

Transport and Highway Engineering Laboratory

ZS1108 & ZS1109, Block Z

Department of Civil and Environmental Engineering,

The Hong Kong Polytechnic University

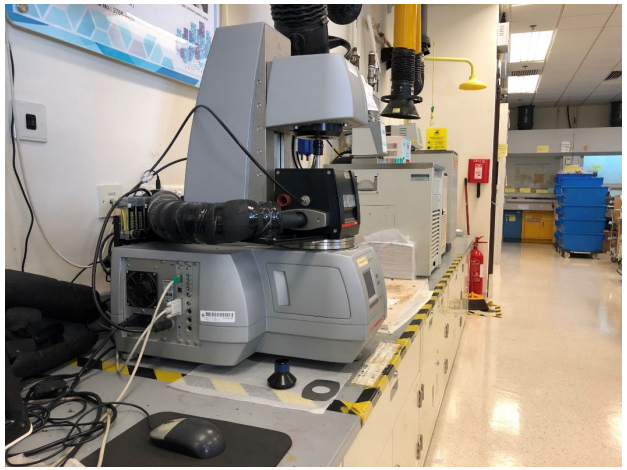
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
土木及環境工程學系

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Introduction

This laboratory caters teaching-related experiments and research activities in Highway Engineering, Traffic Engineering and Transport Planning. The equipment is available for various types of bituminous material and pavement testing and transport related measurement.



The lab equips advanced equipment and software including:

- ELE Penetrometer
- James Cox & Sons Rolling Thin Film Oven
- Anton Paar MCR702 TwinDrive Rheometer
- Control Multi-speed Automatic Compression Testing Machine
- Matest Marshall Compactor
- ELE Marshall Testing Machine
- CoreLok Vacuum Testing Device
- Pavetest DTS-30 Servo-hydralic Dynamic Testing System
- Stanley London Portable Skid-Resistance Tester
- GSSI SIR-30 ROADSCAN SYSTEM
- EMME 4 (software)
- Vissim 10 (software)
- Junction 8 (software)
- Saturn_11 & level H (software)

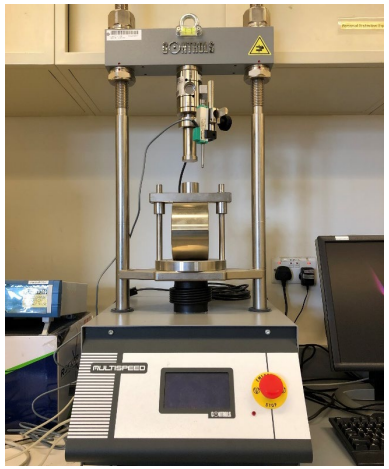
Main Equipment

ELE Penetrometer

Penetrometer is used for measuring the hardness and consistency of bitumen by determining the distance in tenths of a millimeter that a standard needle vertically penetrates the bitumen specimen under known conditions of loading, time and temperature.

James Cox & Sons Rolling Thin Film Oven

The Rolling Thin-Film Oven (RTFO) procedure provides simulated short term aged asphalt binder for physical property testing. Asphalt binder is exposed to elevated temperatures to simulate manufacturing and placement ageing. The RTFO also provides a quantitative measure of the volatiles lost during the ageing process



Control Multi-speed Automatic Compression Testing Machine

Multispeed compression tester is a testing machine with multi-function. It can be used to perform the CBR test, Marshall test and tests under displacement control such as Indirect Tensile test, Quick Triaxial test and Unconfined and Uniaxial soil test.

Main Equipment

CoreLok Vacuum Testing Device

CoreLok Vacuum testing device is a system for sealing asphalt samples so that the sample densities may be measured by water displacement methods. Samples are automatically sealed in specially designed puncture resistant polymer bags. Densities measured with this system are highly reproducible and accurate. Also, the results are not dependent on material type or sample shape.

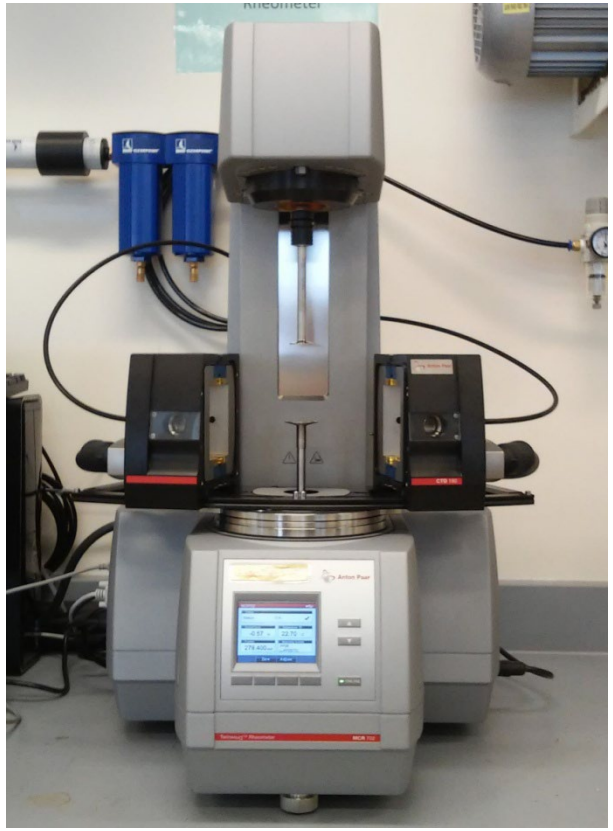
Cooper Pendulum Skid Resistance Tester

The Cooper Pendulum Skid Tester 'CRT-PENDULUM' is a high quality, skid resistance testing instrument. The CRT-PENDULUM measures the frictional resistance between a rubber slider mounted on the end of a pendulum arm and the test surface. This provides highway engineers with a routine method of checking the resistance of wet and dry surfaces to slipping and skidding, both in the lab and on site.

GSSI SIR-30 ROADSCAN SYSTEM

GSSI SIR-30 RoadScan system can quickly collect pavement layer thickness data. The system acquires data at highway speeds, which eliminates the need for lane closures and provides a safer working environment.

Main Equipment



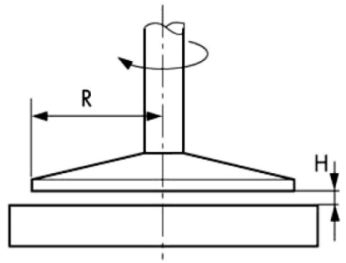
Anton Paar MCR 702 TwinDrive Rheometer

Dynamic shear rheometer (DSR) is used to characterize the viscous and elastic behavior of bitumen and other soft materials at different temperatures and test frequencies.

For general use, The DSR measures a specimen's complex shear modulus (G^*) and phase angle (δ).

In studying bitumen, G^* and δ are used as predictors of rutting and fatigue cracking behaviors of bituminous mixtures.

Asphalt binder is sheared in a narrow gap between parallel plates



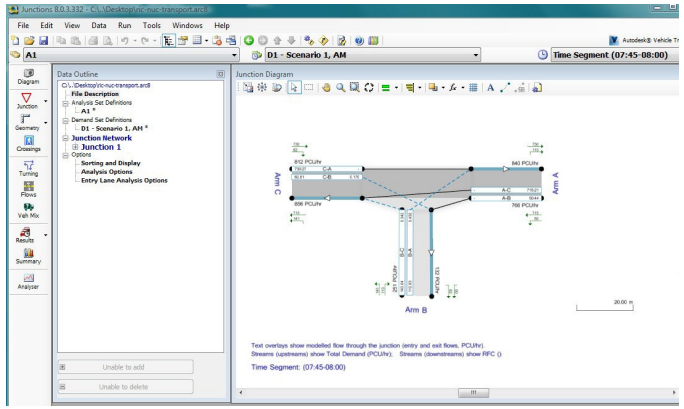
Main Equipment

Pavetest DTS-30 Servo-hydraulic Dynamic Testing System

DTS-30 Dynamic Testing System is a servo-hydraulic testing machine utilizing digital control of a high performance servo valve to provide accurate loading wave shapes up to 100 Hz.

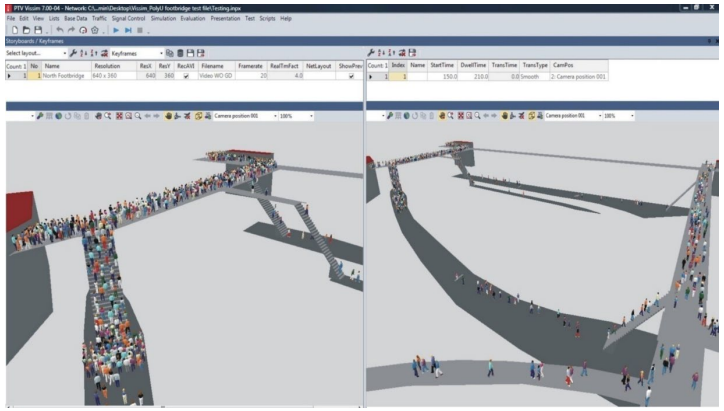
The DTS-30 can be operated in tension, compression dynamic loading and is suited to testing a diverse range of materials such as asphalt, soil, unbound granular materials, fibres and plastics.

Software



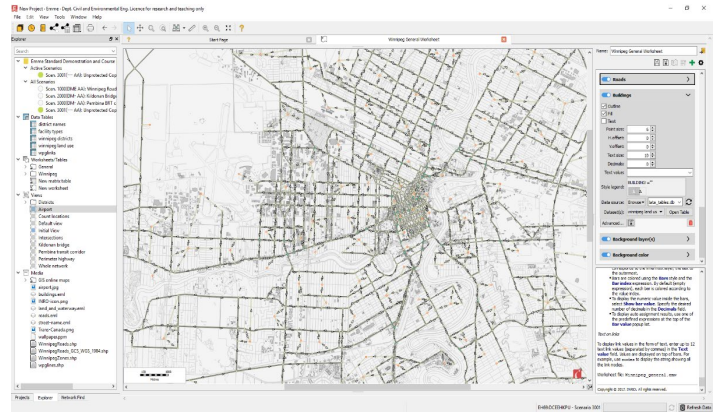
Junction 8

Junctions 8 is the internationally-recognised computer program for predicting capacities, queue lengths and delays (both queueing and geometric) at non-signalised roundabouts.



Vissim 10

Micro-level transport modelling software package for the evaluation and planning of urban and extra-urban transport infrastructure.



EMME 4

Macro-level transport modelling software for urban, regional and national transportation forecasting

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Research Spotlight

Reliability-based Intelligent Transportation Systems in Urban Road Network with Uncertainty

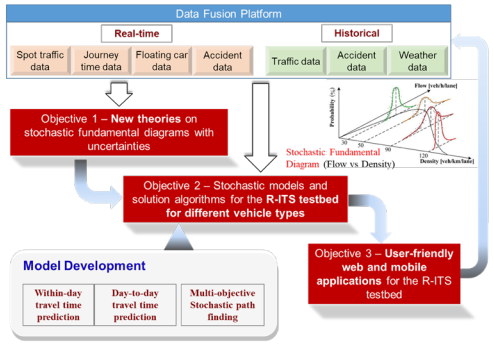
Introduction

Like many other major Asian cities with serious road traffic congestion problems due to relatively high traffic accident rates and annual rainfall intensities, the potential benefits to be gained from exploration of Intelligent Transportation Systems (ITS) for alleviation of these problems in Hong Kong can be substantial particularly for road networks with travel time uncertainties. This project opens new ways of thinking for developing and deploying **Reliability-based ITS (R-ITS) testbed** in congested road networks in Hong Kong as well as other major Asian cities. The project explores new approaches and techniques, and possibly new theories, to enhance the existing ITS for **improving the efficiency and reliability of urban road networks with uncertainties due to traffic incidents and adverse weather**.

Project Objectives

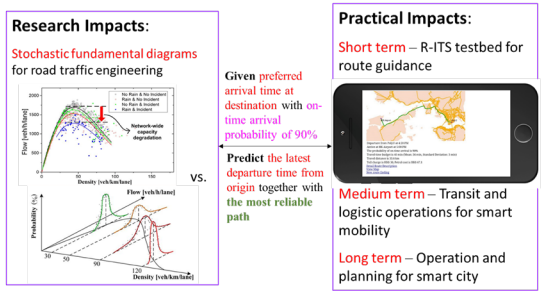
1. To pursue **new theories on stochastic fundamental diagrams** between road link and network under uncertainties in traffic demand and network capacity with stochastic variations over time.
2. To develop stochastic models and solution algorithms for the **reliability-based Intelligent Transportation Systems** (R-ITS) testbed for **different vehicle types** in Hong Kong road network with uncertainties due to adverse weather and traffic incidents.
3. To develop user-friendly web and mobile applications for the R-ITS testbed **for disseminating the quantified uncertainty effects of adverse weather and incidents** on road network in Hong Kong.

Overall Research Framework



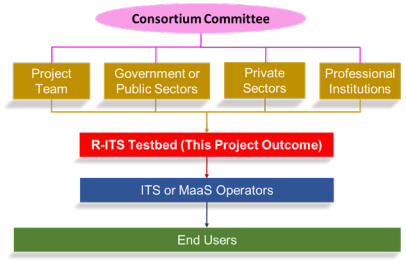
Research and Practical Impacts

Integration of theories and practice



Consortium of ITS Testbed

To establish the ITS testbed **user groups** who can **share and utilize the ITS data** and to ensure the sustainability and full utilization of the proposed ITS testbed for smart mobility in Hong Kong.

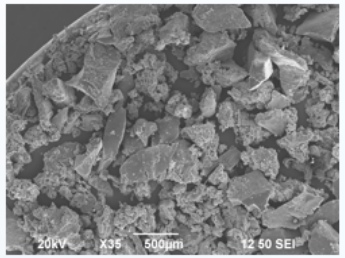


Research on Warm Asphalt Rubber Pavement

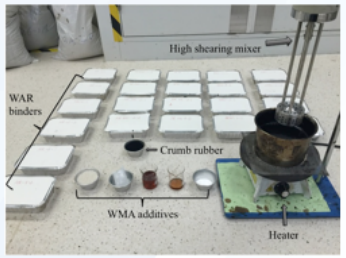
Introduction

Warm asphalt rubber (WAR) is a sustainable paving material which combines the merits of warm mix asphalt (WMA) and asphalt rubber (AR). It brings benefits, such as enhanced rutting resistance, improved durability, efficient waste management, healthier construction environment and low tyre-road noise. These benefits make WAR extremely attractive to high-density cities, like Hong Kong. Dr. Leng and his research team have worked on a RGC project to optimize the formula design of WAR pavement for local condition and investigate the interaction mechanism of this paving material. The major research tasks of this project include:

- Evaluation of rheological properties of AR and WAR binders
- Investigation of component interaction of WAR binders
- Evaluation of mechanical performance of WAR mixtures
- Life cycle assessment of WAR pavement



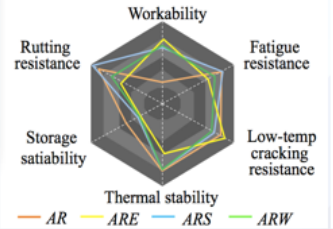
Micro structure of crumb rubber



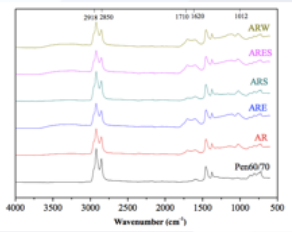
Binder samples prepared at ZS1108

Recent Research

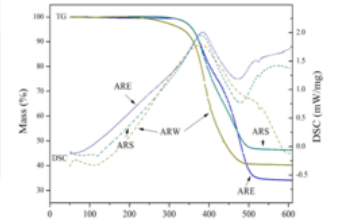
Several WMA additives with different working mechanisms have been selected and applied to modify AR binder. The rheological properties of AR and WARs were evaluated by Dynamic shear rheometer (DSR) while their component interaction were studied by various chemical tools. It was found that: 1) all WMA additives enhance AR's workability; 2) different WMA additives have different effects on AR's rheological properties; and 3) WMA additives promote the dissolution of crumb rubber in base asphalt.



Performance of WAR binders



FTIR spectrums of WAR binders



Extracted source	Oil components (%)	NR and SR (%)	Fillers (%)
AR	1.7	72.2	26.1
ARE	0.8	64.6	34.6
ARS	0.9	52.9	46.2
ARW	5.4	55.3	39.3

Thermal Analysis of extracted rubber for WARs

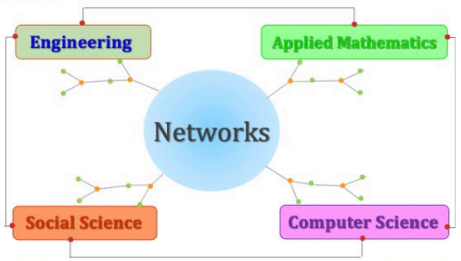
* ARE-AR with Evotherm-DAT; ARS-AR with Sasobit; ARES-AR with combined WMA additives; ARW-AR with 56# paraffin wax

Research Spotlight

Research on Transportation Network Analysis

The Multidisciplinary Paradigm

The transportation engineering paradigm has recently emerged as a revolutionary approach to tackle the challenges posed by modern urban areas. By leveraging on information and communication technologies (ICTs), Smart Cities promise to make more efficient use of the physical infrastructure and resources, to learn and adapt to changing circumstances more effectively, and to engage effectively with citizens in local governance. However, such ambitious goals can be achieved only thanks to advanced data management and modelling, and enabling technologies, through a multi-disciplinary approach, and by a close cooperation among researchers with different, complementary interests and innovation attitude.

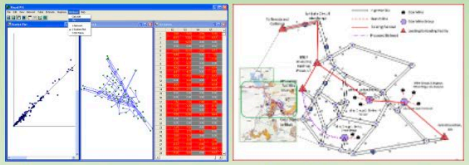


Network Reliability & Vulnerability Analysis

One of the top 50 most cited papers published in the Transportation Research Series

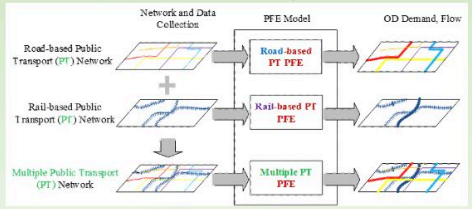
Decision support systems for transportation network vulnerability analysis

Path Flow Estimator (PFE) with Applications



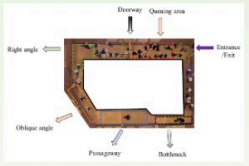
Passenger demand forecast

Freight demand forecast

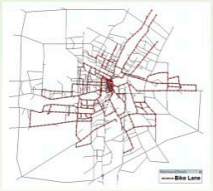


Public transport forecast

Active Transportation



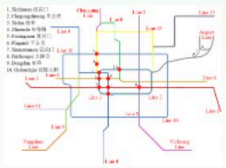
Pedestrian



Cycling

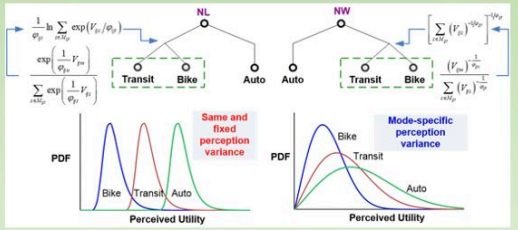
Railway Transportation

Automated map drawing tools

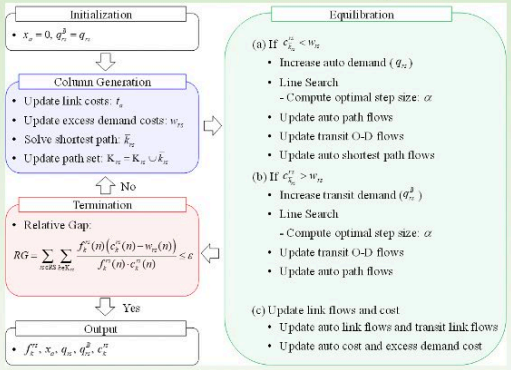


Urban rail network analyses

Network Modeling with Discrete Choice

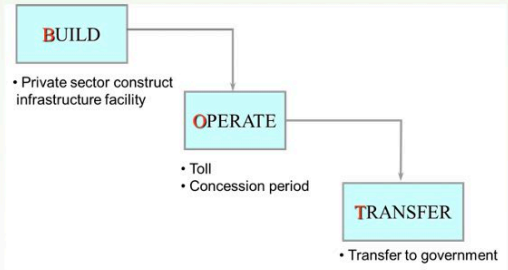


Weibit-based network modelling

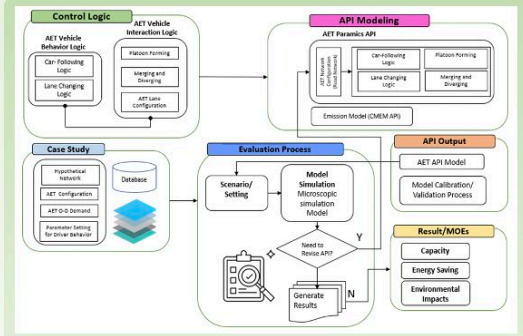


Traffic assignment algorithms

Civil Infrastructure Problems



Build-Operate-Transfer (BOT) infrastructure projects

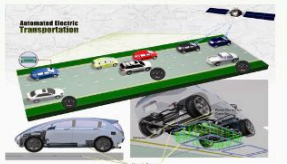


Automated electric transportation

PFE with Emerging Technologies

Availability of big data

Smart mobility (ride share)



Vehicle Technologies

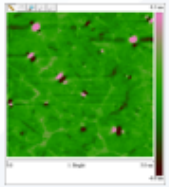
Research Spotlight

Characterization of Physicochemical Properties of Bitumen and Bituminous Mixtures

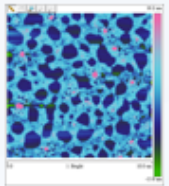
Introduction

Bitumen is used to manufacture a variety of building materials and to construct different types of civil engineering infrastructures. Highway pavements made of bituminous mixtures are perhaps the most massive civil engineering structures on earth. In this lab, we study the fundamental physicochemical properties of neat and modified bitumen and bituminous mixtures, and apply the gained scientific principles to engineering practices. Examples of our research studies include:

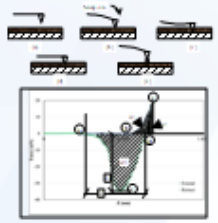
- Fundamental physicochemical properties of bitumen
- Bitumen aging
- Applications of physicochemical characterization in quality control
- Applications of physicochemical characterization in developing new modified bitumen
- Modeling and optimization of bituminous mixture design



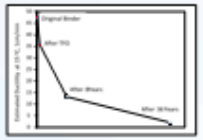
The Peculiar "Bee" Structure in Bitumen



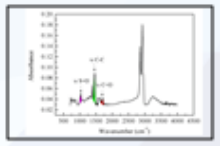
The Asphaltenes in Bitumen



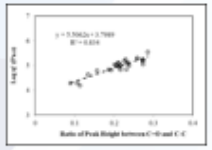
The Force-Distance Curve of Bitumen Obtained from Nano-indentation Test



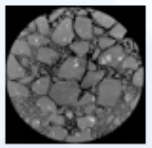
The Changes of Bitumen Engineering Properties with Aging



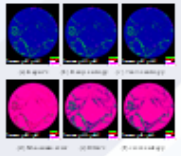
The Changes of Bitumen Chemical Compositions with Aging



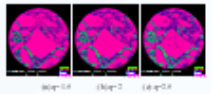
The Connections between Engineering and Chemical Properties



The Fractured Bituminous Mixture



Segmentation of Bitumen, Air Voids, and Aggregate in CT Images



Improved CT Image Segmentation by Using Newly-developed Equations

New-generation Low-noise Rubberised Road Surface

As one of the most densely populated cities in the world, Hong Kong has more than one million people who are affected by excessive traffic noise. Thus, continuous effort has been made by local government to search for the durable low-noise road surfaces (LNRS).

Dr. Zhen Leng and his research team at the Hong Kong Polytechnic University (PolyU) have been dedicated to developing sutainable solutions for Hong Kong's road network since 2012. Specifically, they have developed the new-generation LNRS which is built with waste tyre rubber, conventional bitumen, warm mix additive, and small-sized aggregate with custom-designed gradation.

Such road surface has been proven to be more durable than the conventional bituminous road surface while producing low construction emission. Moreover, it can help recycle approximately 3.5 tons of waste tyre per lane-km and its road-tyre noise is at least 3dB lower than the conventional road surfaces. These significant environmental benefits have been recognized by the 2018 Hong Kong Green Innovation Award. In addition, three government particular specifications regarding producing and recycling the new-generation rubberized asphalt pavements have been developed, which introduced a new "green" pavement material to Hong Kong and kicked off its wide application locally.

Waste tyre

Crumb waste tyre rubber

Warm mix additive

Low Emission Paving

CPX lorry

Lab-in-charge and Technical Staff

Lab-in-Charge

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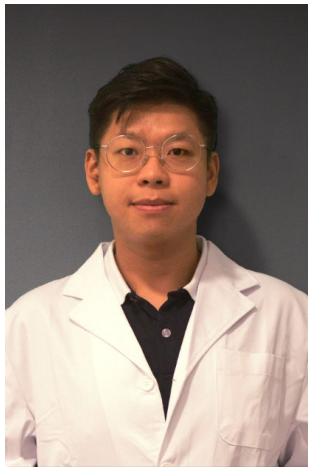

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(excluding Saturday, Sunday & public holidays)