

Legislative Council Panel on Transport

Quality Assurance System for Use of Concrete in Public Works Programme (PWP) Projects

PURPOSE

This paper provides information on the quality assurance system for use of concrete in public works programme (PWP) projects. The paper also reports the latest development and findings of the ongoing investigation into the alleged falsification of concrete test reports associated with the works under the Hong Kong-Zhuhai-Macao Bridge Hong Kong and related projects.

QUALITY ASSURANCE SYSTEM FOR CONCRETE IN PWP PROJECTS

2. The Government attaches great importance to quality of our PWP projects, including civil engineering and building works, and to achieve this, the Government has stipulated stringent quality requirements in PWP projects, in particular on concrete, which is one of the primary construction materials used in Hong Kong.

3. The quality of a concrete structure depends on a host of factors throughout its production process from its mix design, production, transportation, casting and curing. We have detailed specification stipulating stringent requirements at every stage of the process to ensure that the final concrete structure meets its designed performance. A flowchart showing the quality assurance measures throughout the process is given in **Annex 1**.

Production

4. First and foremost, concrete suppliers who supply structural concrete for all PWP projects must be certified under the Quality Scheme for the Production and Supply of Concrete (QSPSC)¹.

5. The QSPSC, is a Product Certificate Scheme administered by Hong

¹ Except for those located at remote areas (such as outlying islands) or where the volume of structural concrete involved is less than 50m³. For these “exceptional” projects, the quality system of the concrete supplier shall be approved by the authorized professional engineer or architect.

Kong Quality Assurance Agency², that consists of two parts: Administrative Regulations (AR) and Technical Regulations (TR). The AR requires (i) the concrete supplier to operate a system which complies with ISO9001, and (ii) the independent certification body certifying the supplier shall be accredited by Hong Kong Accreditation Service (HKAS) or United Kingdom Accreditation Service (UKAS). The TR includes the requirements on material audits and production control as well as tests of various concrete properties during the batching and mixing process, which provides assurance on all raw materials, such as cement, aggregates, etc. for the production of concrete conforming to relevant technical standards.

Transportation

6. There are standard requirements in respect of transporting ready-mix concrete to site, e.g. time of delivery and rate of rotation of mixer of a concrete truck. This is necessary because the properties of concrete are volatile and may vary during transportation from a batching plant to a site or after prolonged mixing/standing time. Slump tests for workability is therefore required to ascertain that the quality of ready-mix concrete is maintained before placing and compacting in permanent works. Ready-mix concrete failing such test would not be allowed to be used on site.

On Site Control

7. With the passed ready-mix concrete, placing, compaction and curing processes have to be conducted by skill labours and are subject to full time supervision of resident site staff to ensure proper workmanship which is vital for securing the final quality of the permanent works. At the same time, testing samples of ready-mix concrete will be taken for preparing concrete cubes (specimens) under the supervision of resident site staff. As explained above, quality of concrete is assured by the quality assurance system being implemented at the very early stage for manufacture of concrete. Testing of samples taken from ready-mix concrete on site serves as an extra check-point in PWP projects. This takes the form of concrete cube tests for compressive strength to ascertain that the quality of ready-mix concrete delivered to site resembles the design mix approved for use in the permanent works.

8. Concrete compression test is a well-established test for determining concrete compressive strength. The tests are conducted by a laboratory independent to the concrete supplier. To make a compression test result representative, testing procedures including measurements, curing and determining the compressive strength in test machine have to be properly carried out. In particular, the loading

² A non-profit-distributing organization by the Hong Kong Government helps industry and commerce in the development of quality environmental, safety, hygiene, social and other management systems.

faces of the test machine must be cleaned and the concrete cube (specimen) is placed at the centre of loading area before applying load on it. If such preparation work is not properly carried out, even a small particle on the loading face of the test machine may affect the load distribution on the concrete specimen during testing and will lead to a misleading test result. Because of this, isolated cases of not meeting the required concrete strength do not necessarily imply non-compliance with the specified requirements for compressive strength. The compliance criteria for a batch of concrete does not depend on the individual test result alone but also count on the statistical averages and standard deviations of the measured concrete strength of all relevant cubes. This is in line with international practice.

Role of Public Works Laboratories

9. It is the Government's policy that materials compliance testing for all PWP projects must be done through the Public Works Laboratories (PWL) of the Civil Engineering and Development Department (CEDD). PWL comprises Public Works Central Laboratory (PWCL) and Public Works Regional Laboratories (PWRL). PWCL delivers the testing services through undertaking tests by its own team and by outsourcing to commercial laboratories.

10. Since the early 1980s, the PWRL have been established at strategic locations throughout Hong Kong to provide engineering-related compliance testing services to support PWP projects in different regions. All PWRL have been operated independently with respect to PWP projects in order to ensure their impartial status. Consultants who operate the PWRL should also declare any possible conflict of interest with the PWP projects for which they are assigned to provide testing services.

11. At present, there are five PWRL, viz. in Tsuen Wan, Tsz Wan Shan, Tai Po, Tin Shui Wai and North Lantau. From end 2012 to March 2017, a designated regional laboratory was set up at Siu Ho Wan (i.e. PWRL(SHW)) to serve the Hong Kong-Zhuhai-Macao Bridge local projects.

12. The PWCL and the regional laboratory at Tsuen Wan are manned by Government officers, comprising professional, technical and clerical staff. Other regional laboratories are overseen by a Government officer and operated by engineering consultants through consultancy³ agreements. For PWRL(SHW), two Government officers were assigned to oversee the laboratory⁴.

³ Approved by the Engineering and Associated Consultants Selection Board (EACSB)

⁴ Unlike other PWRL, PWRL(SHW) might need to operate on weekends and/or public holidays in order to accommodate the project needs.

Laboratory Quality Management System

13. PWL, including both the PWCL and PWRL, are accredited by Hong Kong Accreditation Service (HKAS) under the Hong Kong Laboratory Accreditation Scheme (HOKLAS) for testing and calibration services. The quality management system of PWL meets the requirements of international standard ISO/IEC17025. As part of the quality management system, PWL regularly conduct internal audits and inter-laboratory comparison to confirm the quality standard of testing services by PWCL and PWRL. PWL are also subject to annual HOKLAS assessment audits by HKAS.

14. To cope with the testing demand by the ongoing PWP, the frequent and routine compliance tests of construction materials (such as concrete, steel, bituminous materials and aggregates) are also contracted out to HOKLAS accredited commercial laboratories that operate independently with respect to PWP projects. About 35% of the routine compliance tests were outsourced to contract laboratories in 2016. There are currently 20 laboratory testing term contracts. A dedicated team of professional and technical staff of the PWCL is responsible for administering the term contracts and auditing these outsourced tests.

15. To safeguard the reliability of the outsourced testing services, including both the consultants-manned regional laboratories as well as the contract laboratories, the PWL are exercising additional monitoring measures, including:

- (1) surprise surveillance audits; and
- (2) parallel testing.⁵

16. For each of the Consultants-manned regional laboratories, a Government officer is also stationed in the laboratory on a full-time basis to undertake auditing of testing activities and testing records, and to monitor the delivery and supervision of testing services by the Consultants. For PWRL(SHW), two Government officers were assigned to station in the laboratory. CCTV are installed in some areas of the laboratories for monitoring purposes. Besides, supervisory personnel and laboratory testing technicians as provided by the Consultants should possess adequate qualification and relevant experience that meet the requirements laid down in the consultancy agreements.

⁵ To conduct the parallel testing, an independent laboratory is engaged to produce dummy identical samples. Those samples are distributed to selected laboratories for testing through public works contracts, without notifying the selected laboratories. Test results by the selected laboratories are compared to testify the performance of the laboratories

ALLEGED FALSIFICATION OF CONCRETE TEST REPORTS - INVESTIGATION AND FINDINGS

17. In July 2016, during the auditing of concrete compression test results, the Principle Technical Officer (PTO) of the CEDD who oversaw the concerned laboratory identified anomalies in isolated testing records. He noted that the testing time of some of the concrete compression tests had been tampered with. The testing time was changed, apparently with a view to showing compliance with the requirement⁶ but in fact, the test was conducted late. The CEDD carried out an investigation of the incident. At the same time, the CEDD required the Consultants managing the concerned laboratory to provide a detailed investigation report to explain the incident and propose necessary remedial actions.

18. In September 2016, the Consultants submitted its investigation report, which admitted that some members of its laboratory staff had on occasions adjusted the clock on the compression testing machines in order to make the testing time shown in the records fall within the required timeframe. The investigation by the CEDD also concluded similar findings and examined the effect of such anomaly on test results. The altered testing time have resulted in a higher concrete compressive strength being measured. Nevertheless, the effect was considered insignificant because the delays in conducting the test was relatively short, and the rate of gain in compressive strength of concrete would have slowed down beyond the age of 28 days (see also **Figure 1**).

19. After the above investigation, the CEDD reported the case to the ICAC for necessary actions. The CEDD has rendered full assistance to the ICAC during its investigation. At the same time, concrete compression test results of other regional laboratories were also examined and no anomaly was found.

20. On 18 May 2017, the ICAC advised the CEDD that its investigation unveiled other suspected malpractice involving replacement of concrete compression test samples by a metal cylinder or a 'strong concrete cube' to falsify the tests. The malpractice might have started in early 2015.

21. The CEDD immediately commenced a follow-up investigation by examining the raw data of the concrete compression testing records of the concerned laboratory. Based on the available information from the ICAC, all tests in the period from January 2015 to June 2016 have been examined. Findings on suspected falsified test results have been passed to the Highways Department in batches from 28 May to 1 June 2017.

22. The CEDD will continue to collaborate with the ICAC on their investigation.

⁶ The compression of concrete cubes samples should be carried out at 28 days \pm 8 hours.

FOLLOW-UP ACTIONS

Immediate actions after the unveil of the tampering of testing time

23. Immediate actions undertaken after the unveiling of the tampering of testing time included:

- (i) replacement of the Consultants' staff in charge of the overall supervision of the laboratory;
- (ii) deployment of additional Consultants supervisory staff to tighten the supervision of the concerned laboratory;
- (iii) introduction of additional security measures in the computer system to prevent unauthorised reset of the computer clock;
- (iv) arrangement of further refresher training on the timing requirements of the concrete test and reminder of the essence of the integrity to all laboratory staff of PWL; and
- (v) issue of an adverse Quarterly Consultants' Performance Appraisal Report to the Consultants.

Immediate actions after the ICAC had advised the suspected malpractice of falsifying concrete compression tests

24. After the suspected malpractice of falsifying concrete compression tests which was advised by ICAC on 18 May 2017, further measures have been implemented to step up the quality assurance system of concrete compression tests. These include:

- (i) deploying additional government staff to each of the Consultants-manned PWRL to strengthen the auditing of test and monitoring of supervision by the Consultants;
- (ii) arranging different laboratories to carry out concrete compression tests for PWP projects on a rotational basis;
- (iii) increasing the number of parallel testing;
- (iv) strengthening of routine auditing check of test records; and
- (v) others:
 - (a) imposing requirement of taking photographs of the test samples before and after each test;
 - (b) lengthening the retention period of all tested samples for random audit by Consultants' supervisory staff and Government officers;
 - (c) installation of additional CCTV for detailed monitoring of concrete compression tests (being arranged); and
 - (d) regular rotation of consultant staff to take part in testing of different materials (being arranged).

Regulating Actions against the Consultants Involved

25. To ensure the quality of consultancy services delivered by consultants, we established a mechanism to manage the performance of architectural and engineering consultants in 2001. Such a mechanism has been updated from time to time and the latest update was promulgated through DEVB Technical Circular (Works) (TC(W)) No.3/2016⁷.

26. In view of the unacceptable performance of the Consultants in providing the services in respect of management and operation of the concerned laboratory, the CEDD has decided to suspend the Consultants from tendering for all categories of architectural and engineering consultancy agreements within the jurisdiction of the Architectural and Associated Consultants Selection Board (AACSB) and the Engineering and Associated Consultants Selection Board (EACSB) for a period of twelve months⁸ (from 2 June 2017 to 1 June 2018) after seeking the Boards' endorsement. Depending on the development of the case, the Government may take further regulating action(s) against the Consultants whenever deemed appropriate.

27. To prevent recurrence of similar incidents, the DEVB issued a memorandum in May this year requesting the works departments to review and step up the monitoring of the performance of the architectural and engineering consultants managed by them, particularly from the integrity management and quality assurance perspectives. The works departments will continue to closely monitor the services delivered by the consultant and will conduct any necessary technical audits. In the meantime, the DEVB is conducting another round of review to further enhance the management of architectural and engineering consultants.

Development Bureau June 2017

⁷ For details of DEVB TC(W) No. 3/2016, please refer to the link below:
<http://www.devb.gov.hk/filemanager/technicalcirculars/en/upload/343/1/C-2016-03-01.pdf>

⁸ Towards the end of the suspension period, the CEDD will review whether the suspension period should be extended or not, depending on the development of the case.

Annex 1 - Quality Assurance System for Use of Concrete

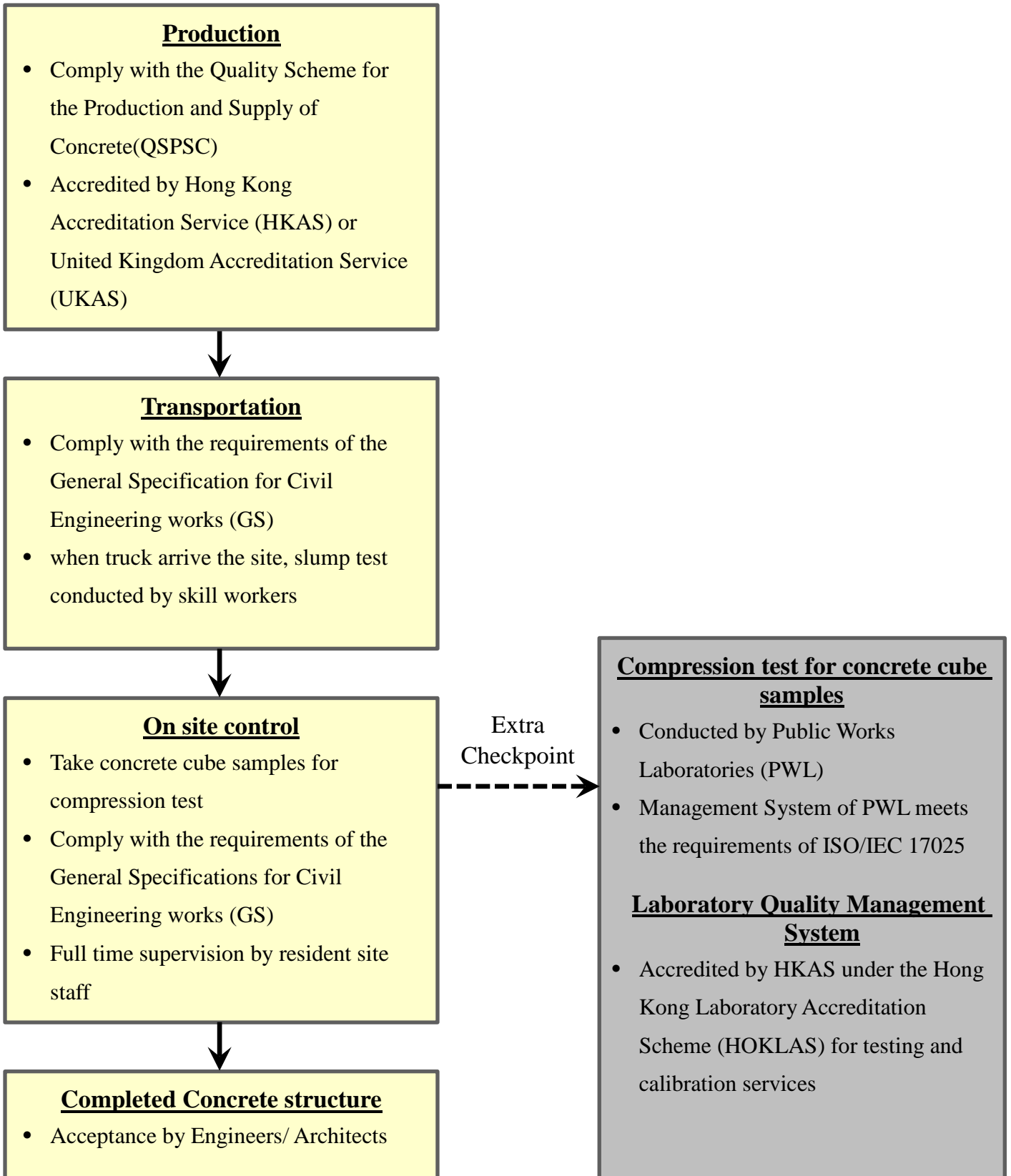
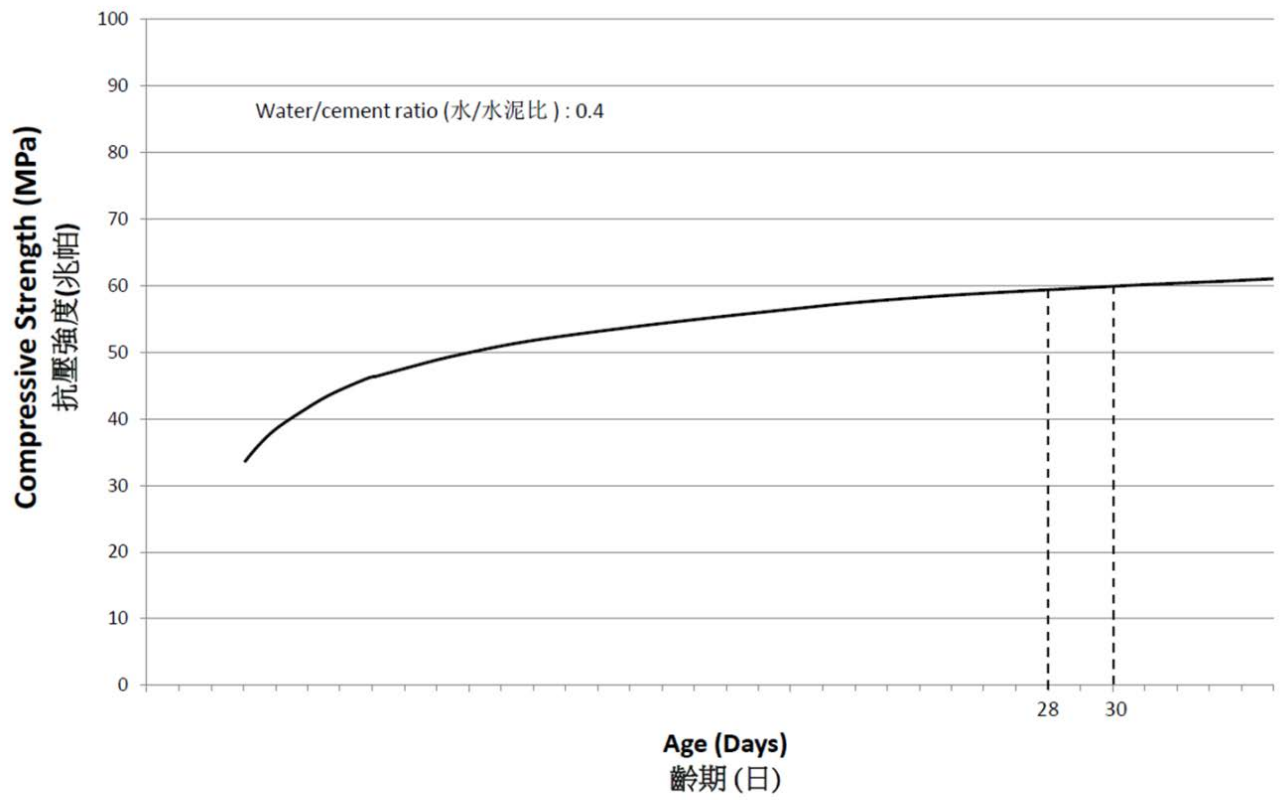


Figure 1 - Compressive Strength of Concrete against Time



Extracted from A.M. Neville, *Properties of Concrete* (4th Edition), p304; with conversion to natural scale from log scale
節錄於A.M. Neville, *Properties of Concrete* (第四版), 304頁, 並將對數刻度轉成自然刻度