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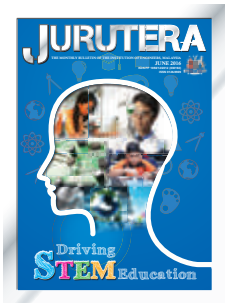

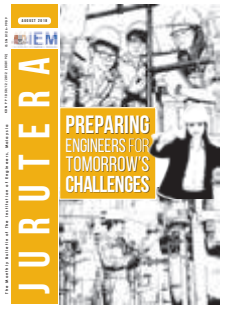

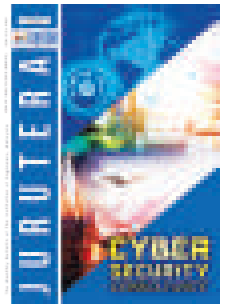

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COVER NOTE

DEVELOPMENT OF FIRE SERVICES INDUSTRY

by Ir. Thin Choon Chai
Chairman, Fire Advisory Board

The Fire Advisory Board (FAB) focuses on fire engineering practices relating to fire codes, standards and installations in the industry.

The history of the FAB started with the firefighting sub-committee headed by the late Ir. T.T. Chiam in the early 1980s. Since then, FAB committee members have worked closely with SIRIM, Bomba and other professional bodies to prepare the Malaysian fire codes and standards on fire equipment and fire systems for the building industry.

FAB members are involved in the revisions of fire requirements in the Uniform Building By-laws and contribute to the drafting of fire codes and Malaysian Standards on fire equipment and systems.

We also hold technical discussions and dialogue sessions on fire-related issues faced by practicing professionals and parties in the fire industry. These help to establish a harmonious working relationship between the professionals and the fire authorities.

IEM continues to contribute to the Malaysian fire codes and standards; and our practising professionals are involved in the design, installation and supervision of fire installations

Perhaps it is time to take extra steps to ensure that these efforts are not wasted, by conducting annual inspections to ensure that fire systems are well maintained and will operate as intended. ■

EDITOR'S NOTE

by Ir. Dr Bhuvendhraa Rudrusamy
Bulletin Editor

SPARK THAT IGNITED INNOVATIONS

Fire is a chemical reaction that releases light and heat when the triangle of fuel, oxygen and heat conspire on an elaborate scheme. Prior to the invention of fire hydrants, firefighters were putting out fires using the only method available, buckets/pails of water. Ironically, the real inventor of the fire hydrant remained a mystery as its patent was destroyed in a fire in 1836.

Fire has ignited various inventions and innovations. I hope this month's bulletin sparks a light on engineering the fire safety within you.

I'm certain every IEM member is busy with work, contributing to the building of our nation and the betterment of our world. Thanks to today's network infrastructure, we are now able to work from home and so help stop the spread of Covid-19. Stay safe, be vigilant. Let's work together to move forward in these trying times. ■

EVOLUTION
OF FIRE SAFEY REGULATIONS

by Ir. Wong See Foong.
Ir. Wong is a Fellow of both the Institution of Fire Engineers (UK) and IEM. He is a partner in engineering consultancy firm MEP Engineering Sdn. Bhd. and has assisted the Fire & Safety Department Malaysia to draft the amendments to the Uniform Building By-laws, 1984.

With the end of World War II and Japanese Occupation, the reconstruction of buildings and facilities was urgently needed to rebuild the economy. At that time, building control was by the "Competent Authority" under the provisions of the Legislation for the Control of Buildings, with the regulations drawn mostly from UK practices due to our colonial ties. These were enforced by the various town boards, sanitary boards or municipalities; each had its own set of regulations and requirements, so it was a nightmare for submitting professionals to ascertain the particular requirements of the local authority he had to deal with.

On top of this, the interpretation of the legislation by the officer-in-charge depended on the officer's experience and exposure. This varied from officer to officer, even within the same department and became a serious impediment to redevelopment.

The Kuala Lumpur Municipality, for example, was the centre of building activities at that time and the situation led to much dissatisfaction and complaints, resulting in the formation of the KL Municipality By-laws Committee to draft the first set of building by-laws. The KL Municipal (Building) By-laws 1958 came into force on 17 April 1958, with the Selangor Government Gazette under the Municipal Ordinance (Extended Application) Ordinance, 1948.

Numerous problems were encountered due to different interpretations by the architects and the local authorities, compounded by the non-uniformity among the many local authorities all over the country. The need for a uniform set of building regulations was critical.

Meanwhile, these regulations continued to be used until they were replaced by the Kuala Lumpur Municipal (Building) (Amendment) By-laws, 1975 which was gazetted on 26 June 1975.

In order to implement a set of uniform building regulations for the country, an Act was needed and this resulted in the Street,

Drainage & Building Act 1974, which was gazetted on 13 June 1974 and empowered State authorities to make by-laws for buildings, street and drainage works. The intent was to amend and consolidate the laws relating to street, drainage and buildings and thus establish a uniform law and create uniform policies to be followed by all local authorities.

The first set of proposed Uniform Building By-laws was published in 1976 but there were so many discrepancies and flaws that the final draft was only ready in July 1982.

Disaster awakens people. It was only after a series of widely publicised fires that greater urgency was given to the issue. The fires involved the Campbell Complex and Bank Bumiputra building in Kuala Lumpur.

Campbell Complex in Jalan Campbell (renamed Jalan Dang Wangi), stood at 17 storeys and had a shopping mall in the podium and an office tower block above it. It was still under construction when fire broke out and there was no provision to fight the fire from inside the building as the fire fighting systems had not yet been installed. After this, the requirement to install temporary fire fighting systems during construction was subsequently introduced into the By-laws.

Another fire involved the 30-storey Bank Bumiputra building in Lebuh Ampang. Helicopters were used to evacuate occupants from the roof but this method proved very risky as the down draft from the helicopter rotors fanned the fire below. Fortunately, this was recognised in time and stopped before a disaster happened and the provision of helipads for evacuation was discontinued.

The Uniform Building By-laws (UBBL) 1984, with emphasis on fire especially for high rise buildings, was finally gazetted and came into force on 1 January 1986. The Ministry of Housing & Local Government set up a UBBL Standing Review Committee on 18 April 1986.

PERFORMANCE-BASED FIRE SAFETY ENGINEERING APPROACH

UBBL 1984 was a set of prescriptive codes and regulations that described what a designer needed to follow and what was not permitted. Some of the clauses were very specific, especially on technical issues, for example for minor items such as the size of pipes. This made it very easy to follow and was suitable at a time when designers were not so well versed in fire safety.

This set of UBBL served us well over the years but as technology advanced and expectations grew, leading to larger and taller buildings with iconic and complex designs, UBBL 1984 was found to be too rigid and restrictive.

When planning the Kuala Lumpur International Airport in Sepang, it was found that the sizes of the ticketing area and other areas far exceeded the limits of compartmentalisation as stipulated in UBBL 1984. It would also not be practical to put up walls to reduce the compartment sizes.

The public spaces were also so high that sprinklers on the ceiling would not be effective as a fire would have spread out of control before the sprinkler heads were activated by the heat from the fire. This led to the application of performance-based fire safety engineering (PBFSE). The aim was to achieve the intent of existing building by-laws through alternative means instead of sticking to strictly prescriptive codes and regulations.

As an alternative to prescriptive-based regulations, PBFSE was a new concept, even in more advanced countries. The fire safety design fell back on the basic fundamentals of fire behaviour. However, there were no uniform standards governing the criteria to follow, for example.

The basis and assumptions adopted for the fire safety concept depended on the fire consultant's views and assumptions. To address the problem of possible inconsistencies, the Fire & Rescue Department required that a checker be engaged to carry out a peer review but this met with limited success due to the lack of recognised and internationally accepted set of standards that the checker could follow.

With the introduction of PBFSE, the opportunity to reduce construction costs by justifying the omission of fire safety systems as stipulated in the prescriptive by-laws, led to abuse. Some fire consultants claimed that, with PBFSE, fire safety systems could be waived. Some also used advanced computer hardware and software developments to create fire simulations and to prove that the solution proposed as an alternative to the prescriptive by-laws would work.

However, practising professionals were very doubtful of the effectiveness of the proposed solutions. Computer simulations were based on assumptions, theoretical fire situations and expected human behaviour. In a real life situation, the circumstances could be totally different and difficult to predict, leading to an uncontrollable life threatening situation.

At the present moment, the Fire & Rescue Department is very careful about accepting projects designed using the PBFSE approach. Such designs can only be accepted for specific aspects of a building where one cannot comply with specific requirements of the present building by-law, and cannot be adopted for an entire building, especially with an intention to waive active fire safety systems for cost saving purposes.

Recognising the need for a standard for PBFSE to follow, the Department of Standards, under the chairmanship of the Fire & Rescue Department, had embarked on preparations for a Malaysia Standard, titled Application on Fire

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Safety Engineering Principles to the design of buildings. The Malaysia Standard will adopt BS 7974 as the guide where fire safety requirement is unable to comply with the UBBL and PBFSE has to be adopted.

UNIFORM BUILDING BY-LAWS, 1984 (AMENDMENT 2012)

The use of PBFSE design will be the exception rather than the norm. UBBL 1984 is still the most important set of regulations governing fire safety for buildings but after more than 30 years, it has long outlived its usefulness. Several attempts were made to revise the building by-laws but this was only successful for very specific issues such as energy conservation, rain water harvesting and the implementation of the Certificate of Completion & Compliance.

In 2009, the Ministry of Housing & Local Government set up multiple committees to simultaneously review various sections of the building by-laws, including space, light and ventilation, structural requirements, constructional requirements and fire requirements. These amendments were finally gazetted in 2012 as Uniform Building By-laws 1984 (Amendment 2012).

Most of the changes were related to structural and fire requirements. Structural requirements would comply with Euro Codes instead of British Standards which we had been following traditionally. This was necessitated by the replacement of British Standards with European Codes when the United Kingdom joined the European Union.

Fire requirements (under Part VII and Part VIII) were also substantially revamped. The clauses were rearranged so that Part VII relating to passive fire safety came under the purview of architects and Part VIII relating to active fire safety, came under mechanical and electrical engineers. With this, architects would have to certify under Form G8 that their design complied with Part VII upon completion, for the purpose of the issuance of the Certificate of Completion & Compliance. Likewise, mechanical and electrical engineers would have to certify compliance with Part VIII in Form G9 for the same purpose.

REVIEW OF BUILDING BY-LAWS 2012

The UBBL is a prescriptive code and we need to follow whatever is prescribed in the by-laws. In UBBL 1984, there were numerous technical details stipulated that were no longer relevant. But just because they were in the UBBL, we still needed to comply with these requirements. This hampered the development of fire design and was one of the reasons for the need to amend the UBBL.

In UBBL 2012, these technical details were omitted as much as possible and reference was made to Malaysia Standards and relevant international standards, the reason being that standards were updated on a regular basis. For example, Malaysia Standards are reviewed every 5 years. This gives us the opportunity to follow the latest technology and innovations whenever they arise and

we are not held back by outdated clauses in the UBBL.

FORTHCOMING UBBL (AMENDMENT 2020)

With the implementation of UBBL 2012 in Selangor and Terengganu (the first states to adopt the amendments), various deficiencies in the clauses were noted and the Ministry of Housing & Local Government embarked on a review although it was only 8 years since its initial implementation. The review has been completed and if all goes well, the new amendments can be implemented in 2020.

During this recent review, there have been attempts by various interested parties to introduce new clauses to promote specific products and ideas. However, we must not lose sight of the intention of the Uniform Building By-laws, which is to promote safety and health in public interest.

SUMMARY

In summary, the evolution of the building regulations started with the first set of by-laws under the Kuala Lumpur Municipal (Building) By-laws 1958 which led to UBBL 1984 being gazetted and coming into force on 1 January 1986. After 28 years, came UBBL 1984 (Amendment 2012).

Although it had been 8 years since it was first published, it had yet to be adopted in all the states. As land matters came under the purview of the individual states, UBBL had to be approved by the respective state assemblies before the local authorities could adopt the by-laws.

To date, only Selangor, Terengganu and Penang have adopted UBBL 2012. Some states, including Pahang and Negri Sembilan, have held back because of the coming Uniform Building By-laws 1984 (Amendment 2012) which is in the final stages of approval by the Ministry of Housing & Local Government. ■

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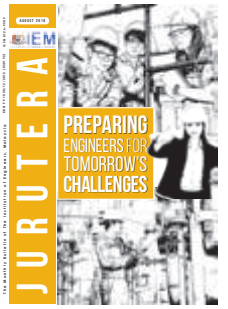

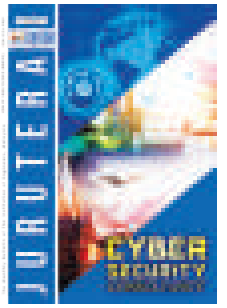

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IMPORTANCE OF FIRE PUMP MAINTENANCE & TESTING

Ir. Cha Hoong Kum

In any development, whether small, medium, big or mega sized, the Uniform Building By-Law (UBBL) stipulates the active and passive systems. Engineers design the systems with reference to relevant standards such as MS 1910 Fixed Firefighting Systems (Automatic Sprinkler Systems Design, Installation and Maintenance, MS 2616 Fixed Fire Fighting System) Fire Pump and NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection and NFPA 25 Standard for the Inspection, Testing & Maintenance of Water-Based Fire Protection Systems for the protection of life and the premises.

The fire protection system, including the hose reel system, wet riser system, hydrant system, automatic sprinkler system, water spray deluge system and foam system which are pressurised systems, will have at least one set of fire pumps consisting of jockey pump, duty and standby pump. In particular, NFPA 25 provides the details for the inspection, installation, testing and commissioning as well as maintenance of the fire pump. Proper planning of the pump room set-up and installation will ease future testing and maintenance.

For reference, see the suggested pump set configuration schematic in this article (sourced from MS2616, page 21). The configuration indicates test line facilities equipped with flow meter pipe discharge to drain or pipe back to water tank. The sizing of the test pipe will depend on the pump design flow rate. For example, for an ordinary hazard group sprinkler system, the suggested test pipe is 4 ins.

How reliable are fire pumps during a fire incident in a building? Pumps are reliable and dependable only if they are properly operated and maintained according to the steps indicated below.

1. Maintenance procedure
2. Method of maintenance
3. Testing procedure
4. Method of testing
5. Analysis of the test results.

Maintenance Procedure: A proper maintenance procedure shall be set up and followed during maintenance work, such as wearing appropriate personnel protection equipment (PPE), having the correct tools and equipment, recording and filling.

Method of maintenance: Setting up the maintenance checklist (weekly, monthly and annually). Below are some sample checklists for reference:

- Pump house ventilation
- Type of fire pump system, e.g. sprinkler system, wet riser system, hydrant system, water deluge system and foam system.
- Electrical system/power supply, controller/panel
- Fire pump functioning/operating test
- Packing gland tightness (normally one water drop per second)
- Suction and discharge pressure gauge
- Check controller operating (auto mode operation)
- Valve position
- Verify pump operating speed
- Suction pipe condition
- Water tank size and water level
- Check power supply
- Diesel fuel oil tank level
- Battery condition, voltage/charging
- Engine cooling water
- Air cleaner/filter
- Exhaust system
- Lubrication oil level

On-site Fire Pump Performance Test Procedure: Before performing the fire pump testing, the following procedures must be followed, according to order and that the working environment is safe.

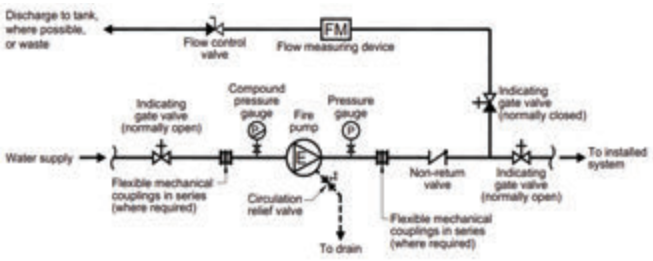
1. Check the Pump Room condition before set-up, i.e. pump condition, piping layout and flow meter location.
2. Notify the person-in-charge of the test and obtain the necessary permit.
3. Record all the pump and driver date on the name plate,

i.e. pump model, design capacity, operating RPM, pump horse power, serial no., motor horse power, etc.

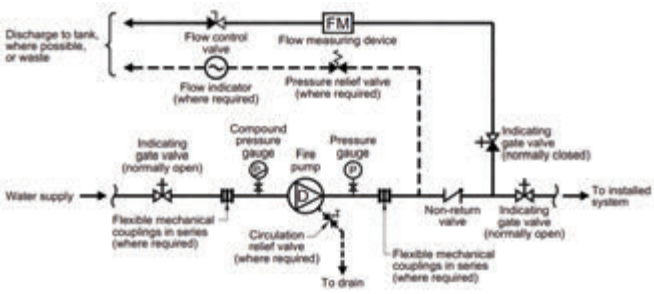
4. Isolate the alarm signal if applicable.
5. Check the power supply for starter panel/controller.
6. Check conditions of the pump sets for diesel engine oil level, diesel supply, batteries, cooling system, etc. together with the associated auxiliary equipment and facilities and ensure the appropriate line up of isolation valves for the pump performance test.
7. Check and witness the pumps start and stop by the technician who does it weekly. Record the pump pressure settings for cut-in and cut-off.
8. Secure an appropriate reflector indicator on the flywheel/counterweight wheel of the pump for measuring the RPM using the portable tachometer.
9. Set up the ultrasonic flow meter in accordance with the manufacturer's recommendation over the discharge line for flow measurement.
10. Identify the discharge devices like fire hoses, hydrants of by-pass discharge line to be opened and/or throttled for flow control.
11. Check that the fire water tank volume has sufficient water supply for the testing.
12. Check that strainers are not choked up.
13. Study the water flow along the system pipeline and identify the type of discharge outlet such as fire hydrants/monitor that need to be opened for flow test.
14. Start the duty pump.
15. Open the 1st, 2nd and 3rd fire hydrant landing valves for discharge outlet (Figure F) for various flow rates.
16. Record the following data for each flow rate: Pump RPM, discharge pressure, flowmeter reading and vibration reading.
17. After the pump flow rate or maximum flow rate is achieved, close the hydrant discharged outlets, one by one.
18. Stop the duty pump.
19. Repeat procedures 15, 16 and 17 for the standby pump.
20. Close all outlets.
21. Normalise the pumps system - jockey, duty and standby
22. Dismantle the testing equipment – ultrasonic flowmeter,
23. Clean up and demobilise.

Figure F: Hydrant discharge flow test

PUMP Room Schematic



(a) Electric motor driven pumpset



(b) Diesel engine driven pumpset

Method of testing: The method of testing the fire pump is flow measurement and pressure recording. The measurement device available is either portable flow meter such as ultrasonic flow meter (Figures A and B) and pitot tube (Figure E) or fixed flow meter installed in the system such as venturi flow meter (Figures C or D) or digital flow meter etc.

Figure A: Ultrasonic flow meter

Figure B: Ultrasonic flow meter transducer mounting

Figure E: Pitot tube

Figure C: Venturi type flow meter

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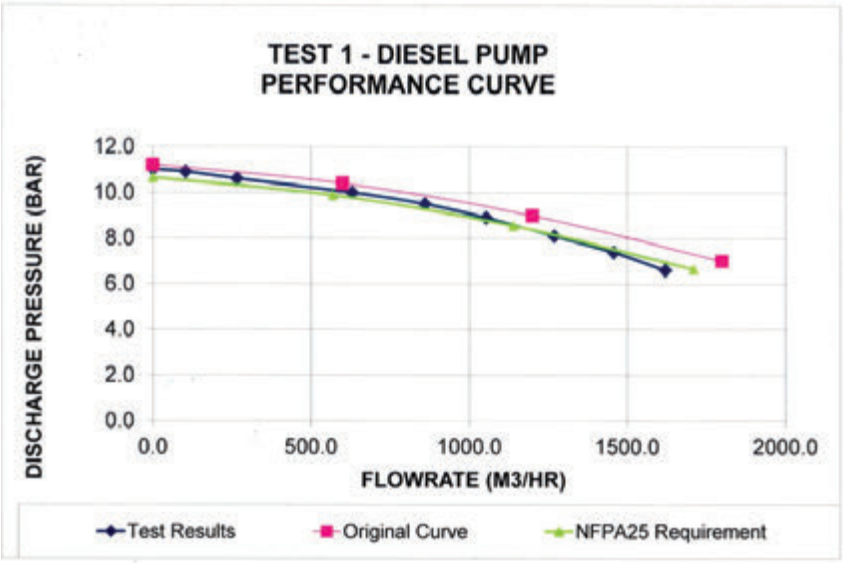
All the above shall provide the accuracy figure. A higher value of accuracy will provide the true result of the pump performance. The pressure measurement is used for suction pressure gauge and discharge gauge.

Figure D: Venturi type flow meter

Analysis of test result: Attached to this article are sample site testing pump curves. From the test results, we will know how well the pump is performing. Does it perform as per the original performance curve or is it below the acceptance level? If it is not up to expected results, find out the possible causes. Below are some possible causes for fire pump performances being unable to meet the original design:

a. Suction strainer clogging
b. Suction pipe size too small
c. Suction pipe too long (water tank location is very far to the pump)
d. Pump impeller obstruction
e. Pump impeller damage
f. Driver speed is slower than the design speed
g. Flow meter not working
h. Delivery pipe too small for the flow
i. Rated motor voltage different from the line voltage
j. Engine operating RPM too low
k. Discharge valve in closed position. ■

Sample Test Result



Author's Biodata

Ir. Cha Hoong Kum set up Versus Solutions Sdn. Bhd. in 2011, offering services for testing and commissioning of fire pumps, design of fire protection systems and supply of firefighting equipment.

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PERFORMANCE-BASED APPROACH TO FIRE SAFETY IN BUILDINGS

Ir. Alan Chan Teck Wai

Fire safety regulations for buildings in Malaysia are designed according to the Uniform Building By-law (UBBL) 1984, which is a prescriptive fire safety design code used by architects and professional engineers when designing fire safety work in a building.

Generally, all passive or active requirements of buildings shall conform to UBBL 1984, and are guided by Malaysia Standards (MS), British Standards (BS) and Australia Standards (AS) for installations of firefighting appliances. All these requirements are prescriptive-based designs in which they set out the objectives of all fire safety measures such as travel distance, fire compartment, building material, fire suppression system and smoke control system. But the prescriptive requirements are rigid and limits the construction of buildings or projects to a certain size and height.

In 2003, several mega projects such as the Kuala Lumpur International Airport and Kuala Lumpur City Centre, had huge fire compartment sizes and travel distances that were beyond the UBBL 1984 fire safety requirements. To resolve this, a performance-based approach (PBA) was adopted. Since there was no local performance-based code to refer to, several international fire safety engineering guidelines were considered.

PBA is an alternative solution to the prescriptive requirements of UBBL 1984 or other standards. It uses quantitative design review engineering analysis (computational fluid dynamics or CFD simulation) to verify the performance objective for the passive or active fire safety requirements to ensure human safety in a building.

So most building designs, including Pavilion Mall KL, MidValley MegaMall and Setia Alam Convention Centre, which could not comply with the 5th and 7th schedules of UBBL 1984, used the PBA.

PBA IN MALAYSIA & AUTHORITY APPROVAL PROCESS

PBA is a methodology for design, evaluation, assumptions, acceptance criteria, fire design sizes, a modelling tool and an assessment method for the fire safety of a building. It identifies an engineering approach to building fire safety and offers guidance on the application of scientific and engineering principles to protect life and property from fires. [1]

The methodology facilitates performance-based designs which meet fire safety objectives of building codes and includes the form of construction, means of escape, occupancy factors, smoke management system, detection system, alarm system and fire suppression system facilities.

A building which undergoes the performance-based study is to address the non-compliance issues of UBBL 1984. Currently, PBA allows deviation in fire compartment sizing (UBBL provision By-law 136, 137 and 5th Schedule) and travel distance (UBBL provision 7th Schedule).

As for the application of PBA in Malaysia, it is recommended to apply it during the conceptual phase of building fire safety system design. A close discussion between the project team, the design consultants (principal submitting persons, architect and M&E) and the Fire & Rescue Department (Bomba) Putrajaya is required.

The detailed design and specifications of fire safety sub-systems may not be specified at this stage. However, it adheres to the decisions and agreements by the stakeholders for PBA application during this phase. The engagement of a fire safety engineer (FSE) is granted thereafter. Figure A shows the flow chart for the PBA application process.

PBA & STANDARDS

Since the PBA is a developing discipline, its conceptual proposal may be subjective and some judgement is required. Therefore, a few workshops and meetings with Bomba Putrajaya on the concept proposal are necessary prior to identifying the parameters and assumptions. These are then documented in the PBA report.

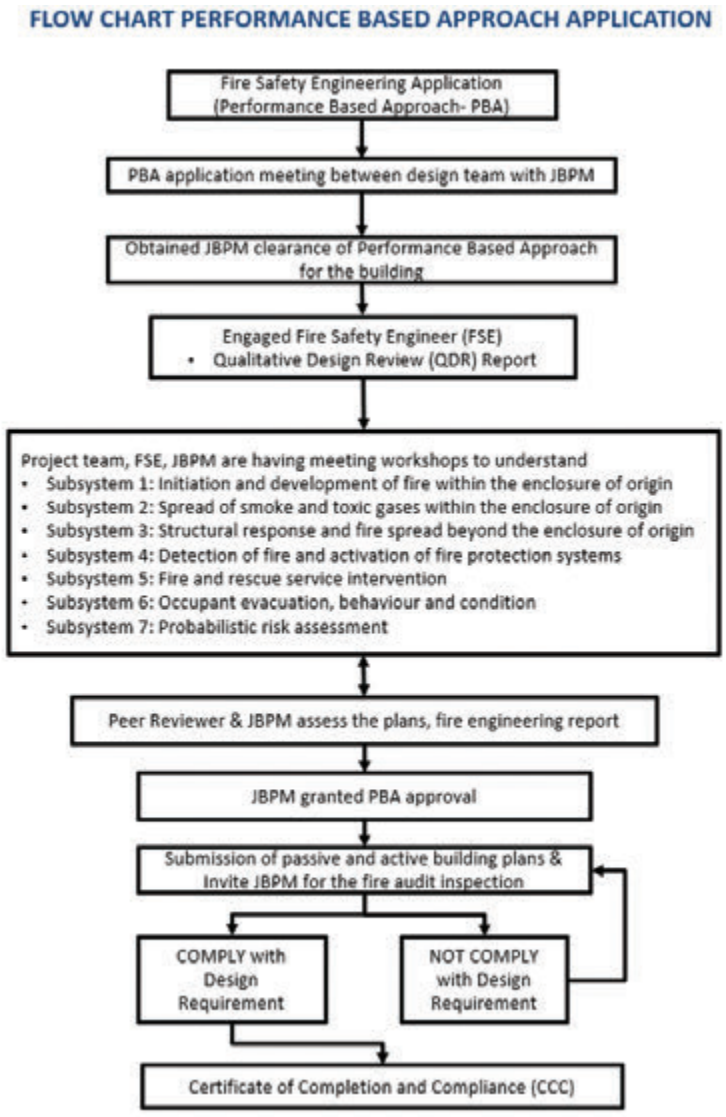

Figure A: Flow chart for the performance-based approach process

When applying the PBA fire safety engineering design, the FSE can refer to several international fire safety engineering guidelines such as International Fire Engineering Guidelines (IFEG), Society Fire Protection Engineer Handbook (SFPE), and British Standard 7974. However, Bomba prefers the British Standard (BS) 7974-2019 Code of Practice which provides a framework for the application of fire safety engineering principles to the design of buildings. In addition, the supporting document PD 7974 provides guidance and information on how to undertake a detailed analysis of specific aspects of fire safety engineering in buildings[4]. Thus, BS 7974-2019 provides a basis preparation of the qualitative design review and fire safety engineering reports.

PBA ACCEPTANCE CRITERIA

PBA begins with a qualitative design review. The scope and objectives of the fire safety design are defined, the performance criteria is established and one or more potential design solutions are proposed. The quantitative analysis shall include the following requirements:

- Subsystem 1: Initiation and development of fire within the enclosure of origin.
- Subsystem 2: Spread of smoke and toxic gases within and beyond the enclosure of origin.
- Subsystem 3: Structural response and fire spread beyond the enclosure of origin.
- Subsystem 4: Detection of fire and activation of fire protection systems.
- Subsystem 5: Fire and rescue service intervention.
- Subsystem 6: Occupant evacuation, behaviour and condition.
- Subsystem 7: Probabilistic risk assessment.

The results of the quantitative analysis are compared and the acceptance criteria will be identified during the qualitative design review.

PBA establishes an acceptable standard for life safety, a comparison of time between the occupants reaching a safe assembly area and conditions to reach agreed tenability limits, as expressed:

Available Safety Escape Time (ASET) > Required Safety Escape Time (RSET). ASET is defined as the time taken between the start of a fire and building incapacitation, including ineffective action to escape to a safe area, while RSET is defined as the time required for an individual occupant to travel from his/her location to a safe assembly area.

According to BS 7974, at 2.5m above ground level, visibility shall be greater than 10m, while the average upper smoke layer temperature shall not exceed 200°C. As occupants are expected to egress past a fire, the radiative heat flux shall not exceed 2.5 kW/m^2 (see Figure B).

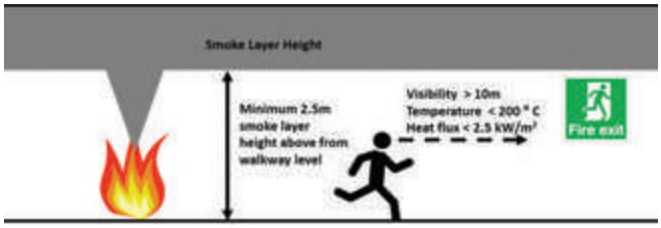

Figure B: Tenability criteria for performance-based application

The engineering design needs to be reliable and accurate before Computational Fluid Dynamics (CFD) analysis is applied, for an accurate ASET estimation. CFD simulation will show smoke flow phenomena and turbulence characteristics of a building fire. The FSE must advise the design team of any change before the onset of the untenable condition environment during ASET. With CFD, the FSE will be able to estimate the errors and provide reliable conclusions.

In summary, the FSE can establish the fire safety of a building using PBA and, by using CFD simulation as a reference to engineering design, be able to simulate worst-case fire scenarios.

PEER REVIEW

Usually, the PBA report will be peer-reviewed by another FSE to ensure consistency in findings and assurance of a building. The engagement of the peer reviewer depends on the scale of the project and the complexity of fire safety issues involved. The peer reviewer's role shall not be limited to the following:

- Design objectives
- Purpose and scope of the study
- Design fires and reference to test fires
- Methodology and PBA guidelines
- Analysis results and safety factors
- Report conclusions and special conditions.

The peer-reviewed report is to be submitted independently to Bomba Putrajaya as a basis for PBA comparison, ensuring compliance and consistency with the design guidelines. Figure C shows a sample of CFD simulation by an independent peer reviewer.

In addition to the PBA application process, Bomba Putrajaya will be invited to audit the inspection testing and verify the design on site as per submission. Bomba will audit a hot smoke fire test based on Australia Standard 4391- Hot Smoke Test Management procedures.

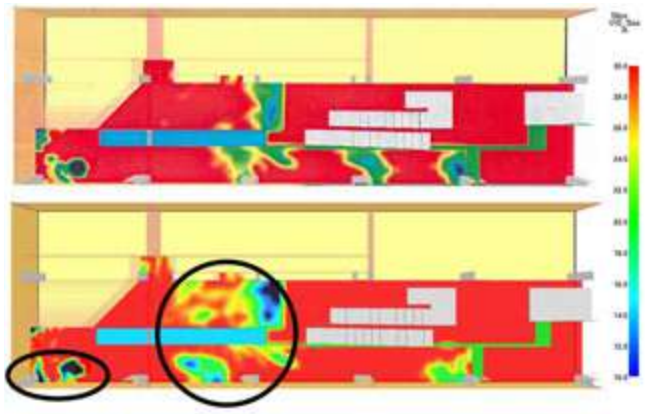

Figure C: Sample comparison CFD results between FSE and PR

CONCLUSION

The PBA application is a design process to ensure public safety. So it is necessary to have a qualified, competent and experienced professional adopting the PBA and who shall be responsible for the design which deviates from UBBL 1984. PBA application can be an alternative solution to issues of modern innovation of buildings. ■

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[1] Peter N. Whiting, "Fire Engineering Report and the Approval Process," 7-9 September 1999

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[3] Australia Standard 4391, Smoke Management Systems, Hot Smoke Test, Edition 1999

[4] British Standard (BS) 7974-2019- Application of fire safety engineering principles to the design of buildings- Code of practice

Author's Biodata

A committee member of IEM's Fire Advisory Board, **Ir. Alan Chan** is also a professional engineer with Board of Engineer Malaysia and a member of Society Fire Protection Engineer (SFPE) and an affiliate member of Institution of Fire Engineer Malaysia (IFEM).

ZERO FIRE POLICY TO REDUCE FIRE HAZARDS IN HEALTHCARE FACILITIES

by Ir. Al-Khairi Mohd Daud

Have you ever wondered what will happen if you are a healthcare facility and a fire breaks out? Will you be evacuated to safety?

There have been many records of fatalities resulting from fires in healthcare facilities. On 24 September 2019, eight newborns perished when an early morning fire blazed through a maternity ward in Algeria. The fire was said to have started from a spark triggered by a faulty anti-mosquito device. In Malaysia, a fire at the Sultanah Aminah Hospital in Johor Baru on 25 October 2016, resulted in the deaths of six patients in the intensive care unit. In both cases, the victims were helpless and could not move themselves to safety.

Even if patients are evacuated, it does not mean that they will be in the best clinical care conditions. In March 2018, a store at the National Institute of Forensic Medicine, Hospital Kuala Lumpur[1], caught fire due to short circuit. Although the store was not near the wards, patients and staff members were evacuated to assembly areas.

Hospital Kuala Lumpur staff members evacuating patients to assembly areas. - Bernama pic

Assembly point at the hospital entrance which impedes the passageway of fire engines

Patients will have to endure the traumatic experience of being relocated via emergency staircases or fire lifts, together with confused and nervous employees and visitors. The situation is also not necessarily better in the assembly areas; patients should be placed in relatively safe areas until the support medical team is assembled to manage them.

In many hospitals, assembly areas are often located in inappropriate places such as the entrance, buildings across roads with heavy traffic, the hospital car park or an open air car park. Some assembly areas even obstruct the access route for fire engines.

In many cases, the fire safety committee only identifies assembly areas after the hospital begins operations. Often, hospital safety officers are not aware of the need to identify appropriate locations and the need for correct directional signages to direct patients and visitors to the assembly areas.

Moving highly critical patients from the ward to the assembly area should be the last option as these patients require special care and are immobile. Moving them may cause more harm especially if they are not directly exposed to the fire hazard in the first place.

Fire risks are higher in older healthcare facilities such as general hospitals which have not been constructed according to the latest building fire code which requires passive and active fire designs. It is next to impossible to renovate these hospitals, especially the structural layout.

To avoid any untoward incident, healthcare institutions should adopt a zero fire policy and ensure adequate protection against fires with good design, well-rehearsed fire plans and trained personnel who can identify fire risks and respond quickly in the event of one. The following steps should be taken when developing healthcare facilities zero fire safety policy.

HEALTHCARE FACILITIES DESIGN

When designing a hospital fire system, fire engineers must have full knowledge of the following:

- Type of care provided
- Mobility of patients
- Planned staffing levels
- Age of patients
- Size of premises

Beginning with the end in mind, they should first look at the evacuation assembly areas. With limited space, especially when located in urban areas, many healthcare facilities have failed to provide relatively safe assembly areas where patients and staff members can take refuge. Healthcare facilities should also be designed to include access passage for fire engines, temporary medical support facilities and assembly areas for disaster and rescue activities.

As a basic guide, the building standard for passive

protection and active systems for healthcare facilities can be found in the Uniform Building By-Laws (UBBL) 1984, Fire Service Act -1988, Private Healthcare Facilities & Services Act 1998. For other applicable Malaysian Standards, refer to the IEM website *(https://www.myiem.org.my/content/bomba-476.aspx)* which has links to all issues related with the Fire Services Department.

Passive design – fire compartments: The most important building feature to protect against fire and smoke is the passive design. Healthcare premises for dependent and very high dependency patients should be divided into a series of compartments which can provide one hour of fire resistance. These should be further divided into sub-compartments. Compartments and sub-compartments should be constructed to provide 60 and 30 minutes of fire containment respectively, without affecting adjacent areas.

Where evacuation involves very high dependency patients, additional consideration must be given to the distance of travel necessary to reach a place of safety where essential treatment and care can be recommenced. It is also important to ensure that fire walls and fire barriers are not breached, rendering the passive fire protection ineffective.

Active design – detection & suppression system: In the event of fire or smoke developing, healthcare facilities need to be protected by an active fire system.

A detection system, sprinklers and hose reels are the basics requirements. However, do note that water is a source of microbial life and can be a serious source of infection. Water discharged by sprinklers may do more damage to the patients and buildings than the fire itself. The following areas require separate fire fighting systems:

Areas	Type of Fire Fighting system
Operation theatres	pre-action/clean agent
Medical record room	clean agent
Server room	clean agent
Kitchen	wet chemicals

Many healthcare facilities now provide these additional services. It is very important that, during the retrofitting, the fire detection and suppression system be checked for adequacy and relevancy so that fire protection management is not compromised.

MANAGEMENT COMMITMENT

Healthcare facilities are only as safe as the management's commitment to fire safety. As such, the facilities manager must understand the following issues when setting up the fire safety management plan:

- Dependency of the patient
- Fire hazards within the premises
- Management policies
- Adequate and competent staff

Patient dependency: Patients are classified into three categories – independent, dependent and very highly dependent – which differentiate between the anticipated dependence of the patients, either during an evacuation or as a consequence of the treatment they are receiving.

Fire hazards – risk assessment: Healthcare facilities have inherent hazards of medical gas piping systems and oxygen cylinders in the wards, LPG piping in the kitchen, inflammable chemicals in pathology and pharmacy department and papers and combustible materials in the medical records and consumable stores. Mentally unstable patients can also be fire hazards.

The facilities manager must conduct fire risk assessments as part of the healthcare facilities integrated risk management plans and the records should be made available. Apart from the mandatory visits by the Fire Service Department visits for the Fire Certificate inspection, healthcare facilities should also carry out regular fire safety audits.

Management policy: At the minimum, healthcare facilities must comply with the Occupational Safety & Health Act 1994. Additionally, the Malaysian Society for Quality In Health has clearly spelt out the need for healthcare management to have a good disaster management plan which includes internal and external disaster plans. Fire safety plans and evacuation drills must be conducted yearly and should involve the Fire Services Department.

Staff training and competency: A fire safety officer who can respond to fire emergencies at any time, must be appointed and he should have the support of an Emergency Response Team (ERT), floor wardens and an Incident Management Team which includes a medical response team. These teams must be trained in basic fire fighting skills and should practise the evacuation process especially when critically-ill patients or patients with limited or no mobility are involved.

The facilities team must fully understand the building(s) architectural design, air-conditioning and mechanical ventilation (ACMV) systems, medical gas systems, fire protection systems, electrical systems and emergency generator system. Most air handling units (AHUs) in healthcare facilities are equipped with duct smoke detectors which automatically shut down the fan where the fire occurs.

FIRE SAFETY STRATEGY

Even with good design, a committed management and competent staff, the facilities manager should still be prepared for fire in the worst case scenario. The following are the three stages of fire safety management strategy:

1. Pre-planning
2. Fire response
3. Evacuation plan

Pre-planning: Fire can occur at any time. Most of the time, it occurs at odd hours, so the facilities management should stay constantly vigilant. Pre-planning for a fire is a proactive means to ensure success in safeguarding the occupants and the building. Pre-planning must also include testing the proposed measures to ensure they can achieve their intended objectives. The overall aim is to ensure that all occupants can escape unharmed to a place of safety, either within the building (progressive horizontal evacuation) or outside the building.

Diagram 1: Steps in preparing a Healthcare Fire Management Plan

To achieve this, there must be a prompt response to the alarm and an effective strategy for evacuation. Diagram 1 is a summary information taken from HTM 05-01 Managing Healthcare Fire Safety[2] and can be taken as a guide for developing a fire safety manual that includes the evacuation process.

Fire response: Healthcare facilities must first ascertain the time needed for the Fire Services Department to arrive as this will define the competencies that the Emergency Response Team will need to equip themselves with. All staff members should be familiar with the fire protection system in their work area and be trained to handle fire extinguishers and hose reels. Isolating the source of the fire is a primary action in extinguishing fires.

It is important that nurses are trained to shut off the oxygen supply at the Area Valve Service Unit (AVSU), especially in critical care units to stop the fire from spreading quickly. The AVSU must be correctly labelled to avoid accidentally cutting off the medical gas supply to unaffected patients.

Fire fighting equipment and systems must be maintained regularly to ensure they function properly. Retrofitting of areas need to be managed as the fire fighting system can be compromised during renovation works. Security personnel in the control room must be trained to look at the fire panels, communicate with the Fire Services Department and to notify the facilities management quickly.

Evacuation plan: Although necessary, evacuation should be the last resort in order to protect the patients. Evacuating all occupants is an enormous exercise and patients may be placed at risk due to trauma or their medical condition. There will be challenges when evacuating the following:

- Patients with restricted mobility
- Patients who use wheelchairs
- Patients confined to a bed which cannot negotiate escape routes, particularly stairways, unaided
- Patients under medication who may require staff assistance
- Patients dependent on electrical/mechanical equipment which cannot always be disconnected or moved rapidly without serious consequences.

For these patients, evacuation should be the last resort and should be based on the concept of progressive horizontal evacuation, so that only those directly at risk from the fire will be moved. A comprehensive fire evacuation plan should involve different departments of building blocks. Fire events should be simulated (with smoke and darkness) to be as real as possible in order to understand the continuity of care for critically-ill patients for whom evacuation itself is a hazard.

Fire evacuation plans and procedures should include:

a) The assignment of personnel to specific tasks and responsibilities, e.g. IMT, ERT, floor wardens.
b) Instructions on the use of alarm systems and signals.
c) Information concerning methods of fire containment and suppression.
d) Information concerning the location of fire fighting equipment.
e) Systems for notification of appropriate persons.
f) Evacuation process, maps on evacuation routes, assembly points.
g) Head count process.
h) Activation of the fire emergency plans (Code Red) or other emergency plans where warranted.
i) Other provisions as dictated by the local situation, such as arrangements for the mobility impaired.

Because of the risks in moving patients, it is highly recommended to have an independent colour code

The author conducting a fire drill using real fire in a hospital building to create urgency and realism during the evacuation process

Patients in wheelchairs taking part in an evacuation during a fire drill

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for evacuation, for example Code Orange[3]. Before triggering a hospital-wide evacuation process, the facilities manager must consider the following conditions:

- Extreme emergency – where there is immediate threat from the fire or smoke.
- Emergency – no immediate threat, but the fire or smoke is likely to spread from an adjoining area.
- Precautionary – no immediate threat to life or safety, but there is a fire on an adjoining floor or in an adjacent building.

In extreme emergency situations, the sequence of evacuation should be:

1. Those in immediate danger
2. Ambulant patients
3. Patients who are not ambulant

The basic strategy for evacuation of dependent or very high dependency patients is to move them on their bed or in a wheelchair, to a safer area on the same floor.

Once the evacuation code has been activated, these are three main stages of evacuation:

Stage 1. Horizontal evacuation from the sub-compartment where the fire originated, to an adjoining sub-compartment or compartment

Stage 2. Horizontal evacuation from the entire compartment where the fire originated, to an adjoining compartment on the same floor

Stage 3. Vertical evacuation to a lower floor substantially remote from the floor where the fire originated, (at least two floors below) or to outside the building.

It is critical that the facilities manager understands the patient-access areas where progressive horizontal evacuation will be carried out except for areas where patients fall into the independent category, e.g. clinics. On a final note, patients should not be located where it is necessary for them to climb a staircase to the final exit.

Outside the buildings, it is important to have clear signages to direct evacuees to safe assembly areas. Patients should be accompanied by staff members at all times during the evacuation and disaster trauma centres should be deployed concurrently as part of the fire safety plan.

CONCLUSION

Evacuating patients immediately every time there is a fire alert is not a good strategy. They should only be evacuated if the fire cannot be contained. During the evacuation process, they may be exposed to higher risks and health hazards that may be detrimental to their healing, or worse, prove fatal due to trauma.

It is more important to adopt a zero fire policy to ensure patients and staff members are protected. To ensure the safety of patients, all parties involved in the design, operation, maintenance and fire disaster management, have to understand the needs of the patients and the hazards of evacuating the patients. The authorities too have to be supportive in ensuring that healthcare facilities are managed by competent fire safety officers. It's only when all parties are committed to minimising fire hazards that patients can sleep well and heal. ■

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Author's Biodata

Ir. Al-Khairi Mohd Daud has over 13 years' experience managing healthcare facilities. He is a surveyor with the Malaysian Society for Quality in Healthcare and is active in improving safety standards in healthcare facilities.

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A member of,

FIRE ADVISORY BOARD'S TECHNICAL DIALOGUE

by Ir. Chong Chew Fan

Group photo

It is the responsibility of the professional engineer as the Submitting Person to ensure that the fire safety design of a building complies with the latest regulations, standards and practices. After further dialogues with the Fire & Rescue Department of Malaysia (Jabatan Bomba Penyelamat Malaysia or JBPM), IEM committee members were updated with the latest developments on guidelines, design practices and submission requirements related to the fire protection industry.

On 13 January 2020, the sub-committee of IEM's Fire Advisory Board (FAB) on Fire Protection Services organised a technical dialogue at Auditorium Chin Fung Kee, Wisma IEM in Petaling Jaya, for IEM members on current fire safety design requirements. All concerns and issues raised will be compiled and forwarded to JBPM. The session, chaired by the FAB chairman, Ir. Thin Choon Chai, was attended by 48 participants. Earlier, IEM members were encouraged to send in questions to FAB before the event.

Participants at the technical dialogue

Ir. Thin began the session with a background of events and highlighted some of the developments in the industry. Among the topics updated by the FAB team were:

1. Development of Amendment to the Uniform Building By-Laws (UBBL) 2019
2. Possibility of Registration of Fire Contractors and Fire Engineers by JBPM
3. Latest Development on Malaysian Standards on Fire Fighting Pumps (MS 2616)
4. Latest Development in the Certificates of Completion & Compliance (CCC)

After brief updates by FAB committee members, Ir. Thin handed over the session to Ir. Leong Siew Meng who briefed the audience on the latest draft of the IEM Testing & Commissioning (T&C) Guidelines for Fire Protection System. He said the aim of producing

this document was to provide a benchmark for the firefighting industry on the proper testing and commissioning to be carried out. It will also help to further improve the quality of T&C works for the firefighting system. Ir. Leong said the draft document should be ready for public comment and stakeholders' engagement by end of 2020.

This was followed by a Q&A session; questions received via e-mail were also addressed. The key issues raised were as follows:

No	Issues/Question	Answer
1.	When do we need to submit for Fire Certificate renewal?	1 year after CCC is issued.
2.	For renovation works on parts of existing buildings, do we need to submit the JBPM submission for the whole building and will the CCC need to include the whole building?	The submission should be limited to areas under renovation, unless the changes affect the overall building (e.g. change in use of renovated areas which will affect the overall building).
3.	For CCC, what are the supporting documents required for the active submission?	Borang G9 is required for active submission. The main supporting document is *Surat Pelepasan Perakuan Berperingkat*, issued by JBPM.
4.	For electrical wiring works in firefighting systems, are we required to use fire-rated cables? Can we use PVC cables in GI conduit or PVC cables concealed in walls instead?	PVC cables in GI conduits are acceptable, subject to the relevant conditions in the respective Malaysian Standards. For example, MS 1745: Part 14 provides details of when fire-rated cables should be used.
5.	Are there any specific guidelines to define the need for firemen intercom-based type of buildings or risks?	Refer to Clause 238 & 239 of the Uniform Building By-laws (UBBL 1984).
6.	Class K extinguishers (for Class K type fire, particularly needed in kitchens) in the market do not have a JBPM certificate. Does JBPM allow the use of such extinguishers? Is it necessary to have other type of extinguishers in the kitchens as well?	Class K extinguishers are not approved by JBPM. MS 1539 uses a different classification for fires involving fats and cooking oil (Class F). The extinguishers used should be certified to MS 1539.
7.	Do we need to provide sprinklers for areas with heights of over 18m or an open air area, i.e. drop off area, canopy area, etc.?	For areas of more than 18m high, sprinklers may not be effective and can be omitted under certain conditions. MS 1910 generally requires all areas to be provided with sprinkler protection, with some exceptions. Refer to Section 4 of MS 1910.
8.	What is the minimum pressure for non-pressurised fire hydrant systems?	Generally, the required pressure is 2 bars.
9.	Can hose reel system, wet riser, sprinkler system and hydrant system share the same fire pump and fire tank? If yes, what is the requirement needed for this combined system? NFPA (National Fire Protection Association) allows such a combined system.	No, combined systems are not allowed. Designs based on NFPA are allowed by JBPM on a case-by-case basis only.
10.	For compliance of MS 1780, does a warehouse with jack roof need to have a smoke curtain or comply to the smoke zone requirement of 2,600 sq. m.?	Yes, either the natural type or powered type is required for smoke control systems.
11.	Can fire curtains be used for electrical rooms with fixed gas suppression system?	Fire curtains can be used, depending on the situation. Do note that TNB no longer permits the use of fire curtains. ■

PREVIEW OF FIRE PROTECTION SYSTEM TESTING AND COMMISSIONING GUIDELINE PROPOSAL

by Ir. Yim Hon Wa

Ir. Leong Siew Meng

Regulations and design requirements of fire protection systems have been well disseminated to engineers and other stakeholders but documented guidelines on testing and commissioning (T&C) requirements for consistent and systematic approach are lacking.

Fire protection T&C activities are normally managed by engineers. Subsequently, after obtaining the design approval from the authorities, the installation work is primarily left to contractors, who also conduct T&C.

In tight project schedule, T&C activities are commonly subjected to a limited timeframe for thorough completion. Such a scenario can be challenging for engineers who want to ensure that comprehensive completion of all T&C activities is achieved.

The IEM Fire Advisory Board (FAB) has deliberated on the challenge of getting proper T&C and to prepare a Fire Protection System T&C guideline. This guideline adheres to a consistent administrative and procedural concept of fire protection system T&C. It will also outline a systematic and consistent approach to ensure all systems and equipment functions are as intended by the owner and design team.

The T&C of fire protection systems comprises many sub-systems, including both active and passive fire protection systems. The proposed guideline will address only the active system, which are within the job scope of mechanical and electrical engineers. The active fire protection system consists of many sub-systems such as:

1. Wet systems:
   a. Hose reels
   b. Wet riser and dry riser
   c. Fire sprinkler system
   d. Water spray deluge system
   e. Pressurised hydrant system/yard system
2. Dry systems:
   a. Fire detection and alarm system
   b. Firemen intercom
   c. Public announcement system
   d. Self-contained emergency lightings and exit sign units
3. Gaseous suppression systems:
   a. Carbon dioxide gas suppression system
   b. Formula gas suppression system
   c. Mist suppression system
4. Foam fire suppression system
5. Wet chemical system
6. Smoke management system
7. Emergency power supply from generator set
8. Electrical isolation switch
9. Firemen lifts.

In the current practice, specialist contractors or suppliers only focus on the respective T&C of a system. Some aspects of integrated T&C activities may be overlooked. The proposed guideline is intended to address gaps in the current T&C of industry practice to ensure that systematic and consistent T&C activity is conducted and documented properly. The objectives of the proposed T&C guideline are:

- To establish a consistent and best-practised approach to fire protection and life safety system testing and commissioning throughout the country.
- To provide guidance for systematic execution and coordination of testing and commissioning process and activities.
- To provide guidance and direction on integrated system tests.
- To ensure fire protection and life safety systems are properly tested in accordance with the respective system requirements and standards prior to Fire &

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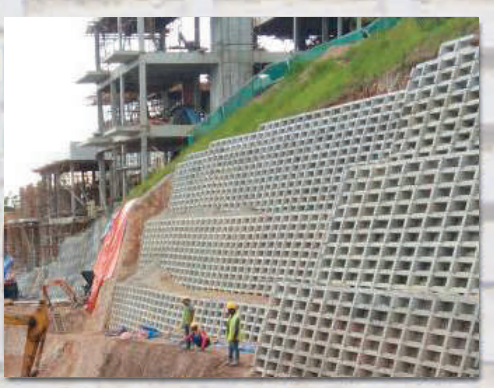

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Rescue Department (BOMBA) inspection.

- To ensure that all T&C procedures and records are properly documented.

The proposed guideline is based on NFPA3:2018 Standard for Commissioning of Fire Protection & Life Safety Systems. However, full adoption of the NFPA3 will be stringent and costly to building owners. Figure 1 shows the proposed T&C guideline.

In the design phase, engineers are recommended to establish several key documents such as Owner's Project Requirements (OPR) and Basis Of Design (BOD), as a reference for commissioning process. A systematic execution & coordination that focuses on the installation stage begins with pre-T&C activities.

Broadly, the guidelines are categorised into two section: Pre-T&C activities and T&C activities. In the pre-T&C section, the PSP or SP stipulates the minimum competency requirements of the commissioning team members and their roles and responsibilities for the commissioning process. The proposed guideline also provides an exemplar for engineers to prepare the fire operation matrix, sequence of operation test form, an overview of functional testing plan and status reporting format. T&C submittals checklists will be part of pre-T&C activities to ensure the installation contractor has T&C testing plans prior to conducting the activities. This provides an opportunity for engineers to review and comment on any discrepancy and inadequacy in the T&C submittals.

The objective of the fire operation matrix is for engineers to establish a reference document for installation contractors to coordinate and conduct integrated tests, especially for large installations that involve interfacing with air-conditioning system, smoke control system, lift system, sounders and strobe lights for evacuation management, roller shutters and door closure control. In addition, systematic T&C reporting enables the PSP or SP to manage and monitor T&C activities with greater confidence prior to inspection by BOMBA.

In summary, the proposed guideline will allow engineers, owners and other stakeholders to address gaps in existing practices and establish a consistent T&C approach to fire protection and life safety system throughout a project implementation. The proposed guideline will be circulated for comments once the draft is approved by IEM. ■

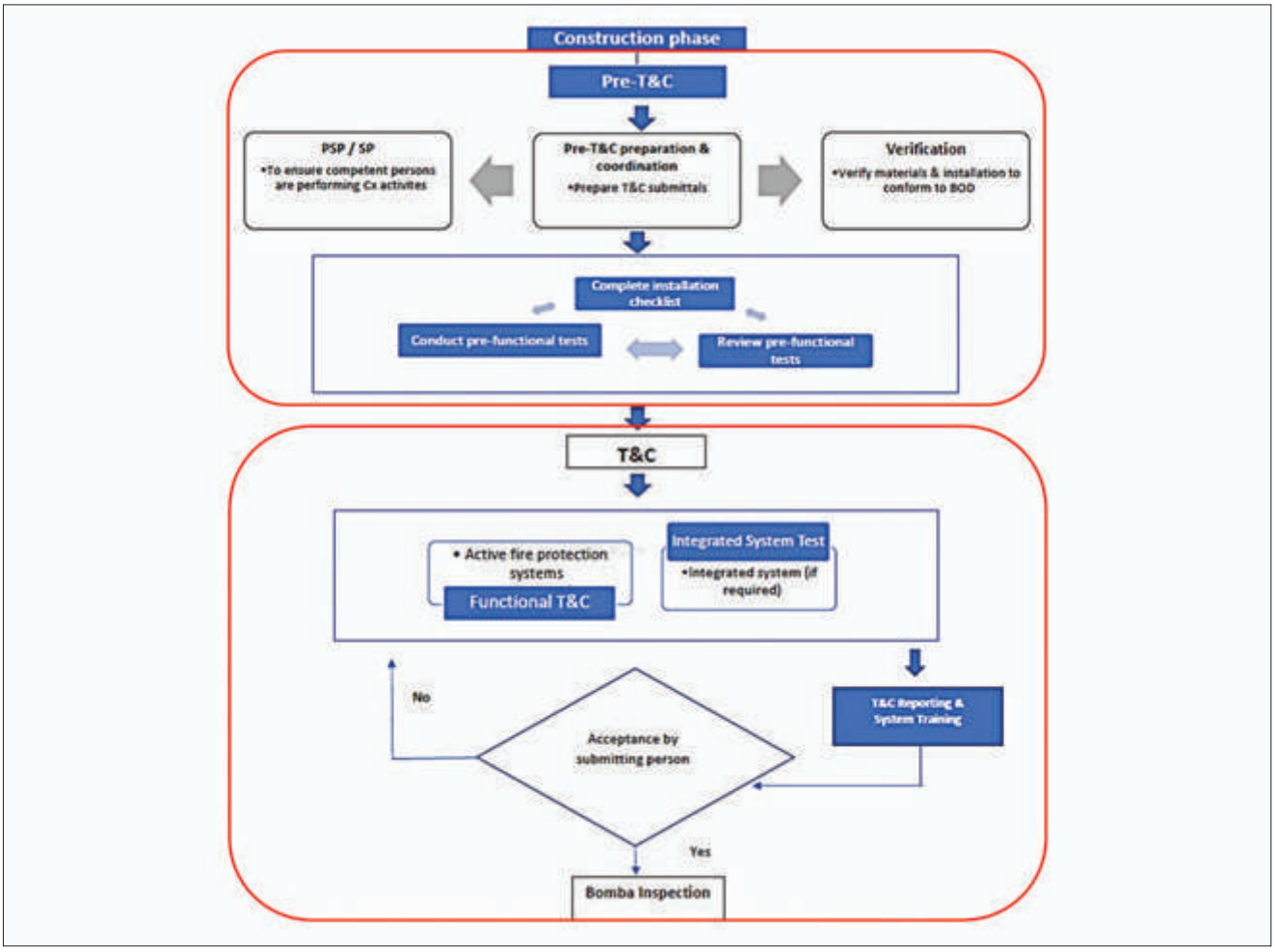

Figure 1: Fire Protection System T&C Flowchart

TECHNICAL VISIT TO KVMRT LINE 2: V207 MINED TUNNEL

by Ir. Dr Rini Asnida binti Abdullah

Participants at V207 site

Fixing reinforcement for tunnel invert concreting

The IEM Tunnelling & Underground Space Technical Division (TUSTD) organised a technical site visit to KVMRT Line 2: V207 Mined Tunnel (West Portal) on 27 of July 2019. An earlier visit was made to the V207 Mined Tunnel (East Portal).

At the briefing for the 10 participants, the project manager, Mr. Vincent Neng, said the tunnel with dimensions of 182m (length), 12.1m (width) and

10.1m (height) was being mined through Kenny Hill, a formation of both interbedded weak rock and residual soil. He then talked about the various stages of construction using the New Austrian Tunnelling Method (NATM).

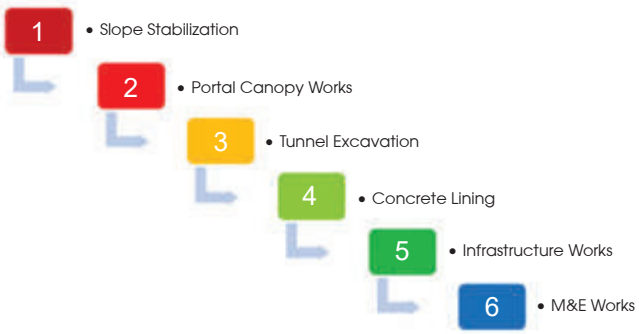

Figure 1: Overall concrete lined tunnel construction stages

Figure 1 shows an overall concrete lined tunnel construction. For the sequential excavation stage, it started with top heading excavation, followed by bench excavation and finally invert excavation. Due to the fair quality of rock mass, the application of forepoling and face bolting as pre-support excavation works (Figure 2) were highlighted. During the excavation works, various support classes were installed based on the geological mapping, such as steel fibre reinforced shotcrete (SFRC), wire meshes, steel ribs and friction bolts.

After the briefing, session chairman Ir. Chong Chi Koong presented a memento of appreciation to Mr. Neng. The participants then proceeded to V207 tunnel site at Taman Universiti. The site of the tunnel had been completely mined and was ready for waterproofing layer, reinforcement and concreting of tunnel invert. ■

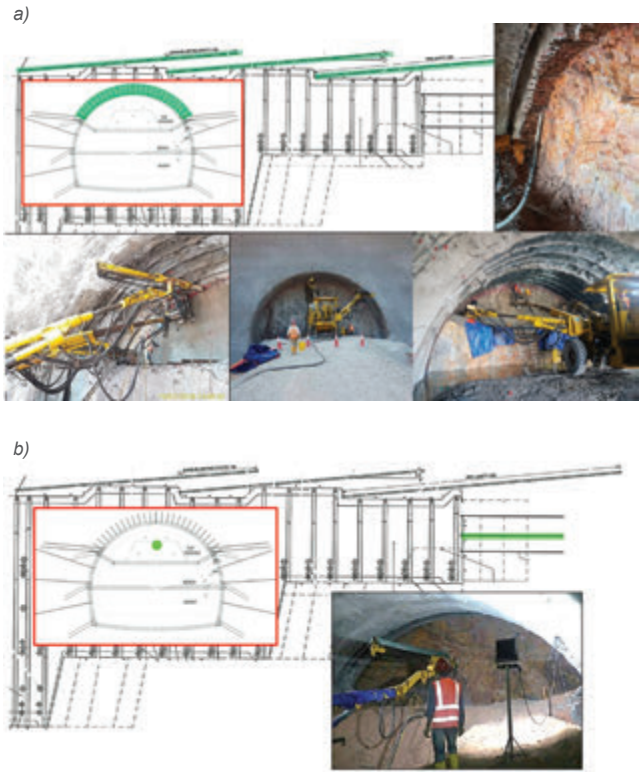

Figure 2: Pre-support application of (a) forepoling, and (b) face bolting

POSTPONEMENT OF 61st ANNUAL GENERAL MEETING

Further to the Special Instruction issued by the Registrar of Societies (ROS) and Council decision on 16 March 2020, IEM wish to announce that the 61st ANNUAL GENERAL MEETING scheduled on 18 April 2020 is hereby postponed to a later date.

IEM will announce the new date once it is confirmed. During this challenging time, IEM hope that all members will abide by directives from the government agencies so as to protect yourselves and others. Stay safe and take care.

IEM Council
17 March 2020

THE WAY FORWARD FOR SMI/SMES IN INDUSTRY 4.0

PART 3: BUILDING AN AFFORDABLE INDUSTRY 4.0 ECOSYSTEM

by Assoc. Prof. Ts. Dr Lee Wah Pheng

Part 3 of a joint project promoted by Urban Engineering Development (UEDSIG) and Mechanical Engineering Technical Division.

In the early stage of building an Industry 4.0 ecosystem, it is necessary to identify the stakeholders in the supply chain (Figure 1). This unique identifier, called Organisation Identifier or Org. ID, is used to trace stakeholders in the entire Industry 4.0 ecosystem. The stakeholder who would like to connect into the Industry 4.0 ecosystem is required to obtain an Org. ID so that other stakeholders will be aware of his/her physical location, business nature and digitised asset information in a secured and trustworthy network.

These stakeholders may not understand Industry 4.0 and so will face difficulties when looking for relevant asset information that may be overloaded with many online and offline media which can be confusing. On the other hand, training courses are either too academic, product-oriented or very specific which may not be suitable for the participants.

One option is to engage an external consultant but this can be costly and may be beyond the means of SMI/SMEs. One possible solution is to have a personalised online learning programme for the SMI/SMEs. This programme should have the flexibility to allow participants to select relevant courses and schedule them accordingly.

As high digital connectivity investment is always the main concern that discourages participation from SMI/SMEs in adopting the Industry 4.0 ecosystem, it is necessary to develop and provide an affordable connectivity framework for them. This framework is called Manufacturing Chain Management (MCM).

MCM (Figure 2) is a software stack in the RAMI 4.0 Architecture Layers to handle tradable digitised asset data delivery between suppliers, production lines and customers, particularly for SMI/SMEs in different geographical locations. SMI/SMEs need only to invest in

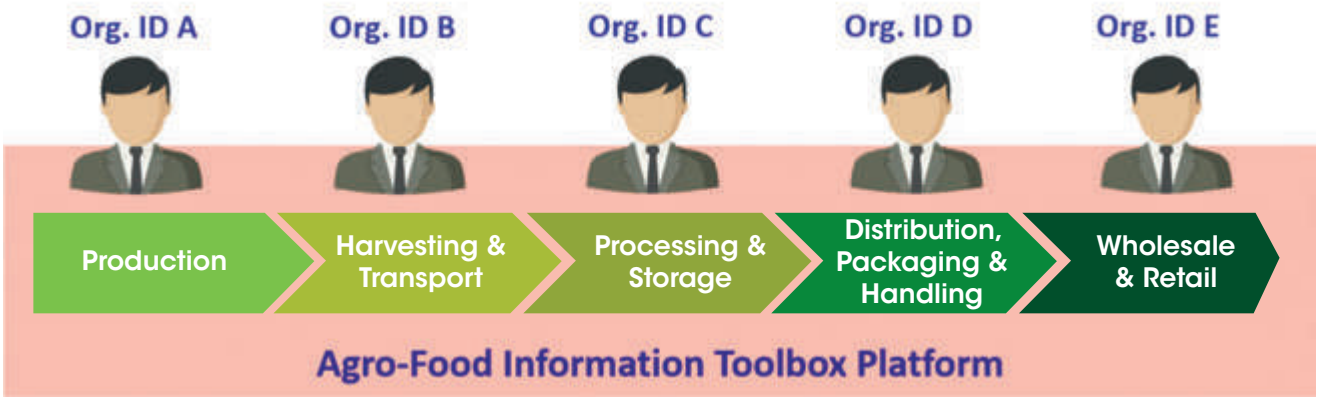

Figure 1: Stakeholders with Org. IDs in the agro food supply chain

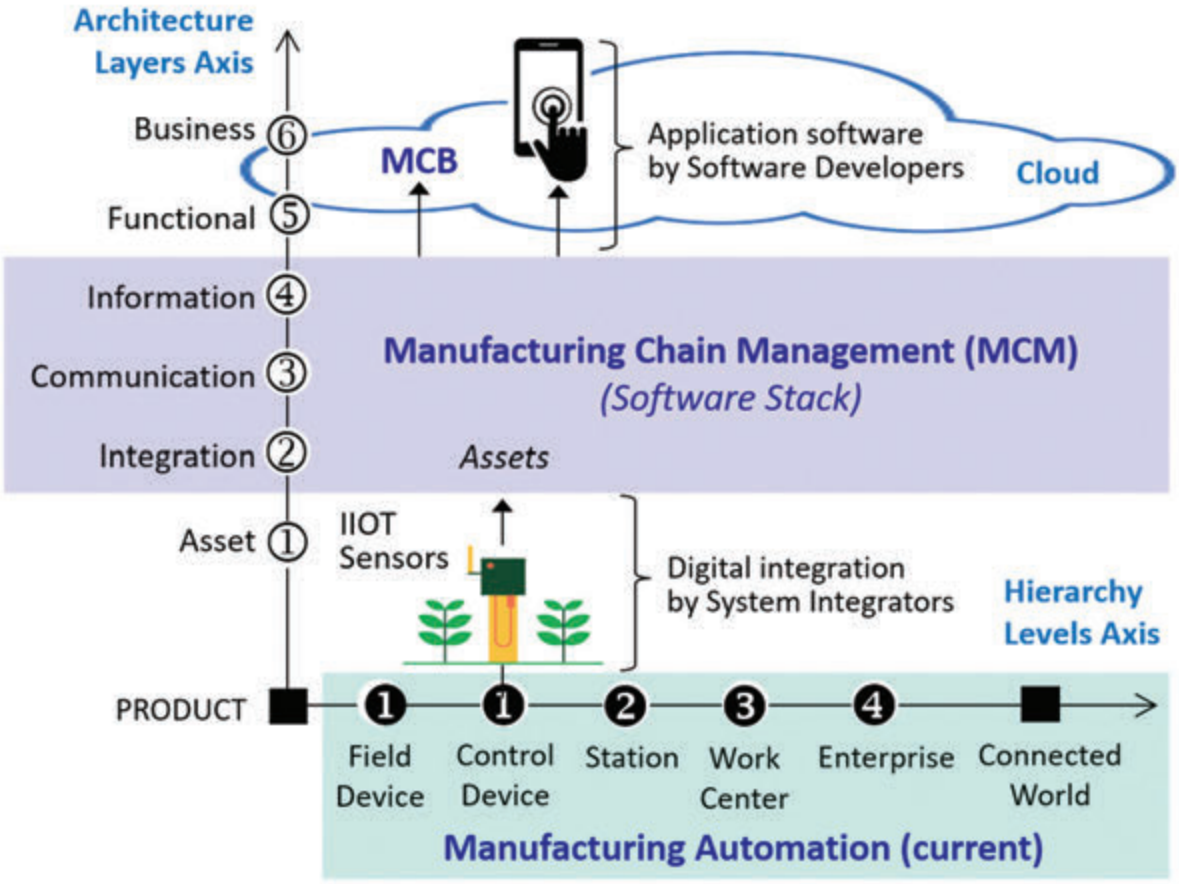

Figure 2: Building Industry 4.0 ecosystem based on RAMI 4.0

the process line digital integration and development of functional software.

Once digitised, the assets in the production line can be indexed by the Manufacturing Chain Broker (MCB) which guarantees data sovereignty and only acts as an intermediary to manage the digitalised asset information repository for all the stakeholders. The MCB is based on the International Data Space Reference Architecture model. Any stakeholder (data consumer) who is interested in obtaining the asset data, will have to register as a member and, through MCB, obtain approval from the stakeholder who owns the asset data (data provider).

Once the infrastructure in the Industry 4.0 ecosystem is developed, the subsequent activities will help connect SMI/SMEs in the ecosystem (Figure 2). The first step is to digitalise the low-level production process and integrate them into MCM. The second step is the development of high-level application software for monitoring the production and business operations based on digitised assets.

During the development stage, an institution of higher learning (IHL) can provide scientific research for the SMI/SMEs. The Fraunhofer model[1] can be adopted to ease the engagement and expectations between IHL and SMI/SMEs as it has been proven to ease the technology transfer from IHL to industry.

In summary, to build a sustainable Industry 4.0 ecosystem in Malaysia, we must increase its awareness through education, develop an affordable connectivity framework, provide asset information brokering platforms in a secure and trustworthy network and encourage institutional support on research. ■

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[1] Marianne Hoffmann, "The Fraunhofer Model – Technology transfer from Universities to Industry", Fraunhofer Headquarters, Japanese-German Symposium, Tokyo, 26-27 April 2018

HAZARD AND OPERABILITY STUDY WORKSHOP

by Tan Sze Hao

IEM UTAR Sungai Long Campus Student Section was started in 2009 to provide a platform for the better development of engineering students.

On 2 March 2019, in collaboration with IEM's Chemical Engineering Technical Division, IEM UTAR Sungai Long Campus Student Section organised a technical workshop on Hazard & Operability Study (HAZOP) at the campus, attended by 23 students.

It was conducted by Ir. Razmahwata from IEM's Chemical Engineering Technical Division who had 20 years' experience in the oil and gas industry, in both design and operations.

The purpose of the workshop was to enhance the students' knowledge of HAZOP. This is a structured and systematic technique for system examination and risk management that is used, in general, to identify potential hazards which may lead to nonconforming products. Using examples of real-life situations, Ir. Razmahwata showed the students how HAZOP could be useful in solving problems in chemical plants.

Gaining such insider knowledge in HAZOP was a huge benefit for the students, especially those studying Chemical Engineering, as they now have a better understanding of industrial expectations as well as an insight into the working environment. ■

Ir. Razmahwata and the workshop participants

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Updated May 2018

ROMANTICISM OF ANCIENT SILK ROAD

Ir. Chin Mee Poon

***Ir. Chin Mee Poon** is a retired civil engineer who derives a great deal of joy and satisfaction from travelling to different parts of the globe, capturing fascinating insights of the places and people he encounters and sharing his experiences with others through his photographs and writing.*

My first trip on the ancient Silk Road was in August 2001. I had joined a group of friends to retrace the footsteps of yesteryears' trade caravans from Urumqi, the capital of Xinjiang Uyghur Autonomous Region of China, to Islamabad, the capital of Pakistan, cutting across the great Taklamakan Desert and skirting the mighty Kunlun Mountain Range to reach Kashgar, and then following the Karakoram Highway over Khunjerab Pass into the extremely beautiful Hunza Valley deep in Karakoram Mountain Range in Pakistan-controlled Kashmir.

From the first I heard about this ancient trade road, it exerted an irresistible attraction on me like a magnet. Its very name exuded a strong connotation of romanticism bequeathed by great travellers of the past.

I have since visited other parts of the Silk Road over the years. In March 2008, my wife and I spent 32 days exploring the Silk Road from Xian to Urumqi. In September-November 2010, we visited many old Silk Road cities in Iran and Turkey over 55 days.

In September 2011, we spent 35 days in Italy to visit Rome and many other cities. In November and December of the same year, we took 49 days to visit old Silk Road cities in Central Asia and in May-June 2017, we spent 44 days in Bulgaria and Romania, visiting yet more old Silk Road cities as well as other places.

Many people think that the Silk Road is a single road extending westwards from Chang-an (present day Xian) to Rome, a distance of about 6,500km. But the name "Silk Road" is really a misnomer as it is actually a network of roads between the East and West. These allowed not only commodities to move one way or the other, but more importantly, they facilitated the propagation of knowledge, technologies, ideologies, cultures and religions over a very large area.

So when German geographer and explorer Ferdinand von Richtofen gave this network of roads the moniker "die Silkenstrasse" (Silk Road) in 1877, he created two misleading connotations: First, that there was only one road and second, that silk was the only commodity that mattered.

Silk was undoubtedly very precious to the westerners before they stole the secret of silk making from the Chinese, but many other valuable goods also moved along the roads, not necessarily between China and the West, but also between the countries along the roads as well.

The network of roads not only ran in an east-west direction but north-south as well. This dense network of roads would certainly have taken a very long time to evolve. No single person or country could claim credit for its creation. Many of the roads passed through territories with hostile climates or people, so traders plying the routes often faced the risk of losing their goods and even their lives. Most confined their activities to small sections of the road, so a bale of silk would have gone though many hands before it reached the western market.

In early 7th century AD, during the Tang Dynasty, Buddhist monk Xuan Zang made a very long journey on the Silk Road from Chang-an to India to study Buddhism. More than 6 centuries later, Marco Polo of Venice followed his father and uncle to the Yuan Dynasty capital (present-day Beijing), also via the Silk Road. These two great travellers are rare examples of the very few who succeeded in traversing the Silk Road extensively.

The Silk Road began its decline as soon as Europe went through the industrial revolution and many countries became maritime powers, sending fleets of cargo ships out on the high seas.

Today, the ancient Silk Road remains a symbol of bygone romanticism, waiting for intrepid travellers to unearth its many past glories. ■

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LAI CHUEN HIEN	BE HONS (NANYANG) (CIVIL, 2012)
MUHAMMAD FIRDAUS BIN A RAHMAN	BE HONS (UTHM) (CIVIL, 2013)
PET ROYSTON BIN PAULUS TINUS	BE HONS (UiTM) (CIVIL, 2013)
KEJURUTERAAN KIMIA	
MOHD HAZUWAN BIN CHE ISHAK	BE HONS (UTM) (CHEMICAL-POLYMER, 2008) ME (UTM) (PETROLEUM, 2015)

PERMOHONAN BARU / PERPINDAHAN MENJADI AHLI KORPORAT

Nama	Kelayakan
KEJURUTERAAN AWAM	
MOHD. TAHA BIN ABD. WAHAB	BE HONS (ARIZONA) (CIVIL, 1988)

PERPINDAHAN AHLI

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
52845	CHEAH SHENG HONG	BE HONS (UTHM) (CIVIL, 2013)
30148	DUANE ALVIN WILLIAM BAYA	BE HONS (UNITEN) (CIVIL, 2012)
104306	JOSEPH CHEN CHO' LIN	BE HONS (SWINBURNE) (CIVIL, 2014)
76050	TAN KEN HENG	ME HONS (NOTTINGHAM) (CIVIL, 2014)
51625	TAN SIANG LOONG	BE HONS (UTM) (CIVIL, 2012)
41750	TAN SOONG CHING	BE HONS (UKM) (CIVIL & STRUCTURAL, 2011)
KEJURUTERAAN ELEKTRIKAL		
93670	JAGDESH RAO A/L KRISHNAN	BE HONS (UTM) (ELECTRICAL, 2016)
29109	LIM KHONG HEAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2006)
107808	MARCO P. KISSOL	BE HONS (UTHM) (ELECTRICAL, 2010)
47167	OOI BAN JUAN	BE HONS (MALAYA) (ELECTRICAL, 2012)
99157	YUVARAJA A/L K. GOKULABALAJI	BE HONS (UNITEN) (ELECTRICAL POWER, 2011)
KEJURUTERAAN ELEKTRONIK		
51683	SITI AISYAH BINTI ANAS	BE HONS (UTeM) (ELECTRONIC (COMPUTER), 2008) ME (UKM) (COMMUNICATION & COMPUTER, 2011)
KEJURUTERAAN MEKANIKAL		
54272	AZIM BIN AZMI	BE HONS (UTM) (MECHANICAL, 2010) MSc (UTM) (MECHANICAL, 2018)
109219	CHONG KOK HONG	BE HONS (UPM) (MECHANICAL, 2008)
46690	FARIS FIRDAUS BIN ABDUL MUTALIB	BE HONS (UiTM) (MECHANICAL, 2014) MSc (UTM) (MECHANICAL, 2019)
27492	LIOW SOON SHAK	BE HONS (UNIMAS) (MECHANICAL & MANUFACTURING SYSTEMS, 2006)
35790	SIEW HAW SHIUN	BE HONS (UTM) (MECHANICAL - MANUFACTURING, 2010)

PERMOHONAN BARU / PERPINDAHAN MENJADI AHLI KORPORAT

No. Ahli	Nama	Kelayakan
KEJURUTERAAN ELEKTRIKAL		
69516	ABANG NIZAMUDDIN BIN ABG MOHD KHALID	BE HONS (UTP) (ELECTRICAL & ELECTRONICS, 2013)
KEJURUTERAAN KIMIA		
19733	BURHANUDIN BIN ABU BAKAR	BE HONS (UTM) (CHEMICAL, 1996)
KEJURUTERAAN MEKANIKAL		
65208	GAN SOON KAI	BE HONS (UTAR) (MECHANICAL, 2013) ME (UPM) (ENGINEERING MANAGEMENT, 2015)
21154	LIM POH SENG	BE HONS (UPM) (MECHANICAL, 2000)

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3	13215	IR. LIM CHEE KOK
4	07078	IR. LOO YEOW CHUEN
5	11946	MR. CHEW YEE CHUAN
6	09362	DATO' IR. AHMAD 'ASRI BIN ABDUL HAMID
7	09952	MR. LIM CHENG SENG
8	14816	IR. CHEW SIANG MENG
9	25525	MR. CHOW CHIN SEANG
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49	87691	MR. MOOI WING QUEN

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No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
48924	KHOO CHEN KIAT	BE HONS (NOTTINGHAM) (CIVIL, 2006) MSc (NUS) (CIVIL, 2010)
27881	LEONG KING YAP	BE HONS (UMS) (CIVIL, 2007)
53730	LO SIE CHIEH	BE HONS (WALES) (CIVIL, 2004)
48896	LOH WEI LUN	BE HONS (USM) (CIVIL, 2010)
49957	MANSOR BIN MOHAMAD	BE HONS (UTM) (CIVIL, 2000)
38777	MASSILAWATI SALWA BINTI MUKHTAR	BE HONS (UKM) (CIVIL & STRUCTURAL, 2005)
66384	MOHD DZULHUZMI BIN NASRUDDIN	BE HONS (UTM) (CIVIL, 2009)
76836	MOHD ZULKHALID BIN AFANDI	BE HONS (MALAYA) (CIVIL, 2013)
17835	NG KIM SENG	BE HONS (MALAYA) (CIVIL, 1999)
37368	NOR AZIZAH BINTI MOHAMMED RUM	BE HONS (UTHM) (CIVIL, 2010)
41314	NUR AIN BINTI SHA'ARI	BE HONS (UiTM) (CIVIL, 2008)
45549	OOI ZI XUN	BE HONS (USM) (CIVIL, 2014)
45283	RAGESH KUMAR LINGAM	BE HONS (UTM) (CIVIL, 2004)
93782	RAHMAT ZULHAIRI BIN MOHAMED	BE HONS (UTM) (CIVIL, 2010)
14962	RICHARD ANAK TAJAN	BE HONS (UiTM) (CIVIL, 1992)
22369	SARAH BINTI ISMAIL	BE HONS (MALAYA) (CIVIL, 2001) MSc (UKM) (CIVIL, 2014)
29489	SHAHRUL BAZLI BIN SHAHARUDIN	BE HONS (UTHM) (CIVIL, 2011)
25570	SIA KIE DING	BE HONS (SOUTH AUSTRALIA) (CIVIL & WATER, 2000) ME (ADELAIDE) (CIVIL & ENVIRONMENTAL, 2008)
44543	SITI AZURA BINTI MAT DAUD	BE HONS (UTM) (CIVIL, 2006) MSc (SHEFFIELD) (URBAN WATER ENG. & MANAGEMENT, 2013)
55880	SONG YU MING	BE HONS (UTM) (CIVIL, 2010) ME (UTM) (CIVIL-STRUCTURE, 2012)
70446	SU KEIN LEONG	BE HONS (CURTIN) (CIVIL & CONSTRUCTION, 2013)
38786	SYAHBRINA BINTI OSIN	BE HONS (UTHM) (CONSTRUCTION, 2006)
38612	TIE KING BANG	BE HONS (USM) (CIVIL, 2006)
24542	V PARANJOTI A/L VEERAPPAN	BE HONS (UTM) (CIVIL, 2001)
38863	YAP WERN YIAN, MICHAEL	ME HONS (IMPERIAL COLLEGE LONDON) (CIVIL, 2009)
90066	YIK YEW SIONG	BE HONS (UKM) (CIVIL & ENVIRONMENTAL, 2011)
89028	ZIKI THENI BIN KUSHAN	BE HONS (UTM) (CIVIL, 2014)
93701	ZURHIJJAS BIN RABIEE	BE HONS (UNIMAS) (CIVIL, 2011)
KEJURUTERAAN BIOPERUBATAN		
93539	KHAIRUNNISA BINTI HASIKIN	BE HONS (MALAYA) (ELECTRICAL, 2007) MESc (MALAYA) (BIOSENSOR, 2010) PhD (USM) (2014)
95827	SITI NORAINI BINTI SULAIMAN	BE HONS (USM) (ELECTRICAL & ELECTRONIC, 2000) MSc (USM) (ELECTRICAL & ELECTRONIC, 2003)
KEJURUTERAAN ELEKTRIKAL		
48783	AAIZUDDIN-HUSSAINI BIN NOH	BE HONS (UTHM) (ELECTRICAL, 2013)
84851	ABD AFFIDZ BIN ABD MOKMIN	BE HONS (UNITEN) (ELECTRICAL POWER, 2013)
40843	AHMAD FADZLI BIN AHMAD TARMUGI	BE HONS (UMP) (POWER SYSTEMS, 2010)
69508	AKMAL ARIF BIN MOHAMMED	BSc (TEXAS AT AUSTIN) (ELECTRICAL, 2008)
58097	CHAN YI VON	BSc HONS (WESTERN MICHIGAN) (ELECTRICAL, 2012)
59068	CHIA HUA MING	BE HONS (USM) (ELECTRICAL, 2012)
88799	CHIENG HING SENG	BE HONS (UTM) (ELECTRICAL, 2003)
90324	CHONG TSE MING	BE HONS (MMU) (ELECTRICAL, 2012)
26224	FADZLIDA BINTI FADZIL	BE HONS (UTM) (ELECTRICAL, 2006)
49923	GEETHA A/P BALAKRISHNAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2008)
56491	GOPI A/L SUBRAMANIAM	BE HONS (UNITEN) (ELECTRICAL POWER, 2009)
65234	HO MIN LOONG	BE HONS (NORTHUMBRIA) (ELECTRICAL & ELECTRONIC, 2000) CONVERSION (UNITEN) (2012)
32590	IRWAN BIN ISMAIL	BE HONS (UTP) (ELECTRICAL & ELECTRONICS, 2003)
48910	KRISHNAN A/L PANERSELVAM	BE HONS (AIMST UNIVERSITY) (ELECTRICAL, 2007)
41249	KU HONG LEONG	BE HONS (UPM) (ELECTRICAL & ELECTRONICS, 2008)
59169	MOHAMAD FAKHRURUDDIN BIN ROMELI	BE HONS (UKM) (ELECTRICAL & ELECTRONIC, 2014)
50166	MOHD ALIF BIN MOHD NOR	BE HONS (UTM) (ELECTRICAL, 2009)
24093	MOHD AZHAN BIN SIDIK	BE HONS (MALAYA) (ELECTRICAL, 2005)
61143	MOHD FIRDAUS BIN MOHAMAD IDRIS	BE HONS (UTM) (ELECTRICAL, 2012) MSc (UiTM) (MANAGEMENT, 2018)
87390	MOHD NAZLAN BIN SAPRI	BE HONS (USM) (ELECTRICAL, 2010)
94150	MOHD SUHAIMI BIN MOHD YUNUS	BE HONS (UTM) (ELECTRICAL, 2006)
56495	MOHD SYAFREN EFFENDY BIN MOHD YUSOFF	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2007)
93849	MOHD YASMER BIN DAUD	BE HONS (UiTM) (ELECTRICAL, 2009)
78483	MOHD YUSRI BIN SARDAR ALI	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2012)
73380	MOHD ZAFROL HAFEEZ BIN SHEE KANDAR	BE HONS (UTM) (ELECTRICAL, 2002)
81269	MUHAMAD FALIHAN BIN BAHARI	BE HONS (UTM) (ELECTRICAL, 2006)
95850	MUHAMMAD EZIRI SAIRI BIN MOHD RAZALI	BE HONS (UNITEN) (ELECTRICAL POWER, 2012)
72646	MUHAMMAD RANDIE BIN ABDULLAH	BE HONS (USM) (ELECTRICAL & ELECTRONIC, 1998)
86550	MUHD ASYIKUN ILAHI BIN ISMAIL	BE HONS (UTM) (ELECTRICAL, 2015)
87049	NAZMI BIN ZULKIFLI	BE HONS (MALAYA) (ELECTRICAL, 2010) ME (MALAYA) (POWER SYSTEM, 2013)
28530	NOR AISYA BINTI ZAKARIA	BE HONS (UTHM) (ELECTRICAL, 2009)
58683	NORHAZIRAH BINTI JAAFAR	BE HONS (UTeM) (POWER ELECTRONIC & DRIVE, 2011)
90143	NURHIDAYAH BINTI IBRAHIM	BE HONS (UMS) (ELECTRICAL & ELECTRONICS, 2012)
61129	PRATAP A/L CHILAPPAN	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2010)
44296	SANDEEP SINGH THALIVAL	BE HONS (UTeM) (ELECTRICAL-POWER ELECTRONIC & DRIVE, 2011)
79319	SIM WEI HONG, JAMES	BE HONS (UTM) (ELECTRICAL, 2010)
90058	SYAKIB ARSALAN BIN KAMARUDIN	BE HONS (UiTM) (ELECTRICAL, 2013)
34847	SYED FAREED BIN SYED OMAR	BE (LOUGHBOROUGH) (ELECTRONIC & ELECTRICAL, 1994) ME (UNITEN) (ELECTRICAL, 2006)
34331	TAN SEE HEAN	BSc HONS (WICHITA STATE) (ELECTRICAL, 2004)
55872	TEE PING HONG	BE HONS (UTP) (ELECTRICAL & ELECTRONICS, 2011)
93810	WAN ABDUL AZIR BIN WAN MUSA	BE HONS (UTHM) (ELECTRICAL, 2005)
81451	WAN MOHD SUKAIRI BIN WAN MUSTAPHA	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2014)
33762	WAN OTHMAN BIN WAN JUSOH	BE HONS (UTM) (ELECTRICAL, 2002)
61911	YU YONG KOK	BSc HONS (WESTERN MICHIGAN) (ELECTRICAL, 2000)
58010	YUSUF BIN MOHD SALLEH	BE HONS (UTM) (ELECTRICAL, 2009)
94130	ZUL HAZUZAN BIN ALI	BE HONS (UMS) (ELECTRICAL & ELECTRONICS, 2011)
KEJURUTERAAN ELEKTRONIK		
87343	ADZNINA BINTI EBERAHIM	BE HONS (UiTM) (ELECTRICAL, 2009) MSc (UiTM) (TELECOMMUNICATION & INFORMATION ENGINEERING, 2011)
54561	AHMAD ZURIYADI BIN PAWZI	BE HONS (UTM) (ELECTRICAL-ELECTRONIC, 2009)
87323	AINON SHAKILA BINTI SHAMSUDDIN	BE HONS (UTM) (ELECTRICAL POWER, 1998) ME (UTM) (MANAGEMENT, 2010)
72615	AZIZUL BIN AWANG ANAK	BE HONS (UTM) (COMPUTER, 2006)
85921	CHOW VOON YANG	BE HONS (AUSTRALIAN NATIONAL UNIVERSITY) (ELECTRONIC & COMMUNICATION SYSTEMS, 2012)
90132	JULIANA BINTI JOHARI	BE HONS (STRATHCLYDE) (ELECTRICAL & ELECTRONIC, 1992)
57036	LAU YEW NEN	BE HONS (UNIMAS) (ELECTRONICS & TELECOMMUNICATION, 2004)
85960	MOHAMMAD FARID BIN SAAID	BE HONS (UiTM) (ELECTRICAL, 2006)
60032	MUHAMMAD SYAHIR BIN BADRUDDIN	BE HONS (UPNM) (ELECTRICAL & ELECTRONIC, 2012)
62062	NG WEE KIAT, DANNY	BE HONS (MULTIMEDIA) (ELECTRONICS-BIOINSTRUMENTATION, 2008)
78065	ROZITA BINTI JAILANI	BE HONS (UiTM) (ELECTRICAL, 2002)
90307	SUZI SEROJA BINTI SARNIN	BE HONS (UTM) (ELECTRICAL, 1999) MSc (UKM) (MICROELECTRONICS, 2006)
34906	TAY CHING EN, MARCUS	BE HONS (UTM) (TELECOMMUNICATION, 2012) PhD (UTM) (ELECTRICAL, 2015)
49970	WAN KHAIRUNIZAM BIN WAN AHMAD	BE (YAMAGUCHI) (ELECTRICAL & ELECTRONIC, 1999) PhD (KAGAWA) (2009)
KEJURUTERAAN GEOTEKNIK		
48501	KANG YEE PING	BE HONS (UTM) (CIVIL, 2010)
32092	ONG KAH PENG	BE HONS (USM) (CIVIL, 2011)
KEJURUTERAAN KIMIA		
80187	MUSA BIN MA'AMOR	BE HONS (UiTM) (CHEMICAL, 2009)
38332	SHAZANA BINTI MOHD IBRAHIM	BE HONS (UTM) (CHEMICAL, 2007) ME (UTM) (ENVIRONMENTAL, 2009)
101011	SHUHAIDA BINTI HARUN	BE HONS (BROOKLYN) (CHEMICAL, 1995) MSc (UKM) (PROCESS SYSTEM, 2008) PhD (UKM, 2014)
26492	SYAIFALIZAN AKMA BINTI JAMALUDIN	BE HONS (UTP) (CHEMICAL, 2002)
102420	YEO WAN SIENG	BE HONS (UTM) (CHEMICAL-BIOPROCESS, 2007) M.PHIL (CURTIN) (CHEMICAL, 2014)
KEJURUTERAAN KOMUNIKASI		
64571	ABDULLAH 'IRFAN BIN ABDULLAH	BE HONS (IIUM) (COMMUNICATION, 2006) MSc (UiTM) (TELECOMMUNICATION & INFORMATION ENGINEERING, 2016)
86301	KHAIRAYU BINTI BADRON	BE HONS (IIUM) (COMMUNICATION, 2006) MSc (IIUM) (COMMUNICATION, 2011) PhD (IIUM) (2016)
KEJURUTERAAN LEBUHRAYA		
48899	SAHARA BINTI SAI'EN @ ABDULLAH	BE HONS (UMS) (CIVIL, 2007) ME (UPM) (HIGHWAY & TRANSPORT, 2013)
KEJURUTERAAN MEKANIKAL		
32304	AHMAD ABIDI BIN JAAFAR	BE HONS (UiTM) (MECHANICAL, 2010)
57025	AHMAD NORSYAHMEY BIN RAMLI	BE (EHIME, JAPAN) (MECHANICAL, 2007)
79004	CHAN YING WAI	BE HONS (UNIMAS) (MECHANICAL & MANUFACTURING, 2013)
79352	CHEAH YUANFENG	BE HONS (MALAYA) (MECHANICAL, 2014)
69507	FOO REN HAW, HUDSON	BE HONS (RMIT) (MECHANICAL, 2011) MSc (RMIT) (BUSINESS ASMINISTRATION, 2013)

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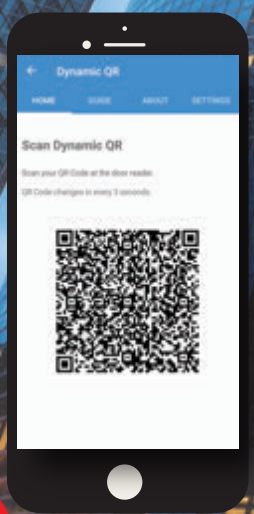

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