

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH  
TECHNICAL VISIT TO MTRC TSEUNG KWAN O DEPORT PROJECT  
LABORATORY ON 20/1/2018



The MTR Corporation (MTRC), formally Mass Transit Railway Corporation, is in everyone's daily life in Hong Kong. Not only do its transport services by means of both railways and feeder buses carry millions of passengers every day, whereas also many people's workplaces and homes are its developments. MTRC is both a key transport services provider and property and infrastructure developer in the territory, and the latter business has seen significant expansion. Five (5) mega-sized railway projects, namely West Island Line, Express Rail Link, South Island Line, Shatin-Central Link and Kwun Tong Line Extension, of total contract value over USD 26 billion were once managed by MTRC simultaneously. The warranty of the quality of the 7 million m<sup>3</sup> concrete and 1 million tonne of steel reinforcements consumed for these projects is critical to the compliance with the relevant statutory requirements and timely completion of the projects, and Institution of Mechanical Engineers Hong Kong Branch (IMEchE-HKB) was privileged to visit the Material Testing Laboratory inside the MTRC Tsueng Kwan O depot and appreciate the methods of assuring the required high quality standard of each construction project.

**Role Model**

Material Testing Laboratory of MTRC Project Division (MTL) was established when MTRC was incorporated for the delivery of the first phase of the metro system in Hong Kong in 1975. In 1990s, its headcount reached 150 delivering quality assurance, testing and certification of concrete, steel and other construction materials. Subsequently from the time of Airport Express Link was built, the MTRC management decided MTL to be focus on testing only concrete and steel bars for reinforced concrete and, with the state-of-the-art highly automated and computerised

facilities, the current laboratory, which entered service in 2009, is operated by only 15 staff members.

The extraordinary high productivity of processing the testing of 7 million m<sup>3</sup> concrete and 1 million tonne of steel bars by one-tenth of the 1990s headcount is possible only with the MTRC in-house developed computer network-based material management system (MTS). MTS utilises radio frequency identification (RFID), QR code, Bluetooth data transmission, smart phone and the modern computing technologies to streamline the entire process of material testing from the receipt of testing samples to the generation of reports. The turnover of report generation has been compressed from up to two (2) weeks with the conventional paper-based process to 24 hours with MTS. About 500 test reports are issued daily and 400,000 test reports have been generated since 2009.

MTS provides numerous advantages over the conventional method which are compared below:-

Areas Concerned	Conventional Method	MTS
1. Importance of material testing	principally fulfil statutory requirements	satisfy both statutory and MTRC requirements
2. Testing arrangement	by Contractor	by MTRC
3. Measurements	manual	fully automatic
4. Change of failed test results	possible	not possible (all results are real time saved and secured in the computer system)
5. Risk of corruption	high	low
6. Chance of human error	high	low
7. Report accuracy	medium	high
8. Report turnover	approximate two (2) weeks	24 hours
9. Chance of disruption of progress due to unavailable test result	high	low

In addition, MTS offers higher level of traceability, credibility and transparency than the conventional method as each step of the testing process is logged, secured and accessible by all parties concerned. Also, MTS is entirely paper-less and hence environmentally friendly. Given each test generates 11 sheets of paper, 4.4 million sheets of paper have been saved.

Testing Method	Work Sheet	Test Report	Client copy	Contractor copy	Laboratory copy	Government copy	Total
Conventional Method	5	1	2	1	1	1	11
MTS	0	0	0	0	0	0	0

### **Secure and Accurate Process**

*Concrete*



Mist Room in MTL: the first facility of its kind in Hong Kong

At the construction site, once the concrete pouring is complete, a RFID tag concealed in a plastic casing is embedded on the surface of the concrete cubes. The RFID tag is the unique identity of the concrete cube and anchors on the concrete cube until the concrete cube is disposed of after the testing finishes. The MTRC technician uses his Android-driven smart mobile phone with the MTS application to first capture the QR code on the Concrete Ticket to capture the information of the concrete mix which makes the concrete cubes, and then the QR code on the RFID tag to identify the concrete cube is from the concerned concrete mix.

All concrete cubes are checked-in to MTL with the QR code on their RFID tag scanned to confirm identity and are accepted only if their identity matches the record in MTS. The checked-in concrete cubes are first detained in the Mist Curing Room for 28 days. The Mist Curing Room is maintained at  $(27 \pm 3) ^\circ\text{C}$  and 95 % relative humidity in accordance with Section 10 “Curing Test Specimens” of Construction Standard CS1: 2010 –Volume 1 of 2 “Testing Concrete” (CS1) published by Civil Engineering and Development Department of the government (CEDD). The Mist Curing Room is the first facility of such in the construction laboratory industry of Hong Kong replacing the curing tank which is conventionally used.

In MTL, contrary to the conventional method of manual measurements and record of data, the concrete cube dimensions are ascertained fully automatically. Once a concrete cube is placed in the checking jig, the RFID sensor identifies the specimen identity and the fully automated measuring devices installed on the checking jig obtain the length, breadth, height and weight of the specimen. The dimensions and the density derived are logged to the MTS server instantly.



Automated dimension measurers and jigs for concrete cubes

The concrete cubes are subject to the destructive Compression Test in order to ascertain the compressive strength of the concrete. The compression testing machines are also equipped with RFID sensor to read the identity of each specimen. In compliance with Section 10.4 “Age of Test Specimen” in CS1, all the specimens aged for 28 days shall be tested within plus or minus eight (8) hours and, should a concrete cube be aged less than 28 days and be outside the given time limit, the operator is prompted not to proceed with the test. Once the test is conducted, the test time and



the compression load are logged to the MTS server real time. As the dimensions and density are known, combining the compression load, the test result, either pass or fail, is derived instantly.

### *Steel Bars for Reinforced Concrete*

Compression Test stations for concrete cubes: test results generated real-time with the compression load

Tensile test is conducted in MTL to determine the tensile strength,

yield stress and elongation of the Grades 460 steel bars extensively used on the MTRC projects, in compliance with Section 6.2 of the CEDD-published Construction Standard CS2: 1995 “Carbon Steel Bars for the Reinforcement of Concrete” (CS2). Same as the concrete cubes, each steel bar specimen is tied with a RFID tag for its unique identity. Upon check-in, MTS verifies the specimen identity with MTS, while the manual markings on the specimen are cross-checked.

Length marks are scratched on the steel bar for determining the elongation during tensile test. While it is an entirely manual process by the conventional method, in MTL it is fully automated. Once a steel bar is placed inside the jig, the length marks with the precision of 0.1 mm are scribed on it by machine automatically.



The specimens are placed inside the “INSTRON” testing machines for tensile test and pulled up to 3,000 kN. The elongation is ascertained by the HK\$50,000-worth extensometer, which is accurate to 1 μm, installed on the testing machines.

INSTRON testing machine for steel bar tensile strength tests

Although Section 1.9 of CS2 requires the Grade 460 steel bars to have 22 % minimum elongation, MTRC projects demands 25 %. The elongation measurement, however, is the only manual undertaking in MTL, because the current technologies do not provide stable and dependable readings for elongation during the tensile test.

### **High Standards**

MTL is accredited to The Hong Kong Laboratory Accreditation Scheme (HOKLAS). The MTL-generated test reports are legally-binding documents and recognised and accepted internationally. Being a network-based operation, MTL is vigilant on the threats from cyber-attacks. MTL equips itself with five (5) sets of back-up system to

warrant the availability of the data. It also engages independent third party auditor to audit its information technology infrastructure (IT), ensuring its robustness and resilience to any IT abnormality.

All measuring devices in MTL are duly calibrated in accordance with their specific calibration schedule to ensure that the measurement uncertainties are within the acceptable limits of the respective devices. Being a HOKLAS testing laboratory, it is capable to perform calibrations in-house. Nevertheless, some devices such as the load cells in the “INSTRON” testing machines are calibrated by external parties. The MTL-performed calibration results are compared with other laboratories to cross-check the calibration precisions.



All measured results are uploaded to the MTL server real-time

MTL opens from 07:00 to 19:00, 365 days a year. Its opening hours may adjust to suit the construction site operations. To maximise the facility up-time under such long working hours, MTL stocks spare parts for the devices available for replacement by its own staff at any time.

The current turn-over of concrete cube testing of MTL is about 800 specimens per day, which is 70 % of the maximum capacity of 1,200 specimens per day. In parallel, MTL tests about 80 % of the 50 mm diameter steel bars consumed in Hong Kong, and is the only non-government in-house material testing laboratory in the territory. Although MTL is not a source of income within the MTRC organisation, it creates HK\$1 million of internal revenue on commercial terms per month at its peak time.

### **Remarks**

Safe and reliable railway infrastructure is crucial to the continuous prosperity of Hong Kong and its building structures must be able to prove their soundness with time. Warranting their quality at the moment of construction is prerequisite, and MTL safeguards the top standard to be maintained for the civil and structural projects of MTRC. MTL excels with its highest productivity, efficiency and profitability, and can be proud of being the role model for the commercial material testing laboratories in Hong Kong. The residents of Hong Kong can be rest assured that the MTRC facilities are quality built and fit to last for decades to come.

IMechE-HKB thanks Mr. Sam Choi, MTRC Senior Engineer, Mr. Chun-Ho Tse and their MTL colleagues for their detailed explanations and demonstrations in the technical visit.

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