Internship report

Internship completed from July 6th to August 28th 2015 at

organized by:

International Association for the Exchange of Students for Technical Experience

Supervisor:

- **Dr. HUNG Wing-tat (Associate Professor, Department of Civil and Environmental Engineering, PolyU Hong Kong)**

Intern:

- **Lucien Zeller (Master student in Civil Engineering the Swiss Federal Institute of Technology EPFL)**

Content

I. Introduction

Incorporated to the Civil Engineer study program, the professional internship's main aim is to introduce the Bachelor students to the main skills of the Civil Engineer. The majority of undergraduated students decides to fulfil this task during summer break before starting their master.

The Swiss Federal Institute of Technology (known as EPFL: Ecole Polytechnique Fédérale de Lausanne) demands from its students to fulfil a two months' professional internship before starting the Master project (4th semester of master's degree). It is very important for young engineers to know not only the theoretical part of its study but also the practical one.

Every year the organization IAESTE proposes several internships to students all over the world. One of them was referring to a lab project in the department of Civil and Environmental Engineering in Hong Kong Polytechnic University.

The Hong Kong Polytechnic University (better known as PolyU) proposed this year (2015) an internship in the framework of the research program: **Low Noise and Air emissions Road Pavement Surfaces**. However the program slightly changed upon my arrival and I had the opportunity to collaborate on another project: **Clean Air Asia exchange programme**.

In the framework of these two projects I could conduct by myself mechanical tests on pavement samples and participate to measurements of road noise level and air quality inside buses.

All these experiences were obviously supervised by professionals and none accident nor safety problem occurred during my whole involvement with PolyU.

II. List of abbreviations

HK	Hong Kong
CPX	Close-Proximity: Equipment to measure level of road noise
CAA	Clean Air Asia
$PM_{2.5}$	Particular Matters (less than 2.5 mm)
VOC	Volatile Organic Compounds
ITST	Indirect Tensile Stress Test (non-destructive test to measure stiffness modulus at a selected horizontal stress)
ITFT	Indirect Tensile Fatigue Test (destructive fatigue test for fatigue resistance assessment)
EPD	Environment Protection Department (HK)
PolyU	The Hong Kong Polytechnic University
LVDT	Linear Variable Differential Transducer
WHO	World Health Organization

III. Activities realized

A. Summary

During my stay, I could take part in two different projects above mentioned. Subsequently, I will enumerate all the activities I could carry out. In appendix the everyday activity programme is provided followed by measurement results.

1. **Low Noise and Air Emissions Road Pavement Surfaces:** located at the laboratory facilities of PolyU in Hung Hom and Fo Tan, Hong Kong.
    - Physical preparation of bitumen samples (sieving, washing and weighing mixed aggregates, compacting the finished samples)
    - Testing asphalt samples (Marshall stability and flow test according to the American Standard for Testing and Materials D6927, ITST/ITSM (cf. List of abbreviations), ITFT (cf. List of abbreviations))
    - Participation to CPX measurements.
    - Participation of road milling, pavement pouring and the entire process from closing to reopening of a road lane
    - Preparation of VOC canisters to be collected when preparing bitumen samples and data extraction

Supervisors: Wing-Tat Hung, Lin Shiying

2. **Clean Air Asia exchange programme:** located at POlyU in Hung Hom.
    - Air quality survey inside buses using portable equipment: PM 2.5 data collection device, NOx data collection device and VOC canisters.
    - Data analysis of surveys

Supervisors: Wing-Tat Hung, Debolina Banerjee, Hoa Pham Ngoc

B. Details of activities

1. Low noise and Air emissions road pavement surfaces

The main goal in this project was to develop an asphalt mixture which is quiet (low noise). Furthermore this mixture should comply with environmental requirements such as a low emission of VOC and $PM_{2.5}$. Our research work was focused on two types of asphalt layers: Stone Mastic Asphalt (SMA) and Friction Course (FC). The former is resistant, durable, dense (surface of SMA is smooth and openings can hardly be seen) and can support heavy traffic loads. The latter is sensitive to chemicals, usually not durable, abrasive and weak. Cracks and isolated gravels can often be seen. However it has the advantage of being quiet but needs subsequently frequent maintenance interventions. The goal was thus to create a mixture whose features are in between these two asphalt mixtures.

The first idea was to add rubber to improve durability of FC mixtures. However adding rubber to this mixture brings also disadvantages. It increases mixture temperature when pouring it. Accordingly odour represents a problem. To face this problem it was decided to add chemicals in order to decrease temperature and disturbing smell.

As an overview Eng. Lin Shiying and I prepared 4 different types of asphalt mixtures during my stay with her:

- PMFC 10 (PM stands for Polymer Modified)
- SMA 10
- PMSMA 6
- SMA 6

a. Preparation of asphalt samples

My first contribution to this research project was to help with time consuming work at the lab. This was to prepare samples which would be tested afterwards. The preparation process included:

- Sieving aggregates
- Washing sieved aggregates
- Weighing washed and sieved aggregates (see picture below)
- Heating prepared aggregates and bitumen to preparing temperature (ca. 160°C)
- Mixing bitumen and aggregates to obtain typical geometrical shapes of samples. At this time it was necessary to collect $PM_{2.5}$ emission as we did with the equipment shown in the figure below.

Figure 1: Containers with separated aggregate sizes before weighing (from 10mm diameter to fillers (<75 microns))

Figure 2: Picture taken by preparing the mixture. Legend : 1. Mixture 2. Equipment measuring $PM_{2.5}$ content 3. VOC canister collecting air sample

- Moulding and compacting the mixture. After having moulded standard compaction was performed with the machine shown below.
- Unmoulding.

Typical dimensions of samples (which is like a cylinder) were:

- Diameter: approx. 102 [mm]
- Thickness: approx. 64 [mm]

Figure 3: Compaction equipment. Legend : 1. Hammer 2. Moulded sample

b. Mechanical tests

The objective with these samples was to compare their performance according to following criteria.

- Mechanical properties:
  - Marshall stability and flow test
  - ITSM test: Stiffness modulus
  - ITFT test: Fatigue resistance
- Acoustic properties:
  - Close proximity method (Noise level)
- Emission behaviour evaluation
  - $PM_{2.5}$
  - VOC content

Unfortunately my contribution to the project did not last long enough to obtain expected comparison results. Thus I could only participate in many kinds of lab standard tests and sharpen my knowledge of lab experiments.

First of all mechanical properties were tested. Samples were tested to Marshall stability flow test according to ASTM Standard D6927.

"This test method covers measurement of resistance to plastic flow of 4 in. (102 mm) cylindrical specimens of asphalt paving mixture loaded in a direction perpendicular to the cylindrical axis by means of the Marshall apparatus. This test method is for use with dense graded asphalt mixtures prepared with

asphalt cement (modified and unmodified), cutback asphalt, tar, and tar-rubber with maximum size aggregate up to 1 in. (25 mm) in size (passing 1 in. (25 mm) sieve)."[1]

The aim is to obtain flow and stability of the sample. As mentioned in the standard D6927 significance of this test is "to monitor the plant process of producing asphalt mixture. Marshall stability and flow may also be used to relatively evaluate different mixes and the effects of conditioning such as with water."[2]

These two parameters are determined thanks to a destructive test performed with the Marshall machine (see Figure below). The equipment uses load cells and linear variable differential transducer (LVDT) in order to obtain peak values of load (Stability) and deformation (Flow). The typical load-deformation curve is shown on Figure 5.

Figure 4: Machine used for Marshall test (in the middle a sample can be seen)

All results of our tests without analysis are shown in Appendix 2.

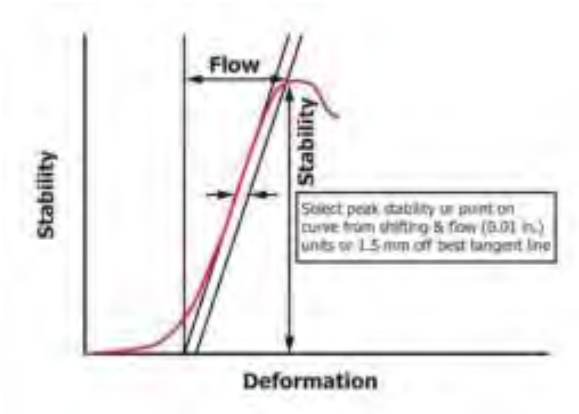


Figure 5: Typical stability vs. flow curve during testing

[1] ASTM: Designation 6927: 1. Scope

[2] ASTM: Designation 6927: 4. Significance and Use

Secondly ITST/ITSM[3] test had to be performed as well. PolyU had laboratories in the suburb of Fo Tan a bit remoted from city center.

ITST's aim is to obtain stiffness modulus of samples. For this test it is very important to start testing only when room temperature is equal to 20°C. Besides previous tests showed that a difference of 1°C can lead to a difference of 10% in stiffness modulus. Therefore it was important to wait until room temperature dropped at 20°C before starting. Tests were performed in a conditioned fridge.

Samples are attached to a specific mould and an actuator administers a load vertically onto the sample in a short amount of time. In parallel two LVDT recorded horizontal displacements on each side of the sample as shown on the screenshot below.

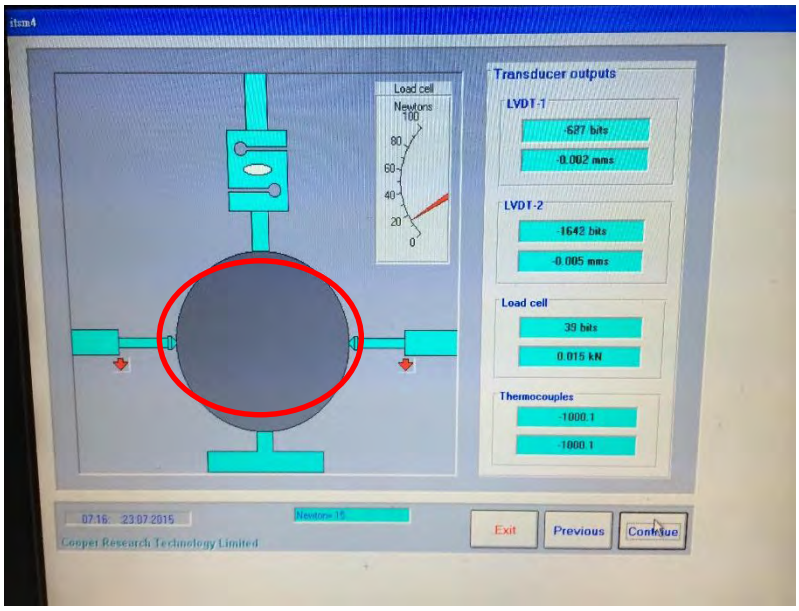


Figure 6: Screenshot of sample with vertical actuator and LVDT attached on each side. The red shape represents the sample deformed. LVDTs are compressed.

Typical result table is shown on the screenshot below. Detailed results are shown in annex 2 (Results of experiments).

Despite bad quality of screenshot 5 result columns can be seen. They represent from left to right

1. Pulse number (mean value of 5 pulses stiffness modulus is considered).
2. Vertical force [kN]
3. Horizontal stress [MPa]
4. Risetime [s e^{-3}]
5. Horizontal displacement [microns]

From these inputs stiffness modulus can be computed in [MPa]. This is visible on last colums.

On the screenshot below results of a PMFC10 can be seen. In order to avoid wrong measurements each sample was always tested twice. That is to say once along two diagonals perpendicular to each other.

[3] Difference between ITST/ITSM is simple. ITST test computes stiffness modulus with horizontal stress constant over time (here 250[kPa]. ITSM test computes stiffness modulus with constant horizontal deformation over time.

Figure 7: Screenshot of typical ITST results. In red values of stiffness modulus measured.

Last mechanical test performed in Fo Tan was ITFT (which stands for Indirect Tensile Fatigue Test). This test is destructive. The sample is placed in the machine (as shown on the picture below) and cyclic loads are administered to the sample. Samples are supposed to break before a settlement of 10 mm approximately. For samples whose diameter is bigger than 100 [mm], it is common to set an upper limit of 10 [mm] for settlement.

The aim of this test is to obtain fatigue resistance. Results are shown in Appendix.

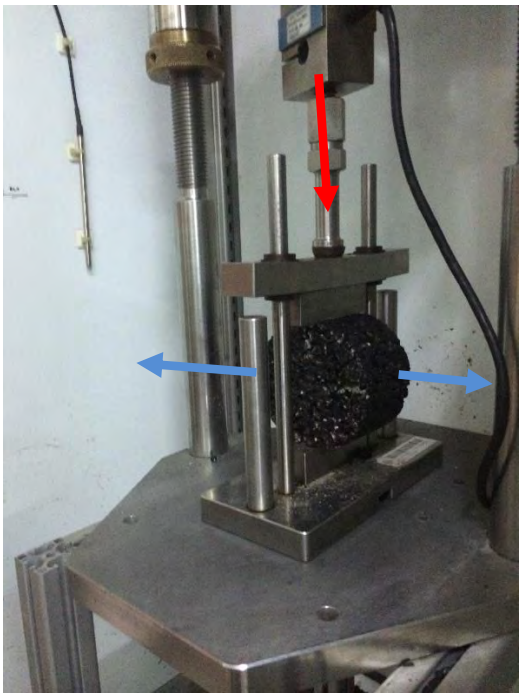


Figure 8: Sample installed in the fridge (test at 20°C)) for Fatigue resistance test. Red arrow stands for load direction and blue arrows for direction of main deformation. Main crack will appear in parallel with load direction

c. CPX measurements

To measure acoustic performances of asphalt layer, a polyU designed Close-Proximity device was used to measure "in situ" level of noise of asphalt layer. Two measurements were performed in total. To do this properly road surface had to been dried and in order to avoid any dangerous situation it was more suitable to take measurements not during normal working hours. That is to say during the night when traffic was rather low.

Principles of use of equipment is the following. A trailer with CPX is attached behind a truck. The trailer has two standardised wheels and microphones are attached nearby to record level of noise. As these microphones are rather sensitives, it was necessary to protect them against dust and aggregates which might be projected by wheels.

The first figure below shows an overview of the trailer and zoomed pictures of a wheel surrounded by microphones. It is important to place the wheel in a box protected from disturbing surrounding interferences (engine noises, surrounding noisy establishments (restaurants, bars), etc.) This kind of measurements has to be performed many times because wrong results can easily be recorded. Therefore it is also very important to be attentive to specific event which might explain insignificant peaks in results such as potholes (holes on the pavement) or rut. That's means it is essential to pay attention to general state of road surface.

Results of different road surface noise level is shown in Appendix 2. It can be noticed that aggregates size seems to have the most noticeable influence on road noise. Once again I was not responsible for data analysis. Therefore results are only shown without any comment.

Figure 9: General overview of the trailer

Figure 10: Zoomed picture of right wheel.

Figure 11: Zoom on the microphone placed next to the wheel

d. Participation of road pavement replacement

As a reward and for my last day of internship I had the opportunity to attend a complete process of road pavement pouring. This means the intervention from road closing to reopening. Our only task this day was to collect air sample for VOC analysis. Therefore my supervisor Lin Shiying and I could perfectly witness the whole process.

The process is completed through following steps.

- Road closing and safety equipment is installed
- Pavement milling
- New asphalt layer pouring (air sampling at the same time)
- Road roller flattens new asphalt layer
- Raw asphalt samples and compacted asphalt samples are collected for quality insurance
- Flatness (evenness) measurements
- Painting of markings on the new asphalt layer
- Reopening of road to traffic

Here under are displayed some photos of the total intervention which lasted around 6-7 hours from 9am to 4pm approximately. The surprise of this day was to see how good was organization and coordination with all different operators of this intervention.

Figure 12: New asphalt is being poured and distributed by workers

Figure 13: Workers are pasting adhesive tape for road markings

e. Preparation of VOCs canisters and data extraction

For each intervention when Eng. Lin Shiying and I had to collect VOCs data. I was responsible to prepare canisters and extract data after sampling.

This process was simple. Basically canisters had to be fulfilled by hot air (around 200°C) until a certain pressure and then emptied. This cyclic process had to be done three times before canister is considered as ready for sampling according to standards.

When air samples are full VOCs concentration could be extracted with an equipment which allows to perform GCMS analysis (GCMS Gac Chromatography Mass Spectrum). This analysis extracted VOCs concentrations.

2. Clean Air Asia exchange programme

In this project I had the opportunity to collaborate with Ms. Debolina Banerjee and Mr. Pham Ngoc Hoa[4] from India and Vietnam respectively. When I joined the team both of them were working on the project named "Health Impacts of $Pm_{2.5}$ and VOCs in Kolkata, India and Hanoi, Vietnam". This project is a part of the bigger organization called Clean Air Asia[5]. It is basically "[…] an international non-governmental organization that leads the regional mission for better air quality and healthier, more livable cities in Asia."[6]

Ms Banerjee and Mr. Ngoc Pham had previously taken measures of air quality inside different bus lines in their respective cities. My participation in the project was to perform the same measurements in the city of Hong Kong in order to compare results with Kolkata and Hanoi. The scope of this study is to identify most polluted locations in HK. Are they acceptable according to WHO limits in terms of VOCs, $PM_{2.5}$, and NOx? And according to HK standards? In this project we worked in collaboration with EPD for our equipment calibration. This kind of data could be used for many purposes. Previously Ms. Banerjee had lead a survey assessing air quality inside and outside schools in Kolkata. Ms. Banerjee analysed in the framework of her study which could be the causes of bad lung functions in schools in Kolkata. This in order to make air quality better in her city. I was very lucky to work with her and Mr. Ngoc as they already did this kind of experiment previously and were experimented.

Unfortunately again for this project I did not have the chance to stay long enough to participate in the whole analysis process. My goal was mainly to collect data and report all relevant informations to Ms. Banerjee and Mr. Pham Ngoc who were responsible for the project.

My responsibility was then to take all the measurements for the city of HK. Therefore in collaboration with our supervisor Dr. HUNG, we (Ms. Banerjee, Mr, Pham and I) had to plan different bus routes in HK which passed through relevant city suburb for comparison purposes.

All measurements had to be performed gathering worst conditions we could have for air quality. Thus all measurements had to be done with dry weather because this is the critical weather for air quality. Besides we expect traffic to be source number 1 of pollution. Therefore we chose to do these measurements during peak hours. That is to say three times a day (morning peak, noon peak and evening peak).

This kind of survey can also be full of wrong data and it is also very important to write down every event which can be the cause of discrepancies (weather, conditions of road, traffic jam, bus route next to an industrial area with high polluting activities etc.). Of course informations like age of bus, last maintenance date and any particular special event had to be reported. One measurement of one route is not enough to have a reliable results. Therefore each route was done six times. Two times for each peak of the day. In total that makes two days per route.

It is also known that pollution is being accumulated throughout the day. Logically highest values should appear for evening peaks. Sometimes this was not the case. These data can bring many informations about pollution state in HK. We had to sort this information because sometimes it

[4] Both of them are exchange students for the Department of Civil and Environmental Engineering at polyU participating in an exchange program funded by Fredskorsept, Norway
[5] http://cleanairasia.org/
[6] Quote from webpage cleanairasia > about us.

could be not relevant. Furthermore to explain high or low values of pollution concentration we had to take into account many parameters like road width, average speed of the bus, idle position time, topography, land use, location of survey inside buses, traffic conditions etc. This is only by considering as many aspects as possible that it is possible to explain our results.

First route was a circular one on HK Island from and to Chi Fu Fa Yuen (Bus number 37B). This route had the advantage to pass through the whole city center of HK Island and Aberdeen Tunnel. Second route starts at Mei Foo and crosses from North to South Kowloon and the Cross Harbour tunnel close to University to finish its route at Sheu Kei Wan on HK Island (Bus route number 102). Third route was only on the mainland. It started at Mong Kok Bus terminal and travel through Mong Kok (very busy part of the city) to finish in Tsuen Wan close to Nina Tower (Bus route number 33A). These routes are shown on screenshot of maps here below.

Throughout all these routes scope was to measure concentration of $PM_{2.5}$ VOCs and NOx inside the bus. Main results are shown in Appendix 3.

Figure 14: Bus route of number 37B

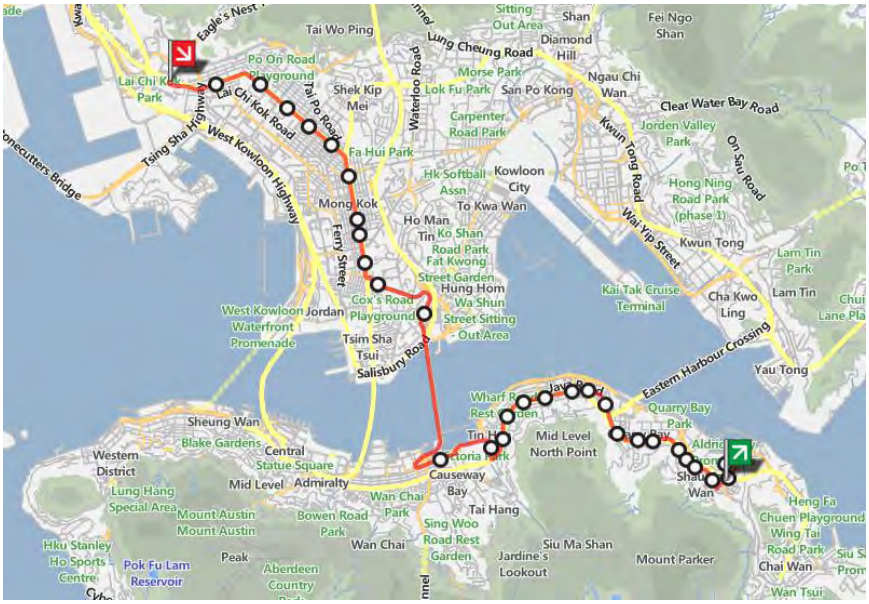


Figure 15: Bus route of number 102

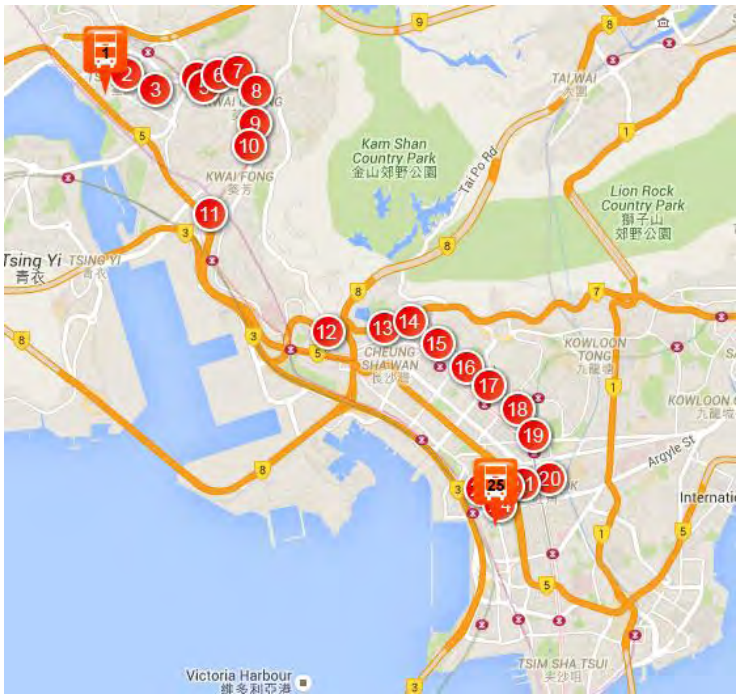


Figure 16: Bus route of number 33A

Air quality inside bus route is rather good and this is mainly a reason which can influence the mode of transportation of people. Is the bus a fast transportation mode and is it clean besides? All these questions can be answered thanks to data analysis of our study. In Appendix two examples of results are shown and these graphs are useful to explain which part of the route is the most polluted and thanks to mean values which route is the most polluted.

IV. Conclusion

In conclusion I must say my apprenticeship in Hong Kong was very rich.

Indeed I was able to see how tests on asphalt samples are performed in the lab and many aspects of problems and constraints someone who leads a study must face. Especially if samples are rare and the researcher has to take care of them.

For Clean Air Asia project it was very gratifying to understand how many aspects I should consider when I lead a study with many different parameters which could explain my results. Indeed air quality is always influenced by many factors and this is hard to identify which ones are the most relevant among others.

Figure 17: Me sightseeing by carrying all the equipment for survey between peak hours

Besides contributing to a project with many other work colleagues from different countries and cultures has increased my ability to work and understand people. It is sometimes very difficult to agree on fundamental points and I was very happy to notice my collaboration with my colleagues in both projects was successful. By experience I know sometimes working in an international environment can be rude in terms of understanding. This point is very important for me.

My biggest regret was not to have stayed long enough to follow these two projects until final conclusions and results are made. I am proud to have received responsibilities for measuring and support my colleagues in their studies but frustrating not to have stayed until the end.

I am very convinced by HK and its way of living. I do not exclude the possibility of applying for jobs after finishing my studies.

This experience is unique and I am sure it will influence positively my vision on future projects.

V. Acknowledgement

I would like to thank IAESTE Switzerland and Hong Kong for their organization and welcome. I could not have imagined to get a better welcome. Cultural activities during week-ends and free time were unbelievable. It was awesome to have people (other trainees and local welcome committee) ready to support, introduce and help throughout our whole stay in HK. I had already come to HK two years ago on vacation but living here and spending time working with local people are much more valuable.

I would like to thank also all my work colleagues (Eng. Lin Shiying, Ms. Debolina Banerjee, Mr Hoa Pham Ngoc) and supervisor (Dr. HUNG) for their help, support and understanding throughout my summer in HK. I spent an unforgettable time with them and I hope future will make our paths cross some day again.

VI. Appendix

1. Appendix 1: Everyday activity table

Internship at PolyU university 2015 Table of activities			
Date		**Programme/activities**	**Supervisor**
Week 1	2015/07/06	Welcome and preparation of office Monday Evening: CPX measurements	Wing-Tat HUNG (WTH)
	2015/07/07		
	2015/07/08	Calibration of PM2.5 device in HK	
	2015/07/09	Working in the lab helping to prepare the sample (washing aggregates; cleaning canister for samples) + visit and attendance of pavement preparation in Fo Tan	Lin Shiying (LS)
	2015/07/10		
Week 2	2015/07/13	Meeting with WTH + Cleant 8 canisters	LS WTH
	2015/07/14	Preparation of samples 16 (binder, aggregates, compaction test)	
	2015/07/15	Work in the lab (unmoulding the samples, weighted and took dimensions) Afternoon: presentation of DB and HPN	
	2015/07/16	Test in the lab (Compressive test) First try to analyse VOCs concentration of canisters.	LS
	2015/07/17	Weighed the samples in Fo Tan Organization of bus measurements (HK)	LS

Week 3	2015/07/20	VOC Analysis at environmental lab Started writing internship report	LS
	2015/07/21		
	2015/07/22		
	2015/07/23	Fo Tan: performed ITSM, ITST and ITFT tests.	
	2015/07/24		
Week 4	2015/07/27	Fo Tan: performed ITSM, ITST and ITFT tests.	LS
	2015/07/28	Organisation of routes for buses surveys + EPD	Debolina Banerjee (DB) Hoa Pham Ngoc (HN)
	2015/07/29	Preparation of Bus surveys (route choice, equipment)	
	2015/07/30	First Bus survey (route 37A)	
	2015/07/31	Calibration of PM2.5 device in HK	
Week 5	2015/08/03	Bus survey	DB HN
	2015/08/04		
	2015/08/05		
	2015/08/06	Check results from first surveys	
	2015/08/07	Last bus survey of the week + Analysis of existing data and preparation of next one	DB HN
Week 6	2015/08/10	Bus survey #33A but interrupted because of rain	DB HN
	2015/08/11	Bus survey	DB HN WTH
	2015/08/12	Bus survey	DB HN WTH
	2015/08/13	Preparation of material for next survey Documentation about pollutants	DB HN

	2015/08/14	Documentation about pollutants	WTH
Week 7	2015/08/17	Meeting with Dr. HUNG Bus survey Data Analysis	WTH DB
	2015/08/18	Bus survey data analysis	
	2015/08/19		
	2015/08/20		
	2015/08/21		
Week 8	2015/08/24	Meeting Dr. HUNG Work lab (preparing new samples)	WTH LS
	2015/08/25	Work Lab Preparing new pavement samples Finalizing data analysis for bus survey	WTH LS
	2015/08/26		
	2015/08/27		
	2015/08/28		

2. Appendix 2: Results of experiments and measurements in Low Noise pavement project[7]

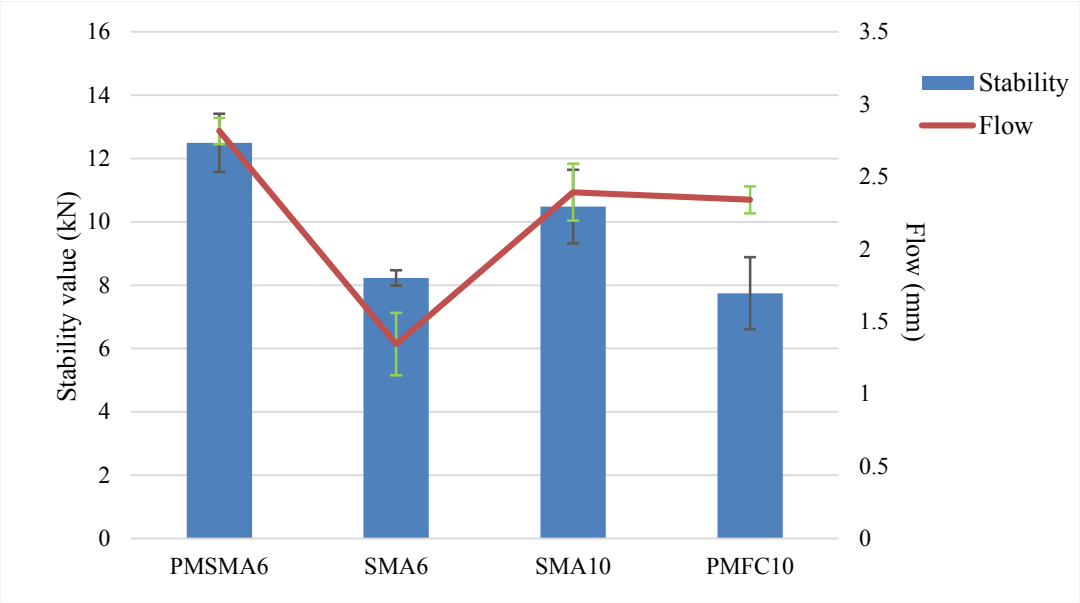


Figure 18: Results of stability and flow tests for different mixture tested (green and black beam cross section represent maximum and minimum values)

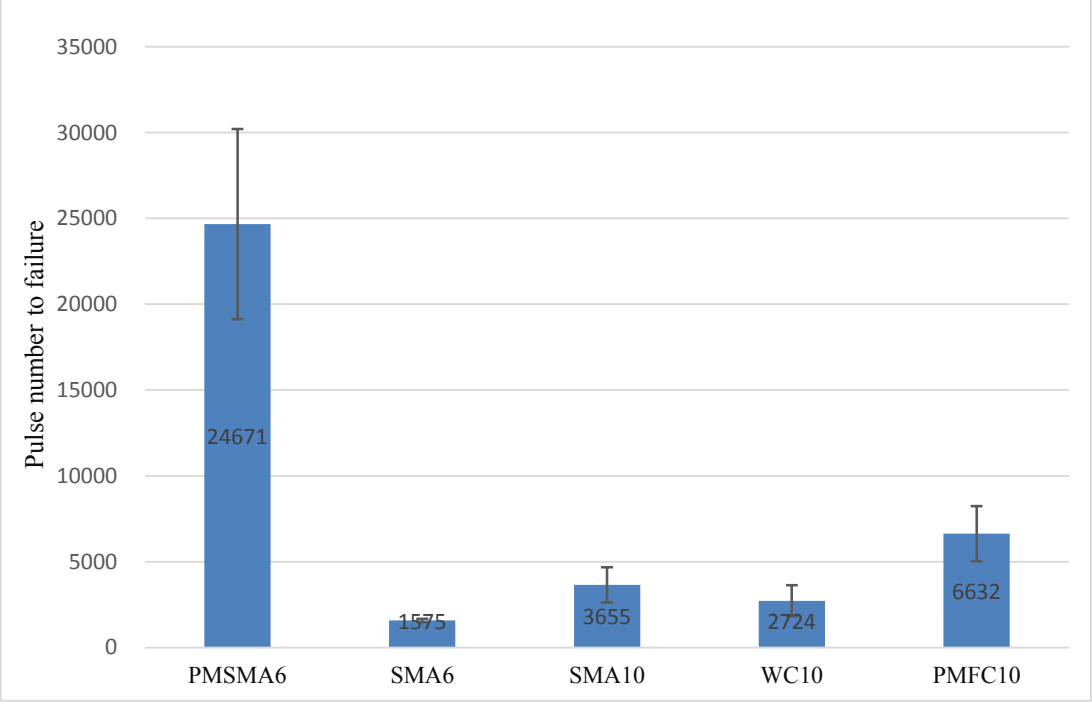


Figure 19: Results of ITFT test

[7] Charts displayed on this appendix have been plotted by Lin Shiying.

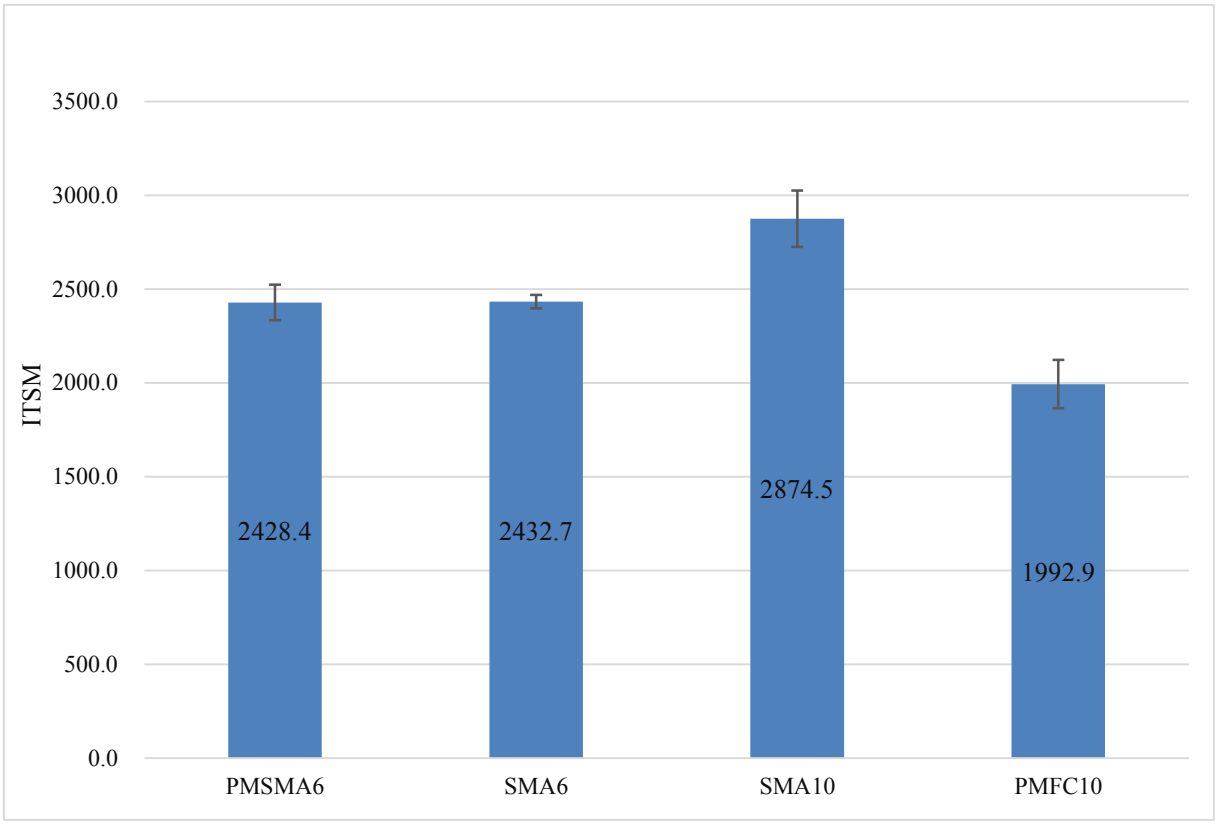
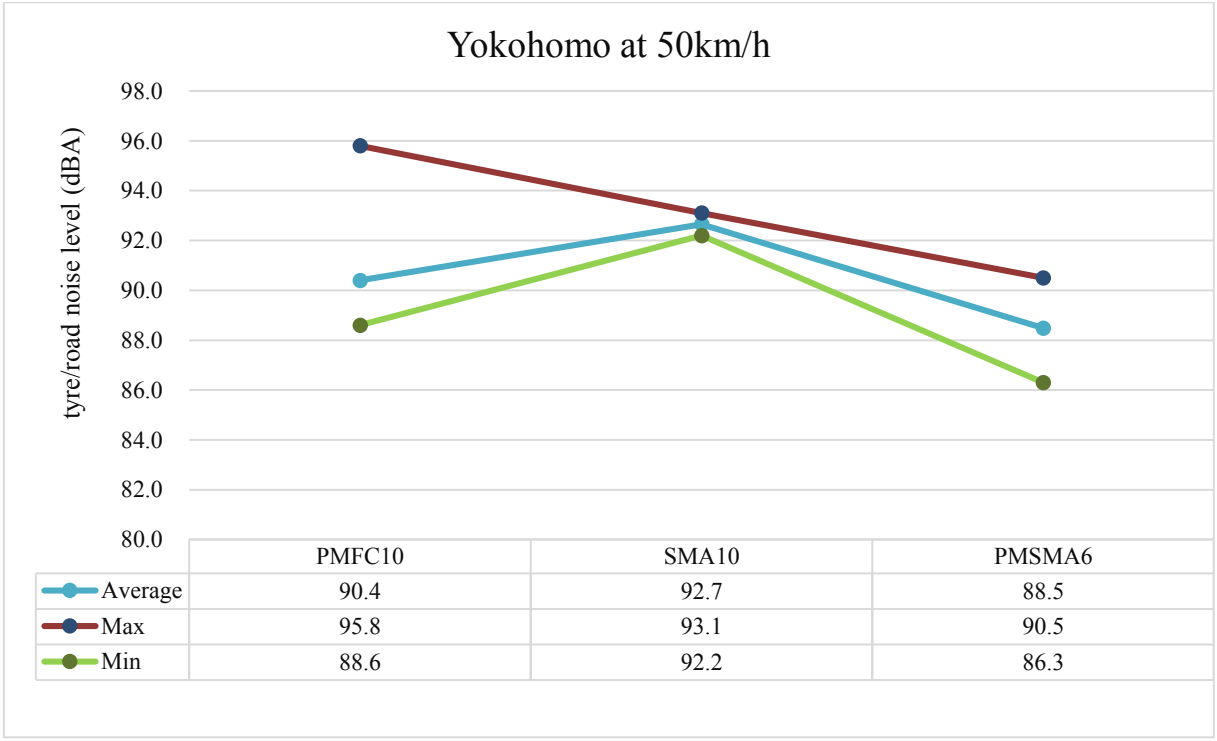


Figure 20: Results for ITSM test.



	PMFC10	SMA10	PMSMA6
Average	90.4	92.7	88.5
Max	95.8	93.1	90.5
Min	88.6	92.2	86.3

Figure 21: Results for Yokohomo Rd.

3. Appendix 3: Results of air quality measurements in buses

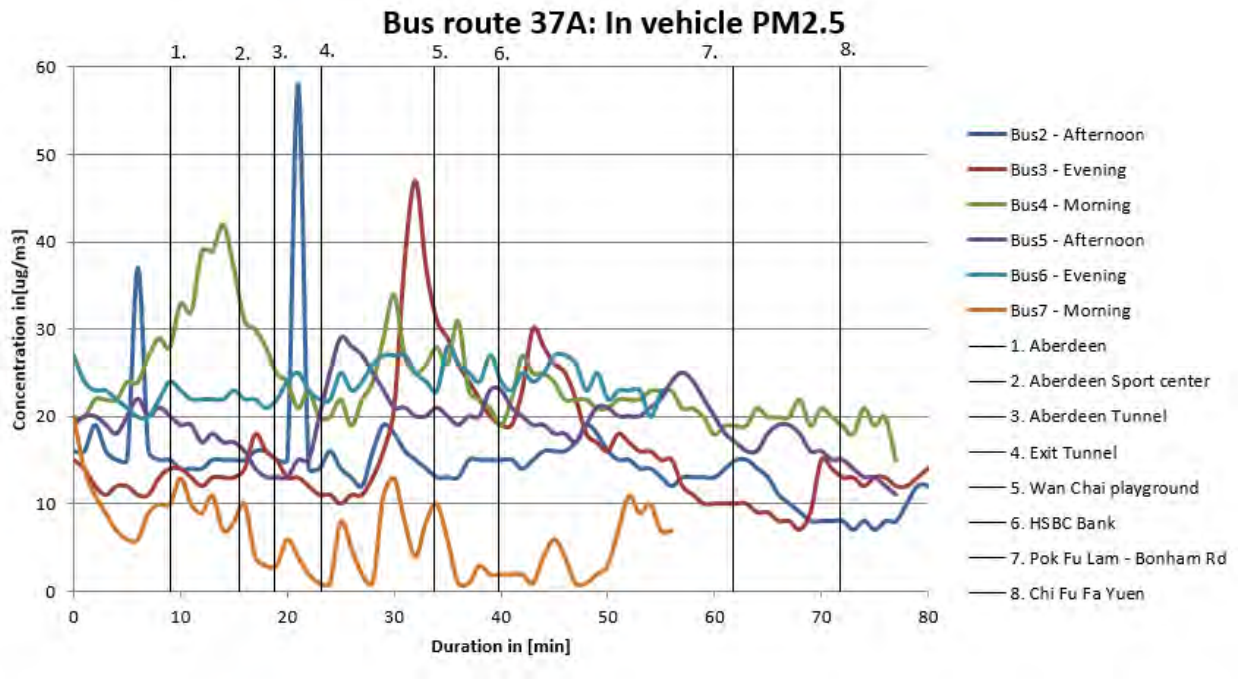


Figure 22: Results of $PM_{2.5}$ measurements on route 37A

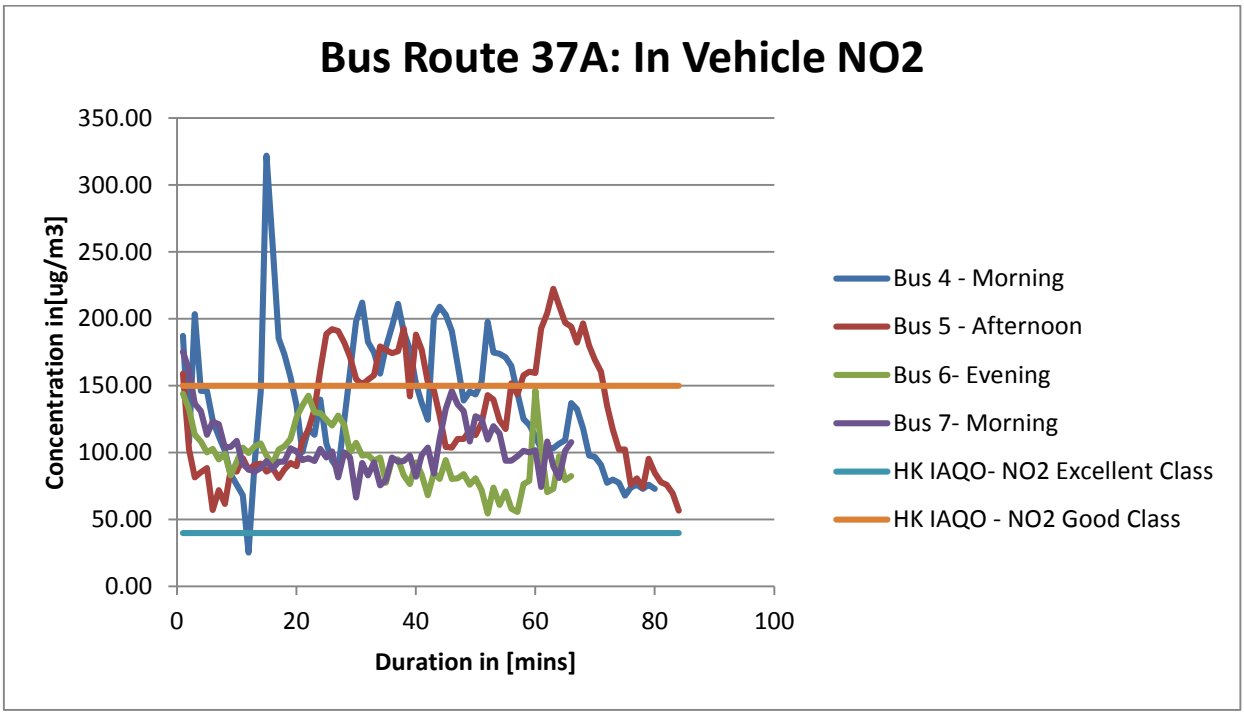


Figure 23: NO_2 concentration along route number 37B

VII. Annex

In Annex I would like to add some pictures summarizing my very pleasant time in HK with all other trainees and my work colleagues.

Figure 24: My work colleagues and me for my farewell drink. From left to right: Eng. Lin Shiying, me, Ms. Debolina Banerjee, Mr. Hoa Pham Ngoc, Mr. King Cheng, Dr. Wing-Tat HUNG

Figure 25: IAESTE trainees and me after a delicious Hot Pot dinner with delicious chicken ball, shark lips and crabs

Figure 26: Me and my mates enjoying a cold beer after on the beach having completed the 50km Hong Kong Trail (12 hours of hiking)

Figure 27: IAESTE trainees and me enjoying a drink on the highest bar of the world in International Commerce Center

VIII. Contact

If you would like to contact me, please find here under my email address.

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