Project Title:	Quality Control and Quality Assurance of Asphalt Pavement Construction Using Innovative Nondestructive Methods
Principal Investigator:	Dr Zhen LENG
Project ID:	CICR/01/14
Research Institution:	The Hong Kong Polytechnic University
Subject Area:	Construction Productivity

Objective

1. To evaluate the feasibility and effectiveness of electromagnetic (EM) density gauge and ground-penetrating radar (GPR) as a quality control (QC)/ quality assurance (QA) tool for asphalt pavement construction in Hong Kong.
2. To recommend the most appropriate nondestructive method and the relevant testing protocol for in-situ asphalt mixture density measurement in Hong Kong.

Background

Traditionally, two techniques have been widely used for measuring density of asphalt pavement:

Laboratory testing on pavement cores and on-site testing using a nuclear density gauge. Although the coring method provided accurate density measurement, it was a time-consuming method causing damages to the newly-built pavements. As for the nuclear gauge method, although it can also provide data at discrete locations, radio-active material was a concerns. Alternatively, EM density gauges, GPR and infrared camera are available in the market but little studies have been carried out to assess their applicability in Hong Kong.

Methodology

1. Prepared 36 hot mix asphalt (HMA) testing slabs with different compositions in laboratory to determine the effects of asphalt mixture compositions on the density gauge measurement accuracy.
2. Collected field data from four construction sites, i.e., Po Shek Wu Road, Lau Shui Heung Road, Lok Ming Street and Hong Lok Yuen Depot.
3. Evaluated the feasibility and effectiveness of EM density gauge and GPR as a QC/QA tool for HMA density measurement based on the laboratory and field tests.

Results and Findings

1. The laboratory testing results indicated that the accuracy of the EM density gauges could be affected by various factors, including asphalt mixture gradation, asphalt content, presence of paint and moisture, and gauge calibration.
2. The field testing results showed that:
   I. Temperature of asphalt mixture did not affect the density measurement using either GPR or EM density gauges;
   II. GPR could be used for compaction monitoring during asphalt pavement construction and provide density and thickness profiles of asphalt mat with acceptable accuracy;
   III. Infrared camera could be used for pavement surface temperature distribution monitoring and temperature segregation detection during asphalt pavement construction.

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Recommendations

Based on the findings of this study, the following recommendations were proposed:

- Contractor's QC testing using Pavement Quality Indicator (PQI) and GPR were recommended, and the EM density gauge should be well calibrated before testing.
- Agency independent QA testing using EM density gauges was not recommended.
- GPR system was recommended as a non-destructive tool to provide the surface layer thickness profile of asphalt pavement.
- Real-time monitoring of asphalt pavement density of the entire pavement was feasible based on the GPR measurement.
- Infrared camera could be utilized as an effective tool to detect temperature segregation during asphalt pavement construction.

Guidelines were also suggested for the local pavement contractors to use the nondestructive tools as below.

1. The EM density gauges should be calibrated before use. For each kind of asphalt mixture, at least 5 samples are required for calibration purpose.
2. For improving the measurement accuracy, Mix Calibration is recommended as the calibration method of PaveTracker. PQI should be calibrated following the manual.
3. During asphalt mixture paving, infrared camera can be used to provide the temperature distribution colour map of the laid loose mixture. If the overall mixture temperature is below the lower boundary of the desired paving temperature range, construction should not be continued. For area with relatively lower temperature, more compaction should be applied to make sure its final density is similar to those of other areas and can meet the specification requirement.
4. During the compaction process, GPR measurement should be made after each compaction pass. When the GPR signal reflection amplitudes become relatively constant, the compaction process can be stopped, and the density of the compacted mixture should be verified by the EM density gauge.
5. After the final compaction of the asphalt pavement, the full-coverage 2-D GPR data should be collected. The locations corresponding to the maximum GPR signal reflection amplitude and minimum GPR signal reflection amplitude should be identified, and EM density gauge data should be collected at these two locations as the controlling density values. The density values at other locations can then be estimated to produce a GPR density colour map to give density distribution of the paved asphalt mat.