DISCUSSION ON APPLYING THE AMERICAN FIRE SAFETY EVALUATION SYSTEM FOR BUSINESS OCCUPANCIES IN HONG KONG

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ABSTRACT

The possibility of applying the American safety system: Fire Safety Evaluation System of the National Fire Protection Association, USA for business occupancies in Hong Kong is discussed. Fire safety parameters concerned are compared with key parameters listed in the local fire codes. Discussion is highlighted on passive building design, fire services installation and control of the key risk factors appeared in local codes. It is found that the approach is suitable for designing new buildings, and for working out fire safety management in existing buildings. However, the fire safety parameters and their score spreading should be specifically designed for Hong Kong.

1. INTRODUCTION

As reviewed in the literature [e.g. 1], US fire codes allow the provision of 'equivalency clauses' in accepting alternative approaches that meet the instant of prescriptive requirements. The Fire Safety Evaluation System of National Fire Protection Association (NFPA) (labeled as NFPA-FSES in this paper) [2-9] is a more formal equivalency-determination system introduced to four occupancies, i.e. health-care, correctional facilities, board and care home, and business occupancies. This is a multi-attribute approach to evaluate fire safety performance and to determine equivalence to the NFPA Life Safety Code [8]. An alternative approach for design to satisfy the regulation can then be allowed if they provide the same level of fire safety. This can be regarded as an equivalent concept to the US fire codes for promoting economical upgrading of fire safety.

The objective of NFPA-FSES is to compile an equivalent system that is easily workable and presents useful information for the amount of effort paid, i.e. the result is to see whether the design complies or not with the codes. The most important part is on the fire safety parameters introduced and scores assigned to each parameter under different conditions. Relative scores [10] for specific building features were provided, with positive values for enhancing safety and negative values for detracting safety.

Building fire safety codes in Hong Kong are prescriptive [11-14]:

- Means of access (MoA) code [11]
- Fire resistance construction (FRC) code [12]
- Means of escape (MoE) code [13]
- Fire services installation (FSI) code [14]

With the rapid development of the construction industry, the government is eager to upgrade the fire safety provisions in buildings by modifying the fire code, with the acceptance of engineering approach [15,16] or engineering performance-based fire codes in overseas [17-22] in designing fire safety. Fire safety codes are updated for new buildings [11-14]. Not only that, existing buildings are watched carefully and there are proposals [23] on upgrading the fire safety provisions. However, the suggestions are not too strongly backed up by research works. The NFPA-FSES might be a good starting point to follow and is briefly discussed in this paper.

Out of all types of building uses, 'business occupancies' [24] should be studied urgently. It is because there are crowds of people staying in those kinds of buildings. Occupants are not supposed to be familiar with the building environment and so they may not be able to locate the escape routes in case of fire.

2. THE NFPA-FSES AND REVIEW OF RECENT WORKS

As classified by NFPA 101 [8], business occupancies are used for transactions and mercantile such as government offices, adult instructional facilities and classrooms buildings under 50 persons. In the NFPA-FSES [8,9] for business occupancies, 12 parameters are identified. Parametric value spread to rank the different fire safety parameters for business occupancies were

analyzed [10]. The 12 parameters are on assessing: construction, segregation of hazards, vertical openings, sprinklers, fire alarm, smoke detection, interior finish, smoke control, exit access, exit system, corridor/room separation (compartmentation) and occupant emergency program. In fact, these give some views on the items to be considered in the fire safety code. Of those 12 safety parameters, 8 parameters are on calculating a building's fire control score, and 10 for an egress score. A general fire safety score can be compiled from those scores of the 12 parts.

Feasibility studies of using similar approach in Hong Kong for housing estates [25] and karaokes [26,27] were discussed. A preliminary outline of using the NFPA-FSES was reported [28]. Differences between the NFPA-FSES and the local fire codes are:

- Non-combustibles and combustibles are classified under NFPA 220, Standard on Types of Building Construction [29]. Non-combustibles are materials passing the American Society for Testing and Materials (ASTM) E 136 [30].

  Materials are required to be non-combustible in the local FRC code [12]. However, this term was not yet defined scientifically [11-13]. There are clear descriptions in the fire resistance construction in local code [12]. Except the testing standards [e.g. 31], awareness on the fire safety of structural elements are similar.

- The fire load density (FLD) is an important risk factor. The fire severity computed from the FLD in a room of a given geometry is important to determine the hazard levels. This part depends on the FLD, room geometry including areas and openings, burning rate, burning area, and flashover.

  FLD is also important in the local codes with an upper limit of 1135 MJm^{-2} [32,33].

- Provision of sprinkler is important in NFPA-FSES. This is similar to the local FSI code on believing that installing sprinkler system would give good protection.

- In the NFPA Life Safety Code [8], the flame-spread ratings of interior finish materials tested under NFPA 255 [34] are important.

  Materials are required in the local FSI code [14] to be tested under the British Standard (BS) 476 on the surface spread of flame [35]. The flaming conditions for this test are different from the NFPA 255 [34].

In this paper, the fire safety parameters are discussed along with the two parts referred to the local codes [11-14] and a new proposal on using fire safety management [36-41]:

- Passive building design (PBD) following local MoA, FRC and MoE codes [11-13].
- Fire services installation (FSI) or active fire protection system following local FSI codes [14].
- Fire safety management (FSM) [36-41].

3. GROUPING OF FIRE SAFETY PARAMETERS

The 12 fire safety parameters in NFPA-FSES can be grouped into 2 areas on PBD [11-13] and FSI [14] following the local codes, and the proposal of using FSM:

- PBD
  - Parameter 1 on construction type.
  - Parameter 2 on segregation of hazards, basically following fire resistance construction requirements and sprinkler provisions.
  - Parameter 3 on vertical openings.
  - Parameter 7 on interior finish.
  - Parameter 9 on excess access.
  - Parameter 10 on exit system.
  - Parameter 11 on corridor/room separation, in fact, compartmentation.
- FSI
  - Parameter 4 on sprinkler system.
  - Parameter 5 on fire alarm.
  - Parameter 6 on smoke detection system.
  - Parameter 8 on smoke control.
- FSM
  - Parameter 12 on occupant emergency program.

The ranked fire safety parameters with score spreading by Watts Jr. [10] are:

- Parameter 1 on construction type with 15% of score spreading.
- Parameter 4 on sprinkler system with 13% of score spreading.

- Parameter 10 on exit system with 12% of score spreading.
- Parameter 3 on vertical openings with 12% of score spreading.
- Parameter 11 on corridor/room separation with 11% of score spreading.
- Parameter 2 on segregation of hazards with 7% of score spreading.
- Parameter 5 on fire alarm with 6% of score spreading.
- Parameter 7 on interior finish with 5% of score spreading.
- Parameter 9 on exit access with 5% of score spreading.
- Parameter 12 on occupant emergency program with 5% of score spreading.
- Parameter 6 on smoke detection with 4% of score spreading.
- Parameter 8 on smoke control with 4% of score spreading.

Using the score spreading for each parameter, assuming parameter 2 to be equally divided by PBD and FSI, the weighting on the 3 parts are:

PBD : 63.3%
FSI : 31.4%
FSM : 5.3%

It is obvious that fire resistance plays an important part and should be the case. However, in working out an equivalence system, this part might be too high in Hong Kong as local building characteristics are highrise buildings with reinforced concrete or protected steel structures. This system is found to be not so suitable in Hong Kong for adopting as an equivalence system based on the following:

- Buildings in Hong Kong are governed by the FRC code [12]. Building structures and components would have adequate fire resistance period (FRP). It is difficult to convince others to accept design in having a 50-storey building without adequate FRP, no matter using which approach, prescriptive or performance-based.

- Parameter 7 on interior finishes has to be considered carefully. Full-scale burning tests such as ISO 9705 [42] should be considered, in addition to accepting the fire spread index approach as in ASTM.

- Weighting to FSI is far below the expectation. For example, fire hydrant (mainly for use by firemen!) and hose reel systems are not included at all. This is unlikely to be accepted by the local government for highrise buildings.

- FSM should be more emphasized, the weighting is far too low and including only the emergency program is insufficient.

4. RECOMMENDATIONS

Fire safety parameters for local use of equivalence system for a certain occupancy, such as for business occupancy, are:

- Apart from assessing fire spreading of interior finishes, all the fire safety parameters for PBD can be followed:

  - Fire resistance construction.
  - Interior finishes with fire spreading assessed using tests agreed by the authority and the industry.
  - Consideration of specifying heat release rate curves for the design fires agreed under different occupancy.
  - Exit access without dead ends.
  - Exit systems with adequate corridor width, fire doors and protected staircases for highrise buildings.
  - Compartmentation design for room and corridor structure.

- The part on FSI should be enhanced by including the 4 fire safety parameters recommended in NFPA-FSES, but with different scores:

  - Sprinkler systems.
  - Fire alarm.
  - Smoke detection systems.
  - Smoke control.

- And include the following new ones on FSI:

  - Fire hydrant and hose reel systems.
  - Emergency lighting system.
  - Exit signs.
  - Emergency power supply systems.
  - Fire extinguishers.

  It appeared that there might be overlapping with the exit system and exit access.

- Consider to include peak heat release rate [e.g. 43] of combustibles stored in the building.

5. FIRE SAFETY MANAGEMENT

FSM should be enhanced for buildings seeking for approval with equivalence design, or for those buildings passing codes years ago to upgrade their fire safety. There, the fire safety plan should include [36-41]:

- A maintenance plan.
- A training plan for both occupants for residential highrise buildings and management staff for non-residential buildings or big resident estates with strong management teams.
- A fire prevention plan.
- A fire action plan basically for management staff.

Fire safety management elements should be worked out individually for a certain building with reference to the missing provisions for fire safety. For example, if the corridor width does not satisfy the new requirements of 1.2 m, good housekeeping should ensure nothing are placed in the corridor. It is a common practice to have shoes placed outside a unit and this would block the exit routes, especially those not satisfying the new requirements.

6. CONCLUSION

The possibility of using the NFPA-FSES [8,9] for business occupancies [24] in Hong Kong was further discussed [28]. The following points appeared to be good to follow:

- Thorough consideration of exit access and exit systems is very important. Evacuation pattern should be designed carefully.
- Provision of sprinkler, fire alarm, smoke detection system, and smoke control would improve fire safety.
- Accepting alternative designs which can demonstrate an equivalence system, giving opportunity for performance-based approach [15-22].

However, this approach is just a starting point for quantifying fire safety for business occupancies. New design for buildings can follow a similar approach. For existing buildings [23], results of the assessment would provide guidance on how to work out FSM [36-41] as for karaokes [26,27]. Discussion in this paper was made with reference to the local codes which is basically on PBD [11-13] and FSI [14].

The concept on NFPA-FSES is worthwhile to consider and follow, but with different fire safety parameters for the special architectural features and huge number density of highrise buildings in Hong Kong. Suggestions on determining the fire safety parameters and working out the score spreading [10] are made. This should be a longer-term study with support from the local construction industry.

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