Hot Issues in Fire Engineering

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The Four Fire Code Systems

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1. Introduction

With rapid economic growth in Asia, including Mainland China, Taiwan, Hong Kong, Japan, Korea, Singapore, Malaysia and Indonesia, many large-scale construction projects are completed, or in the planning stage. Different types of construction projects are undergoing in the region: supertall buildings over 300 m tall, long tunnels over 30 km, subway stations built 40 m below the ground and shopping mall complexes with atria larger than 28,000 m^3.

There are always difficulties [1-3] for buildings to comply with the existing prescriptive codes (PC) on fire safety [4,5]. The practices in advanced countries might not work in Asia, where occupant loading and fire load density are higher. More importantly, people in Asia behave differently. The required fire safety provisions are very different for buildings of similar configurations in the overseas. Furthermore, green building features might be at odds [6] with the PC fire safety requirements. For example, better natural ventilation supplies more oxygen for combustion and facilitates fire spread over the horizontal surface. Flashover takes shorter time if building façade has better thermal insulation [7]. Vertical flame spread over a combustible thermal insulating façade will lead to disastrous consequences. Green building designs with double-skin façade creates additional fire hazards [8].

The recent fatal accidental fires [e.g. 9-11] showed that fire engineering professionals should come up with more appropriate safety design as a precaution, in order to lessen the burden of firemen.

2. EPBFC System

There are proposals of moving from the current PC system to engineering performance-based fire codes (EPBFC) [12,13]. Note that performance-based codes are starting to develop in other areas in building including structural codes, wind loading codes, ventilation codes and

energy codes. However, the implementation of EPBFC will encounter the following problems as raised [14] years ago:

- There must be systematic research to support the fire safety objective, acceptance criteria, engineering tools for hazard assessment, statistical fire record and verification method.
- Long-term research that will take decades will be needed to guarantee fire safety in supertall buildings, long tunnels, deep underground stations, large halls and structures with green architectural features.
- Research funding is very low [13].
- It will take a long time for officials, professionals and concerned parties to familiarize with the new system and able to handle EPBFC.

3. Other Approaches

Two other coding approaches are found between the two extremes on PC and EPBFC:

The first approach is performance-based design (PBD) [15,16], which has a clear requirement of fire safety objectives and prescriptive data derived from long-term systematic research. For example, the new PBD code of New Zealand [17] specifies a design fire of 20 MW for non-storage area and 50 MW for storage area, even most of the projects are small houses. However, fire research is still very limited in places like Hong Kong and Mainland China. For example, the specified design fires in the new Fire Safety Code [4] are not supported with adequate experimental research as in Japan and Korea.

The second approach is known as Fire Engineering Approach (FEA), which has been implemented in Hong Kong since 1998 [4,18]. The approach is to demonstrate that fire safety provision is equivalent to prescriptive codes. Again, because of limited associated research, FEA has to be worked out on a case-by-case basis. Consequently, very low design fires had been used.

4. The Four Code Systems

In summary, there are four possible fire code systems:

- Engineering Performance-Based Fire Code (EPBFC)
- Performance-Based Design (PBD)
- Fire Engineering Approach (FEA)
- Prescriptive Code (PC)

The benefits and problems of the four systems are listed in Table 1.

5. The Way Forward

Professionals are in great demand, as they have to handle design for supertall buildings, deep underground subway stations, large halls, long tunnels and big green architecture. Therefore, it is necessary to provide fire engineering education at degree and high levels [3]. However, there is no systematic research to obtain the necessary data. Even the fire safety objectives are not investigated with thorough research.

All the officers and professionals have been trained to use PC for decades, and even firefighting and rescue strategies are based on such premises. Therefore, it is very important to provide adequate education and training for professionals, officers, owners and all related personnel to handle the other three systems: FEA, PBD and EPBFC.

Fire engineering curriculum must be developed [3] to enable officers and professionals to understand the possible fire problems for buildings in Asia. They can then update the PC regularly, and implement FEA more realistically to avoid mistakes such as the improper use of timeline analysis [19,20]. Systematic long-term research is required before implementing PBD and EPBFC. A long time is required before EPBFC can be implemented successfully, because such fire research is not even started in this part of the world.

In contrast to other engineering subject disciplines, basic fire science should be integrated with real-life practices. A fire scientist without working experience in a construction site might not even understand the problem, which might be solved by common sense. Professional accreditation of the fire engineering programmes is therefore very important. Quality teaching on these topics should be backed up by in-depth research.

An encouraging move is that local fire officers are very active to upgrade themselves. New safety codes [22] are therefore established to provide more reasonable fire protection [23], say in crowded railway and subway stations with parallel traders.

References

1. W.K. Chow, “Performance-based design on fire safety provisions in the Far East”, 2011 SFPE Annual Meeting: Professional Development Conference and Exposition, Engineering Technology Conference, 24-25 October 2011, Portland, Oregon, USA (2011).

2. W.K. Chow, “Experience on implementing performance-based design in Hong Kong”, Welcome speech, The 9th Asia-Oceania Symposium on Fire Science and Technology, 17-20 October 2012, Hefei, China (2012).
3. W.K. Chow, “The need for fire engineering education in Hong Kong”, A talk presented at the Kick-off Seminar for Establishment of the “Forum for Advanced Fire Education/Research in Asia”, 27-28 December 2012, Tokyo, Japan; Talk compiled as a paper to appear in International Journal for Fire and Technology (2013).
4. Code of Practice for Fire Safety in Buildings 2012, Buildings Department, The Hong Kong Special Administrative Region, Draft version released for public consultation in September 2011, Implemented April (2012).
5. Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection Testing and Maintenance of Installation and Equipment, Fire Services Department, Hong Kong Special Administration Region, China, April (2012).
6. W.K. Chow and C.L. Chow, “Green influences”, Fire Prevention & Fire Engineers Journal, September, p. 34-35 (2003).
7. W.K. Chow and C.L. Chow , “Fire safety concern on building design for reducing solar heat gain”, 3rd China-Japan-US Symposium on Structural Health Monitoring and Control and 4th Chinese National Conference on Structural Control, Dalian University of Technology, Dalian, China, October 13-16, 2004, Edited by Hongnan Li, Hui Li and Guoxin Wang, p. 150 (2004).
8. C.L. Chow, “Full-scale burning tests on double-skin façade fires”, Fire and Materials, Vol. 37, No. 1, pp. 17-34 (2013).
9. W.K. Chow, “Hidden fire problems: Consideration after the Fa Yuen Street big fire”, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, December (2011). Available at: http://www.bse.polyu.edu.hk/researchCentre/Fire_Engineering/Hot_Issues.html
10. W.K. Chow, “Large fire in Fa Yuen Street”, In: G. Rein (editor), International Association for Fire Safety Science Newsletter No. 32, p. 13, April (2012).
11. South China Morning Post, “An accident just waiting to happen”, 1 December (2011).
12. W.K. Chow, “A preliminary discussion on engineering performance-based fire codes in the Hong Kong Special Administrative Region”, International Journal on Engineering Performance-Based Fire Codes, Vol. 1, No. 1, p. 1-10 (1999).
13. J. Torero, “Structures in fire or fires in structures: What do we need to know to achieve innovative fire safety”, International Fire Conference & Exhibition Malaysia (IFCEM 2012), 20-21 November 2012, Kuala Lumpur, Malaysia (2012).
14. Kenny S.M. Kong and W.K. Chow, “Possibility of using engineering performance-based fire codes for higher education institutes”, One-day Symposium on Advances in

Building Services, Hong Kong Institute of Engineers, 21 November 2000, Kowloon Shangri-la Hotel, Hong Kong – Paper presented (2000).

15. British Standards Institution (BSI), BS 7974-6:2004, The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors: Life safety strategies – Occupant evacuation, behaviour and condition, BSI, London, UK (2004).
16. National Fire Protection Association, NFPA 5000, Building Construction and Safety Code, Quincy, MA, USA (2009).
17. C. Fleischmann, "The future of performance Based codes", International Fire Conference & Exhibition Malaysia (IFCEM 2012), Kuala Lumpur, Malaysia, 20-21 November (2012).
18. PNAP 204 Guide to Fire Engineering Approach, Practice Note for Authorized Persons and Registered Structural Engineers, Buildings Department, Hong Kong Special Administrative Region, March (1998).
19. V. Babrauskas, J.M. Fleming and B.D. Russell, "RSET/ASET, a flawed concept for fire safety assessment", Fire and Materials, Vol. 34, pp. 341-355 (2010).
20. W.K. Chow, "Comment on 'RSET/ASET, a flawed concept for fire safety assessment' by V. Babrauskas, J.M. Fleming and B.D. Russell, Fire and Materials, Vol. 34, pp. 341-355 (2010)", Letter to the Editor, Fire and Materials. Article first published online: 27 March 2012, DOI: 10.1002/fam.2134.
21. Department news, "Joint research programme with the Fire Services Department", Department of Building Services, Engineering, The Hong Kong Polytechnic University (2011). http://www.bse.polyu.edu.hk/deptNews/news_2011.html
22. Guidelines on Formulation of Fire Safety Requirements for New Railway Infrastructures, Fire Services Department, Hong Kong Special Administrative Region, January (2013).
23. W.K. Chow, "Necessity of studying fire safety for the subway system", Abstract submitted to Texas Section Fall Centennial Conference to be held at Dallas, Texas, 11 - 14 September (2013).

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Table 1: The four fire code systems

Code System	Benefits	Problems
Engineering Performance-Based Fire Code EPBFC	• It is applicable to all buildings. • It allows flexibility and innovative design. • Long-term systematic research will clarify all uncertainties, such as whether fire suppression systems should be installed in big halls.	• Very few professionals are able to do EPBFC. • It takes time to adjust to this code system. • The potential cost is high. • It requires long-term fire research, and there is limited fire research supported with practical experience in this part of the world.
Performance-Based Design PBD	• There is clear supplementary data obtained from systematic research. • The acceptance criteria are clear.	• Very few professionals are able to do PBD. • Systematic research is required. • It takes time to adjust to this code system. • The compensation cost will be high in case of big fires. • The potential cost is high. • It was only applied to low fire scenario, therefore the difficult tasks of suppressing big fires are left to firefighters.
Fire Engineering Approach FEA	• There are no other alternatives. • It allows flexibility. • It is applicable in the transition stage before upgrading to PC.	• Demonstrating equivalence to PC. • No clear data derived from systematic research is available. • This approach only consists of case-by-case studies. • The compensation cost will be high in case of big fires. • Firefighting schemes are not designed for this approach. An example is to handle fires in places with very long travel distance. • It was only applied to low fire scenario, therefore the difficult tasks of suppressing big fires are left to firefighters.
Prescriptive Code PC	• Professionals all over the world have been using this. • Officers and professionals are trained to implement this code, so it is easier than other code systems. • Professionals will be protected from liabilities if everything complied with the code.	• It is only applicable to traditional buildings. • The flexibility is low. • Innovative designs will not be possible, as they are excluded in the coding system.