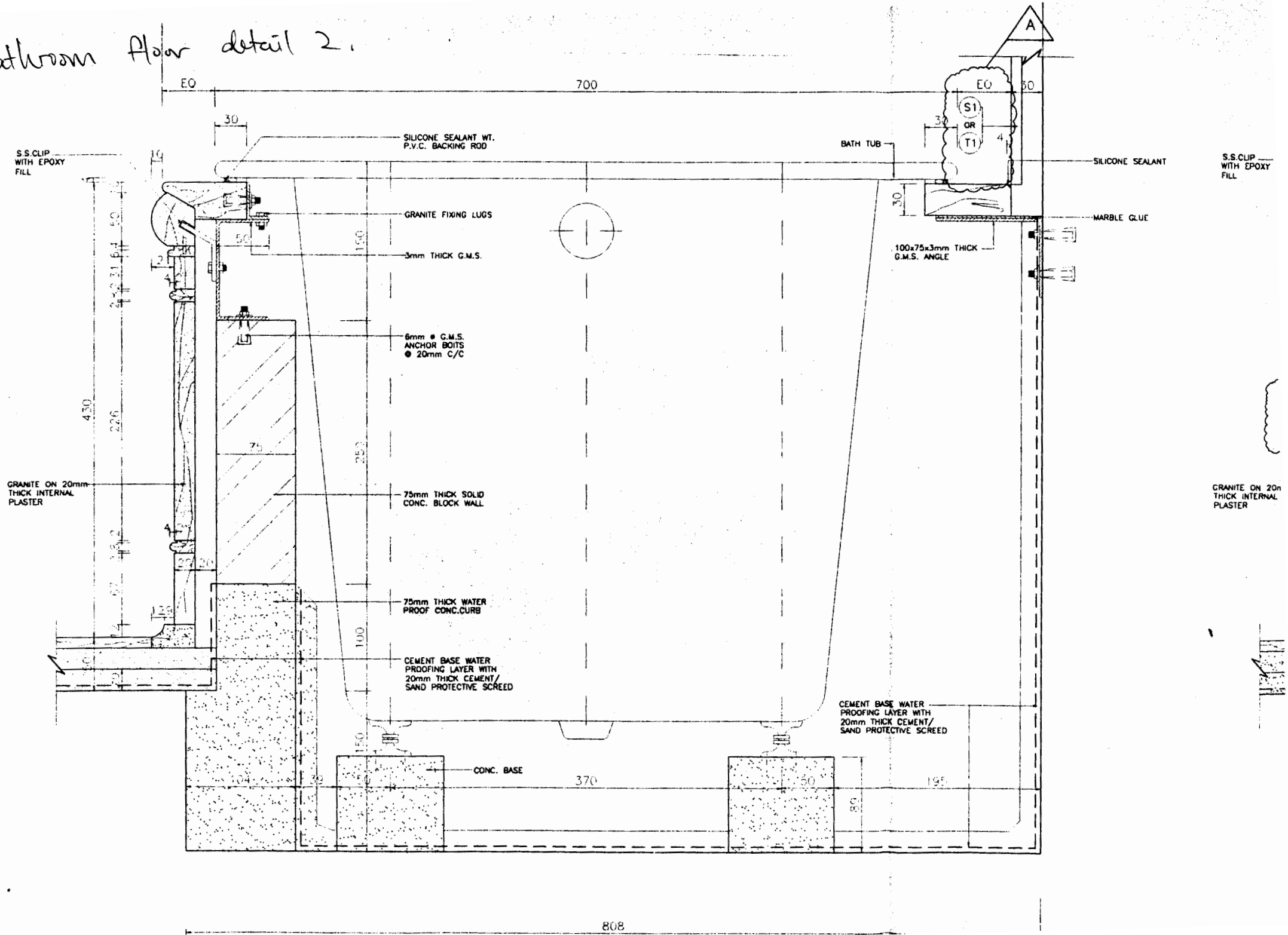


E DETAIL SECTION

NS-D4-DE-06 OF GLASS PANEL 1:1
FOR SHOWER CUBICLE
(MASTER BATHROOM)



Bathroom floor detail 2.



APPENDIX Q : CONSULTANT'S RESPONSES TO HA COMMENTS

APPENDIX Q1 CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 1 INTERIM REPORT

APPENDIX Q2 CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 2 INTERIM REPORT

APPENDIX Q3a CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT (received on 4TH NOV 04)

APPENDIX Q3b CONSULTANT'S RESPONSES TO QS COMMENTS ON 3RD REVISED FINAL REPORT (received on 25TH OCT 2004)

APPENDIX Q3c CONSULTANT'S RESPONSES TO QS COMMENTS ON FUNCTION UNITS (received on 25TH OCT 2004)

APPENDIX Q3d CONSULTANT'S RESPONSES TO HA COMMENTS ON PROPOSED ALTERNATIVES (received on 8TH NOV 2004)

APPENDIX Q3e CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT- APPENDIX C (received on 19TH NOV 2004)

APPENDIX Q4a CONSULTANT'S RESPONSES TO HA COMMENTS ON REVISED FINAL REPORT (received on 14TH FEB 2005)

APPENDIX Q4b CONSULTANT'S RESPONSES TO HA COMMENTS ON SOFTWARE

APPENDIX Q4c CONSULTANT'S RESPONSES TO HA COMMENTS ON FUNCTIONAL UNITS OF APPENDIX A

APPENDIX Q1 : CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 1 INTERIM REPORT

APPENDIX Q1 : CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 1 INTERIM REPORT

Section	Description	Comments	Consultant's Response/ Action Taken
1.1	Introduction	• Suggest to give brief definitions of LCA and LCC (for those unfamiliar with the terms) and cross reference to detailed descriptions later in the report.	• LCA/LCC will be defined in Section 1.1 as follows: • LCA is an environmental evaluation tool in which all impacts arising from the manufacture, use and disposal of a product or service are quantified. These impacts include all extractions from (i.e. resources) and all emissions to (i.e. pollution) the environment throughout the whole life cycle. LCA allows the potential impacts posed to the environment and human health from different design alternatives to be assessed (see *Section 2.1* for more detailed explanations). • LCC is an economic evaluation tool in which all costs arising from owning, operating, maintaining, and disposing of a project are quantified. LCC is particularly suited to the evaluation of alternative designs that satisfy a required performance level but have different investment, operating, maintenance, or repair costs and possibly life spans. LCC allows the trade off between capital and operating costs for different design alternatives to be compared (see *Section 2.4* for more detailed explanations).
	Line 3 of para. 1	• Suggest to add "an initial" before "25 products" may suffice.	• Agreed. Report amended accordingly.
	Line 6 & 7 of para. 3 – "The main goal of this assignment is to develop an integrated decision support tool that …."	• Suggest to add "in HA's context" between "develop" and "an" of the sentence in order to make the objective clearer.	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
Contents page, 1.2.1, 1.4 and other relevant sections, Figure 1.4a etc.	Development Branch, Management Branch, Allocation Branch	• The Organization Structure of Housing Department was changed with effect from 1 January 2003. • "Development Branch" has been re-named as "Construction Division". • "Development Division" has been re-named as "Development Subdivision" • "Management Branch" has been re-named as "Estate Management Division". • "Allocation Branch" has been re-named as "Allocation & Commercial Division". • Therefore based on the above major changes, it will involve changes in functions and responsibilities between the original "Branches" and the new "Divisions".	• Subsequent to review of HKHA's Departmental General Circular No.6/2002, relevant sections of the report have been accordingly amended.
1.4.1	Line 1 of Architectural Section	• Please replace with "responsible for <u>design and standards</u>, research and development of <u>materials</u> specifications that are implemented by the Projects subdivisions for the construction of new HKHA <u>developments</u>.	• Agreed. Report amended accordingly.
1.4.2	Lines 3 and 4	• "branches" should be replaced by "divisions" and "divisions" be replaced by "sub-divisions".	• Agreed. Report amended accordingly.
	Line 6	• "Technical Development Unit" should read "Technical Advisory and Support Unit"	• Agreed. Report amended accordingly.
	Line 7	• Suggest to omit the sentence starting with "In addition ……Division 3"	• Agreed. Report amended accordingly.
	Last sentence	• Please omit the word "Therefore" and replace "Management Branch division" with "Estate Management Division"	• Agreed. Report amended accordingly.
1.4.3	Second sentence of Para.2 – "The TPS and HOS …"	• Suggest to omit this sentence	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
1.4.3	4th word of Line 6 on page 5	• Suggest to replace "neither" with "any"	• Agreed. Report amended accordingly.
	2nd para on page 5	• Suggest to omit "most significant"	• Agreed. Report amended accordingly.
2.1.1	Line 1 of para. 1 – "LCA is a technique for assessing the environmental aspects ….".	• Suggest to add ", from the whole life cycle point of view," between "assessing" and "the" of the sentence.	• Agreed. Report amended accordingly.
2.2.2	Figure 2.2 – Schematic Diagram of a Life Cycle System Illustrating Inputs and Outputs.	• Please consider whether "Water" shall also be indicated as Inputs in the diagram.	• Agreed. Report amended accordingly.
2.4	Line 4 of first para. on page 21 – "…tick box tools don't not give the required……".	• To delete the word "not" prior to the word "give" from the sentence.	• Agreed. Report amended accordingly.
	International LCA Models and Tools	• Apart from UK, it seems that other countries LCA models from other countries can be mentioned, e.g. SimaPro as discussed in Sec. 2.5.3	• Agreed. The LCA models from other countries reviewed for this project will be included.
2.5, 4.2.2, 4.3.2.1, 4.3.2.2, 4.3.2.3, 4.3.2.4, etc.	"New Harmony Block (Option 2)" or "New Harmony Block 1 (Option 2)"	• They should be read as "New Harmony 1 (Option 2) Block".	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
2.5.3	Last para. on page 28	• Please indicate what databases SimaPro contain.	• Databases available in Simapro include the following, as noted in the revised report : 1. BUWAL 250 as described in section 2.5.2.2 2. Data-Archive as described in section 2.5.2.3 3. ETH ESU 96 as described in section 2.5.2.6 4. IDEMAT 2001 as described in section 2.5.2.11 5. Industry Data as described in section 2.5.2.12
2.6	Line 2 of para. 1 – "… a New Harmony Block (Option 2) building.	• Should it be New Harmony 1 Block (Option 2)? • How many and which projects of NH1 (Option 2) have been assessed?	• Agreed. Report amended accordingly. • Since the NH1 (Option 2) has not yet completed a full life cycle, historical projects have to be used as the point of reference. A number of blocks of varying ages (still to be determined) will be studied to establish an overall profile. This will be clarified in the report.
3.1.1	Line 2 of para. 2 – "… namely building services related such as Electrical, Fire Services and Air Conditioning Installations."	• For communal services installation, building services installations are Electrical, Fire Services, Water Pumps, Lifts and Automated Refuse Collection System (ARCS). • Generally for rental NH1 standard block, there is no provision of Air Conditioning Installation in common areas.	• Agreed. Report amended accordingly. • The statement made in the report is intended to be a general reference to the practices of HA and will be clarified in the revised report.
	Line 2 of final para. "eliminate" approved lists	• Suggest replacing "eliminate" with "rationalize".	• Agreed. Report amended accordingly.
3.2.1	Para. 2 under HAHA's Spec Library on page 37	• Suggest to omit the last sentence	• Agreed. Report amended accordingly.
	2nd and 3rd sentences in the last para on page 37	• Suggest to word, as "It is understood that the current specification format is under review, aiming towards adopting performance specifications • This means that designers can specify……."	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
3.2.2	"Feedback Forms" , 3rd para under Material Selection	• It is not true that the main route for feeding back was through "Feedback Forms" prepared by Estate Managers. It is quite common for project teams and contractors to provide feedbacks.	• Agreed. Report amended accordingly.
3.3.3	3rd line in para. 1	• Please omit the words "an arbitrary"	• Agreed. Report amended accordingly.
	10th line in last para.	• Please omit the sentence starting "The simple addition ……"	• Agreed. Report amended accordingly.
3.3.4	Last word of 1st line in para. 1	• Suggest replacing "fairly" with "slightly".	• Agreed. Report amended accordingly.
4.2.2	Repair and Maintenance Stage	• The paragraphs may be too descriptive for the purposes of the report and should be confined to concise definitions of emergency, day-to-day and planned maintenance.	• Agreed. Report amended accordingly.
4.2.3	Line 8 of para. 1 under sub-heading of Operation Stage – "… public and the occupier areas …"	• Please elaborate your methodology and provide more information on your sources of LCC data in operation stage of NH1 in both public and occupier areas be obtained in your study.	• These information sources include published data from EMSD and others, in addition to utility bills and data obtained from HKHA for this and previous studies. The methodology for the use of this information coupled with the Operational Energy Model will be elaborated in the revised report.
4.3.1	Regionalisation -	• Is Simapro free to be used? Any copyright problem.	• Characterised, regionalised and normalised data from sources such as SIMAPRO provides the basis of the HA LCA/LCC model. Since the raw data and tools themselves do not form part of the model, HA licensing of such sources is therefore not required. This will be clarified in the report.
4.3.1.1	Energy Mix	• Please annotate where the UK energy mix data.	• The annotation will be included in the report.
	Line 2 of para. 7 – "… this study intends to measure 33 3[4.]"	• For the document reference "33", please provide more specific information on which recent study, type of buildings, date of study etc. • Under the table at the footnote for the document reference "33", please elaborate what the "Main Electrical Equipments" are.	• Document references 33 and 34 have been rationalized and now specify the study details. • The "Main Electrical Equipments" refers to items such as Switchboards and Generators and these are described in the revised report.

Section	Description	Comments	Consultant's Response/ Action Taken
4.3.1.2	Table 4.3a	• One of the timber door set participants should be Tai Wah Construction Ltd.	• Agreed. Report amended accordingly.
4.3.1.3	Last sentence	• Please indicate where the data for the Chinese energy mix or transport could be obtained from.	• Chinese data for transport and energy mix originates from INET/ITEESA Tsinghua University (Beijing). The data is held in GEMIS version 4.1 for the years 1995 and 2000. Transport data comprises type of trucks, trains, ships, etc, and related emissions. The report has been accordingly amended to highlight this. References: 1. Deshun L., Hao W., Jingfei G., (1998) Final Report of the Peer Review of EM – China Database, INET/ITEESA Tsinghua University, Beijing. 2. INET, Institute of Nuclear Energy Technology, Tsinghua University, Beijing. 3. EPO, Environmental Protection office, Ministry of Electric Power, Beijing. 4. BERI, Beijing Economic Research Institute of Water Resources and Electric Power. 5. South China Institute of Environmental Sciences, SEPA. 6. Web site: www.scies.com.cn 7. GEMIS, Global Emission Model for Integrated Systems (Version 4.1). 8. Web site: www.oeko.de/services/gemis/
4.3.2.1	Line 6 of para. 1 – "… only one key aspect, the transportation distances of construction materials from manufacture plant to the construction site"	• It appears that the energy used in transportation the raw materials and components of function units to the place of manufacturing should also be included in the study as far as practicable.	• Transport of raw materials to their place of manufacturing is inseparable from the extraction and processing of raw materials and manufacture of finished materials. These factors are being regionalised as described in *Section 4.3.1*, however the "Transportation Study" addresses specifically the transport of finished material from factory to site. This will be clarified in the report.

Section	Description	Comments	Consultant's Response/ Action Taken
4.3.2.2	Line 1 of para. 3 – "… information from the standard bills of quantities…"	• For building services installations, there is no standard bill of quantities. Please advise how the quantities be established.	• Since a standard bill of quantities is not provided by HA for the building services elements of the NH1 (Option 2) block, data will instead be obtained from the tenders of nominated sub-contractors. Whilst it is understood that these quantities are not necessarily accurate for the completed building, they are still considered as an acceptable reference guide within the context of the whole model, particularly since building services elements are not initially intended to be the focus of detailed investigation. This will be clarified in the report.
	Line 1 of para. 4 – "… identification of country of origin …"	• Would it be more appropriate using "place of manufacturing" instead of "country of origin" for the study of energy used in transportation?	• The information is based upon HA material approval forms, which only list the country of origin. This will be clarified in the report.
4.3.2.3	Line 2 & 3 of last para. on page 55 – "…in any analysis these two countries will dominate the results.".	• Suggest to replace the word "countries" by the word "regions" or "areas".	• Agreed. Report amended accordingly.
4.3.2.4	1st para	• According to the Transportation study, HA construction will have a lower env impact due to transportation element. Should this be truly reflected by reducing its relative weighting rather than "leaving the international environmental data unadjusted" per your recommendation?	• On balance, the distances found in places like Europe are similar to the distances in Hong Kong for most of the major materials – the report will be amended accordingly to reflect this.
	Line 1 of para. 3 – " … probably not distort the results is the evaluation of the constituent materials, such as cement and aggregate."	• Such conclusion for constituent materials of concrete may be reasonable, however, it may not be applicable for all types of other building materials. Would it be more appropriate to look into each type of materials individually?	• Ideally it would be more appropriate to look into the constituent "ingredients" of any material. Reliable data for all ingredients is however limited, even overseas, and could not be completed for all materials. The overall impact of this level of detail is also likely to be relatively small.

Section	Description	Comments	Consultant's Response/ Action Taken
4.3.3.4	Last sentence	• Please indicate which country is "CML" located.	• CML is located in the Netherlands and this has been described in the revised report.
4.3.4.1	Note 38 at bottom of 62	• Please give full name of EDIP	• Environmental Design of Industrial Products in Denmark – accordingly described in the revised report.
4.3.4.3	Table 4.3c on page 65 and Table 4.3d on page 66.	• Even under the same category of environmental impact like "Ozone Depletion", the Normalised Values for Material A and Material B have different decimal places as "0.175" and "0.0699" respectively and the Ecopoints Score are "0.864" and "1.73" respectively from the impact of "Acid Deposition". Suggest to round the values to 3 decimal places if appropriate.	• Agreed. Report amended accordingly.
	Line 5 counting from bottom of page 65 – "….impact coming from Eutrophication, Photochemical Ozone ….".	• The word "Eutrophication" should be replaced by "Pollution to Water: Human Toxicity" since the latter impact is with the greatest Normalised Value of 4.27.	• Agreed. Report amended accordingly.
	Line 3 of second para. on page 66 – "…from Climate Change, Fossil Fuel Depletion and Eutrophication, reflecting…..".	• The word "Eutrophication" should be replaced by "Pollution to Water: Human Toxicity" since the latter impact is with the third greatest Ecopoints Score of 11.0.	• Agreed. Report amended accordingly.
4.3.5.3	Data Consideration & Analysis	• Suggest that the paragraphs be simplified. • Figure 4.3e may need more annotations to make it more self-explanatory, i.e. what are the dimensions? What does 0.0 represent and what are the values/units of .5, 1.0 etc. • Figures 4.3f to h would probably need a legend for symbols and graphic representations.	• Agreed. Report amended accordingly. • The discussion on Figure 4.3e has been clarified to make it more self-explanatory. • The symbols and graphic representations have been defined.

Section	Description	Comments	Consultant's Response/ Action Taken
4.3.5.9	Weighting of Group Preferences	• Please elaborate the methodology how the results of weighting of group preferences be applied to this LCA/LCC study. Is it to be reflected in Impact Assessment and LCA database?	• The following text has been added as *Section 4.3.5.10*: "The series of workshops geared toward the derivation of the weighted group preferences yielded preferences that are based on local, regional and global concerns. All these weighted concerns can be used concurrently so that the benefits from each source can be cross-verified. However, since the decision tool (i.e., the acceptability curve) is a dynamic system that builds its strength from previous experiences, therefore, the best decision on which source of preference (i.e., local, regional, or global) is likely to come once the system is in operational mode (or "run-in")."
	Tables & Figures	• Double check if Table 4.3g, Fig 4.3i & 4.3j are for (Global), whereas Table 4.3i, Fig 4.3m & 4.3n are for (Local).	• Tables have been doubled checked and amended as necessary.
4.4.1	Line 3 of para. 4 under sub-heading of Format of Data and Information Sources – "… building services contracts …"	• Please refer to comments on sub-section 3.1.1 above on the types of building services installations provision in communal areas.	• Agreed, the report will be amended as per item 3.1.1
4.4.2	Line 2 & 3 of para. 5 on page 80 – "The primary data source for all quantities will be the bills of quantities and the schedules of rates used on main construction contracts."	• Suggest deleting the word "all" from the sentence. • How about the schedule of rates for Building Services Subcontracts?	• Agreed. Report amended accordingly. • As for the comment on *Section 4.3.2.2*, quantities entered by the sub-contractors will be used for compiling the model.

Section	Description	Comments	Consultant's Response/ Action Taken
	Line 6 & 7 of para. 6, p 81 – "…..proposed to analyse similar block types over the last 20 years….".	• Please specify the types of blocks as to be the similar block types.	• These will be existing Harmony 1 blocks and, where trends from older buildings are necessary, trident and other cruciform shaped buildings. The revised report has been clarified.
4.4.2	2nd last para	• A research study has just been completed by HKPU on construction waste management in HA contracts, and waste indexes are available for your analysis. Please see copy attached.	• The HKPU report has previously considered but is thought not to accurately reflect industry practice in the real world as is unlikely to be agreed with by contractors. Waste percentages are therefore instead based upon ArchSD published guidelines.
	Last phrase, last para, p 82	• A typo error, "ain" should be "an"	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
4.5	The Operational Energy Model	• It has been pointed out previously and is still unclear how the proposed energy model be applied to the assessment of each building material or for a building envelope how to "normalize" and "apportion" the energy use to each envelope materials.	• The purpose of the Operational Energy (OE) Model is not to apportion energy use to any particular material, but rather to quantify the OE component of the life cycle cost and hence provide some context when considering the benefit of alternative materials. • The OE model will be used, with reference to energy bills and published data from the utilities and Electrical and Mechanical Services Department for existing buildings (of which there are no NH1 Option 2 examples), to establish the OE use, cost and environmental impact of the base building. • Where alternative materials are to be considered that are known not to affect OE (e.g. substituting one tile for another) this base data will still be valid and the OE model need not be rerun. However, where the alternatives are known to affect OE (e.g. fabric insulation or double glazing), the OE model can be used to assess their likely life cycle impacts. • In other words, the OE model provides an additional tool for use when it is necessary to review the impact of specification changes to the building envelope or HVAC regime that might increase embodied impacts but reduce OE use. Without such a predictive model the affect of such changes upon OE impacts and costs cannot be calculated. • The report will be clarified as such.
4.5		• It is important to provide a clear boundary of each building material/function unit relating to operational energy model.	• HA drawings of New Harmony 1 (Option 2) Blocks collected on 5 Feb 2003 will provide the boundary for each material/functional unit for simulation.

Section	Description	Comments	Consultant's Response/ Action Taken
		• Please provide a clear and comprehensive assumption/methodology on how the operational energy in tenant areas is modeled.	• Detailed heat-flow simulation software, Visual DOE 3.0, will simulate OE in tenant and landlord areas. Energy will be simulated in a thermal zone created by the materials that compose a construction element such as building envelope. Lighting, cooling, small power, heating, cooling and domestic hot water energy use will be calculated. This OE Model will convert this into costs and environmental impacts (using the same characterisation, normalisation and weighting procedures as previously described) for reference to the results of the LCA/LCC Model. • In tenant areas OE will be simulated based on the following information and the report will be clarified as such: 1. Configuration drawings of thermal zones of Harmony Block tenant areas (Liv/Din room, Bathroom, Bedroom, Kitchen) 2. Thermal-zone occupancy pattern including lighting, small power loads (equipment) and domestic hot water operational pattern, light and equipment power density, sensible heat gain and latent heat gain per person 3. Materials and construction details of roof, floors, partitions, walls, glazing and windows 4. Air conditioners used
	Line 3 of para. 2 – "… mechanical transport in the public areas .."	• Would it be lift installation?	• Yes, mechanical transportation has been replaced with lift installation.
	Line 7 of para. 2 – "…Kw/hours…"	• Would it be the electricity energy unit kWh?	• Agreed. Report amended accordingly.

Section	Description	Comments	Consultant's Response/ Action Taken
4.5	Line 1 of para. 3 – "Hong Kong Building Energy Codes and codes of practice for energy efficiency will form part of the model through their use as benchmarks."	• Those COPs are prescriptive requirements in achieving a certain standard of energy efficiency. Please elaborate how they can be used in your operational energy modelling in tenant and communal areas.	• For instance, we use the thermal conductivity figures (k-value) of "Code of Practice for OTTV in buildings 1995" as benchmark material k-value.
4.5.1	Table 4.5a – Operational model : Activities and Assessment method	• Where are the sources of data for the domestic energy end-use survey 1999-2000 of cooling, lighting, cooking, water heater etc. usage pattern of Harmony Block? • Water consumption should not be under energy model unless they are used to model the energy consumption for supplying the amount of water required to a Harmony Block. • For landlord areas, electricity consumption for water supplies should be included.	• The energy end-use survey data source is CLP Power, which appointed City U Consultants Ltd. to conduct the domestic energy end-use survey in 1999 (inserted as a table note). • Agreed. Water consumption provides the basis to model energy use in water supply. This will be clarified in the table. • Electricity consumption for water supplies is included into other demands as shown in *Table 4.5a*.
4.5.2	Figure 4.5d – Operation air conditioning energy end-use pattern	• It is doubtful why air conditioning is used in wintertime. • Does the curve represent the energy consumption of an air conditioning unit at bedroom, living/dining room or a whole flat?	• Figure 4.5d in the report in fact presented OE usage patterns rather than air conditioning and has thus been removed. Air conditioning usage will be simulated with usage patterns from the 1999-2000 CLP survey, with an on/off schedule set to off for winter periods. • The Domestic energy end-use survey 1999-2000 report prepared by CLP Power described that the curve were presented in kW and represented typical appliance owners (whole flat) patterns by half-hour interval in a typical summer months for average HK owners.

Section	Description	Comments	Consultant's Response/ Action Taken
4.5.2	Table 4.5b – Appliance Ownership in Public Rental and Housing Ownership Scheme	• "Housing Ownership Scheme" should be "Home Ownership Scheme" • Why water heaters, cooking stove and the types of fuel used in these appliances are not included?	• Agreed. Report amended accordingly. • The table extracts typical appliances from the 1999-2000 domestic energy-use survey. Others such as water heaters and stoves and their fuel usage are included. This will be clarified in the table.
4.6.2	Line 6 to 9 of para. 6 – "… if the capital cost assessment does not include the cost of window air conditioners then the operational costs associated with these items of equipment should not be included in the overall assessment of the operational costs for the building.	• It seems that this paragraph contradicts Section 4.5 for the assessment of operational energy in tenant areas. Please clarify.	• Line 6 to 9 of para 6 opposite refer to the base LCA/LCC model, which will not indeed include the costs of occupier installed equipment in line with industry LCC standards and methodologies. Section 4.5 of the amended report, however, will clarify that such appliances will be included in the OE model, which is available for use when necessary to assess design alternatives that will have an impact on OE such as fabric insulation or double glazing, etc (as described in the response to comment 4.5 above). • This issue reveals an interesting deviation between current LCA and LCC standards. Models based upon such standards may therefore be inconsistent on this point, however since the OE model for this assignment is to be used for comparison alongside the LCA/LCC model, this difference will not affect the effective functioning of either.
5.	Stage 2 of the Assignment – The Way Forward	• The "ranking of the top 10 materials with the most environmental and economical impact" should also be spelt out as one of the objectives of this next stage. • Please include sources of operational energy and related data.	• Agreed. Report amended accordingly. • A new subsection on sources of operational energy and related data will be included, using the basis described in the response to comment 4.5 above.

Section	Description	Comments	Consultant's Response/ Action Taken
5.3.2	Last sentence – "…some functional units… cannot be identified separately…, which is not possible within the scope of this study.	• What are these functional units? Please provide detailed information or examples.	• This is general way forward and the details will be provided in the stage 2 report.
5.5	4th Paragraph	• Though it is understood that environmental impact data is unlikely unless new and more accurate information or new materials are added, it is still preferable to allow for the capability to make changes in case revisions would be necessary in future.	• The environmental factors cannot be changed within the software, new items can be added and a completely new data set added, but existing data cannot and will not be changeable.

(Lr15-Annex1)

APPENDIX Q2 : CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 2 INTERIM REPORT

APPENDIX Q2 : CONSULTANT'S RESPONSES TO HA COMMENTS ON STAGE 2 INTERIM REPORT

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
-	General	● To facilitate readers' understanding, please provide as far as possible a step-by-step example (with calculations) of a function unit going through the processes of regionalization, characterization, normalization, weighting while taking into account the quantum model, cost model, operational energy model etc. to arrive at Eco-Points and the LCC. ● It seems that the review/verification of data should be under Stage 2 rather than Stage 3. ● Function units should form an Appendix; our comments on Functional units are given separately in Annexes 2 and 3. ● Suggest that there should be another appendix indicating the combined LCA and LCC ranking of functional units.	● The full step by step guide will be provided in the manuals accompanying the model and therefore are not provide in this report. ● The review process is being carried out during both Stages 2 and 3 since it relates to the model usage and some problems can only be identified as it is used. ● Comments on functional units are addressed separately and are now listed as an appendix. ● Combined ranking now included.
Contents Page	Appendices	● Appendix A should probably be 'Environmental Impact Ranking of Functional Units at Initial Construction Stage'; ● Appendix B should probably be 'Cost Ranking of Functional Units at Initial Construction Stage'; ● Appendix C should be 'Elemental Environmental Impact Profile (based on initial impacts)' ● Appendix D should probably be 'Elemental Life Cycle Cost Profiles (based on initial impacts)';	● Titles have been revised for all appendices.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
		● Appendix E should probably be 'Elemental Whole Life Environmental Impact Profiles'; and ● Appendix F should probably be 'Elemental Whole Life Cost Profiles'.	
Executive Summary Page I	Footnote 3 – New Harmony 1 (Option 2) Block	● Suggest to indicate "6/00 Revision to 1/00 Edition"	● Revised
Executive Summary Page III	Line 1 of first para. under Building Material Ranking	● Should 'functional units' be 'elements'? ● The top ten ranking of 'functional units' rather 'elements' as indicated than would be more relevant in this Study's context.	● Revised ● Revised
Proposed Alternative Materials Page III	Line 1 – potential alternatives arising from the ranking process;	● Suggest to add 'LCA and LCC' in front of ranking process if it is the case. ● Detailed comments on Proposed Alternatives please refer to comments on Section 5.2.	● Revised ● Comments on alternatives addressed separately.
	Towards the end of the first sentence in the last para. of page III and last para of 5.1 "… to be sensitive to the current usage profile without being seen externally to downgrade the finishes block.	● It depends, if alternative is less expensive but environmentally more friendly, it would be ok.	● Noted and text revised.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
Page IV	1st bullet of Way Forward	● Is Review/Verification of data a residual activity under Stage 2?	● It is an ongoing activity to ensure there are no problems / anomalies in the data.
1.1 on page 1	Core team of experts	● Should WSP and L&O be mentioned also?	● Added as assisting parties, not core team members.
2.1	Framework of the Proposed Database Model	● Please refer to comments on the software at Annex 4.	● Response addressed separately.
2.2.5 on page 6	Summary "…. flexible tool through wheel data is processed…"	● Should it be "which"?	● Revised
3.1.1 on page 7	2nd para.	● '10H' base materials is a typo? ● Component materials making up 'Functional Units' should form an Appendix to the Stage 2 Report. ● Our comments on the 'Functional Unit' are at Annexes 2 and 3.	● Revised ● Noted and added. ● Comments addressed separately.
	last paragraph last sentence	● Do not understand.	● Reworded in revised version to simplify.
3.2.2.3 on page 10	Cost	● Current description could be misinterpreted and should be amended to read as para. 3.4.1.2 (page 24) "In terms of the specific rates used, recent district term contracts and CARE contracts have been used as a basis."	● Text revised.
3.2.1 on page 8	Clarification of Assumptions	● The defects liability period of current projects should be 24 months instead of 12 months.	● Revised

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
	The 4th bullet point – "….., 12 month defects period, ……".		
3.2.2 on page 9	Sources of Data	● It would be desirable for the sources of data to be listed comprehensively as an Appendix.	● This is now added.
3.2.2.1 on page 9	Last sentence of 1st paragraph – "general orders of magnitude and inter-relationship analysis has been carried out"	● Cannot quite understand.	● Text modified to simplify and aid comprehension.
	Line 1 & 2 of second para. – "…from the standard BQ documents prepared by the Housing Authority, "	● Please check and replace these two lines with "The initial quantum data for the superstructure works comes from the Standard BQ for New Harmony 1 (Option 2) Block (6/00 Revision to 1/00 Edition)". • Consultant should check and clarify the sources of initial quantum for building services works, piling works, substructure works, demolition works, maintenance works (historical data on which block types?), etc. for this study.	● Text revised. ● Sources of data now set out in report.
3.3.2 on page 13	Last para. – "The collection of LCT data…..".	● Please clarify whether "LCT" should be read as "LCI".	● Revised
	Second bullet at the top of page 13 –	● Are <u>fuel</u> inputs and outputs the same as <u>energy</u> inputs and outputs (the heading of 3.3.2.1)? If	● Revised should read fuel.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
	"Regionalisation of fuel inputs and outputs.	the same, it may be better to keep it consistent.	
3.3.2.3 on page 15	Line 2 of 2nd paragraph	● Should it be … 41-45.6 "MJ" in stead of "kg"	● Revised
3.3.3.6on page 23	Review process	● It would be desirable for DHV and BRE to declare results of their verification, maybe in the form of certificates appended to the Final Report.	● The formal certification will be included in the final report.
3.3.4 on page 19	Normalization	● "100 or 1 (?) Eco-points sets to be equivalent to the typical environmental impacts caused by a HK citizen a year" should be mentioned somewhere.	● 1 Eco-point = 1 HK Citizen / year. Now clarified in the text.
3.3.4 on page 20	"Average normalize value" at the end of the Normalized profile of 1kg fiberglass table	● It seems that the resultant figure of 0.0169494533 is a summation rather than an average of the various impact data.	● The table has been revised.
3.4 on page 23	Line 1 – "The cost data used in the model has been obtained form a number of sources." Line 1 & 2 – " The data as a whole are all prepared on the basis of current prices (October 2003),…".	● Please state the sources. ● Please state any rationale in using cost data on the basis of current prices (October 2003) instead of June 2003 prices for easy comparison with Construction Cost Yardsticks.	● Sources now identified. ● The use of current prices reflected when the model was prepared. Since the rates can be adjusted to any price level using TPI the actual base data is not significant. It should be noted that the model is not intended to give exactly the same answer as the cost yardstick.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
3.4.1 on page 23	Line 1 of second para. – "…..that the block being studied ……"	● Please insert "NH1 (Option 2)" between "block" and "being" for clarity sake.	● Revised
3.4.1.1 on page 23	Line 2 and 3 – "….for those projects comprising free standing Harmony 1 blocks."	● Please clarify and state the reasons why not use cost data from New Harmony 1 blocks instead of Harmony 1 blocks in this study.	● The simple answer is that this block is too new and only one or two projects have been tendered to date. The objective is to give a reasonable reflection of the current market cost for the different components hence the exact pricing from the NH1 block should not be the focus, especially since the alternatives will use pricing form other projects.
3.4.1.4 on page 24	Line 1 – "Since this type of block has never been built before…."	● Please insert "NH1 (Option 2)" between "block" and "has" for clarity sake.	● Revised.
3.4.2 on page 25	Line1 &2 – "….., a thorough review will be conducted by both DLSM and the Housing Authority on all aspect of costs …..".	● Please check and clarify the roles of DLSM and Housing Authority in this study.	● Text revised.
3.5 on page 25	Line 1 – "The quantum data used in this study has been sourced from a number of areas, most of which ……"	● Please specify the details of areas.	● Text revised to state details.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
3.5.1 on page 25	2nd paragraph – "…repair and maintenance quantum is derived using percentages of the total function unit"	● Further explanation is necessary as to how this will function in practice.	● Details now given in the revised text.
3.5.2 on page 25	Line 1 & 2 – "…..will involve a systematic review of all the quantum data. The main……..and maintenance date."	● Please specify the details of systematic review of all the quantum data. ● The main "four" is a typo? Should it be "focus"? ● Please clarify the maintenance date should be maintenance data.	● Details now added. ● Revised ● Revised
3.6.1 on page 27	Line 2 & 3 in second para. – "type of glazing of building and typical metrological year (TMY) daylight illuminance levels.". Line 1 in third para. – "The validity of the data and dry-run results were verified by WSP.".	● Please define the term typical metrological year (TMY). ● Please put the full company name for WSP. A certificate from them forming an Appendix would be desirable.	● Detailed explanation now added. ● Revised. Certificate will be in the final report.
3.6.2.2 on page 27	Input Data	● Do not understand why the supply air temperature from air conditioner (?) changed to 14.5degree C. ● Would it be possible for the set of input data	● Text revised and note added. ● This will be provided separately and would not form part of this report.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
		for the AC load evaluation to be provided for reference?	
3.6.2.3 on page 28	There is a difference of 555,807 between Initial Input (3,373,000) and Adjusted Input (3,928,807) in the Column "Calculated Annual Electricity Consumption (Kwh)".	● Please specify the mechanism how to obtain the difference 555,807 and therefore the Adjusted Input. ● Please annotate the source for the "Statistical Electricity Consumption".	● Text revised to address this point. ● Text revised.
4.1 on page 29	Functional Units	● Function units should form an Appendix; our comments on Functional units are given separately in Annexes 2 and 3. ● Suggest that there be another appendix indicating the combined LCA and LCC ranking of functional units.	● Appendix added. ● Appendix added.
4.1.1 on page 29	Cost	● Appendix B should be mentioned.	● Revised
4.1.3 on page 30	Comments in general	● Appendix A should be mentioned. ● Suggest to use "HK Eco-point" instead of "HKE Point" and annotate that 1 Eco-point (?) sets to be equivalent to the typical environmental impacts caused by a HK citizen a year.	● Revised ● Revised
4.1.4 on page 31	1st paragraph – it's mentioned that	● It seems that the exclusion of these affect the present LCC ranking? Would you liaise with	● These items are lump sum items and not linked to functional units therefore the ranking of

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
	labour and mgt costs associated with routine estate management or building service system maintenance are excluded at Stage 3 , but would be factored into the final report	estate mgt colleagues to provide info in the meantime?	functional units will not be revised. These are all allowances and are part of the running of the building as a whole rather than any specific functional unit.
	2nd paragraph – the top 10 areas (not in order of precedence)… are:…	● Listing the top 10 in order of precedence is preferred. Should there be another appendix indicating the combined LCA and LCC ranking of functional units.	● This has now been added.
	4th paragraph ….”intern al churn rate”	● The calculations of costs presumably have taken ‘internal churn rate’ into account, is the churn rate based on HD data?	● The churn rate is based upon existing HKHA estates of varying ages.
4.2 on page 32	Results- Line 2 of 2nd paragraph on page 32 – Appendices A and B contain …in terms of their “rental” cost and environmental impact.	● Don’t understand “rental”, should it be “cost and environmental impact <u>at initial construction stage</u>” as mentioned in Page II of the report (under ’Building Materials Ranking’)?	● Typo, text revised.
	Last paragraph –	● A typo	● Revised

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
	"norm" for al the alternative assessment. …..; There will be a final verification process	● How long will the verification be? It's a very critical process and may affect the ranking.	● The verification process is basically complete and the ranking only slightly changed. The verification merely ensures that the model responds correctly to the use of different functions.
4.3, pages 32 and 33	Comparison with EPP Report Zinc chromate paint, aluminium paint, copper, chromium brass, lead, bitumen under LCC/LCA comparison with EPP	● Please indicate function and/or location of the materials, e.g. zinc chromate as a primer?, bitumen used as waterproofing in kitchen and floor finishes etc.	● These items are taken from the EPP report which does not specify locations, however, we have now annotated our materials for ease of reference.
5.1 on page 34	Selection Rules Last sentence in last paragraph "… and not seen externally as a downgrading or value duction in the finished block"	● Should it be "reduction"?	● Revised
5.2 on page 34 and 35	Proposed Alternative Materials	● As conveyed in our 2.12.03 meeting, it would be desirable to bring in L&O as early as possible to give architectural input/expert opinion.	● L&O will be involved in the identification and specification of the details of the alternatives being proposed.
Current Unit	(1) Aluminium Windows	● uPVC can be investigated, but HD experience on several pilot projects indicate much higher capital costs. ● Are steel windows already phased out? Would water-tightness be a concern?	● Will be examined although the cost impact is noted. ● Steel windows will not now be considered as discussed in recent meetings. ● Alternative glass options might be considered

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
		● How about low-e glass for west facing windows?	although cost impacts are likely to be high with limited beneficial environmental material impact
	(2) Panel walls	● Gypsum partition can be studied, but unsure about water resistance at bathroom walls.	● This will be addressed through the technical assessment.
	- Gate sets	● They are no longer provided in HD projects, i.e. 3/03 Edition.	● Noted, proposal deleted.
	- Sink units	● The proposed alternative construction of plastic laminate on MDF carcass may not be suitable due to water resistance durability of MDF.	● These are used in the private sector and are therefore considered a valid alternative, but this issue will be addressed.
	(4) Fresh waster installation	● Suggest to describe it more specifically as "UPVC lined GI pipe".	● Description revised.
	(5) Wall finishes (corridor & lobbies)	● Tiles are no longer provide in new version of NH1 (3/03 Edition), may be alternative types of paint can be explored, e.g. synthetic, acrylic, emulsion etc.	● Details of proposal being finalized and will be presented separately.
	(6) Floor finishes (corridor & lobbies, kitchen & bathrooms)- homogeneous tiles	● Proposed "varied usage of tiles" too vague, use of ceramic tile, linoleum tile as clarified on 2.12.03 can be explored.	● The exact proposed alternative is still being explored and will be presented separately.
	(7) Roof system	● Proposed "alternative materials and/or construction details too vague. Suggest to change it to "review of roofing system with the objective to save materials" as discussed in our 2.12.03 meeting.	● Description revised, but full detail still be established.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
	(8) Water meter doors	● May be better described as "S.S. enclosure to water meters on typical floors" ● "alternative material usage" can be GRP or timber.	● We are retaining the heading at the moment since this reflects the wording in the tender documentation, but a full proposal will be issued separately. ● Different materials are currently being examined.
	(9) Cooking benches	● The alternative construction of plastic laminate on MDF carcass for cooking bench instead of the existing SS cladded light weight concrete construction may be explored.	● Refer comments on sink units.
	(10) Internal Waterproofing	● As discussed, the alternatives to the bituminous paint on waterproofing can be studied, e.g. all-in-one waterproofed screeding	● We are looking at composite systems and a full proposal will be submitted separately.
	(11) Timber doors	● As discussed in our 2 Dec 03 meeting, please look at alternatives to hardwood doors, i.e. softwood which have fire resistance, GRP	● These will be examined.
	(12) GMS railing in staircases and roof and cat ladder at roof	● Suggest fibre glass railing and cat ladder can be looked at.	● These will be examined in more detail.
	1st paragraph on page 35 – "…. (doors and sanitary fittings are two examples)"	● Do you mean non-timber doors?	● Yes, text revised.
6 on page 36	LCC/LCA Decision Making Tool	● Need to be illustrated by case study, including acceptability curve.	● Included.
7.3 on page 37	Documentation Preparation	● "Grade" in (b) and (c) should be "Guide" ● The User Guide should contain step-by-step	● Revised and expanded.

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
		guidance for viewing/accessing, updating and maintaining the LCA and LCC database, as well as guidance to comparing different material options and adding new function units/editing existing units.	
Appendix A and B	Environmental Impact Ranking of Functional Unit & Cost Ranking of Functional Units	● Please provide or demonstrate all the basic data, quantum, weight conversion factors, formula, etc. in obtaining the HK Eco Points and also the costs for each functional units. ● It appears that Automated Refuse Collection System (ARCS) is missing.	● This will / has been done separately in meetings. ● The ARCS has been excluded since this has only appeared in a few estates and is a combined system involving a number of blocks. In terms of this study its inclusion would be confusing.
Appendix C	Elemental Environmental Impact Profiles (Based on Initial Impacts)	● Please specify the price level and the Edition of Design for NH1 Block under the Project Details. ● Please double check the CFA for NH1 (Option 2) Block (6/00 Revision) as our record is 41,540 m2. ● Please provide or demonstrate all the basic data, quantum, weight conversion factors, formula, etc. in obtaining the HK Eco Points for each Elements.	● Added. ● This is still being verified, (our areas are calculated to be 41,758m2) but it only appears on the elemental analysis report. ● This will / has been provided separately.
Appendix D	Elemental Cost Profiles (Based on Initial Impacts)	● Please specify the price level and the Edition of Design for NH1 Block under the Project Details. ● Please double check the CFA for NH1 (Option 2) Block (6/00 Revision) as our record is 41,540 m2. ● Please provide or demonstrate all the basic	● Added. ● Refer note above. ● Refer note above. ● ARCS – Refer previous comments, Contingency – these are a general allowance and not a construction cost, Fluctuations – these would only apply if the construction period was

Section No.	Description	Comments/Suggestions	Response to Comments (using same bullet point references)
		data, quantum, formula, etc. in obtaining the Cost for each Elements. ● It is observed that no ARCS, Contingency and Fluctuation is allowed in the Elemental Cost breakdown. Please clarify why. ● It is observed that there is cost difference between this Appendix with Cost Yardsticks of Housing Department. Please review the estimate.	longer then 21 months and in the current market the resultant impact is close to zero or negative. ● This model will not give exactly the same answer as the cost yardstick since the costs are based upon actual projects (hence not strictly an estimate) rather than an average of a number of projects, also the 2003 cost yardstick for the NH1 was prepared prior to any tenders being returned for this block type.
Appendices E and F	Whole Life Environmental Impact Profiles & Whole Life Cost Profiles	● Please specify the price level and the Edition of Design for NH1 Block under the Project Details. ● Why the total cost in year 2 and 3 before discounting are the same (57,601,962.91) since interim payments for initial construction works vary with time? • It would be desirable for us to be provided the soft copy with data and formula for our sample checking of the calculations.	● Added. ● For ease the amounts for the construction cost have been split equally over 2 years, we appreciate that actual payments will vary but this tool is not a cashflow estimating tool it represents indicative payments. However even following the theoretical mathematical cashflow curve over 2 years the payments would be equally split. ● We will provide separately some of the back-up data as an illustration of the methodology but not all the back-up data.

(LCA\Lr-24 Annex 1)

APPENDIX Q3a CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT (received on 4TH NOV 04)

APPENDIX Q3a : CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT (received on 4TH NOV 04)

Section No.	Description	D&S's Comments/Suggestions	Consultant's Further Response to Comments
Executive Summary Page (iii)	**Environmental Impact Categories** 2nd paragraph	➢ Unit of impact should ideally be the same as page (xli) in Appendix C.	➢ Unit of impact were revised.
Executive Summary Page (xiii)	**Functional Units No. 4 and 11**	➢ Please add notations that alternatives for these 2 functional units were investigated (though not ranked amongst the top 10 architectural materials with the most LCA, LCC impact) because they were of HD's particular interest.	➢ Notations were added.
Ditto	**Functional Unit No. 5**	➢ The proposed alternative should be "Reduce lowest screed thickness by **10** mm"	➢ Corrected.
3.2.6 Page 103	**Architectural functional units** Footnote 73 at bottom of the page.	➢ Items related to panel walls should be **6** and **15**, not 3 and 12 as indicated.	➢ Corrected
	Functional Unit no. 5 and 8 (internal waterproofing and	➢ Please footnote explaining why alternatives for these 2 units were	➢ Unit no. 8 was corrected.

Section No.	Description	D&S's Comments/Suggestions	Consultant's Further Response to Comments
	gatesets)	not investigated. (Reason for Unit no. 8 is because gatesets are no longer provided by HD and therefore no need to study alternatives)	➢ Exclusion for internal waterproofing because there are no technically acceptable alternatives. The proposed alternative of deleting it completely is addressed under the alternative for kitchen bathroom floor finishes.
	Function Unit no. 11 (sink units)	➢ Is this referring to Cooking Units being studied as Proposed Alternative 3 ? If so, please amend to achieve consistency.	➢ No, the text is correct, sink units are No.11. Cooking benches were looked at because they had a more straightforward detail and if they worked in terms of LCC / LCA then the sink units could be examined.
3.3.2 Page 105	**Footnote 76** – This is a local impact and not directly related to the use of the market …..	➢ Should the word be **'material'** instead?	➢ Corrected
4.1 Page 107	**Selection Rules** Line 3 of paragraph 1 … plumbing works are not classified..	➢ Suggest to amend the word to "**pipeworks**"	➢ Corrected

Section No.	Description	D&S's Comments/Suggestions	Consultant's Further Response to Comments
4.3.4 Page 114	**Alternative 4** Footnote 81 ….The initial capital cost impact is a 0.04% increase	➢ It is rather unlikely that the initial cost for standard PVC pipe is higher than uPVC lined GI pipe.	➢ This was a typing error it should read a 0.04% decrease.
4.3.12 Page 124	**Alternative 12** Line 3 in the last paragraph - … result in a 0.06% reduction in the environmental impact,…	➢ To align with Table B in the Executive Summary, should it be "**0.05%"** instead?	➢ Corrected
Appendix C in the 3rd Revised Final Report, LCC Best Practice Guide, User Guide to LCA & LCC Method	**Figures 13, 17, 18, 19, 23**	➢ The year grouping should probably be 5-8, 9-16, 17-31, 32-41, 42-54 to align with whole life profiles indicated in the other appendices.	➢ Figures 13, 17,18,19,23 were corrected.
	Operational Energy	➢ Some steps have been missed to demonstrate how the Operational Energy data have been integrated in the final E-point and Whole Life Cost for the living room	➢ This has been added and expanded

Section No.	Description	D&S's Comments/Suggestions	Consultant's Further Response to Comments
		aluminium window unit.	
	Figure 19-Whole Life HK E Points Line 4 in para.1 – The initial impact has been divided over <u>two</u> years ….	➢ Should be "**<u>three"</u>** years and the initial impact figures to be spread accordingly. ➢ For easy follow up, Figure 12 is suggested to be cited.	➢ This has been corrected ➢ This has been corrected.
Software			
➢ uPVC Linings (function unit nos.106 and 107) are still duplicated.			➢ This has been corrected
➢ The year grouping needs to be amended.			➢ This has been corrected
➢ Consultant to provide locking and unlocking password.			➢ The password is "admin"

APPENDIX Q3b CONSULTANT'S RESPONSES TO QS COMMENTS ON 3RD REVISED FINAL REPORT (received on 25TH OCT 2004)

APPENDIX Q3b : CONSULTANT'S RESPONSES TO QS COMMENTS ON 3RD REVISED FINAL REPORT received on 25TH OCT 2004

Section No.	Description	QS/SB3's Comments/Suggestions	Consultant's Further Response to Comments
2.5.2.2 on page 56	Line 3 in Paragraph 1 of page 56	➢ According to the Appendix, there should "***154 functional*** units" instead of 146. Please follow up.	➢ Corrected.
6.3.2 on page 141	**Maintenance of LCA and LCC Model** Point 1 and 2 of the lower table at the Responsible Party "column".	➢ Please amend "CQS/CS" to "CQS" due to combination of QS Sections.	➢ Corrected.
Appendix C Page (xviii)	**Illustrative Step by Step Guide** Figure 2 – LCI Inventory of Data It seems that item No. 217 to 253 as shown on the "Substance" column has not been included in this Appendix.	➢ Please clarify and amend if necessary.	➢ This has been added
Appendix C Page (xl)	**Figure 6 – Normalisation of LCI Data** Total impacts as shown on 6th Column of the Table Population as shown on 8th Column of the Table	➢ Please provide the back-up data and information for obtaining the figures as shown on the 6th Column for the total impacts for the 10 impacts mentioned. ➢ Please provide the back-up data and information for obtaining the figures as shown on the 8th Column for the	➢ All the references are contained in the final report. ➢ All the references are contained in the final report.

		population for the 10 impacts mentioned.	
Appendix C Page (xli)	**Figure 6 – Normalisation of LCI Data** Table for Glass on page **(xli)** Table for Aluminium on **(xli)**	➢ Only the Characterized Total "238.3000" for Energy and "13.1000" for Climate Change (or Global Warming) in the Table for Aluminium can be followed and checked against **Figure 5** on pages (xxx) to (xxxix) and found in order. However the characterized total "8221.5428" for Eco Toxicity in the Table for Aluminium was found to be only "1.52" as shown in Figure 5 of the previous version (July 2004) for the Guide and comments have been given previously. Please review and amend if necessary. ➢ Please provide the back-up data and information for obtaining all the figures ,except the two mentioned above, as shown on the 3rd Column "Characterized Total" in the Tables for Glass and for Aluminium respectively. for the population for the 10 impacts mentioned.	➢ As previously explained this is a guide and not a complete mathematical back-up to the data in the model. The total value for Eco=Toxicity contained a number of different components and only one part of the calculation is shown in the guide. Therefore the totals in the model are correct. ➢ Detailed back-up data will not be provided for all the environmental impact information, only the illustrative data provided.

Appendix C Page (xliii)	**Figure 7 – Weighted Process** Weighted Impact for Ozone Depletion in Table for Glass	➢ The Weighted Impact for Ozone Depletion as shown in Table for Glass **(Figure 7)** is "0.000000". Please review and confirm that the correct figure should be "0.000001".	➢ Corrected.
Appendix C Page (xliv)	**Figure 8 – Quantities Derived From BQ and Drawings** Quantity of glass for windows based upon the window size = 0.58 m2 x thickness of glass (5mm) = 0.0029 m3	➢ The figure 0.58 m2 seems low for 1 m2 window area (i.e. 58% glazing). Please review and check this figure again. ➢ Please provide the back-up data and information for the two figures : 0.002617 m3 (quantity of aluminium frame) and 0.000488 m3 (quantity of aluminium burglar grilles).	➢ This has been reviewed, refer to separate response ➢ These are quantities measured directly from the HKHA standard drawings. There is therefore no specific back-up data or dimensions. We will however remeasure these quantities to annotate how they are calculated. This will be issued separately.
Appendix C Page (liii)	**Figure 17 – Calculation of Total Repair and Maintenance Costs for a Functional Unit** The periods in years as shown are as follows: Years 4 – 7 Years 8 – 15 Years 16 – 30 Years 31 – 40 Years 41 – 54	➢ In accordance with **Appendix J**, the periods in years should be as follows: Years 5 – 8 Years 9 – 16 Years 17 – 31 Years 32 – 41 Years 42 – 54 ➢ Please review this **Figure 17**, **Appendix J** and the periods in years as shown under HKHA Life Cycle Console 1.4.0 for the calculation of Repair & Maintenance costs, etc, and	➢ Amended. ➢ This has been amended in the model and report.

		amend the periods in years accordingly for all relevant calculations. (**Figure 17**, **Appendix J** are attached separately for easy reference)	
Appendix C Page (lv)	**Figure 19 – Calculation of Whole Life HK E-Points** Year 1 - Nil Year 2 - 50.02 Year 3 - 50.02 Year 4-7 - Nil Year 8-15 - Nil Year 16 – 30 - 0.77 Year 31 – 40 - 5.13 Year 41 – 54 - 14.38	➢ Please advise how to build-up the HK E-Points figures as shown on the left hand column. ➢ The figures 50.20 for both Year 2 and Year 3 could not be found from **Appendix M**, please advise. ➢ The period of years should also be noted and amended if necessary.	➢ The figures have been corrected and are now clearly shown ➢ Amended. ➢ Amended.
Appendix C Page (lvii)	**Figure 21 – Calculation of Initial Costs for Material** Last paragraph – "The above process is then repeated for the glass items…….. after adjustment."	➢ For the sake of clarity, please specify the calculated total net mass for glass in this last paragraph.	➢ Amended.
Appendix C Page (lix)	**Figure 23 – Calculation of Whole Life Costs** Year 1 - Nil Year 2 - HK$517,375.15	➢ Please advise how to build-up the HK$ figures as shown on the left hand column. Why is the initial cost not divided over three years as **Appendix J** instead of two years? Please clarify. ➢ The figures here are not tied with those	➢ Amended. ➢ Amended.

	Year 3 - HK$517,375.15 Year 4-7 - Nil Year 8-15 - Nil Year 16 – 30 - HK$4,536.28 Year 31 – 40 - HK$30,241.87 Year 41 – 54 - HK$84,677.24	figures in **Appendix J**, please advise. ➢ The period of years should also be noted and amended if necessary.	➢ Amended.
Appendix C Page (lix)	**Discounting** Line 1 and 2 of the paragraph – "……..this is generated using the standard net present value approach whereby the discount rate……"	➢ Please specify what is "F" represented for under the stated formula. What is the name for "F"?	➢ Amended.
Appendix G Page 1 of 1	Given the HK E-points for each element, it is observed that calculated figures for "/m2 CFA" and "/Person" as shown on this Table are not tie in with the calculated significant figures. **Example 1 :** **/m2 CFA** **Calculated** 1.2 Substructure 0.0015 0.0017 **Example 2 :** **/Person** **Calculated** 1.2 Substructure 0.0202 0.0219	➢ Please check and amend accordingly for the whole of this Appendix.	➢ This has been amended in the model and a new appendix will be issued separately.

HKHA Life Cycle Console 1.4.0 Software	**Standalone Version of the LCA/LCC Software 1.4.0** E-mail to Mr. Steve Humphrey dated 25.6.2004 : **A mathematical checking on the calculation of the major functional units has been performed. Attached please find our annotated comments concerning the following functional units for your further checking and review:-** **1. P.C. Facades / R.C. Walls / External Wall Finishes** **2. Floor Finishes** **3. Wall Finishes** **4. Aluminium Windows** **~~5. Piles / Pile Caps / Substructure~~**	➢ **Please also thoroughly review other "Functional Units" and "Capital Cost By Element Type" and let us have the revised software and Appendices as soon as possible.** ➢ **Attachment will be separately issued under the e-mail.**	➢ This has been done. ➢ This has been done refer also to separate comments.

APPENDIX Q3c CONSULTANT'S RESPONSES TO QS COMMENTS ON FUNCTION UNITS (received on 25TH OCT 2004)

APPENDIX Q3c : CONSULTANT'S RESPONSES TO QS COMMENTS ON FUNCTION UNITS received on 25TH OCT 2004

P.C. FACADES/R.C. WALLS/EXTERNAL WALL FINISHES

	Material	Wastage (%)	No. Reuse	Price per kg	Comment	Consultant's Further Response to Comments
1	**Precast concrete**					
	Facade Type 1	2.5	0	**1.05**	Unit Price per kg difference, Please advise and clarify.	Generally - The same items will not necessarily have the same unit rate in the model because as you will be aware contractors do not consistently price similar items. Rates vary by location and also they are not always proportional to each other, for example a 20 mm thick screed would not necessarily cost 50% of a 40mm thick screed. Therefore when these rates are converted into KG they will vary from item to item. This is why similar or the same items have different rates in the model, it is not an error or inconsistency, it is a direct response to the average pricing from the tenders used to build up the rates. PC Facades - The rates for PC Facades are grouped under only two items (Precast concrete and acrylic paint). As you are aware the pricing of these items in the BQ are lump sums per unit therefore it is not possible to break the rates down into individual components. The numbers of reuse is a reflection of the numbers of façade units in a block and based upon information provided by contractors. The number of Type 1 and Type 2 facades are different and hence the number of blocks they can be used on will also vary. The different wastage for reinforcement is a response to the fact that RC Walls Fairfaced uses the mesh type rebar sheets with these bars only fitting at the edges and in certain isolated locations making them more standardized which in turn results in a lower wastage factor when compared with the RC Wall generally which is loose bars cut to suit the layout. In the case of the Acrylic paint, this has been corrected in the latest version of the model.
	Facade Type 2	2.5	0	**1.24**		
2	**Steel - Reinforcement**					
	Facade Type 1	3	0	**0.00**	Price = 0, Please advise and clarify.	
	Facade Type 2	3	0	**0.00**		
	RC Walls - Generally	**5**	0	3.73	Wastage difference, Please advise and clarify.	
	RC Walls - Fairfaced	**2.5**	0	3.73		
3	**Timber - Formwork**					
	Facade Type 1	5	**10**	**0.00**	Price = 0, Please advise and clarify.	
	Facade Type 2	5	**15**	**0.00**	No. Reuse difference, Please advise and clarify.	
	RC Walls - Generally	5	6	6.37	Why not use steel formwork for facade?	
4	**Paint - Acrylic**					
	Facade Type 1	7.5	0	501.31	Wastage difference, Please advise and clarify.	
	Facade Type 2	7.5	0	501.31	Unit Price per kg difference, Please advise and clarify.	
	RC Walls - Fairfaced	7.5	0	501.31		

	External Wall Finishes - Generally	**5**	0	**403.12**		
5	**Tiles - Glass Mosaic**					
	External Wall Finishes - Facades	5	0	**8.10**	Unit Price per kg difference, Please advise and clarify.	
	External Wall Finishes - Generally	5	0	**12.85**		

FLOOR FINISHES

	Material	Wastage (%)	No. Reuse	Price per kg	Comment	Consultant's Further Response to Comments
1	**Cement Sand Screed**					
	Floor Finishes - Corridors & Lobbies	7.5	0	**0.59**	Unit Price per kg difference, Please advise and clarify.	Generally - The same items will not necessarily have the same unit rate in the model because as you will be aware contractors do not consistently price similar items. Rates vary by location and also they are not always proportional to each other, for example a 20 mm thick screed would not necessarily cost 50% of a 40mm thick screed. Therefore when these rates are converted into KG they will vary from item to item. This is why similar or the same items have different rates in the model, it is not an error or inconsistency, it is a direct response to the average pricing from the tenders used to build up the rates. Floor Finishes - Comments on rates refer above. Wastage for Homogeneous tiles, these are different because of the extent of cutting involved, corridors have a grano margin therefore the tiles are usually not cut, except at the ends and lobbies, kitchen and bathroom tiles on the other hand have more cutting at edges and around fittings. Clay Quarry tiles have the same issue, Refuse Rooms have fittings and layouts which require more cutting, staircases have nosing tiles which means that generally whole tiles are used, hence less wastage.
	Floor Finishes - Kitchens & Bathroom	7.5	0	**0.89**		
	Floor Finishes - Main Entrance Lobby	7.5	0	**3.57**		
	Floor Finishes - Plant Rooms	7.5	0	**0.82**		
	Floor Finishes - Refuse Room	7.5	0	**1.30**		
	Floor Finishes - Staircases	7.5	0	**1.18**		
2	**Tiles - Homogenous**					
	Floor Finishes - Corridors & Lobbies	**2.5**	0	**7.67**	Wastage difference, Please advise and clarify.	

	Floor Finishes - Kitchens & Bathroom	**5**	0	**8.32**	Unit Price per kg difference, Please advise and clarify.	
3	**Tiles - Clay Quarry**					
	Floor Finishes - Refuse Room	**5**	0	**18.99**	Wastage difference, Please advise and clarify.	
	Floor Finishes - Refuse Room	**5**	0	**15.54**	Unit Price per kg difference, Please advise and clarify.	
	Floor Finishes - Staircases	**2.5**	0	**16.84**		

WALL FINISHES

	Material	Wastage (%)	No. Reuse	Price per kg	Comment	Consultant's Further Response to Comments
1	**Cement Sand Rendering**					
	Wall Finishes - Corridors & Lobbies	7.5	0	**2.33**	Unit Price per kg difference, Please advise and clarify.	Generally - The same items will not necessarily have the same unit rate in the model because as you will be aware contractors do not consistently price similar items. Rates vary by location and also they are not always proportional to each other, for example a 20 mm thick screed would not necessarily cost 50% of a 40mm thick screed. Therefore when these rates are converted into KG they will vary from item to item. This is why similar or the same items have different rates in the model, it is not an error or inconsistency, it is a direct response to the average pricing from the tenders used to build up the rates. Wall Finishes - Comments on rates refer above. Wastage for steel in plant rooms this has been corrected in the latest version of the model. Ceramic tiles wastage is again a reflection that the amount of cutting is less in internal flat areas. Paint to ceilings this has been corrected in the latest version of the model.
	Wall Finishes - Internal Flat Areas	7.5	0	**2.39**		
	Wall Finishes - Plant Rooms	7.5	0	**2.72**		
	Wall Finishes - Refuse Rooms	7.5	0	**2.14**		
	Wall Finishes - Staircases	7.5	0	**4.04**		
2	**Steel - Zinc Coated**					
	Wall Finishes - Corridors & Lobbies	5	0	30.50	Wastage difference, Please advise and clarify.	
	Wall Finishes - Internal Flat Areas	5	0	30.50		
	Wall Finishes - Plant Rooms	**2**	0	30.50		
	Wall Finishes - Refuse Rooms	5	0	30.50		
	Wall Finishes - Staircases	5	0	30.50		
3	**Paint - Plastic Emulsion**					

	Wall Finishes - Corridors & Lobbies	10	0	**294.96**	Wastage difference, Please advise and clarify.	
	Wall Finishes - Internal Flat Areas	**15**	0	**356.59**	Unit Price per kg difference, Please advise and clarify.	
	Wall Finishes - Plant Rooms	10	0	**339.62**		
4	**Tiles - Glazed Ceramic**					
	Wall Finishes - Internal Flat Areas	**2.5**	0	**8.10**	Wastage difference, Please advise and clarify.	
	Wall Finishes - Plant Rooms	5	0	**10.04**	Unit Price per kg difference, Please advise and clarify.	
	Wall Finishes - Refuse Rooms	5	0	**15.66**		

ALUMINIUM WINDOWS

	Material	Wastage (%)	No. Reuse	Price per kg	Comment	Consultant's Further Response to Comments
1	**Aluminium - Anodised**					
	Aluminium Windows - Kitchen	1	0	**64.25**	Unit Price per kg difference, Please advise and clarify.	Generally - The same items will not necessarily have the same unit rate in the model because as you will be aware contractors do not consistently price similar items. Rates vary by location and also they are not always proportional to each other, for example a 20 mm thick screed would not necessarily cost 50% of a 40mm thick screed. Therefore when these rates are converted into KG they will vary from item to item. This is why similar or the same items have different rates in the model, it is not an error or inconsistency, it is a direct response to the average pricing from the tenders used to build up the rates. Aluminium Windows - Comments on rates refer above. comments on wastage have already been corrected in the latest version of the model.
	Aluminium Windows - Kitchen Stainless Steel Grilles	1	0	**84.48**		
	Aluminium Windows - Living Area	1	0	**36.25**		
	Aluminium Windows - Living Area Stainless Steel Grilles	1	0	**35.01**		
	Aluminium Windows - Plant Rooms	1	0	**121.37**		
	Aluminium Doors & Windows - 1/F	1	0	**144.25**		
	Aluminium Windows - Bathroom	1	0	**128.62**		
	Aluminium Windows - Bathroom Stainless Steel Grilles	1	0	**131.32**		
	Aluminium Windows - Bedroom	1	0	**43.14**		
	Aluminium Windows - Bedroom Stainless Steel Grilles	1	0	**42.05**		
	Aluminium Windows - Corridor	1	0	**110.19**		
	Aluminium Windows - Lift Lobby	1	0	**77.41**		

2	**Glass - Clear Float**					
	Aluminium Windows - Kitchen	**2**	0	7.85	Wastage difference, Please advise and clarify.	
	Aluminium Windows - Kitchen Stainless Steel Grilles	**5**	0	7.85	Unit Price per kg difference, Please advise and clarify.	
	Aluminium Windows - Living Area	**2**	0	7.85		
	Aluminium Windows - Living Area Stainless Steel Grilles	**5**	0	7.85		
	Aluminium Windows - Plant Rooms	**2**	0	7.85		
	Aluminium Windows - Bedroom	**2**	0	7.85		
	Aluminium Windows - Bedroom Stainless Steel Grilles	**5**	0	7.85		
	Aluminium Windows - Corridor	**2**	0	**17.69**		
	Aluminium Windows - Lift Lobby	**2**	0	**17.69**		
3	**Glass - Georgian Wired**					
	Aluminium Windows - Kitchen	2	0	17.69	Wastage difference, Please advise and clarify.	
	Aluminium Windows - Kitchen Stainless Steel Grilles	**5**	0	17.69		

	Aluminium Windows - Plant Rooms	2	0	17.69		
	Aluminium Doors & Windows - 1/F	2	0	17.69		
4	**Glass - Georgian Wired Obsc**					
	Aluminium Windows - Bathroom	2	0	13.94	Wastage difference, Please advise and clarify.	
	Aluminium Windows - Bathroom Stainless Steel Grilles	**5**	0	13.94		
5	**Stainless Steel - Mill**					
	Aluminium Windows - Kitchen Stainless Steel Grilles	2	0	**6.00**	Unit Price per kg difference, Please advise and clarify.	
	Aluminium Windows - Living Area Stainless Steel Grilles	2	0	**14.71**		
	Aluminium Windows - Bathroom Stainless Steel Grilles	2	0	**35.54**		
	Aluminium Windows - Bedroom Stainless Steel Grilles	2	0	**17.09**		

APPENDIX Q3d CONSULTANT'S RESPONSES TO HA COMMENTS ON PROPOSED ALTERNATIVES (received on 8TH NOV 2004)

APPENDIX Q3d : CONSULTANT'S RESPONSES TO HA COMMENTS ON PROPOSED ALTERNATIVES RECEIVED ON 8TH NOV 2004

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
1. Aluminium Windows – Bedrooms	UPVC Window	0.78 %	- 1.28 %	N	0.26%	-1.28%	● According to previous control lists and current Building Material Database, no suppliers were registered for the last few years. Companies are either inactive or closed down. Please provide names and contacts of 3 local suppliers.	● There is only one really active supplier that we can identify, Starform Services Ltd. Tel. 28423882
2. Internal Precast Panel Walls	Within flat wall systems to comprise of gypsum board (12.5mm thick) on either side of a metal framework. For inter-flat partitions, use a double layer system with central void filled with insulation material.	-0.25 %	-0.16 %	N	-0.1%	-0.07%	• Different descriptions such as gypsum based metal framed partitions, drywall, gypsum dry wall system for the proposed drywall system have been used in the Report and the proposed specification. For clarity, please ensure same description is used. • In the Report, the proposed drywall system is comprised of 12.5mm gypsum board on either side of a metal framework. In the specification, the proposed drywall system is comprised of 12.7mm cement board and 16mm gypsum fiber board. Please clarify. • The specification for proposed dry wall system at	• Corrected to be "gypsum dry wall system" for consistency. • 12.7mm thick gypsum board is the actual thickness and 16mm thick gypsum fibre board is also correct, the report has been corrected. • The construction detail is the same.

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
							Appendix P1 covers drywall within flat only. Drywall as inter-flat partitions is not mentioned. • Since the proposed drywall system is designed by the contractor, please provide specification clauses for necessary submissions such as shop drawings, installation procedures, calculation etc. • Please follow the format of Specification Library regarding the submission requirements and performance requirements of materials. • Please consider providing specification clauses for coordination with Nominated Sub-contractor for Electrical Installation for the installation of conduits, sockets, switches etc. • Please provide drawings showing how the proposed drywall system is incorporated into our domestic flats. • Please provide names and contacts of at least 3 local suppliers.	• These have been added. • Revised • Added • Outside Consultant's scope of assignment • C& I Ltd. 23041296, Successful Engineering CO. Ltd 23974866 and

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
								any agent of British Gypsum
3. Cooking Unit/Bench (Prefabricated concrete with stainless steel cladding)	Timber framed plastic laminated plywood faced unit with a stainless steel covering on the counter top.	- 0.25 %	- 0.80 %	N	-0.1%	-0.07%	• If the proposed cooking bench is covered by the existing specification, please identify relevant specification clauses for easy reference.	• COM 15
4. Floor Washing Pipework (Galvanised iron pipe with UPVC lining)	Standard PVC pipes (similar to products used for fire services and flushing systems)	0.00 %	0.02 %	Y	0%	-0.04% (?) Unlikely higher initial cost	• Please revise the uPVC lined galvanized **iron** pipes in the Report to uPVC lined galvanized **steel** pipes • Please cite existing spec clause no. • Why there is no cost savings? Please clarify.	• Corrected • SUP 1.M130 • Corrected to be "0.04% decrease" in the report
5. Roof System (consisting of 40 – 120mm screed on concrete structure, waterproofing with insulation, 25mm screed topping and precast concrete paving blocks on top with sealer	Reduce lowest screed thickness by 10 mm	0.01 %	0.00 %	Y	0.01%	0%	• According to Finishes Detail 'A' of standard drawing STD/H1N7/A/AS-11/B, the thickness of lowest screed is 25 - 120mm, not 40 – 120 mm. • Please check. • Why there in no cost savings? Please clarify.	• After further checking with latest versions of drawings and HA library specs., it was find that a 25 - 120mm thick screed is specified. Drawings used in the study were from a live project which did not adopt this latest drawing revision. Therefore, this is no longer a valid alternative since

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
filled joints)								screed thickness cannot be reduced any further. Necessary revisions will be made in he Final Report. • There is cost saving but in respect to the overall life cycle cost/initial capital of the entire building, the percentage savings are too small to be shown.
6. Flat Entrance Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating and plywood facing)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied	0.01 %	0.18 %	Y	0.01%	0.26%	• Please follow the format of specification library regarding the material, design, submission requirements, performance and testing requirements of materials. • For the material clause, details like density, moisture content etc. should be specified. • Please clarify whether painting for doorsets is factory-applied. What is the type of the paint? • Are there any performance requirements similar to the existing doorsets in Worksection COM 8 for the proposed softwood doorsets? • Is it technical feasible for door frame and lipping made of softwood as well?	• Corrected • Corrected • Painting to be factory applied to provide better control of finishing • Included • Technically it is possible.

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
							• Please provide names and contacts of at least 3 local suppliers. • Please provide quotations support from different suppliers to show there is cost savings.	• Enful Eng. Ltd.26144688, • Joint Billion International Ltd. 23932636, Kwok Shing 26916468 • Will not be provided
7. Kitchen Doorsets (50mm thick solid cored timber doorsets with a ½ hour fire rating, plywood facing and Georgian wired glass window)	Fire rated softwood door with overall thickness and framing details remaining the same and original ironmongery to be applied.	0.02 %	0.06 %	Y	0.01%	0.31%	• Same comments for flat entrance doorsets above • Please provide quotations support from different suppliers to show there is cost savings.	• Refer above • Will not be provided
8. Floor Finishes – Kitchen and Bathroom (cold applied waterproofing system overlaid with 40 mm thick screed, with homogenous tiles bedded on mortar backing).	Reduce overall thickness of screed to 25 mm.	0.05 %	0.41 %	Y	0.01%	0.29%	• The floor screed may be easily cracked if reduced (unless no waterproofing provided). • According to clause 6.4.3(b) of BS 8204-1: 1999, the thickness of unbonded screed should be not less than 50mm. Please provide justification for the proposed screed with reduced thickness. Is this practice common for private projects?	• Commonly applied in private sectors eg. Nan Fung/USI in Shatin, New World/Sino/Wharf at Kings Park, Cheung Kong at Beacon Hill • Yes this is common as previously justified.
9. Wall Finishes – Corridors and Lobbies (40mm	Reduce screed thickness to 25 mm	0.02 %	0.11 %	Y	0.04%	0.19%	• Should the "Wall Finishes" in clause 4.3.9 be "Floor	• Corrected to be "floor finishes"

Top Ranking Architectural Functional Unit	Proposed Alternative	HK-Eco-point (LCA) Improvement (to base building)	Total Cost (LCC) Improvement (to base building)	Within Acceptance Curve ? (Y/N)	Initial Env. Improvement	Initial Cost Improvement	Other Considerations e.g. Practicality, Supply, Technical Performance…. etc.	Consultants Further Response to Comments
thick screed with homogenous tiles bedded on mortar backing)							Finishes"? • Is this practice common for private projects?	• Yes as previously explained.
10. Bathroom Doorsets (for larger flats : 46.3 mm hollow cored timber doorsets with plastic laminate plywood facing and for smaller flats : plastic folding partition)	Plastic folding door for all flats	0.10 %	-0.01 %	Y	0.18%	-0.01%	• If existing spec are used, please cite spec clause nos.	• COM 11.M180
11. Fresh Water Pipework (Galvanised iron pipe with UPVC lining)	Copper piping	-1.05 %	0.34 %	N	-0.08%	0.67%	• No comments.	
12. Lift Lobby Wall Finishes (tiles)	Acrylic Paint	0.05%	0.21%	Y	0.22%	0.75%	• No comments.	

(LCA\Proposed Alternative-HD comments)

APPENDIX Q3e CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT- APPENDIX C (received on 19TH NOV 2004)

APPENDIX Q3e : CONSULTANT'S RESPONSES TO HA COMMENTS ON 3RD REVISED FINAL REPORT (APPENDIX C) received on 19TH NOV 2004

Section No.	Description	HD's Comments/Suggestions	Consultant's Further Response to Comments
Appendix C Page (xv)	**Figure 1 – Input and Output Tables for 1kg of "Aluminium & Glass"**	➢ Should it be just "Aluminium" and Glass is not included.	➢ Corrected
Appendix C Page (xix)	**Figure 2 – LCI Inventory of Data** Although item No. 217 to 253 on the "Substance" column has been added in this Table, however item 292 to 328 shown on the previous version have been deleted.	➢ The title should be just for "Aluminium" and Glass is not included. ➢ Please clarify and amend if necessary.	➢ Corrected ➢ Corrected
Appendix C Page (xl)	**Figure 6 – Normalisation of LCI Data** Population as shown on 8th Column of the Table	➢ Are population statistics based on census? Please annotate source.	➢ They are based upon Census and Statistics Department, full references are given in the main report. Note Added.
Appendix C Page (xliv)	**Figure 8 – Quantities Derived From BQ and Drawings** Quantity of glass for windows based upon the window size = 0.58 m2 x thickness of glass (5mm) = 0.0029 m3	➢ The figure '0.58' m2 seems too low for 1 m2 window area (i.e. 58% glazing). Can't see separate response as stated. ➢ Please provide the back-up data and information for the two figures : '0.002617' m3 (quantity of aluminium frame) and '0.000488' m3 (quantity of aluminium burglar grilles).	➢ This is the area of glass within the living area and not the percentage of glazing. ➢ As previously advised we are not going to remeasure this items again.

Appendix C Page (liii)	**Figure 17 – Calculation of Total Repair and Maintenance Costs for A Function Unit**	➢ Please add "in the context of the whole building" at the end of paragraph 1.	➢ Corrected

Appendix C Page (lv)	**Figure 19 – Calculation of Whole Life HK E-Points** Year 1 - Nil Year 2 - 33.49 Year 3 - 33.49 Year 4 - 33.49 Year 5-8 - Nil Year 9-16 - Nil Year 17 – 31 - 0.77 Year 32 – 41 - 5.13 Year 42 – 54 - 14.38	➢ Is it possible to build-up the HK E-Points figures as shown on the left hand column? If not, please provide some description of the basis.	➢ Description added
Appendix C Page (lvii)	**Figure 21 – Calculation of Initial Costs for Material** Last paragraph – "The above process is then repeated for the glass items…….. after adjustment."	➢ For the sake of clarity, please specify the calculated 'total net mass' for glass in this last paragraph.	➢ Corrected
Appendix C Page (lix)	**Figure 23 – Calculation of Whole Life Costs** Line 4 of paragraph 1 – " The initial cost has been divided over two years ….."	➢ Should the two years be amended to <u>three</u> year? Please clarify and amend if necessary.	➢ Corrected

	Year 17 – 31 - HK$4,536.87 Year 32 – 41 - HK$30,241.87 Year 42 – 54 - HK$84,677.24	➢ Please advise how to build-up all the HK$ figures as shown in Figure 23. ➢ The figures here on the left hand column are not tied with those figures in **Appendix J**, please advise. **Figures in Appendix J are:** Year 17 – 31 - HK$26,373.73 Year 32 – 41 - HK$175,824.84 Year 42 – 54 - HK$492,309.56	➢ These are the summation of all the functional units ➢ Corrected
Separate Marked up comments on Appendix C page (vii)			➢ Corrected
Separate Marked up comments on Appendix C page (lv)			➢ Corrected
Separate Marked up comments on Appendix C page (lvi)			➢ Corrected
Separate Marked up comments on Appendix C page (lvi)			➢ Corrected

APPENDIX Q4a CONSULTANT'S RESPONSES TO HA COMMENTS ON REVISED FINAL REPORT (received on 14TH FEB 2005)

APPENDIX Q4a: CONSULTANT'S RESPONSES TO HA COMMENTS ON 4TH REVISED FINAL REPORT received on 14TH FEB 2005

Section No.	Description	HD's Comments	Consultant's Response to Comments
3.2.6 on page 102	**Combined Whole Life Results** Line 5 in Paragraph 5 of page 102	➢ The word "is" before the word "turn" should be read as 'in". Please clarify.	• The report has been amended accordingly.
4.3.8 on page 120	**Alternative 8 – Floor Finishes Corridor and Lift Lobbies** First line of last paragraph – "The above results illustrate that in the context of…"	➢ For the sake of clarity, please delete the word "above" from the paragraph if the diagram is put after this paragraph.	• The report has been amended accordingly.
5.1.2 on page 126 and 6.3.2 on page 141	**Updating Party** **Maintenance of LCA and LCC Model** <u>Task</u> 1. Maintaining Cost Data 2. New Quantities – Initial	➢ Different disciplines handle different nature of works, therefore for a clear division of labour, please review and revise the Responsible Party as follows: <u>Responsible Party</u> CQS for initial building cost (builder's works) CBSE for initial building cost (B.S. works) EMD for repair & maintenance cost CQS for builder's works CBSE for B.S. works	• The report has been amended accordingly.
6.3.1 on page 138	**Technical Specifications for Alternatives Identified** Line 3 of last para – "…developed for Alternatives 5, 9 and 10, details for …. "	➢ The paragraph should be read as "developed for Alternatives 2, 5 and 6, details for the ……" Please clarify.	• The report has been amended accordingly.
6.4 on page 143	**Overall Conclusion** Line 3 of second paragraph – "…… it could be possible to achieve a 0.26% environmental saving ……."	➢ Please check if the correct percentage is 0.25% instead of 0.26%.	• The report has been amended accordingly.
Appendix C on page (xlix)	**Figure 12 – Calculation of Initial Impact in HK E-Points** Aluminium Total HK E-Points = 0.00363	➢ Please check and advise why only 5 decimals figure is used for the Total HK E-Points for Aluminium. It will be 0.003633 if 6 decimals figure is used like glass. ➢ If 0.003633 is used, other relevant calculated figures should be amended as well to page (xlix), etc.	• A note has been added below Figure 12 to clarify that values in the worked example are rounded to aid presentation (calculations in the model are in fact accurate to the full number of decimal places).

Section No.	Description	HD's Comments	Consultant's Response to Comments
Appendix C on page (xlix)	**Figure 12 – Calculation of Initial Impact in HK E-Points** Last line in last paragraph – "……the total HK E-Points for this functional unit in the context of the whole building is 99.9810"	➢ In **Figure 19** on page (lvi), the total for Year 2, 3 and 4 is 100.4724 in Whole Life HK E-Points (Refer to Appendix N) while the corresponding figure in Figure 12 is 99.9810 as shown on the left hand column. Please check and clarify the difference.	• This discrepancy is a consequence of rounding the decimal figures. Inconsistencies have been clarified in Appendix C.
Appendix C on page (lvii)	**Figure 20 – Calculation of Repair and Maintenance Rates** "Complete replacement of external windows HK$1,950 / m2" "Replace / Repair Burglar Grilles HK$850 / m2"	➢ The rates as shown on the left hand sides should be HK$ / Flat rather than HK$ / m2, otherwise the calculations followed that are not correct and illogical. Please check and clarify.	• Appendix C has been amended accordingly.
Appendix C on page (lxi)	**Figure 24 – Optional Energy Values** Line 2 of the third paragraph – "…..the above factor of 0.0000148 HK E-Points generates a total of 22.6444 HK E-Points after rounding."	➢ Please check and advise if the figure 22.6444 as shown on the left hand side should be 22.5524 instead.	• Appendix C has been amended accordingly.
Appendix E page 1 of 1	**Elementary Breakdown of the Initial Capital Costs** Percentage (%) Column is 100%.	➢ Please note that the calculated percentage (%) is 99.99% instead of 100%. Please check and review.	• This is again a consequence of rounding the decimal figures. If the individual percentages were shown to 18 decimal places their arithmetic sum would be 100.000000000000000000%.
Appendices G, I, J, L, M	**Figures**	➢ Please explain why the figures circled in ***Annex 1A*** are different from those of the previous report.	• Discrepancies in CFA and occupancy have been corrected, resulting in accurate values for HKEP/m^2 and per person (the HKEP totals in *Appendix G* were previously correct and have not changed). • Operational energy has been recalculated further to discussions with HKHA. Apart from revisions to operational energy, the whole life costs and environmental impacts (in *Appendices I, J, L and M*) were previously correct and have not changed.
Appendix P1	**Specification for Gypsum Dry Wall**	➢ Suggest to omit because it should not be a proposed likely alternative because it is not desirable in terms of LCA and LCC .	• The report has been amended accordingly.

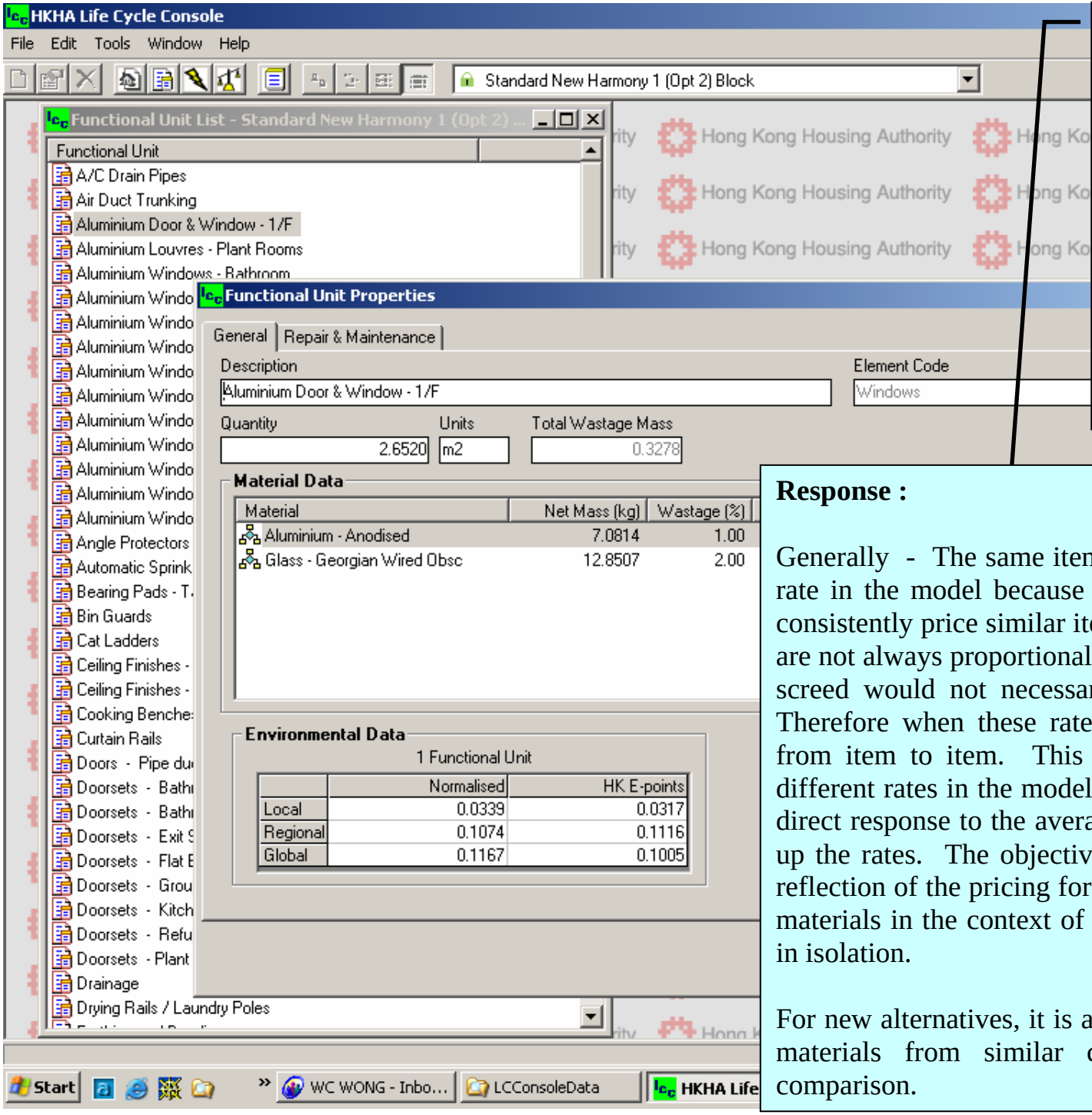
Section No.	Description	HD's Comments	Consultant's Response to Comments
Appendix P2 and Q3d Item 6	**Specification for proposed Sustainable Timber Doorsets**	➢ Please amend the proposed specification format to the 2004 edition, extract of timber door specification and related clauses (COM5 and FIN7) is at ***Annex 1B***. ➢ Paint should be applied in the factory in lieu of being applied on site as proposed in order to provide better control on the quality of finish. ➢ Would the use of softwood require a different pesticidal or preservative treatment to that specified for hardwood?	• Appendix P has been amended based on revised specification in 2004 edition. • Factory applied paint has been incorporated in Appendix P2. • Same specification is applicable.
Appendix Q3c Page 1 of 8	**Consultant's Further Response to Comments at the Table's 7th Column** Line 2 of second paragraph – "PC Facades – The rates for PC Facades are grouped under only two items (Precast contract and acrylic paint.)"	➢ The word "contract" as shown on the left hand column should be read as "concrete". Please check and clarify.	• The report has been amended accordingly.
Appendix Q3d Page 5 of 6	**Floor finishes – reduce overall thickness of screed to 25mm**	➢ Please provide waterproofing and tiling details used in the quoted private sectors projects, if possible.	• Sample details have been incorporated in Appendix P3.
Appendix R	**HA's BC Paper**	➢ Can be omitted.	• The report has been amended accordingly.

(Lr33-Annex 1)

CONSULTANT'S RESPONSES TO HA'S REQUEST ON 20 JAN 2005

Section No.	Description	HD's Comments	Consultant's Response to Comments
-	-	HA requested for more basic information (densities, etc) on the materials and/or the functional units contained in the software for future operations of the LCA/LCC tool by internal staff.	• Information was issued to HA staff in the software training workshop held on 25 May 2005 and with guidance given in the workshop, these were deemed to be adequate for operating the LCA/LCC tool and investigating alternatives.

APPENDIX Q4b CONSULTANT'S RESPONSES TO HA COMMENTS ON SOFTWARE



CASE 1 (20.1.2005)

Why the Price per kg of the same Materials with different prices?
e.g. "Aluminium – Anodised" ,the Price per kg is $144.25, $128.62, $131.32, $43.14, etc.

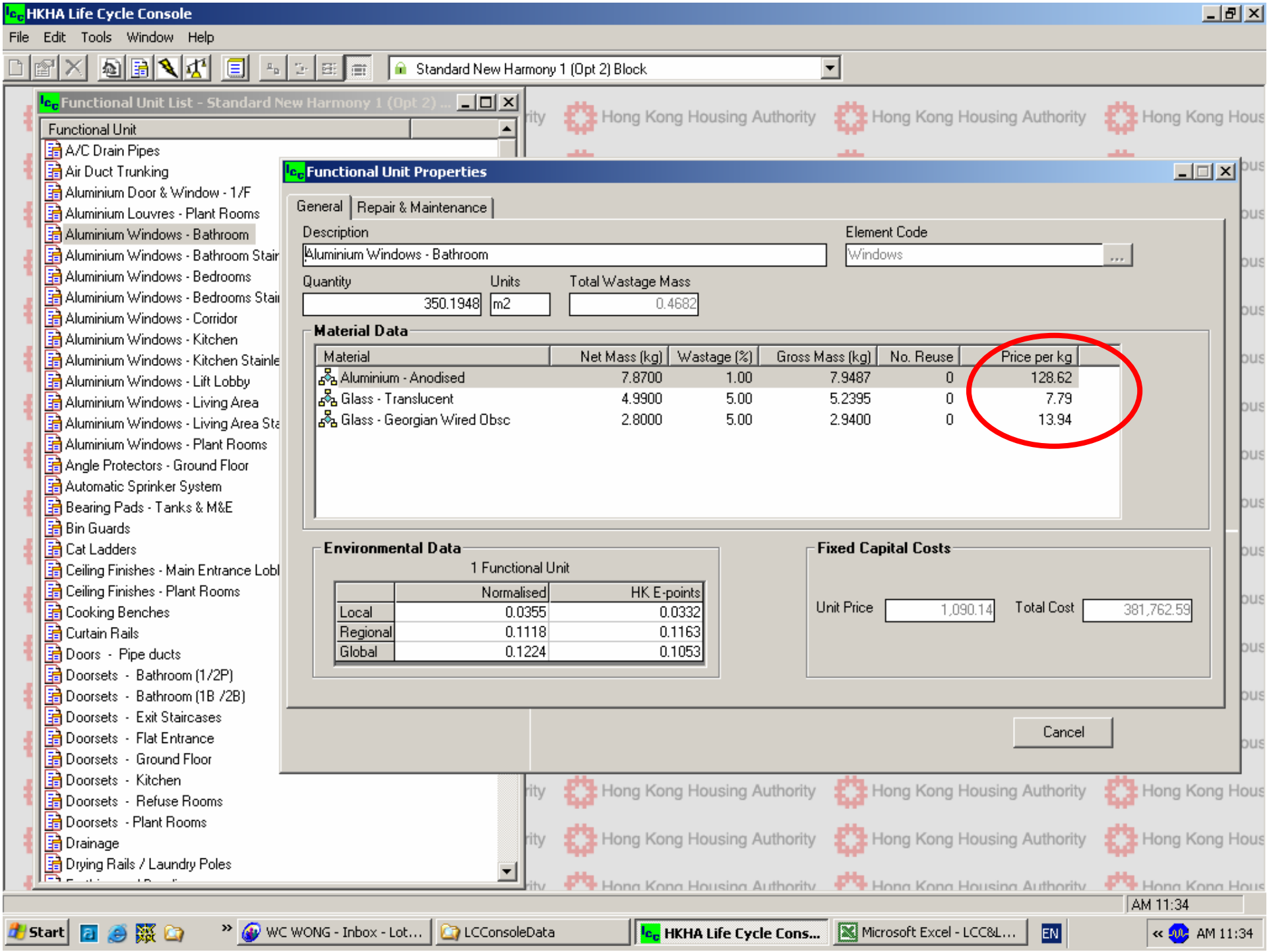
e.g. "Glass – Georgian Wired Obsc", the price per kg is $17.69, $13.94, etc.

Please explain.

Response :

Generally - The same items will not necessarily have the same unit rate in the model because as you will be aware contractors do not consistently price similar items. Rates vary by location and also they are not always proportional to each other, for example a 20 mm thick screed would not necessarily cost 50% of a 40mm thick screed. Therefore when these rates are converted into KG they will vary from item to item. This is why similar or the same items have different rates in the model, it is not an error or inconsistency, it is a direct response to the average pricing from the tenders used to build up the rates. The objective of the model is to provide an accurate reflection of the pricing for a NH1 block therefore we are pricing the materials in the context of the functional units and not the materials in isolation.

For new alternatives, it is advised to select components based on the materials from similar configurations or functional units for comparison.


HKHA Life Cycle Console
File Edit Tools Window Help
Standard New Harmony 1 (Opt 2) Block
Functional Unit List - Standard New Harmony 1 (Opt 2) ...
Functional Unit
A/C Drain Pipes
Air Duct Trunking
Aluminium Door & Window - 1/F
Aluminium Louvres - Plant Rooms
Aluminium Windows - Bathroom
Aluminium Windows - Bathroom Stair
Aluminium Windows - Bedrooms
Aluminium Windows - Bedrooms Stai
Aluminium Windows - Corridor
Aluminium Windows - Kitchen
Aluminium Windows - Kitchen Stainle
Aluminium Windows - Lift Lobby
Aluminium Windows - Living Area
Aluminium Windows - Living Area Sta
Aluminium Windows - Plant Rooms
Angle Protectors - Ground Floor
Automatic Sprinker System
Bearing Pads - Tanks & M&E
Bin Guards
Cat Ladders
Ceiling Finishes - Main Entrance Lobl
Ceiling Finishes - Plant Rooms
Cooking Benches
Curtain Rails
Doors - Pipe ducts
Doorsets - Bathroom (1/2P)
Doorsets - Bathroom (1B /2B)
Doorsets - Exit Staircases
Doorsets - Flat Entrance
Doorsets - Ground Floor
Doorsets - Kitchen
Doorsets - Refuse Rooms
Doorsets - Plant Rooms
Drainage
Drying Rails / Laundry Poles
Functional Unit Properties
General
Repair & Maintenance
Description
Aluminium Windows - Bathroom
Element Code
Windows
Quantity
350.1948
Units
m2
Total Wastage Mass
0.4682
Material Data
Material
Net Mass (kg)
Wastage (%)
Gross Mass (kg)
No. Reuse
Price per kg
Aluminium - Anodised
7.8700
1.00
7.9487
0
128.62
Glass - Translucent
4.9900
5.00
5.2395
0
7.79
Glass - Georgian Wired Obsc
2.8000
5.00
2.9400
0
13.94
Environmental Data
1 Functional Unit
Normalised
HK E-points
Local
0.0355
0.0332
Regional
0.1118
0.1163
Global
0.1224
0.1053
Fixed Capital Costs
Unit Price
1,090.14
Total Cost
381,762.59
Cancel
Hong Kong Housing Authority
Start
WC WONG - Inbox - Lot...
LCConsoleData
HKHA Life Cycle Cons...
Microsoft Excel - LCC&L...
EN
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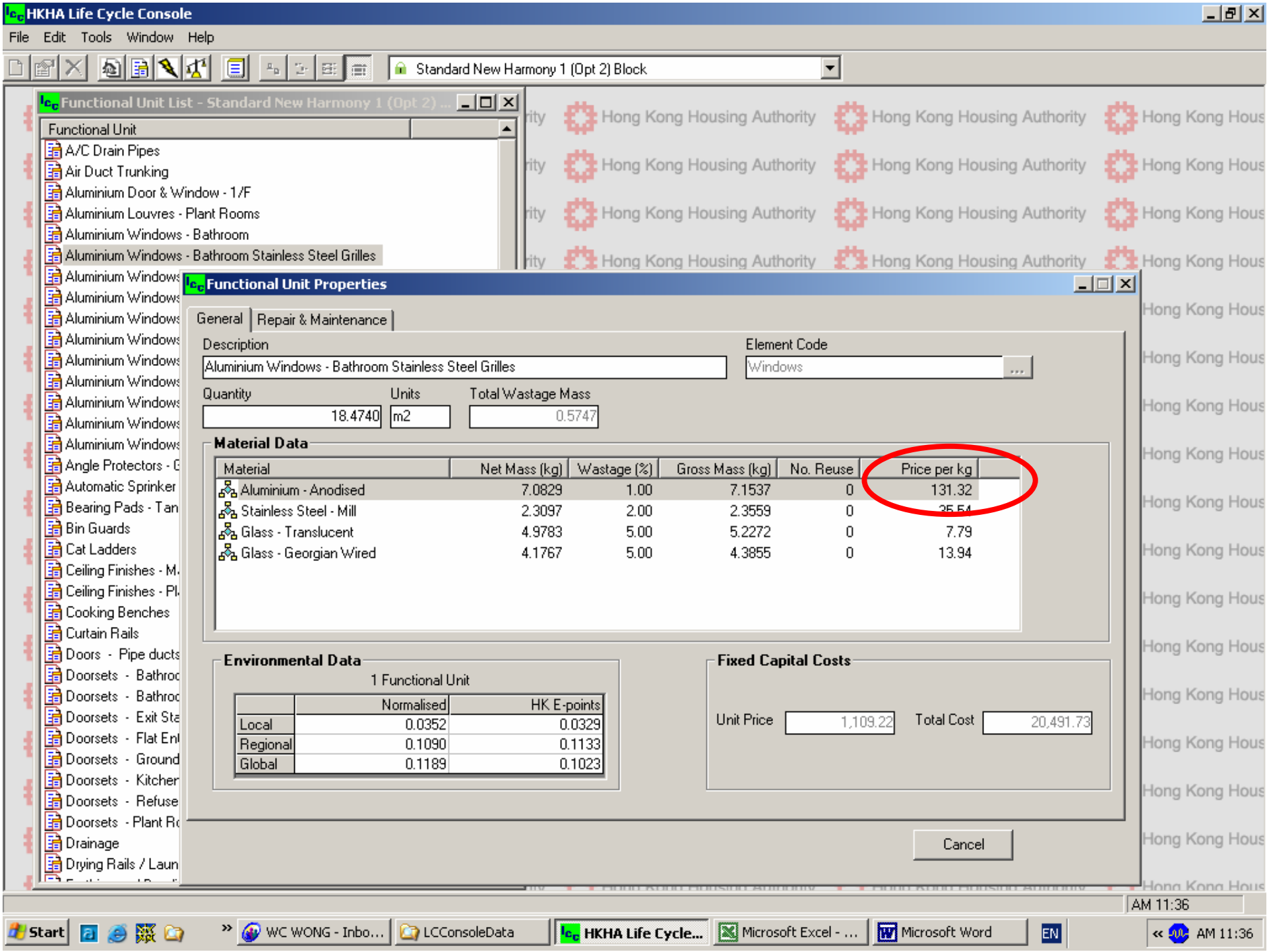
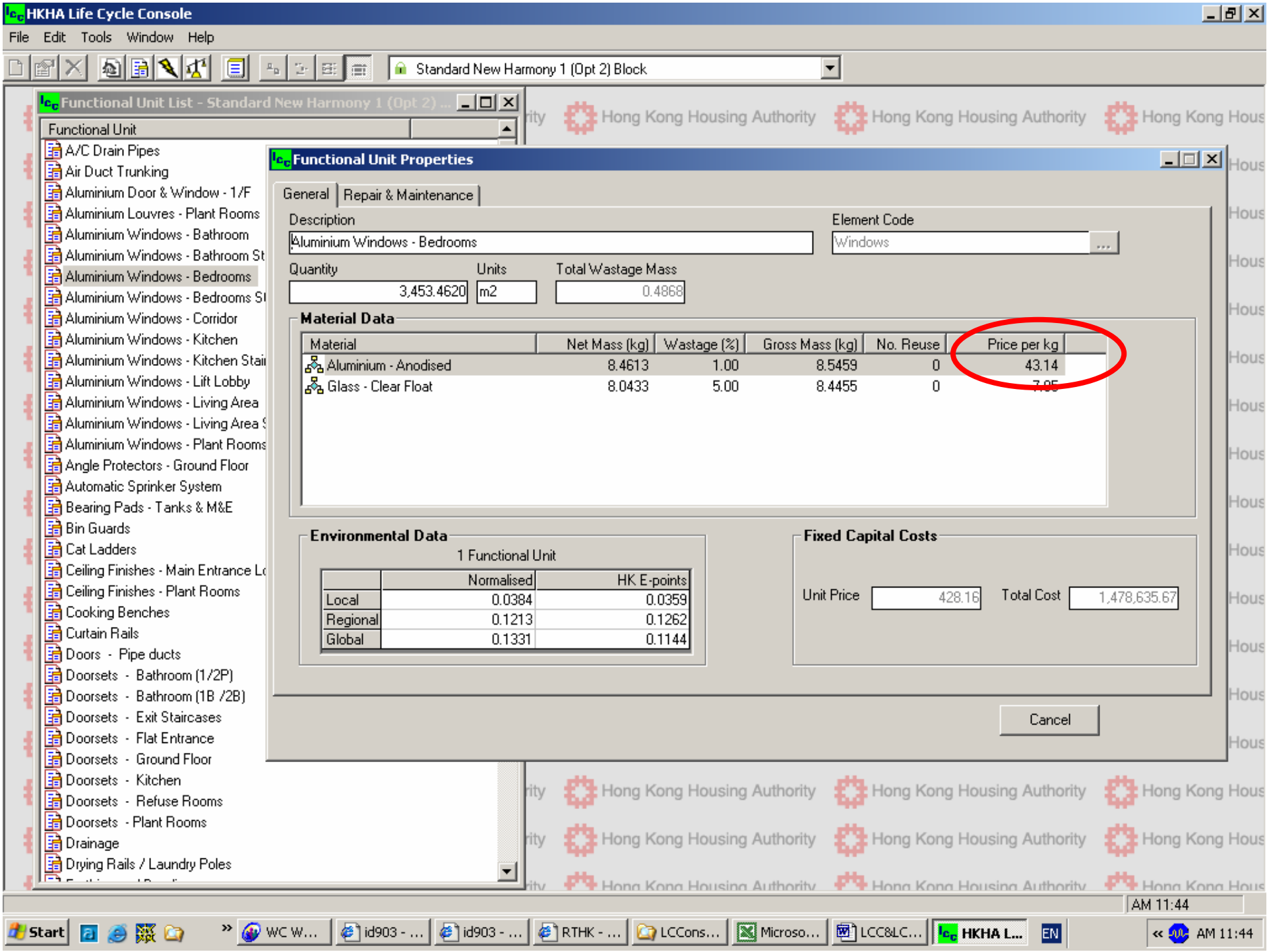
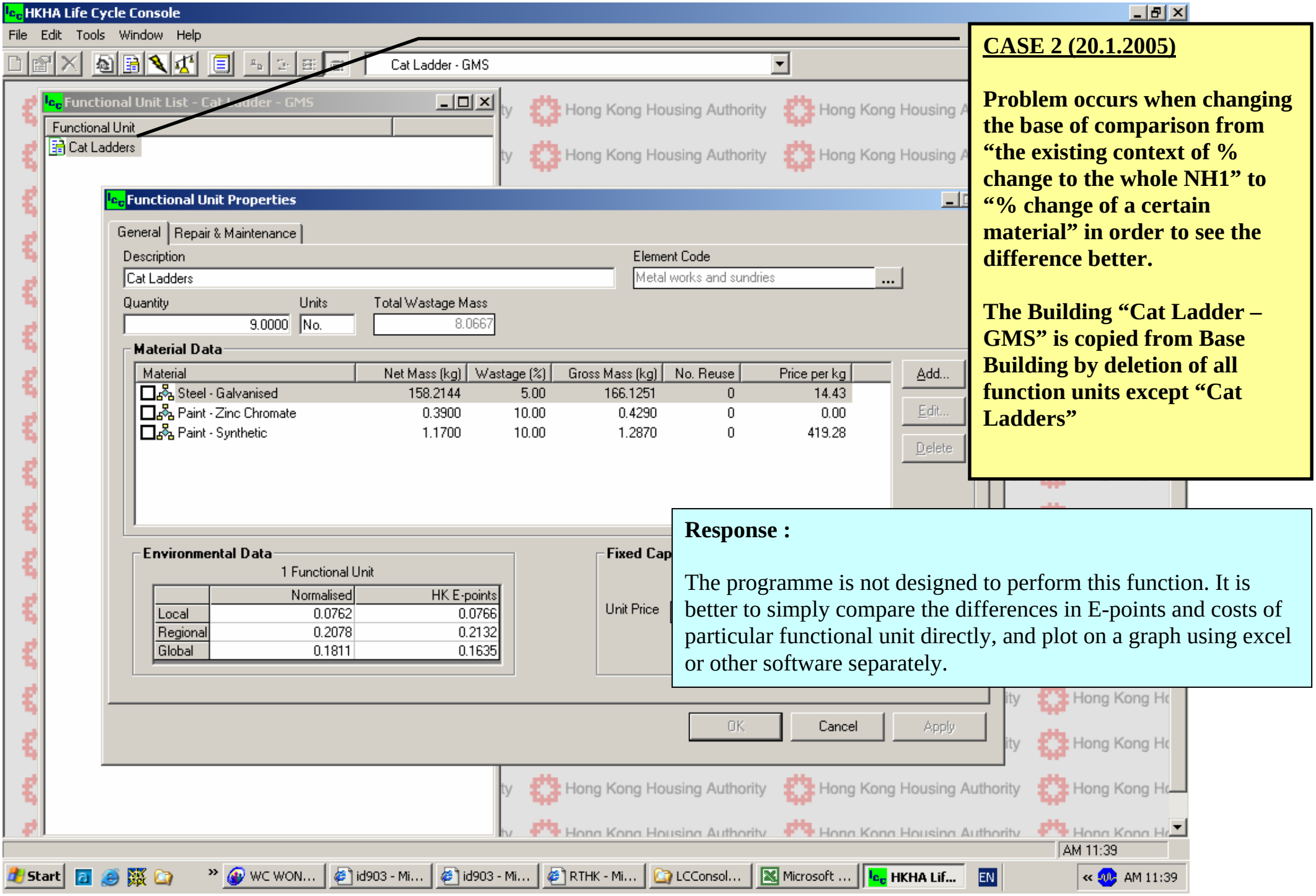

HKHA Life Cycle Console
File Edit Tools Window Help
Standard New Harmony 1 (Opt 2) Block
Functional Unit List - Standard New Harmony 1 (Opt 2) ...
Functional Unit
A/C Drain Pipes
Air Duct Trunking
Aluminium Door & Window - 1/F
Aluminium Louvres - Plant Rooms
Aluminium Windows - Bathroom
Aluminium Windows - Bathroom Stainless Steel Grilles
Functional Unit Properties
General
Repair & Maintenance
Description
Aluminium Windows - Bathroom Stainless Steel Grilles
Element Code
Windows
Quantity
18.4740
Units
m2
Total Wastage Mass
0.5747
Material Data
Material
Net Mass (kg)
Wastage (%)
Gross Mass (kg)
No. Reuse
Price per kg
Aluminium - Anodised 7.0829 1.00 7.1537 0 131.32
Stainless Steel - Mill 2.3097 2.00 2.3559 0
Glass - Translucent 4.9783 5.00 5.2272 0 7.79
Glass - Georgian Wired 4.1767 5.00 4.3855 0 13.94
Environmental Data
1 Functional Unit
Normalised
HK E-points
Local 0.0352 0.0329
Regional 0.1090 0.1133
Global 0.1189 0.1023
Fixed Capital Costs
Unit Price
1,109.22
Total Cost
20,491.73
Cancel
Hong Kong Housing Authority
AM 11:36
Start
WC WONG - Inbo...
LCConsoleData
HKHA Life Cycle...
Microsoft Excel - ...
Microsoft Word
EN
AM 11:36


HKHA Life Cycle Console
File Edit Tools Window Help
Standard New Harmony 1 (Opt 2) Block
Functional Unit List - Standard New Harmony 1 (Opt 2) ...
Functional Unit
A/C Drain Pipes
Air Duct Trunking
Aluminium Door & Window - 1/F
Aluminium Louvres - Plant Rooms
Aluminium Windows - Bathroom
Aluminium Windows - Bathroom St
Aluminium Windows - Bedrooms
Aluminium Windows - Bedrooms St
Aluminium Windows - Corridor
Aluminium Windows - Kitchen
Aluminium Windows - Kitchen Stai
Aluminium Windows - Lift Lobby
Aluminium Windows - Living Area
Aluminium Windows - Living Area S
Aluminium Windows - Plant Rooms
Angle Protectors - Ground Floor
Automatic Sprinker System
Bearing Pads - Tanks & M&E
Bin Guards
Cat Ladders
Ceiling Finishes - Main Entrance Lo
Ceiling Finishes - Plant Rooms
Cooking Benches
Curtain Rails
Doors - Pipe ducts
Doorsets - Bathroom (1/2P)
Doorsets - Bathroom (1B /2B)
Doorsets - Exit Staircases
Doorsets - Flat Entrance
Doorsets - Ground Floor
Doorsets - Kitchen
Doorsets - Refuse Rooms
Doorsets - Plant Rooms
Drainage
Drying Rails / Laundry Poles
Functional Unit Properties
General
Repair & Maintenance
Description
Aluminium Windows - Bedrooms
Element Code
Windows
Quantity
3,453.4620
Units
m2
Total Wastage Mass
0.4868
Material Data
Material
Net Mass (kg)
Wastage (%)
Gross Mass (kg)
No. Reuse
Price per kg
Aluminium - Anodised
8.4613
1.00
8.5459
0
43.14
Glass - Clear Float
8.0433
5.00
8.4455
0
Environmental Data
1 Functional Unit
Normalised
HK E-points
Local
0.0384
0.0359
Regional
0.1213
0.1262
Global
0.1331
0.1144
Fixed Capital Costs
Unit Price
428.16
Total Cost
1,478,635.67
Cancel
Hong Kong Housing Authority
AM 11:44
Start
WC W...
id903 - ...
id903 - ...
RTHK - ...
LCCons...
Microso...
LCC&LC...
HKHA L...
EN
AM 11:44



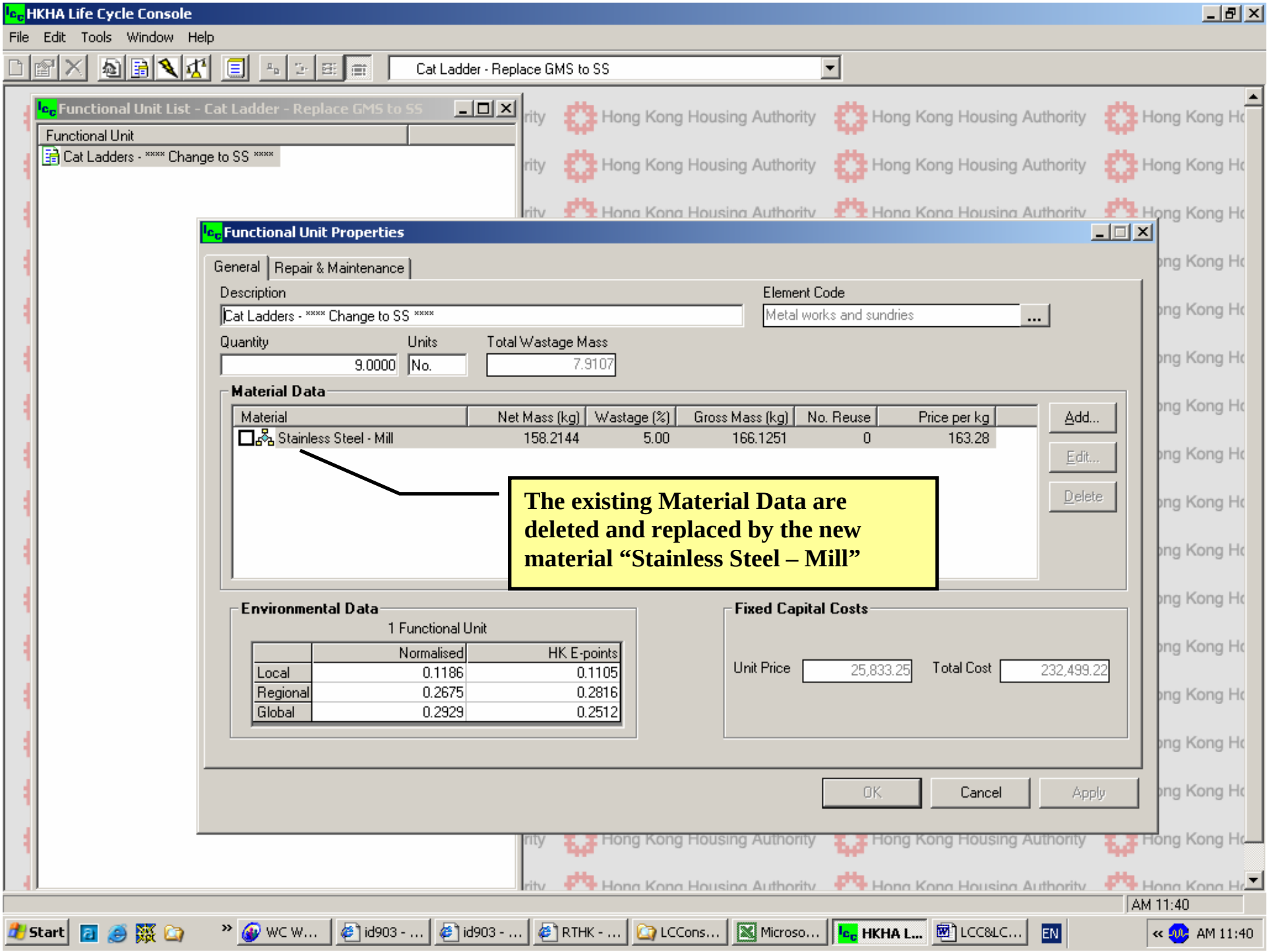
CASE 2 (20.1.2005)

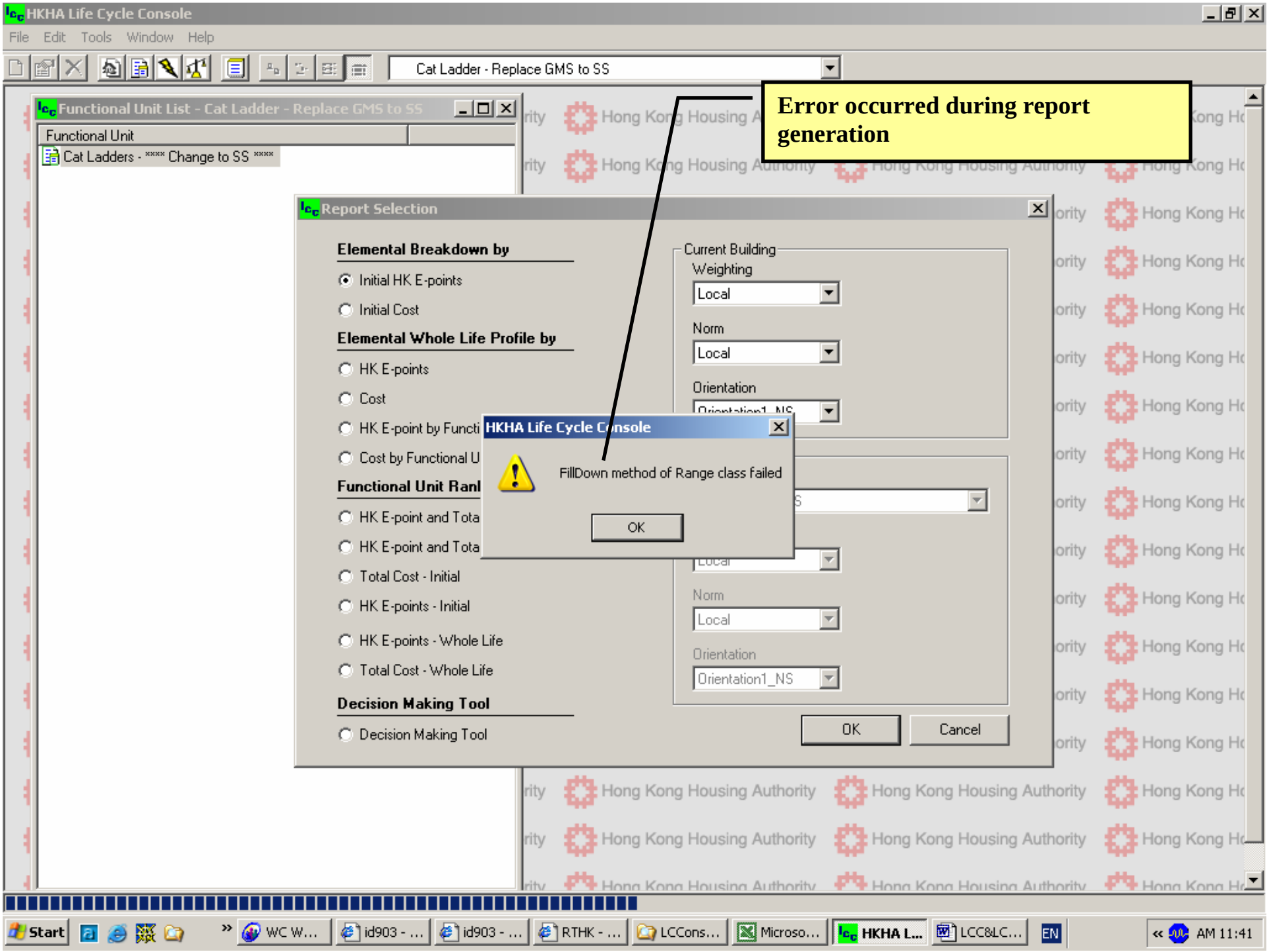
Problem occurs when changing the base of comparison from "the existing context of % change to the whole NH1" to "% change of a certain material" in order to see the difference better.

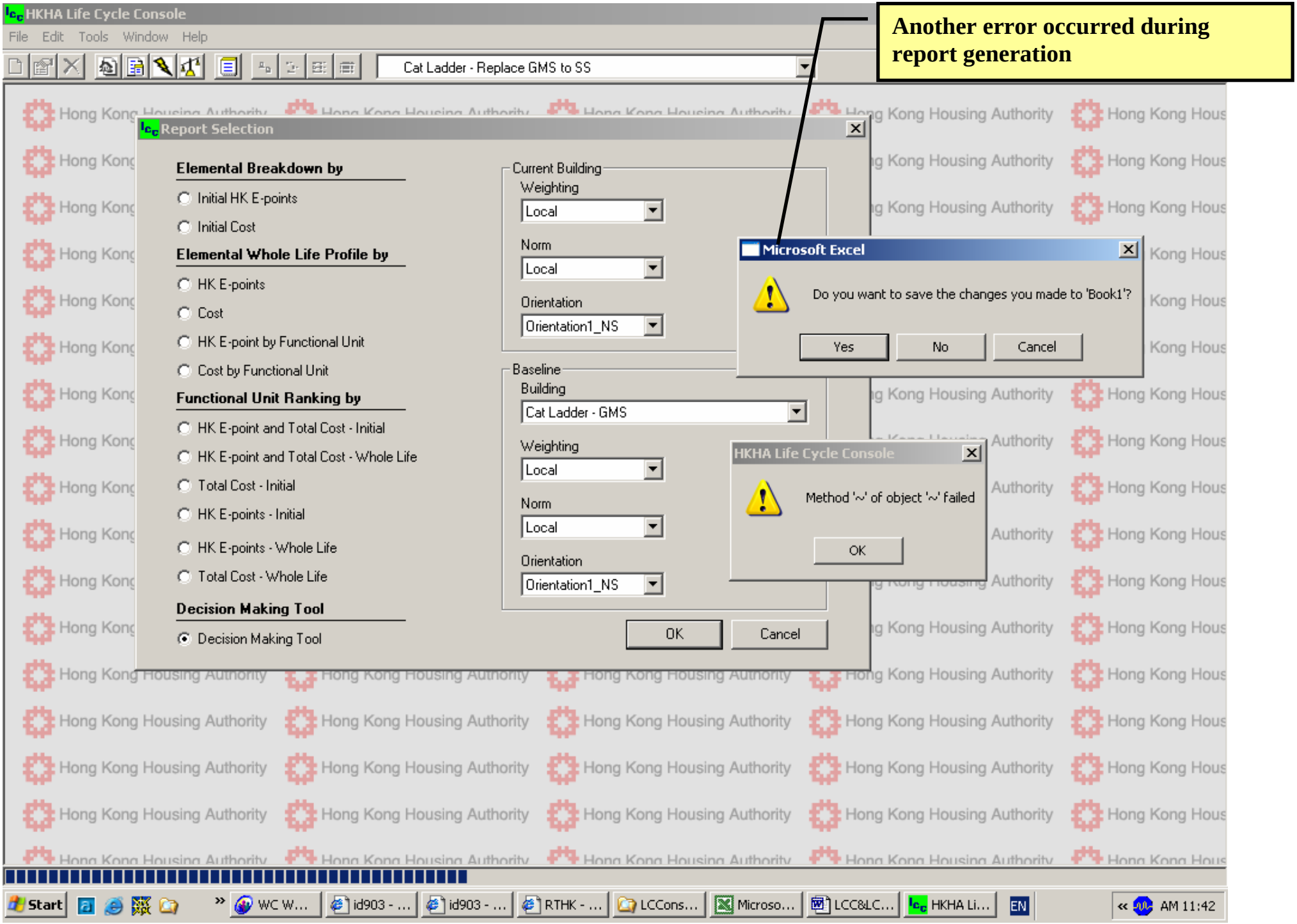
The Building "Cat Ladder – GMS" is copied from Base Building by deletion of all function units except "Cat Ladders"

Response :

The programme is not designed to perform this function. It is better to simply compare the differences in E-points and costs of particular functional unit directly, and plot on a graph using excel or other software separately.


HKHA Life Cycle Console
File Edit Tools Window Help
Cat Ladder - Replace GMS to SS
Functional Unit List - Cat Ladder - Replace GMS to SS
Functional Unit
Cat Ladders - **** Change to SS ****
Functional Unit Properties
General
Repair & Maintenance
Description
Cat Ladders - **** Change to SS ****
Element Code
Metal works and sundries
Quantity
9.0000
Units
No.
Total Wastage Mass
7.9107
Material Data
Material
Net Mass (kg)
Wastage (%)
Gross Mass (kg)
No. Reuse
Price per kg
Stainless Steel - Mill
158.2144
5.00
166.1251
0
163.28
Add...
Edit...
Delete
The existing Material Data are deleted and replaced by the new material "Stainless Steel – Mill"
Environmental Data
1 Functional Unit
Normalised
HK E-points
Local
0.1186
0.1105
Regional
0.2675
0.2816
Global
0.2929
0.2512
Fixed Capital Costs
Unit Price
25,833.25
Total Cost
232,499.22
OK
Cancel
Apply
Hong Kong Housing Authority
AM 11:40
Start
WC W...
id903 - ...
id903 - ...
RTHK - ...
LCCons...
Microso...
HKHA L...
LCC&LC...
EN
AM 11:40


HKHA Life Cycle Console
File Edit Tools Window Help
Cat Ladder - Replace GMS to SS
Functional Unit List - Cat Ladder - Replace GMS to SS
Functional Unit
Cat Ladders - **** Change to SS ****
Error occurred during report generation
Report Selection
Elemental Breakdown by
Initial HK E-points
Initial Cost
Elemental Whole Life Profile by
HK E-points
Cost
HK E-point by Functi
Cost by Functional U
Functional Unit Ranl
HK E-point and Tota
HK E-point and Tota
Total Cost - Initial
HK E-points - Initial
HK E-points - Whole Life
Total Cost - Whole Life
Decision Making Tool
Decision Making Tool
Current Building
Weighting
Local
Norm
Local
Orientation
Local
Norm
Local
Orientation
Orientation1_NS
OK
Cancel
HKHA Life Cycle Console
FillDown method of Range class failed
OK
Hong Kong Housing Authority
Start
WC W...
id903 - ...
id903 - ...
RTHK - ...
LCCons...
Microso...
HKHA L...
LCC&LC...
EN
AM 11:41


HKHA Life Cycle Console
File Edit Tools Window Help
Cat Ladder - Replace GMS to SS
Another error occurred during report generation
Report Selection
Elemental Breakdown by
Initial HK E-points
Initial Cost
Elemental Whole Life Profile by
HK E-points
Cost
HK E-point by Functional Unit
Cost by Functional Unit
Functional Unit Ranking by
HK E-point and Total Cost - Initial
HK E-point and Total Cost - Whole Life
Total Cost - Initial
HK E-points - Initial
HK E-points - Whole Life
Total Cost - Whole Life
Decision Making Tool
Decision Making Tool
Current Building
Weighting
Local
Norm
Local
Orientation
Orientation1_NS
Baseline
Building
Cat Ladder - GMS
Weighting
Local
Norm
Local
Orientation
Orientation1_NS
OK
Cancel
Microsoft Excel
Do you want to save the changes you made to 'Book1'?
Yes
No
Cancel
HKHA Life Cycle Console
Method '~' of object '~' failed
OK
Hong Kong Housing Authority
Start
WC W...
id903 - ...
id903 - ...
RTHK - ...
LCCons...
Microso...
LCC&LC...
HKHA Li...
EN
AM 11:42

APPENDIX Q4c CONSULTANT'S RESPONSES TO HA COMMENTS ON FUNCTIONAL UNITS OF APPENDIX A

APPENDIX Q4c: CONSULTANT'S RESPONSES TO HA COMMENTS ON FUNCTIONAL UNITS OF APPENDIX A

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials	Response
3	Aluminium Door & Window - 1/F **(pls indicate location)**	Aluminium - Anodised Glass - Georgian Wired Obsc	Access to the canopy (in lobby)
4	Aluminium Louvres - Plant Rooms **(Still indicated as clear float glass in the software)**	Aluminium - Anodised Glass - Georgian Wired	Has been amended in the final version of the model
6	Aluminium Windows - Bathroom Stainless Steel Grilles **(Are they located at 1/F & 2/F? If yes, pls annotate it.)**	Aluminium - Anodised Glass - Georgain Wired Glass - Translucent Stainless Steel - Mill	Yes, 1 & 2/F
8	Aluminium Windows - Bedrooms Stainless Steel Grilles **(same comment as Item 6)**	Aluminium - Anodised Glass - Clear Float Stainless Steel - Mill	Yes, 1 & 2/F
9	Aluminium Windows - Corridor **(Still indicated as clear float glass in the software)**	Aluminium - Anodised Glass - Georgian Wired	Has been amended in the final version of the model
11	Aluminium Windows - Kitchen Stainless Steel Grilles **(same comment as item 6)**	Aluminium - Anodised Glass - Clear Float Glass - Georgian Wired Stainless Steel - Mill	Yes, 1 & 2/F
12	Aluminium Windows - Lift Lobby **(Still indicated as clear float glass in the software)**	Aluminium - Anodised Glass - Georgian Wired	Has been amended in the final version of the model
14	Aluminium Windows - Living Area Stainless Steel Grilles **(same comment as item 6)**	Aluminium - Anodised Glass - Clear Float Stainless Steel - Mill	Yes, 1 & 2/F
15	Aluminium Windows - Plant Rooms **(Should not be any Clear float glass?)**	Aluminium - Anodised Glass - Clear Float Glass - Georgian Wired	Has been deleted in the final version of the model
45	Flashing - Refuse Chute **(no flashing in refuse chute shown in dwg., only 8 nos.of vent pipe indicated in dwg., but material with no s.s instead of Lead collar)**	Paint - Synthetic Paint - Zinc Chromate Stainless Steel - Hairline Steel - Galvanised	We have drawings showing both versions, although the ss may be project specific
51	Floor Finishes - Refuse Room **(2 items of Clay tile indicated in software)**	Cement Sand Screed Tiles - Clay Quarry	One relates to floor tiles one relates to skirtings
52	Floor Finishes - Staircases **(G/F to 1/F Staircase no.2 only)** **(Other staircase location - no tiles, it is precast fairface)**	Cement Sand Screed Tiles - Homogenous Tiles - Rubber	Correct this is what is measured
62	Gates - Refuge Area **(Is Refuge area referring to Roof?) Or are you referring to metal gate outside water meter cupboard at F14, F15 & F26, only 10 nos. can be counted, but 13 nos. indicated in software.**	Cement Board **(Location?)** Paint - Aluminium Paint - Synthetic Paint - Zinc Chromate Steel - Galvanised	these are gates G10 and the isolated gate shown in the BQ Cement board is infill panel

Summary of Functional Units in a NH1 (Option 2) (6/00 Revision to 1/00 Edition)

	Functional Unit	Materials	Response
92	Minor RC Concrete Items **(Indicate Location pls?)**	Concrete Concrete Concrete - 20/20 Paint - Acrylic Paint - Formwork Paint - Plastic Emulsion Plastic Pipes Steel - Reinforcement Timber - Formwork	Examples include kerbs, pipe surrounds on roof, plinthes, etc
120	Roof Block Walls **(Location of Steel? Steel ties?)**	Concrete Blocks - Solid Steel - Galvanised	Yes, steel ties
139	Stainless Steel Door - Plant Rooms **Same as no.91 (Metal door-Plant Room)?** **Same location with different types of door? Duplication?**	Paint - Bitumastic Silicone Sealant Stainless Steel - Hairline Steel - Galvanised	No these are different doors, these are for GF service rooms
145	Towel Rails **(No steel component shown in drawing.)**	Paint - Zinc Chromate Stainless Steel - Mill	Stainless steel handrails and bolts
149	Wall Finishes - Internal Flat Areas **Can living room & bedroom separated from kitchen &** **bathroom because they have different finishes?** **(Steel component Location?)**	Cement Sand Render Paint - Plastic Emulsion Steel - Zinc Coated Tiles - Glazed Ceramic	Different finish could be added as a new functional unit by users Metal lathing / dividing strips
151	Wall Finishes - Movement Joints, etc **(Stainless steel not shown in the drawing)**	Polyurethane Foam Stainless Steel - Mill	Metal lathing / dividing strips
152	Wall Finishes - Plant Rooms **(Steel component Location?)**	Cement Sand Render Gypsum Plaster Paint - Acrylic Paint - Alkali Resisting Primer Paint - Plastic Emulsion Paint - Prepolymer Sealer Paint - Synthetic Steel - Zinc Coated Tiles - Glazed Ceramic	Metal lathing / dividing strips
153	Wall Finishes - Refuse Room **(Steel component not shown in drawing)**	Cement Sand Render Steel - Zinc Coated Tiles - Glazed Ceramic	Metal lathing / dividing strips
154	Wall Finishes - Staircases **(Steel component not shown in drawing)**	Cement Sand Render Paint - Synthetic Steel - Zinc Coated Tiles - Homogenous	Metal lathing / dividing strips