

**Memorandum for Review Committee on Quality Assurance Issues  
Relating to Fresh Water Supply of Public Housing Estates  
of the Hong Kong Housing Authority**

**Quality Control and Supervision of  
Off-site Manufactured Precast Concrete Components  
for Use in Housing Authority's Public Housing Developments**

**PURPOSE**

This paper informs Members about the quality control and supervision of off-site manufactured Precast Concrete Components (PCC) for use in the Housing Authority (HA)'s public housing developments.<sup>Note 1</sup>

**PCC AT KAI CHING ESTATE**

2. In Kai Tak Site 1A project (i.e. Kai Ching Estate), Yau Lee Wah Concrete Precast Products Co. Ltd. (YLV) was engaged by the Main Contractor, China State Construction Engineering (HK) Ltd. (CSHK), for the production of the volumetric precast bathroom (VPB) and volumetric precast kitchen (VPK).

3. Other than the precast concrete elements and wet trade in architectural water proofing and tiles, the installation of water pipes and sanitary fitments was a trial that started in the project from the middle of the production period. All copper water pipes and sanitary fitments were of surface-mounted design, and the water pipes pre-installed in the factory were only part of plumbing system, the inspection of which could be effected by the site inspection team upon arrival on site. The Main Contractor was responsible for checking the entire fresh water plumbing system to ensure that they all complied with the Water Supplies Department (WSD)'s approved drawings and relevant regulations as well as the contract requirements.

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Note 1 Since apart from Kai Ching Estate, plumbing installation is not included in off-site PCC production process, quality assurance of off-site PCC production is not relevant to how HA controls against the risk of lead in plumbing system and this paper is for Members' information.

4. Based on the experience gained from the pilot conducted at Kai Tak Site 1A (i.e. Kai Ching Estate) of pre-installing sanitary fittings and water pipes in factory <sup>Note 2</sup>, we observed that some of these pre-installed components were damaged during transportation. Upon further study and review, we decided not to pre-install sanitary fittings and water pipes in volumetric precast units in subsequent projects.

## DEVELOPMENT OF PCC IN HA

5. Since 1990s, HA has been widely using PCC for public housing developments to assure product quality and enhance buildability of construction by transferring the more difficult in-situ construction works at height to the manufacturing ground in a factory environment with more effective supervision. Fewer wet trades on site can enhance the safety and health at the place of work, and reduce the critical labour demand in particular for skilled carpentry. Also, the use of steel mould for PCC fabrication can greatly reduce timber formwork and reduce waste on site. These are conducive to promoting quality products and green construction.

6. The common types of PCC <sup>Note 3</sup> that are mandatory for all current projects include precast façades (all with cast in window frames), semi-precast floor slabs, and precast staircases. Furthermore, there are other non-mandatory but common use of PCC such as precast beam, concrete partition wall, refuse chute and scissor stairs. The use of VPB/VPK were first tried out in small scale in Tseung Kwan O Area 73A in 2000 and later piloted in Kwai Chung Flatted Factory Redevelopment in 2005 (**Paper No. BC 129/2002** refers) for making extensive use of prefabrication and precasting to enhance quality and sustainability. The VPB/VPK were then extensively used at Kai Tak Sites 1A & 1B in 2009, in view of the project scale with large quantity of units in achieving economies of scale. Similar to conventional construction of cast-in-situ bathroom and kitchen, all plumbing and drainage pipes are surface mounted and not embedded (Diagram of VPB and VPK at **Annex 1** refers).

7. With regard to the design of precast concrete components, Engineer's Design approach is generally adopted by project teams except at the

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Note 2 In the Kai Ching Estate development, about 14% of the total quantity of copper water pipes by length were pre-installed in precast kitchens and bathrooms at the factory.

Note 3 Panel wall partition ("Drywall") is classified as a building component which is controlled by a performance-based specification and site surveillance test carried out by the Central Team.

early introduction stage of VPB in Tseung Kwan O Area 73A and the VPK for the Kai Tak Site 1A project where the respective designs were initiated by the Contractors. Moreover, for the two projects procured under the Integrated Procurement Approach, namely, Kai Tak Site 1B (Tak Long Estate) and Anderson Road Sites A & B (under construction), all the precast concrete components were designed by the Contractors.

## **PRODUCTION FACTORY**

8. Before 1997, there were only few local suppliers to supply Precast Concrete Façade (PCF). The Building Committee approved, vide **Paper No. BC 131/97**, the production of PCF outside Hong Kong by off-site supplies in order to secure a more competitive environment for the supply of PCF for public housing projects. This was in line with the World Trade Organization Agreement on Government Procurement (WTOGPA) effective on 19 June 1997 to open up the market to off-territory supplies. The Paper also approved the establishment of an approved list for monitoring of performance and to enhance the control of the quality of PCFs for off-site supplies.

### **The Approved List System**

9. In June 1998, a List of approved suppliers for off-site production of PCF (the Approved List) was established vide **Paper No. BC 79/98**. Six suppliers were included in the Approved List. In October 1998, the Building Committee permitted the suppliers to expand their scope of products to include production of precast concrete structural elements (PCSE)<sup>Note 4</sup> and approved another eight suppliers for inclusion in the List, giving a total of 14 approved suppliers<sup>Note 5</sup> (**Paper No. BC 136/98** refers).

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Note 4 PCSE included precast facade, precast staircase and semi-precast slab.

Note 5 14 approved suppliers are China State Construction Eng. Corp., Dyna Concrete Ltd., Golden Trend Construction Ltd., Hong Leong Industrial Manufacturing Ltd., International Precast System Ltd., Kin Hing Precast Concrete Products Company Ltd., Lamma Rock Products Ltd., Nippon Hume Concrete (H.K.) Ltd., Orientfunds Precast Ltd., Redland Precast Concrete Products Ltd., Shen Zhen Sun Wah Concrete Products Co. Ltd., Unicon Concrete Products (H.K.) Ltd., Wai Hing Construction Material Co., Ltd., and Yau Lee Wah Concrete Precast Products Co. Ltd.

## **The Control List System**

10. Given the ever increasing number of trades in the Approved List of building materials and suppliers of building components and interested suppliers seeking inclusion into the Approved List, a comprehensive strategic review was conducted at the end of 1998 with a view to improving the effectiveness and efficiency of administration. In mid-1999, the Building Committee approved the migration of Approved List System to a 3-level Control List System which was operated under rules of administration for registration and retention on the List (**Paper No. BC 127/99** refers).

11. In the 3-level Control List System, different building materials/components and building services materials were categorized under Control List I, II and III. Precast concrete components were categorized under Control List I. In essence, the Main Contractors of building contracts were required to select suppliers from Control List I which consisted of 15 suppliers <sup>Note 6</sup>.

## **The Performance-Based System**

12. To further enhance market competition and operation efficiency, the Control List System was dissolved and replaced by the Performance-Based System in mid-2004 in which the Main Contractors are no longer required to select PCC suppliers from Control List I but free to source and propose any PCC suppliers that meet the contract requirements.

13. At the beginning of each building contract, the Main Contractor proposes a PCC production factory for the Contract Manager's approval. The Main Contractor can source any PCC production factory from the open market provided that the factory satisfies the quality requirements as stipulated in HA's Contract Specification. There are currently six active PCC production factories located in Guangdong Province. They are –

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Note 6 15 PCC suppliers under Control List I are Beatrice Construction Ltd., China State Construction Eng. Corp., Dyna Concrete Ltd., Golden Trend Construction Ltd., International Precast System Ltd., Kin Hing Precast Concrete Products Company Ltd., Lamma Rock Products Ltd., Main King Industrial Ltd., Nippon Hume Concrete (H.K.) Ltd., Orientfunds Precast Ltd., Redland Precast Concrete Products Ltd., Shen Zhen Sun Wah Concrete Products Co. Ltd., Unicon Concrete Products (H.K.) Ltd., Wai Hing Construction Material Co., Ltd., and Yau Lee Wah Concrete Precast Products Co. Ltd.

- Shenzhen Hailong Construction Product Co. Ltd.
- Shenzhen Sun Wah (Shenzhen) Concrete Products Co. Ltd.
- Shenzhen Sun Wah (Zhongshan) Concrete Products Co. Ltd.
- Shunde Lunjiao Quon Hing Construction Material Co. Ltd.
- Wing Hong Shun Enterprises Ltd.
- Yau Lee Wah Concrete Precast Product Co. Ltd.

## QUALITY ASSURANCE

14. The following measures are adopted to ensure the quality of off-site manufactured precast concrete components, with different levels of control to suit their structural significance and characteristics.

### (i) Buildings Department's Requirements

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According to Buildings Department's "Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers PNAP-APP 143" (**Annex 2** refers) for key precast concrete elements not fabricated on the building site issued in 2006, the PCC production factory is to be certified to ISO 9001 for its quality management system.

### (ii) HA's Additional Standards

HA requires the PCC production factory to be certified to the following standards, on top of Buildings Department's requirements -

- ISO 14001 for its environmental management system;
- OHSAS 18001 for its occupational health and safety management system;
- Quality Scheme for the Production and Supply of Concrete (QSPSC) for concrete used in casting PCC.

### (iii) Quality Assurance Scheme

The factory submits a Quality Assurance Scheme (QAS) for the production of structural precast concrete components in the factory via the Main Contractor to the Contract Manager (CM) for approval before mass production is allowed. The scheme should have adequate provisions in

ensuring the quality of production complying with the Contract Specification and the approved plans. The items to be covered under the QAS are -

- Quality control tests of materials;
- Calibration of laboratory equipment for quality control tests;
- Efficiency and proper operation of equipment at the casting yard;
- Production process;
- Testing procedures and requirements;
- Frequency and extent of inspection by in-house staff and independent parties; and
- Frequency and extent of audit by in-house staff and independent parties.

Other than the submitted QAS, past performance of the PCC factory is important when project teams consider a PCC factory proposed by the Main Contractor. For factory with no track record of supplying PCC to HA's construction projects in the past five years, a pilot production run is to be carried out by the manufacturer to demonstrate its technical capability and effectiveness of its Quality Assurance Scheme before acceptance for production.

Upon commencement of each contract, an initial joint factory inspection is conducted among the Project Team, Central Team <sup>Note 7</sup> and Main Contractor, to select PCC for demonstration of production to ensure the capability and buildability before mass production.

**(iv) Qualified Supervision**

HA follows Buildings Department's requirements on qualified supervision of structural works in PCC production factory as set out in PNAP-APP 143.

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Note 7      The Central Team is an in-house independent team to monitor the performance of precast concrete factory.

To fulfill the requirements, HA, since early 2007, has commissioned two Independent Professional Services Providers (PSPs)<sup>Note 8</sup> for centralized management of factory supervision for precast concrete structural elements. On top of the statutory requirements, HA requires the independent PSPs to deploy full time resident supervisors in factories to inspect the structural works together with some essential architectural items, including aluminum windows and conduits installation in precast façade, and also the waterproofing, floor tiles and wall tiles in VPB and VPK construction, which would require inspection before covering up.

In addition to resident supervisors, the PSPs are to deploy Registered Electrical Workers (REW) to carry out audits to the factories for those concealed and fixed electrical installations in precast concrete components against the Electricity (Wiring) Regulations at monthly intervals.

The qualified supervision of precast concrete production in factory provided by HA above the statutory requirements is summarized in **Table A** as follows.

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Note 8      PSPs are local Consultant firms and each PSP is responsible for three PCC production factories located in north or south regions of Guangdong Province.

**Table A – Qualified Supervision of Precast Concrete Production in Factory**

	<b>Statutory Requirements</b>	<b>HA's Requirements</b>
<b>Structural Works</b>		
RSE Stream Supervision	Assign a structural quality control supervisor to supervise (not necessary full time but only no less than once a week) the PCC works.	Deploy a team of RS led by a Lead RS (LRS) full time to supervise the PCC works in the factory, with at least one RS per typical project. The team of full-time RS to carry out inspection on structural items at a frequency not less than that of reinforcement concrete works on site.
RSE Audit	At least once every month.	At least twice every month, and to cover all types of PCC, if available, in the factory in every two consecutive months.
Project Manager (PM)	Nil	Deploy a PM to pay visits twice a month to each factory to review adequacy of RS resource and quality issues.
RC Stream Supervision	Same as statutory requirements for RSE stream	
RC Audit	At least once every month	
RSE / RC Audit Reports	To be submitted for each project	
<b>Architectural Works</b>		
Architectural Works Inspection	Nil	The team of full-time RS is to carry out inspection on essential architectural items which would require inspection before covering up at a frequency not less than that of building works inspection at construction site.
<b>Building Services Works</b>		
Building Services Works Audit	Nil	Deploy a Registered Electrical Worker (REW) to conduct monthly audits to installation of electrical works items in PCC.

Legends

- RSE Registered Structural Engineer  
 RS Resident Supervisor, and LRS denotes Lead Resident Supervisor  
 RC Registered Contractor of the building contract



**(v) Surveillance Checking**

In addition to the initial Joint Factory Inspection conducted by the project team together with the Main Contractor and the Central Team, the project team will pay ad hoc inspections to the factory when necessary as production proceeds. Besides, the Central Team conducts quarterly coordination factory visits to monitor and mentor the performance of PSP.

**(vi) Materials Testing**

For structural materials, apart from the concrete quality assurance tests by the PCC production factory itself, HA also carries out routine tests for steel reinforcement bars and concrete constituent materials (e.g. aggregate and cement) by HA's Direct Testing Contractors (DTC) with additional parallel tests by the Housing Department Material Testing Laboratory (HDMTL) to monitor the quality of materials put to use.

For architectural materials which require fixing in advance, the resident supervisors will check the materials against the approved samples upon delivery to the factory. For tile grouts, tile adhesives and stainless steel 4-bar window hinges, the resident supervisors will take samples for test by the DTC.

For building services materials, i.e. concealed electrical conduits and junction boxes in precast facade, the resident supervisors will check the material against the approved samples upon delivery to the factory.

All the materials testing and checking are carried out at a frequency not less than those on site.

**(vii) On-site Checking and Testing**

When the PCC arrive on site, the site inspection team will carry out checking (e.g. size, type and no. of steel reinforcement starter bars) and testing (e.g. covermeter test to precast façade) according to the delivery information and construction drawings. Upon installation of the PCC in place, further checking (e.g. crack on concrete surface) will be carried out before final acceptance.

Any deficiency of PCC identified on site immediately triggers a feedback to the concerned parties for investigation and review, with improvement and control measures taken as appropriate. As a feed forward mechanism, other project teams and the central team are alerted of the PCC deficiency through the bi-weekly monitoring reporting system of untoward incidents in project sites so that they can take preventive actions as necessary.

**(viii) Performance Assessment Scoring System (PASS)**

PCC is included in the Performance Assessment Scoring System (PASS) to draw the main contractors' attention to the quality assurance of PCC produced by the factories and make the main contractors responsible for their domestic sub-contractors. The PASS score of PCC is assessed by Central Team and will be applied to all the main building contractors who engage the factory in producing PCC for HA projects.

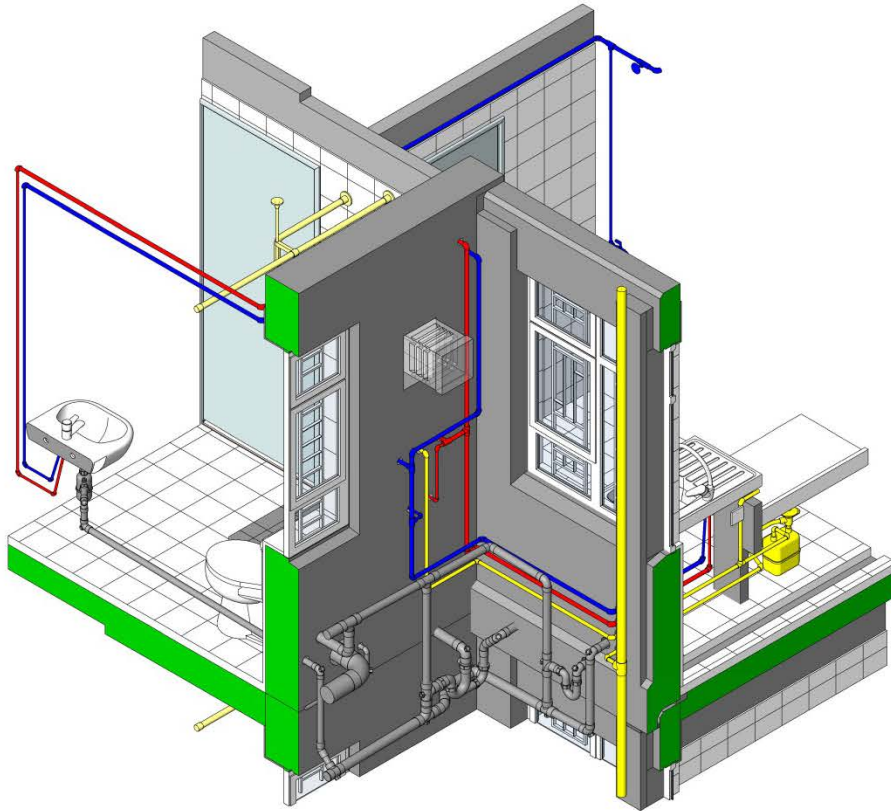
**INFORMATION**

15. This paper is for Members' information.

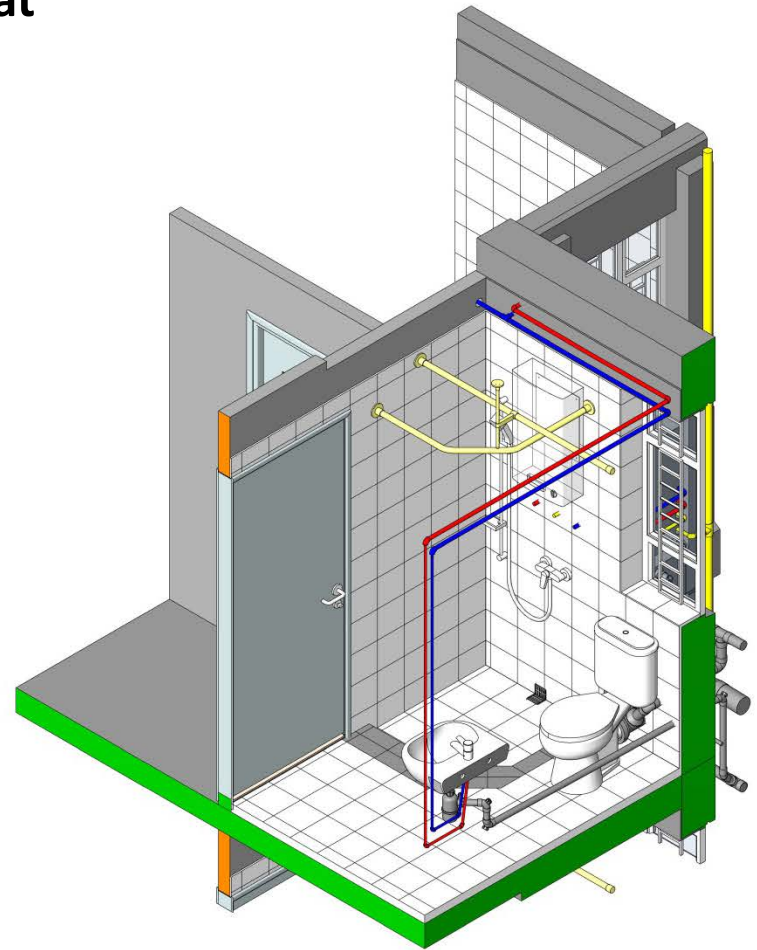
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## Typical Plumbing Layout inside Modular Flat



**External wall of bathroom and kitchen with surface mounted water supply pipes**



**Interior view of bathroom**

## **Quality Control and Supervision of Precast Concrete Construction**

### **Introduction**

In recent years, the use of precast concrete in private building developments in Hong Kong has increased. To ensure that the precast concrete elements are of good quality, proper supervision and adequate quality control are necessary during the production, erection and inspection processes of the concrete elements. This practice note sets out the requirements for the quality control and supervision of key precast concrete elements not fabricated on the building site. The requirements stipulated in this practice note do not apply to minor elements such as non-structural precast concrete block work, architectural features and planters.

### **Duties of the Authorized Person, Registered Structural Engineer and Registered Contractor**

2. The Authorized Person (AP), Registered Structural Engineer (RSE) and Registered Contractor (RC) have the responsibilities under the Buildings Ordinance (BO) to ensure that the precast concrete works comply with the provisions and standards of the BO and the approved plans. In accordance with Section 4(3)(a) of the BO and Regulation 37 of the Building (Administration) Regulations (B(A)R), adequate supervision has to be provided by the AP and RSE for the carrying out of the precast concrete works, whereas the RC has to provide continuous supervision, as required under Section 9(5)(a) and 9(6)(a) of the BO and Regulation 41 of the B(A)R, for the carrying out of such works.

### **Quality Assurance**

3. Under item 6 in Section 17(1) of the BO, a condition will be imposed, when giving approval of plans, that precast concrete elements should be manufactured by a factory with ISO 9000 quality assurance certification.

4. Under Regulation 10 of the B(A)R, a requirement will be imposed, when giving approval of plans, that a copy of the Quality Assurance Scheme of the manufacturer should be submitted prior to the application for consent to the commencement of the works. Such submission should be appended with a statement signed by the RSE to confirm that the scheme has adequate provisions in ensuring the quality of production complying with the provisions of the BO and the approved plans.

5. The Quality Assurance Scheme should cover the following items:

- (a) Quality control tests of materials;
- (b) Calibration of laboratory equipment for quality control tests;

/(c) .....

- (c) Efficiency and proper operation of equipment at the casting yard;
- (d) Production process;
- (e) Testing procedures and requirements;
- (f) Frequency and extent of inspection by in-house staff and independent parties; and
- (g) Frequency and extent of audit by in-house staff and independent parties.

### **Qualified Supervision**

6. Under item 6 in Section 17(1) of the BO, a condition will be imposed, when giving approval of plans, that qualified supervision should be provided by the RSE and the RC for the fabrication, erection and examination of precast concrete elements.

7. The RSE should assign a structural quality control supervisor to supervise the precast concrete production works. The RSE should determine the necessary frequency of supervision, which should be no less than once a week. The minimum qualifications and experience of the quality control supervisor are to be the same as grade T3 technically competent person (TCP) under the RSE's stream, as stipulated in the Code of Practice for Site Supervision.

8. The RC should assign a quality control co-ordinator to provide continuous supervision of the precast concrete production works in the factory. The minimum qualifications and experience of the quality control co-ordinator are to be the same as grade T1 TCP under the RC's stream, as stipulated in the Code of Practice for Site Supervision.

9. The names and qualifications of the supervisory personnel assigned by the RSE and RC respectively should be recorded in an inspection log book. The details of precast concrete production, inspection, auditing and testing should be recorded in the log book by the supervisory personnel. The log book should be kept in the factory and a copy of it should be kept at the building site office and, when required, produced to officers of the Buildings Department for inspection.

10. In addition, the RSE and the Authorized Signatory (AS) of the RC should inspect and carry out audit checks to the precast concrete factory at least once every month. Under Regulation 10 of the B(A)R, a requirement will be imposed, when giving approval of plans, that a copy of the RSE's audit reports of the precast concrete factory and a copy of the AS's audit reports of the precast concrete factory duly endorsed by the RSE should be submitted to the Buildings Department for record purpose. The RSE and AS's audit reports should respectively also cover the qualified supervisions by the structural quality control supervisor of RSE's stream and the quality control co-ordinator of AS's stream. Minimum requirements of the audit checks are detailed in Appendix A.

11. As an alternative to the requirement for the RSE's qualified supervision at the precast concrete factory specified in paragraph 10 above, the RSE may consider carrying out on-site audit checks to the quality of the precast concrete elements delivered to the building site. In such situation, the RSE is required to notify the Building Authority in writing before commencement of works, and to submit a copy of on-site audit reports on the quality of the precast concrete elements delivered to the building site to the Buildings Department for record purpose, covering the qualified supervisions by the structural quality control supervisor. Minimum requirements of the on-site audit checks by the RSE are detailed in Appendix B.

12. For good practices in the design, construction and quality control of precast concrete works, reference should be made to the recommendations and guidelines given in the Code of Practice for Precast Concrete Construction issued by the Buildings Department.

### **Separate Registered Structural Engineer**

13. For precast concrete elements not affecting the stability of the parent structure, such as the precast concrete façade or staircase, a separate RSE may be appointed to prepare the design and to supervise the production and erection of such precast concrete elements. In such situation, the specified Forms BA4 and BA5 notifying the appointment of a separate RSE and the scope of works for which he/she is responsible are required to be submitted together with the plans for approval. The project RSE shall also notify the Building Authority in writing that he/she is fully aware of the appointment of a separate RSE and the demarcation of responsibilities. Upon completion of the precast concrete construction works, the separate RSE so appointed is required to certify the satisfactory completion of the works in accordance with Regulation 25(3) of the B(A)R.

14. The separate RSE's submission should be accompanied by an assessment report prepared by him/her giving an account of the effect of the proposed precast concrete works on the parent structure. The assessment report shall be appended with a statement of the project RSE to confirm that he/she is fully aware of the connection details and their effects on the parent structure.

15. The separate RSE shall be responsible for the supervision of the production and erection of the precast concrete elements, including the connection between the precast concrete elements and the parent structure, i.e. ties, anchor plates, cast-in embeds etc., except in the event where such associated works have been installed in the parent structure prior to his/her appointment. For such cases, the structural details and layout of the pre-installed parts should be given in the superstructure plans submitted for approval by the project RSE who shall then be responsible for the supervision of the installation of such parts. The separate RSE should refer to the pre-installed connection details when designing the precast concrete elements and should co-ordinate with the project RSE for any necessary amendment if different connection details are to be used.

16. The separate RSE shall ensure that the conditions and requirements of the quality assurance and qualified supervision as stipulated in paragraphs 3 to 5 and 6 to 11 above respectively are complied with. He/she shall also be responsible for the submission of the documents required in paragraph 4 above.

/17. ....

17. A similar practice note is issued to registered contractors.

( AU Choi-kai )  
Building Authority

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This PNAP is previously known as PNAP 299

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**Minimum Requirements of the RSE and AS's Audit Check  
at Precast Concrete Factory**

The audit checks carried out by the RSE and the AS at the precast concrete factory should include the following works items:.

<b>Works Item</b>		<b>Scope</b>
1	Formworks	<ul style="list-style-type: none"><li>● Smoothness, cleanliness and dimensions of steel mould</li><li>● Application of mould releasing agents</li></ul>
2	Steel reinforcing bars	<ul style="list-style-type: none"><li>● Size, pattern, fixing and layout of the steel reinforcing bars</li><li>● Spacers</li><li>● Concrete covers</li><li>● Material testing reports</li></ul>
3	Concrete	<ul style="list-style-type: none"><li>● Placing and compaction</li><li>● Curing</li><li>● Material testing reports</li></ul>
4	Finished products	<ul style="list-style-type: none"><li>● Concrete surface</li><li>● Sizes and dimensions</li><li>● Starter steel reinforcing bars</li></ul>
5	Inspection records	<ul style="list-style-type: none"><li>● Log books of the structural quality control supervisor/quality control co-ordinator</li></ul>
6	Others	<ul style="list-style-type: none"><li>● Any other items considered essential by the RSE/AS for the project.</li></ul>



**Minimum Requirements of the RSE's On-site Audit Check  
on Precast Concrete Elements delivered to the Building Site**

The audit checks on the precast concrete elements delivered to the building site carried out by the RSE as an alternative to the audit check on precast concrete elements at the precast concrete factory as specified in Appendix A should comply with the requirements specified in paragraph 2 below.

2. The rate of sampling for the audit checks shall be at least 1% of the precast concrete elements with a minimum of one per every 20 batches of delivery to the building site. The audit check for each sample of the precast concrete element should include the following works items

<b>Works Item</b>		<b>Scope</b>
1	Steel reinforcing bars	<ul style="list-style-type: none"> <li>● Opening-up of the concrete surface at 3 locations, each with an area of 100mm x 300mm, to check the size, pattern and layout of the steel reinforcing bars; and the concrete covers</li> <li>● Measurement of the concrete cover to steel reinforcing bars by covermeter at 6 locations, each with 6 readings taken in an area of 450mm x 450mm</li> <li>● Material testing reports</li> </ul>
2	Concrete	<ul style="list-style-type: none"> <li>● Concrete coring at 3 locations tested for verification of concrete strength</li> <li>● Material testing reports</li> </ul>
3	Finished products	<ul style="list-style-type: none"> <li>● Concrete surface</li> <li>● Sizes and dimensions</li> <li>● Starter steel reinforcing bars</li> </ul>
4	Inspection records	<ul style="list-style-type: none"> <li>● Log books of the structural quality control supervisor</li> </ul>
5	Others	<ul style="list-style-type: none"> <li>● Any other items considered essential by the RSE for the project.</li> </ul>

Remarks :

Tests for compressive strength of concrete cores should be carried out in accordance with the method specified in CS1:2010, by a laboratory accredited under HOKLAS for the particular test concerned. Test results should be reported on a HOKLAS Endorsed Certificate and submitted within 60 days of the delivery of the precast concrete elements to the building site.

( 07/2012)