Preliminary views on implementing engineering performance assignment

Key points on suitability of implementing EPIC in Hong Kong, or preserving restrictive codes but with active updating are discussed. Approaches used overseas are briefly reviewed to illustrate that this is not so easy in comparing with prescriptive codes. Points to be considered Including fire safety objectives, full-scale burning tests with building characteristics and materials used, social responsibility and education are highlighted. Nevertheless, EPIC should not be Implemented Just for reducing the cost on fire safety provisions.

In fact, higher cost might be required as higher safety level should be provided. Bearing In mind that public safety Is the first criterion to consider. . Introduction Architectural features in Hong Kong have changed rapidly in the past 20 years. Along malls, atria, multi-purpose complexes and public transport interchanges. Although Hong Kong is now under very critical conditions with its many advantages over other cities such as cheap and efficient workforce lost, price for apartment is still more than double that ten years ago.

The Asian economic depression has brought the construction industry back to a more reasonable state, so that the price is not so abnormal. Citizens can no longer earn high income within a short time through ' easy investment. They have to go back to the golden age of development where their earlier generations had to work diligently for survival. Manpower, both quality and cost, are under challenges from China, Taiwan, Korea, Singapore and others. Despite these, new projects such as the new railway lines, Cyber Port and numerous real estates are to be constructed.

High-rise commercial and residential buildings have emerged since the sass. Consequent to several big fires [e. G. 2, 3], including the one at the new airport terminal before its coming into operation, local citizens are very concerned about the fire safety provisions in Hong Kong. Several actions were taken by the new Special Administrative Region (SARA) government: Upgrading the fire safety provisions in old high-rise buildings [4]. E Setting up new regulations for karaoke establishments [5, 6].

Implementing Building Safety Inspection Scheme (IBIS) [7] to take care of structural stability, external finishes and fire safety for existing buildings. Acceptance of building submission through fire engineering approach [8] with appropriate committees established to assess the designs having difficulties to satisfy the local fire codes [9-12]. Upon smooth reunification to China, the SARA government is very open. Before setting p or implementing any new codes or regulations, comments will be invited from the professionals including local academics and consultation papers [e. G. 5] will be distributed.

Many cases, such as the Karaoke Establishments Bill [6], were turned down by the Legislative Council because the SARA government could not demonstrate the usefulness of the codes. Government officers are upgrading themselves by attending Continued Professional Development (COP) programmed including Masc. degree programmed, with strong support from their departments. Buildings Department (BAD) is one of the best examples in sending their staff to attend useful COP programmed. This is a move towards the right direction of being a world class city, being politically stable with an open, clean and responsible government!

It is obvious that fire codes [e. G. 9-12] have to be updated frequently to cope with the development of the construction industry. For example, ‘ green building utilizing more daylight and natural ventilation by increasing the glazing area might lead to fire safety problems [1]. Safety and security issues should be considered in addition to environmental protection to give an overall picture on building performance. Bearing this in mind, local fire codes [9-12] were updated frequently by the government departments responsible for fire safety.

Basically, passive building design (PAD) is taken care of by the BAD [9-11]; and active fire protection systems Services Department (FSP). These codes are prescriptive in nature. Fire safety design based on the engineering approach (EAI) [8] will also be considered if there are difficulties in following the codes. To cope with the new architectural design features, in addition to updating the prescriptive codes, implementing engineering performance-based fire codes (EPIC) 13-34] is another possible candidate to consider.

Note that EPIC is not the only choice and there are lots of problems associated with that as demonstrated while assessing fire safety design based on EAI. Active updating of prescriptive codes might be easier to follow. A consultant was appointed to study how EPIC can be implemented. However, the period of 3 years is rather short. There is no mention of in-depth research support, say with full-scale burning tests [e. G. 35] in the project bereft [36]. In fact, before deciding whether to stick to prescriptive codes with active updating or o use EPIC, well-planned long-term investigation works should be carried out.

This should also be a ‘ life-long research project for upgrading the code to solve new problems encountered. This was well recognized by The Hong Kong Polytechnic University (Polyp). There, EPIC has been studied since 1995 with some support of Area of Strategic Development: Construction Industry Development Studies and Research Centre. A Journal [37] reporting the development, problems encountered, scientific principles, engineering Judgments and practical examples was established.

It appears that if EPIC is applied properly by experts with good raining in fire safety engineering such as those holding PhD degrees, and with practical engineering experience up to Chartered Engineer status, the following can be achieved as reported in the literature [13-34]: Better fire safety provisions than described in the older versions of prescriptive codes for both passive and active fire safety measures [18]. Regulations requiring systems that might not work in a fire or even give adverse effect can be pointed out and updated.

The requirements of installing sprinkler at high headroom atrium and in escape staircases are obvious examples. This is similar to imposing the local peed limit of 50 km per hour in downtown areas where almost all drivers will not pay attention to! Those drivers who follow the code and drive slower than the limit might be in trouble. Higher flexibility in selecting different fire safety provisions to satisfy the individual building requirement and use. Good demonstration that the fire safety provision is safe through scientific analysis and engineering Judgment.

Of course, there are good reasons [38] for keeping the prescriptive codes with active development: Easier to implement by the Authority. Officers are well-trained to enforce the codes. Developed for many years and professionals are familiar with the requirement. Follow. For EPIC, even the terms ‘ goals’ and ‘ objectives’ [32] have to be distinguished. But for buildings with special geometry or uses such as karaoke establishments which are not yet included in the codes, there might be some problems in deciding the fire safety requirements.

However, similar problems might also be encountered in applying EPIC to these buildings if there is no in-depth research to support the methods to be used, or the fire safety objectives have to be revised when accidents are reported in those buildings. In this paper, preliminary discussion on implementing EPIC is presented. This will help government officers to assess the proposed works and give some indications on what should be done in Hong Kong. 2.

Background There are four key prescriptive fire codes in Hong Kong [38]: Means of Escape (MOE) Code [9] Fire Resisting Construction (FRR) Code [10] Means of Access for Fire Fighting and Rescue (MOA) Code [1 1] Fire Services Installation (IFS) Code [1 2] The first three codes [9-11] concern the passive means of fire safety design and are taken care of by BAD. There are many figures, tables and data specified without rather explanation nor appendixes as in the NAP Life Safety Code [e. G. 34] on citing the references. Therefore, giving a wrong impression that local codes were set up without good reasons.

This point is not too correct. In fact, most codes come from practices in U. K. As Hong Kong was under British Administration for over a century. British Standards, U. K. Practices and design guides in fact are all supported by in-depth investigations from government officers, scientists, building professionals and even manufacturers. There are lots of papers in the literature describing the physical basis behind. Perhaps, more time should be spent on reviewing the background literature to understand why the codes were set up. The fourth code [12] is governed by the FSP and is quite ' performance-based' already.

Very few design data such as space volume of 28, 000 mm and upper limit on fire load density of 1, 135 MGM-2 are included. Again, there are reasons for using those figures [e. G. 39]. Officers will discuss with the engineers concerned on the type of IFS required and the associated design data. Criticisms are always welcome and advices from academics used to be sought. Officers in FSP are also eager to attend COP programmed and enroll in programmed up to Masc. degree level. Further, codes set up at different time would have different requirements.

It is not fair to ask all existing buildings to upgrade their fire safety provisions by following all requirements specified in the new codes. PAD cannot be changed easily as the obvious example is to extend the corridor width from 1. 05 m to 1. 2 m in karaoke [5, 6]. Even IFS cannot be installed at any time the occupants like. For example, it is not easy to get rooms to house the sprinkler water tank. Therefore, engineering approach [8] on alternative fire safety design is accepted for all buildings where here are difficulties in following the new fire codes, both for PAD and IFS. 3.

The Consultancy Project The project title on EPIC is “ Consultancy Study on Fire Engineering Approach and Fire Safety in Buildings”. The aims are [36]: To carry out a detailed study on fire safety in buildings. To carry out a detailed study on fire engineering approach. To produce the relevant Codes of practice and handbook for use by local building professionals. All standards, codes, legislations on means of escape, means of access, fire resisting construction, fire services installations, emergency vehicular access and testing of alluding materials related to fire safety should be reviewed.

Buildings include both new buildings and existing buildings. It is interesting to learn how all these can be completed within 36 months! Can a design handbook be prepared and demonstrated to be applicable in Hong Kong within 36 months? Technical contents in the codes are expected to be very complicated as demonstrated in reviewing the proposed practice of EPIC overseas later in this paper. Even holding meetings and seminars on dealing with explanations, clarifications, arguments and debates might take several years! Perhaps the project rife was decided with too optimistic views.

Note that such a study has been carried out for years with a large team of experts in U. K. , only a technical report is published at the moment [20, 28], though a draft guide is under review. 4. Brief Review on Some Overseas Approaches Fire safety engineering and performance-based fire protection had been considered carefully elsewhere. In fact, EPIC has been implemented in some countries. The approaches to be used in U. K. And European countries via the BBS ASSIST 13387: 1999 Fire Safety Engineering [28]; and the ESP. Engineering Guide to Performance-Based

Fire Protection Analysis and Design of Buildings 2000 [32] of the Society of Fire Protection Engineers in U. S. A. Are taken as references to demonstrate the complexity for local professionals. Design process: Qualitative design review (CARD) Quantitative analysis of design Assessment against criteria CARD is the key element [40] which includes review of architectural design, setting up objectives and scope of study, fire hazard identification, trial design, fire scenarios, acceptance criteria and method of analysis. Outputs of CARD such as agreed fire safety objectives will be used for quantitative analysis.

Quantitative analysis of design is to carry out a time-based quantified analysis using the appropriate subsystems. Knowledge on fire dynamics [e. G. 41] is expected. Evaluation of fire safety design off building is divided into five subsystems SSI to ASS for simplification in this technical report [28]: SSI: Initiation and development of fire and generation of effluents. ASS: Movement of fire effluents. ASS: Structural response and fire spread beyond the enclosure of origin. ASS: Detection, activation and suppression. ASS: Life safety: occupant behavior, location and condition.

Scientific knowledge and practical engineering Judgments have to be applied in dealing with SSI to ASS. Full-scale burning tests are desired to verify some design or extract key empirical data, if necessary. Scenarios not yet considered before, say for new architectural features, should be studied more carefully. For example, empirical correlations such as the relationship between the atrium smoke filling time TTS and its time constant (Atrium with and without considering the traveling time of smoke front to the roof will be very different [42, 43]. [pick] . It is obvious that mathematical fire models [44-48] will play a key role.

For the ESP. approach [32] in U. S. A. , basic building design and construction process includes the following: Feasibility studies Conceptual design Schematic design Design development Design documentation Construction and installation Commissioning Certificate of occupancy Change in use and refurbishment Steps in the performance-based analysis and the conceptual design procedure for fire protection in this approach [32] include: Defining project goals Identifying goals Defining stakeholder and design objectives Developing performance criteria Developing design fire scenarios Developing trial designs Evaluating trial designs

Testing whether selected design meets performance criteria Developing a fire protection engineering design brief Selecting the final design Performance-based design report Prepare design documentation Specifications, drawings, operations and maintenance manual Again, mathematical fire models will be a key element though it is not equivalent to EPIC as pointed out by Sheppard and Mecca [49]. 5. What Should Be Done? EPIC has been studied at Polyp, with the mission to offer ‘ Quality Teaching, I. E. Teaching supported by research to serve the society including the country, for over 6 years.

The backbone of EPIC, I. E. Thematic fire models [44-48] (though should not be taken as equivalent to EPIC as pointed out by Sheppard and Mecca [49]), had been studied for 20 years with more than 20 PhD students graduated. Both fire field models or application of Computational Fluid Dynamics (CUFF) [e. G. 48] and fire zone models [e. G. 47] are studied in depth. Research and consultancy projects on advanced fire science and engineering are now grouped under the Research Centre for Fire Engineering.

Preliminary studies indicated that the following should be considered: Providing reasonable fire codes well-supported by experimental studies with active development should be a long-term project. Three years will definitely be insufficient! The time is not even enough for a more detailed review on the physical basis of the present MOE code [9], the fire safety objectives, the limitations of using it, and the areas for improvement. EPIC should not be taken as putting something not satisfying the code requirements; or for reducing the costs of fire safety provisions.

An obvious example is not to provide adequate fire resistance to some structural members. It is not easy to convince people that structural steel with glass structures can be installed without fire protective coating! If anything happens with associated compensation. Proper implementation of EPIC might be even more expensive as higher safety level will be achieved. The whole design process should be carried out scientifically, allowing a good chance to apply advanced fire science to solve practical engineering.

Japan is one of the countries with engineering design on fire safety carried out properly through engineering experience, physical experiments (both full-size and scale modeling) and numerical simulation since the early sass. Full-scale burning tests were carried out for some projects such as allowing timber to e used as building materials for apartments [e. G. 50]. There is also high-level scientific inspection of fire services installation designs based on fire safety engineering for shopping malls and airports in Taiwan [51]. Both building features and occupants characteristics in Hong Kong are very different from elsewhere.

Basically, the building features in Hong Kong can be summarized as follows: Structural elements are non-combustibles, either concrete with steel reinforcement or steel framework with fire protection. However, timber products were extensively used as partition walls before 1996 when fire-rated gypsum plaster roads were not so popular. Glazing is used extensively in commercial buildings and the FRR codes [10] should be revised to consider thoroughly the fire resistance requirement by taking into account new research results such as interaction with water-based system.

Behavior of the glazing under typhoon should be watched as glass was peeled away in a typhoon before. Adequate provisions of evacuation routes for buildings built after 1972. Good provision of IFS [12] for new buildings. Tight control on combustibles used or stored by keeping the fire load density to be less than 1, 135 MGM-2 [9-12]. Further, occupants characteristics, especially their sense of social responsibility are different.

Overseas citizens might complain when they see some fire extinguishers are not put in the right positions; or when there is inadequate ventilation in an underground carpal. Local citizens seldom complain and security guards in some factories might even lock the emergency exits by chains! Therefore, the performance requirements, design objectives, acceptance criteria and assessment methodology should be worked out carefully for local use. Without clear performance-based design guides standardized and tailored for local use, significant mount of professional efforts and time would be required.

Note that cost- effectiveness is not only counted for the cost-effective building design (benefit to developers), but also for saving engineering and documentary time of architects, fire engineers, developers and government officers (benefit to the public/taxpayers). But this can never be achieved without in-depth research. The following items listed in the three parts on documentation, design levels and topic specific intent of International Code Council (ICC) [52] should be Judged, if Fire safety objectives and acceptance criteria. Design parameters.

Characterization of buildings and its occupants. Identification of potential fire hazard scenarios and their possible consequences. Assessment against the safety criteria. As summarized by Illogical [40], questions on the acceptable fire safety level; factors limiting solutions; the worst hazard scenario and its consequences; method of scenario analysis; and fire safety measures, both PAD and IFS, to be provided; have to be addressed to fit local needs. This would require knowledge of fire science and engineering together with practical experience under local conditions.

Mathematical fire models [e. G. 4-48] are a key element for analyzing potential fire scenarios. Full-scale burning tests [35, 53], scale models studies [e. G. 54] and site measurements [e. G. 55] should be carried out when necessary. 6. Mathematical Fire Models Mathematical fire models [44-48] are useful in the analysis of consequences of fire hazard scenarios.

Instead of carrying out physical tests, they have to be used in implementing EPIC. There are arguments and debates on using fire models.

If the predicted results are not verified scientifically, say by full-scale burning test [35, 53], the process would appear as a ‘ curve-fitting exercise’. Since the intermediate chemistry in burning materials, mixing of air and fuel due to turbulence and thermal radiation are difficult to model in a fire, the heat release rate is taken as the input parameter in most mathematical fire models. Full-scale burning tests should be carried out to establish a heat release rate database on local materials and consumable products. Zone models [e. G. 7] can be applied to understand the fire environment with a certain design fire. However, care should be taken for tall buildings and buildings with large floor areas. Concerns that can be Jotted down immediately are: Time taken for a smoke layer to develop in large buildings. Traveling time of smoke front up a tall building. Assessment of the ventilation opening conditions. Fire field models or application of CUFF [e. G. 48] are good only for studying smoke movement at the moment. Problems encountered in addition to the hardware Assignment of free boundaries by extending the computing domains to outside the building.

Although commercial CUFF packages are user-friendly, theories behind COP should be well understood. Experts are required to carry out CUFF simulations for studying fire-induced air flow, not Just relying on an engineer without DOD training in CUFF. Note that CUFF itself is a rapidly developing subject. Even in describing the turbulent effects, there had been lots of arguments on using different approaches such as Reynolds Averaging the Navies-Stokes equation or Large-eddy simulations [e. G. 56]! 7.

Conclusions Local codes used to be blamed that the data are outdated as they are prescriptive and so EPIC has to be used. It is obvious that fire codes including EPIC, have to be changed frequently to cope with the living standards, building features, and crucially, the sense of social responsibility (links with general education) of citizens. Implementing EPIC is not Just solving a scientific problem, but also a social problem concerned by the government officers, developers, building professionals, and most importantly, the citizens.

EPIC should not only be targeted for new projects, but also on upgrading the fire safety provisions for existing buildings. However, setting up EPIC for local use must be supported by in-depth systematic research with full-scale burning tests [35, 53]. It is no good Just following overseas fire codes, both prescriptive and performance-based. Responsibility of citizens and their awareness on safety should be taken into account. Reference can be made to overseas practices but not direct applications.