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The Necessity of Offering Higher Education in Fire and Safety Engineering in Hong Kong

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Abstract: The necessity of providing higher education in Fire and Safety Engineering in Hong Kong will be discussed in this paper. Subjects including Fire Engineering and Safety Engineering such as Fire Dynamics; Computational Fire Modelling for Building Design; Fire Engineering System; Legislation Aspects of Fire Safety Management; Design Considerations for Fire Safety Management; Safety Aspects in Construction; Occupational Health and Ergonomics; Accident Prevention, Hazard Assessment and Control; and Safety Management Systems and Safety Auditing should be offered.

Key words: Higher education; Fire and Safety Engineering; Hong Kong

0 Introduction

With the growing construction industry in Hong Kong (now the Hong Kong Special Administrative Region HKSAR), there are lots of new architectural features such as atrium, green or sustainable buildings, and large building complex with high occupant loadings. Fire safety provisions in these buildings [1], together with existing buildings [2] should be watched due to the new style of living and new materials used.

Fire engineering is not a new profession, including only the active fire protection systems or called fire services installations (FSI) in Hong Kong. This part is taken care of by the Fire Services Department (FSD) under the Fire Services Ordinance and FSI codes [3]. Design, installation, operation and maintenance of FSI are normally held responsible by the building services engineers. Basically, there are three main areas on fire hydrant/hose reel (FH/HR) systems; fire alarm and detection systems; and sprinkler systems. FH/HR and fire alarm systems are required in all high-rise buildings. Sprinkler systems are required in almost all non-residential buildings. Smoke management systems might be installed for underground spaces or atria with space volume larger than certain values. Special areas like transformer and computer rooms might have gas protection systems.

Passive building constructions (PBC) such as fire resisting construction, compartmentation and evacuation routes should also be provided. PBC is controlled by the government Buildings Department (BD) with codes on means of access (MoA), means of escape (MoE) and fire resisting construction (FRC) [4~6]. Normally, these are taken care of by the architects, structural engineers and building surveyors. Note that there are lots of prescriptive guidelines, regulations or codes for PBC, the design is quite routine with very little flexibility. The fire engineering profession in the past did not look so scientific. Engineers have to deal with human relationship in arranging construction of PBC and installation of different

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FSI by different contractors. Therefore, management is even more important than technical aspects.

However, since the implementation of fire safety engineering approach [1, 7] on PBC by the BD in 1998, the "fire engineering" profession has become a much more scientific subject. There are not yet engineering performance—based fire codes (EPBFC) [8 ~ 11] in Hong Kong. Such code on PBC will be drafted later and a consultant has been appointed to complete a draft code within three years. The FSI code [3] itself is quite "performance—based" as there are neither clear design data nor fire safety objectives. Officers would consider fire safety engineering approach for buildings with difficulties to comply with the FSI code; and accept the design if the engineers are able to demonstrate the performance of the systems.

Safety engineering deals with all safety aspects such as in construction sites, industrial plants or even domestic appliances. However, there are not many factories left in Hong Kong now, with a large percentage moved to the North. Construction safety therefore becomes the biggest market. The Hong Kong Institution of Engineers (HKIE) is considering whether a discipline of "Safety Engineers" should be identified. But before doing so, there must be well—structured first degree programmes [12 ~ 14] offered by local educational institutes, with strong support from research and development activities.

The recent serious and fatal accidental fires [e. g. 2] indicated that the professionals in fire and safety engineering really bear great responsibilities in achieving safety in appropriate design and also in improving safety in all aspects of the buildings.

In order to enhance their knowledge, well-structured degree programmes [12] offered by the local educational institutes with strong research and development are required. Higher education in fire and safety engineering in Hong Kong is in great demand.

Application of fire modelling, EPBFC, hazard assessment and fire safety management [15] are all included. Research results revealed that current regulations on building fire safety are set up without carrying out extensive studies. The fire protection systems installed might not be able to control a fire.

In this paper, the necessity of conducting research and teaching in fire and safety engineering in Hong Kong is discussed. What should be included in an MSc programme are stated.

1 Education Desired

Consequent to the Asian economic depression, the pattern of the workforce in Hong Kong has changed. Because of the high labour cost as salary is linked with the high land price (though it has dropped by almost 60% of the peak value), competition is very strong. The unemployment rate has gone up to almost 8%. Labours, whether skilled or unskilled, professional or general, are eager to train up themselves to increase their competitive power. They would carefully choose the programmes to suit their needs. Not only can they get an MSc award, but also have the real power and strength to compete with others in the industry. An MSc in Fire and Safety Engineering programme cannot be offered without strong scientific research support. This should be a collaboration between experts in the Mainland and Hong Kong.

Advanced research activities related to fire engineering are carrying out actively at the PolyU through the Research Centre for Fire Engineering, Department of Building Services Engineering. Those research projects are carried out for solving practical engineering problems, searching for advanced knowledge in fire engineering and maintaining the quality of teaching. These are essential in achieving excellence in teaching at the PolyU where advanced and practical degree courses up to MSc level are offered with the mission to conduct Applied Research. The research findings are useful to the industry of Hong Kong, and would be applicable to the Mainland.

An MSc programme in Fire Safety Engineering was offered at PolyU in 2000 with the aims to provide continuing education in fire and safety engineering to those working in the industry with qualifications at professional level; to enhance students' knowledge in fire and safety engineering as well as to improve their learning attitude, study skills and their intellectual

and imaginative power; and for students to understand the requirements for providing fire safety in all aspects and how to achieve this by appropriate design. One aim is to enhance quality teaching in Hong Kong on the new topic of EPBFC. On safety engineering, emphasis is put on improving the safety aspect of buildings. Accident prevention, hazard assessment, risk analysis, safety management and auditing, and safety in construction sites would all be discussed.

2 Fire Safety Concerns for New Architectural Features

The environmental problem of global warming has been announced for decades. Advanced functions and facilities in buildings such as extensive use of artificial lighting and air-conditioning system are the major sources of environmental problems. Therefore, developers and architects have to take their responsibilities to improve the building designs in order to minimize the energy use and thus the green house gas emission. Their efforts have been evolved into the prevailing idea of green architecture, which means environmental friendly and energy conservation. It is also taken as a top priority by the local government. As emphasized in the Policy Address by the Chief Executive in October 2001, enhancing the quality of life and improving the living environment is one of the principal policies. Government departments have started to promote green buildings collaboratively [16].

New architectural features in Hong Kong can be seen in most of the new developments. Their design objectives are focused on the reduction of energy consumption, introduction of natural resources and also integration of both natural and artificial environment. Some examples are internal building voids, double glazed wall, glass curtain wall, natural ventilation design and the use of materials with good thermal insulation.

Internal building void becomes a favorable design in some new residential buildings since larger area of desirable views, such as a harbor view, and natural daylight can be provided to the living room by such design and it is still code-compliant [17]. However, the internal void, with full building height, where bathrooms and kitchens of every unit are opened to is found imposing additional fire risk [18]. Flashover is likely to occur when there is certain amount of combustible materials. Study also shows that the spread of smoke from the fire room to the adjacent levels through the building void is easily induced by natural driving forces of air flow including stack effect, wind-induced action and buoyancy of hot smoke.

Daylight is frequently introduced through the glass wall and window to minimize the use of artificial lighting, especially for the office towers because sufficient lighting is able to ensure the productivity of the office operation. However, the solar heat may be trapped inside the building and results in the increase of cooling load. Therefore, a double glazing system is created to overcome the problem. Two glass panes are installed parallel to each other, leaving an air gap in-between to let the heat be driven away. Most of the newly-erected government office towers have been built with this special external wall [19]. Glass is a non-combustible material but it will be weakened when heated up to its maximum operating temperature. Cracking may be resulted [20] because heat is difficult to transfer in a glass pane from the area exposed to the fire to the other region due to its poor conductivity, and in the worst case, the whole piece of glass will fall out from its frame [21]. For the double fa?ade buildings, the air gap between the two layers of glass may introduce a channel for smoke spreading when there is a fire.

Introducing natural ventilation is one of the means to maintain thermal comfort for human other than using mechanical ventilation system. Air flow induced by wind action is able to cool down the internal temperature and also improve the internal air quality by providing some fresh air. Some of the domestic developments are applying this design feature, however, it is only applicable for those premises in the newly-developed areas in Hong Kong due to the compacted urban space in other developed districts. Wind action outside a building would generate pressure difference across the building envelop. When there is a

fire inside one of the stories, the opened windows would create a pathway for the spreading of smoke. A negative pressure may probably be generated on the leeward side of the building. Flame and smoke would then spread out through the windows easily and to the other stories and buildings.

Apart from wind action, using envelop with high capacity of thermal insulation is another way to attain thermal comfort. Only little solar heat can pass through the building envelop of low heat transmission and good thermal insulation into the occupied spaces. Heat gain inside is thereby minimized. However, some newly-developed materials, such as sandwich panels, have not yet been tested thoroughly against fire safety problems. For example, flame spreading may probably occur over a thermal insulation sandwich panel.

In the local codes, prescriptive-based is still the main approach [22]. Minimum requirements based on the size and use of premises are specified. The incremental legislation is developed after each time a big fire had occurred. The new requirements will be added as an extension to the existing building codes. The prescriptive codes, developed for tens of years, might not be able to respond to the fast track of construction development in this era. Premises nowadays have their unique features while the older generation of buildings applied similar plans. Performance-based fire codes may be a solution to the potential fire hazard associated with innovative building designs and materials.

Fire behaviour of new materials has to be considered. Results measured from fire tests on building materials should be referred to. These tests give information on burning materials including heat release rate, flame spread, and their contributions to flashover. In testing the brand new materials, the newly-evolved fire test methods are more suitable than those outdated tests. For those creative building designs which are not code-compliant, Computational Fluid Dynamics [23] can be used to study the smoke movement, however, it should also be supported by experimental data in order to verify the results. All these are already out of scope of the existing prescriptive fire codes. Therefore, it is more appropriate to have the fire engineering approach to assess the fire hazard associated with new architectural features.

Traditionally, fire engineering is not so a "high-level" profession. Local engineering professionals follow the UK practice of having Chartered Engineers (CEng) under the Engineering Council (EC) and now, the HKIE. Previously, fire engineers were not grouped under the UK-EC and could only use the title of CEng if they are also corporate members of engineering institutions recognized by the EC. This might be reviewed by HKIE later as implementing EPBFC would change "fire engineering" to a high-level profession.

Exploring the scientific understanding of building fire problems and fire protection engineering becomes very critical in implementing EPBFC for providing better safety to people. There have been research activities at PolyU which can be divided into theoretical studies and practical activities. For the theoretical aspect, intense effort has been put into fire modelling. Research on fire spread using the field modelling technique [23] (or sometimes called application of Computational Fluid Dynamics CFD or Numerical Heat Transfer NHT) should be performed to solve practical fire problems encountered by the local industry. Hot topics in Hong Kong include water system research, smoke management, false alarms in fire detection system, and fire aspects in industrial buildings, hotels, karaokes, tunnels, car parks and university campuses.

3 Local Safety Aspects

There are about 3.4 million workers in Hong Kong [24] with about 0.77 million working in construction sites [25]. Accident rates in the construction industry remain high throughout the years. The accident occurrence rate and fatal rate were 3.6 times and 8.3 times of those in all other industries in 1999 [26]. In year 2001, the construction industry accounted for about 32.3 % of the total number of industrial accidents and 82.4 % of the total industrial fatalities in Hong Kong [27]. The number of accidents (9,206 cases in 2001) still remains unaccept-

ably high, though the fatality rate (0.349 in 2001) was observed to be decreased by 52.7 % when compared to the average rate (0.728) of the past 10 years.

In the coming five years, the government is going to develop many large infrastructure projects of value over HK $210 billion, involving the expansion of construction workforce to 115,000 by 2003 [28]. The accident rate is expected to rise due to tight schedules and employment of foreign workers. Several serious accidents had just happened even in removing a 'balcony'. Safety and health policies must be improved and established properly. A mature and integrated safety management system or framework should be developed as soon as possible.

The legal framework on safety in Hong Kong includes the Factories and Industrial Undertakings (Safety Management) Regulation [29]. This is a prescriptive legislation which advocates Occupational Safety and Health (OSH) coverage to industrial workplaces in a system approach including factories and construction sites. Requirements on safety management systems, safety auditors and supervisors are specified. Another legislation is the Occupational Safety and Health Ordinance [30] which covers all industries in Hong Kong [28]. This has a longer-term objective on adopting the performance-based approach.

An occupational safety and health branch was set up by the Labour Department in 1996 to provide more effective training and support to their staff. OSH briefing sessions are introduced to the industry on new legislation and related amendments. The government and statutory bodies, employer and trade associations, unions and other safety professional organizations are providing education and promotions on safety concepts and training. Courses on safety at work are offered by the Vocational Training Council, Employees' Retraining Board and major tertiary education institutions. The Hong Kong Polytechnic University, with the mission of providing 'Quality Teaching', is active in providing safety education and carrying out high-level safety research projects. A Central Steering Committee on Fire Safety and six District Fire Safety Committees were set up by the government to promote and coordinate strategies on fire safety.

As reviewed [31], major causes of accidents in the construction industry can be investigated in four aspects including people, project nature, legislation and management. Employers are profit-oriented. Workers are lacking in safety consciousness and of low education level to learn new and updated skills. They might refuse to use Personal Protective Equipment. Old workers might not have enough physical strength and fast response to hazards. Workers from mainland and other countries might have communication problems.

Contractors are forced to use low knockdown prices because of the economic depression which led to competitive bidding nature. Short-cuts, inferior materials, old equipment and incorrect working procedures might be taken to gain a little profit. Investment in safety aspects was then reduced. Workers always need to work over-time and under adverse climatic conditions due to time constraint. Multi-layer subcontracting system causes hardship in safety management. Large project size increases difficulties, resulting in more serious accidents.

Safety management should be proceeded in companies involving top management. Management policies must be well implemented and promoted to lower level with sufficient monitoring. Responsibilities are not defined clearly and penalty is too lenient to have deterrent effect. Legislation is not quite strictly enforced without 'effective' punishment. Therefore, safety policies are not communicated well. Perhaps, self-regulation might be too ideal for the local industry at the moment as reflected by the high accident rates.

Suggestions to improve the situation include benchmarking the policies in countries with good performance in safety management [31]. It is also recommended to have heavy punishment, reinforce in-house commitment, establish a well-implemented auditing system, involve representatives in the industry to plan safety guidelines, carrying out regular inspection and assessment, establish a systematic accident investigation scheme, and promote publicity and

training. In-depth research and development should be carried out and supported by the Authority. Results published would increase the public awareness to change the culture towards safety. This is the first step to achieve the final goal of using self-regulation as the end-up strategy in safety management. Perhaps, new practices in China on requiring the top officials in a province to be responsible for big accidents should be enforced.

4 Fire Engineering Subjects Desired

Fire Engineering subjects desired for appropriate training are:

◦ **Fire Dynamics**

Basic concepts in fire including fire fundamentals, ceiling jets and plume, fire properties of materials, concepts in active and passive fire control design of buildings will be introduced. Experiments on some topics, such as ignition and burning behaviour of materials will be conducted. Other topics include theoretical fire extinguishing mechanisms, investigation and appraisal of current development and research in building fires and applications of active fire protection systems.

Thermal radiation in room fires will be discussed by introducing basic laws of thermal radiation, radiation properties, the use of shape factors, zonal method and its application. Besides, thermal radiation flame spreading and its application in fire safety design will also be illustrated.

Different fire stages and complex phenomena such as flashover in compartment fires will be highlighted. Transition to flashover will be studied by non-linear physics with heat balance equations, and Semenovs diagram. Other topics such as fire induced turbulence flow and fire retardant will be introduced.

◦ **Computational Fire Modelling for Building Design**

The subject aims to provide a good understanding on the updated development in fire modelling. Basic physical theories and numerical techniques for fire models will be introduced for evaluating and improving active control systems and passive fire protection design for buildings. Complicated fire models such as the zone models and field (application of CFD/NHT) models [23] for simulating fire environment in different scenarios for design purposes will also be introduced. The theory behind a two-layer zone model will be introduced with the key equations solved to illustrate the applications. Plume equations for smoke filling process are derived. The uses of common zone models will be demonstrated and students can use them for practice to predict the fire environment in multi-compartment buildings.

The concepts and formulation of the key equations in a field model will be explained. Conservation equations of mass, momentum and enthalpy are derived. The set of three-dimensional, non-linear, transient partial differential equations cannot be solved analytically. Finite difference methods with discretization such as using the control volume methods will be covered. Turbulence modeling including Reynolds Averaging Navier-Stokes (RANS) equations method such as k-ε type of models and Large Eddy Simulations (LES) will be introduced. Stochastic behaviour of turbulence and multi-scale phenomena will be included. Fire models applicable for predicting fire environment in atrium will be highlighted. Commercial CFD packages commonly used in engineering consultant firm will be demonstrated.

◦ **Fire Engineering System**

The objective of this subject is to provide an in-depth and up-to-date knowledge of fire engineering systems associated with the building services industry, based on a rational and critical analysis of the systems. The basic engineering science of various fire engineering systems such as sprinkler systems, water-based fire engineering systems including foam, water mist systems, gas protection systems with clean air agent including heptafluoropropane, and smoke management systems will be introduced.

Thermal sensitivity of sprinkler heads and the concept of Response Time Index (RTI) will be introduced. Experiments will be performed in a specially designed wind tunnel, for both plunge test and ramp test. Technology in fire detection on image processing electronics will be taught and unwanted fire alarm is specified. Various detection mechanisms, such as the use of ionization current, photoelectric detection will

be introduced. Pattern recognition technique using image processing techniques and neural network will be applied to study smoke and fire detection systems. Various parameters causing unwanted fire alarm problems will be studied. Theory of fire extinguishment, combustion and fire extinguishing mechanisms of various agents such as inert gases, heptafluoropropane, halogenated agents and dry chemicals will be covered. Fire engineering systems commonly used and also new technologies will also be included. Besides, water-based fire suppression and control systems and detection systems, and smoke control systems will be introduced. Smoke management systems and their application will be discussed. Worked examples on designing smoke control systems in atria and shopping malls will be illustrated.

◦ **Legislation Aspects of Fire Safety Management**

The purpose of this subject is to provide legislation knowledge with respect to fire safety management. Students can learn about regulations in relation to fire safety provisions such as FSI [3], the recommended practices for buildings of different uses and the integration with fire safety for the building as a whole. Comparison with overseas regulations on fire safety management and the use of fire statistical records to improve the fire safety provisions and management strategies will be discussed.

Prescriptive codes [3—6] will be reviewed. Fire engineering approach in fire safety management, EPBFC [e.g. 8—11], fire resisting construction, model of the role of management in construction fire safety failure scenarios, the use of risk assessment models in fire safety design, risk analysis, engineering approach and fire safety management plans in special buildings such as railway stations and karaoke establishments will be included. These are at the level of practicing building services engineers who are working in the area of fire engineering or interested to learn more.

◦ **Design Considerations for Fire Safety Management**

This subject aims to provide fire protection engineers with appropriate design knowledge to ensure a thorough understanding of the design considerations of fire safety management. Basic fire sciences in fire safety management will be discussed first. The design criteria, main performance characteristics, limitations, applications, operation and maintenance of the existing fire safety systems will then be reviewed.

Topics related to fire engineering with concepts on smoke control design, design of means of escape, fire behaviour of building materials, risk analysis, reliability of FSI will be included. Fire safety management schemes in hotels and karaoke establishments, principle of fire safety administration within an organization, fire safety management in engineering approach of fire safety design and role of fire dynamics in fire safety management will be highlighted. The design, operation and maintenance of smoke control and ventilation systems in special structures will be introduced with examples on the design principles for smoke ventilation in enclosed shopping centres.

5 Safety Engineering Subjects Desired

As reviewed [27], the reasons for high injury and fatality rates in the local construction industry include the problems in the existing culture of people, project nature, legislation and management systems. Enhancing education might improve the current situation. Two levels of programmes can be offered for the top management professionals and the workers. High-level courses should be offered to the professionals including developers, designers and engineers to raise their awareness towards safety; and to provide sufficient training on skills and knowledge in planning and implementation of safety management. After taking such training, they can work out practical and safety courses for their workers who are exposed to accident risks under their own working environment. Requirements of safety officers and supervisors are specified in the legislation. To pursue the end-up strategy of performance-based safety management, to carry out in-house management systems and to practice auditing of subcontractors, there exists a high demand for education and training in safety engineering.

To help the industry achieve that, four subjects are important in Safety Engineering: Safety Aspects in Construction; Occupational Health and Ergonomics; Accident Prevention, Hazard Assessment

and Control; and Safety Management Systems and Safety Auditing.

◦ **Safety Aspects in Construction**

Acquisition of knowledge on construction safety management is the basic requirement in safety engineering. The focus of the subject of Safety Aspects in Construction is to offer necessary information on safety management in the construction industry, especially construction sites. It covers site-related safety and health legislation, risk assessment in construction safety, and engineering principles for accident prevention. Detailed discussions on safety technology for construction activities at special conditions, environment, operations, handling of equipment, machinery and dangerous substance, fire safety, electrical safety, protective equipment, information and communication are included. This helps the students to apply suitable measures for accident prevention, hazard control and workplace emergencies. Subcontracting system in Hong Kong induces problems in supervision and implementation of management systems down to lower level. These are discussed under the topics of contractor evaluation and selection.

◦ **Occupational Health and Ergonomics**

The subject of Occupational Health and Ergonomics aims to provide the students the knowledge on evaluation and control of occupational health hazards in workplaces involving industrial ventilation, noise and industrial hygiene [32]. It is useful for them to recognize those relevant codes and standards, different engineering systems, system requirements, system performance evaluation and the use of monitoring programs for biological, chemical, physical and radioactive workplace hazards. Topics on risk assessment, ergonomics and human factors, evaluation and measuring techniques, analytical instrumentation, the use of microcomputer and software and associated techniques for data processing and statistical analysis are designed to help them in interpreting the results and identifying the causes of ill-health at work, such that suitable engineering solutions and mitigation measures can be taken.

◦ **Accident Prevention, Hazard Assessment and Control**

The subject of Accident Prevention, Hazard Assessment and Control was designed to help the students to have an in-depth investigation of the accident causation and to seek methods for prevention. Topics on risk assessment, reliability engineering, and safety concepts are covered. System safety engineering [33] enables students to assess system safety by concepts like Preliminary Hazard Analysis and Failure Modes and Effects Analysis. Risk assessment and simulation techniques including Fault Tree Analysis, Management Oversight and Risk Tree Analysis, Event Tree Analysis, Hazards and Operability Analysis, Cause-Consequence Analysis and Loss Incident Causation Models are introduced so that they can be able to carry out qualitative and quantitative assessment on possible hazards. Management strategies and hazard control measures are also introduced. Active actions can be taken to reduce and eliminate possible failures and accidents. Passive actions like setting of redundancy and isolation can be considered. These help to improve safety in the working environment.

◦ **Safety Management System and Safety Auditing**

To ensure a practical and well-implemented safety management system, students need to know about the concepts, development, key elements, implementation and effectiveness of the safety management systems. Those are emphasized in the subject Safety Management System and Safety Auditing. Local and successful management systems and regulatory aspects in overseas countries are reviewed. This helps the students to examine the inadequacy in the existing legislation, to be exposed to new systems and techniques and to develop appropriate systems for in-house implementation and the local industry. This is important for the planning and application of the performance-based safety management system in future. Topics on theories and practice of safety auditing are highlighted. These include audit protocols, procedures, scheduling, auditing programs and associated techniques for documentation and statistical analysis. This would help to fulfill the demand for training of safety auditors and related assessment works.

6 Professional Recognition

To strengthen the programme for serving our

community better, professional recognition is our concern. The following are some of the possible professional recognitions to be obtained in Hong Kong:

· Member of Hong Kong Institution of Engineers (HKIE)

· MSc/MEng top-up in The Chartered Institution of Building Services Engineers (CIBSE)

· Registered Safety Officers and Registered Safety Auditors

The possibility of recognizing part of the PolyU MSc in Fire and Safety Engineering programme by the government Labour Department is under exploration. Graduates applying for registration as Registered Safety Officers under the Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations [34, 35]; and Registered Safety Auditors might get some exemption, depending on their background and subjects taken.

7 Conclusion

It is necessary to offer higher education in Fire and Safety Engineering in Hong Kong. However, institutions offering the programme must have strong research support. That is the meaning of 'Quality Teaching' as stressed many times by PolyU.

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在香港提供消防与安全工程研究生教育的必要性分析

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摘要: 论述了在香港提供消防与安全工程研究生教育的必要性, 为了培养高质量人才, 消防与安全工程高等教育的科目应当包括消防工程学和安全工程学(如火灾动力学), 用于建筑设计的计算机火灾模拟, 消防工程系统, 火灾安全管理立法因素, 用于火灾安全管理的设计事项, 建造的安全因素, 职业安全和人类工程学, 事故防范、危害评估和控制, 安全管理系统和安全审核。而这些重要课程的质量提高都强烈依赖于相关研究的进展。

关键词: 香港; 消防与安全工程; 研究生教育

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