ON THE FIRE SAFETY REQUIREMENTS FOR EXISTING OLD BUILDINGS

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ABSTRACT

Consequent to several big fires since the Garley Building fire in 1996, the Fire Safety (Buildings) Ordinance [FS(B)O], Chapter 572, Laws of Hong Kong was enacted on 3 July 2002 to upgrade the fire safety standards of composite and domestic buildings constructed on or before 1 March 1987. As these buildings have fewer fire safety provisions than required now, there are difficulties in upgrading. Therefore, the Ordinance has not yet come into effect because of many reasons.

A "Fallback Plan" for FS(B)O was implemented since 1 January 2004 by both enforcement authorities of the Ordinance. The objectives are to publicize the Ordinance, abate existing fire hazards and arouse the public on the importance of fire safety. Under this "Fallback Plan", 900 composite buildings will be inspected every year.

As observed, the current fire safety requirements are taken as reference. Such requirements might not work for those old buildings. It is necessary to explore clearly the architectural features, current fire safety provisions specifications and suitability of those requirements in FS(B)O. All these areas will be discussed in this paper. The total fire safety concept is proposed. Systematic long-term research on the specifications is suggested to demonstrate whether the specifications are suitable.

1. INTRODUCTION

Highrise buildings, both residential and non-residential, have to be constructed in dense urban areas in the Far East such as Hong Kong (now the Hong Kong Special Administrative Region HKSAR). Over half of the top 100 tall residential buildings in the world are in Hong Kong. Many big accidental fires had happened [1] since the big Garley Building fire [2] in several older highrise buildings. Accidental fires occurred in cross-harbour tunnels [3], subway systems [4], buses [5], enclosed markets [6], shopping malls [7] and industrial buildings [8].

Consequent to the big fire [e.g. 2] in the Garley building during the replacement of lifts on 20 November 1996, there are concerns on fire safety in those highrise buildings, especially the old ones built before 1987 [1]. Their fire safety aspects have to be explored [9,10]. Actions taken by the SAR government in addition to the existing fire codes [11-14] were:

- Old highrise buildings, i.e. those erected before 1987 without tight fire regulations, were requested to upgrade their fire safety provisions.
- New Fire Services Ordinance [15] on sprinkler system has been set up.
- Implementation of Fire Safety Inspection Scheme [16] on structural stability, external finishes and fire safety.
- Request on installing temporary doors with adequate fire resistance in the lift shaft while replacing the lift, after the big Garley building fire [2].
- A 4-year project on reviewing current fire codes.

Implementation of the code and responsibility of the management (especially during refurbishment) should be considered.

There were not so many fire safety provisions for those buildings constructed before 1987, in comparing to those specified now. To upgrade the fire safety standards of composite and domestic buildings constructed on or before 1 March 1987, the Fire Safety (Buildings) Ordinance [FS(B)O], Chapter 572, Laws of Hong Kong [17] was enacted on 3 July 2002. There are problems such as space constraint in following those actions for the existing highrise buildings. Though enacted, the Ordinance has not yet come into effect at present due to various considerations. There are even queries whether such requirements will work. One of the possible reasons as observed is that no systematic long-term research on the specifications was demonstrated. In contrast to other countries, very few papers were published in the literature on explaining why such requirements are specified, though such requirements had been demonstrated to be reasonable by those incidents [1-8].

In this interim period, both enforcement authorities of the Ordinance – the Buildings Department (BD) and the Fire Services Department (FSD) have rolled out a "Fallback Plan (折衷方案)" on 1 January 2004 [17]. The aims are to publicize the Ordinance, abate existing fire hazards and arouse the public on the importance of fire safety. Under this "Fallback Plan", both BD and FSD will inspect 900 composite buildings every year. Letters will be issued to advise the owners to upgrade or improve the building fire safety measures by following the provisions required by the Ordinance on a voluntary basis. To review the effectiveness of this "Fallback Plan" and to seek advices for further improvement in its mode of operation, a questionnaire survey was carried out to collect the views and opinions of various stakeholders under the purview of the "Fallback Plan".

In this paper, suitability of the FS(B)O will be discussed with reference to the specified fire safety requirements [11-14]. Fire safety provisions in old highrise buildings, especially those residential buildings with crowded occupants such as cage houses [18] and industrial buildings for offices [19], are difficult to upgrade. The total fire safety concept [10,20] is proposed for providing better safety. Implementing a fire engineering approach FEA [21,22] for those existing buildings is a solution. It might be more suitable than the prescriptive requirements [11-14].

2. TYPICAL FIRE SAFETY PROVISIONS IN HIGHRISE BUILDINGS

As reviewed before [23], typical fire safety problems for highrise buildings are:

- Direct rescue by ground applications from the building exterior is impossible, especially for supertall buildings.
- Direct water application by fire fighting jets from the building exterior is impossible or much hindered.
- Normal escape routes for occupants are downward through staircases or lifts.
- Firemen access and equipment delivery to rescue people and fight against the fire are upward through staircases or lifts.
- Fire fighting techniques (water application, fire ventilation, etc.) are to be applied inside the building.

Current fire safety measures specified [11-14] for those highrise buildings are prescriptive codes developed when under British Administration [e.g. 24]:

- Passive building construction [11-13]

  Main passive means is important when the 'preventive' defense line is broken. The fire is attempted to be controlled within the confined area while burning the combustibles. Adequate means of escape for occupants and means of access for firefighting should be provided. Items include fire-resisting constructions such as walls, doors and floors, and compartmentation and structural elements. The fire resistance period FRP [13,25] of such provisions should be longer than the duration of the fire.

- Active fire protection system [14]

  Active protection systems are also known as fire engineering systems or fire service installations (FSI) in Hong Kong [14]. Basically, the systems are divided into groups as alarm and detection, suppression and control, smoke removal and others such as stand by generations and emergency lighting. These systems might not be successful in controlling fires, such as when hot gases are spreading out from the confined area due to air leakage and stack effects. Among all the fire-fighting agents, water is still the most important suppression agent. It has a good cooling effect and is non-toxic, cheap, and easily available. Essential FSI for highrise buildings are fire hydrants, hose reel systems and sprinkler systems.

- Preventive measures adopted to minimize fire occurrences might be taken as part of fire safety management.

The objective is basically for protecting against accidental fires. Therefore, the building fire safety codes will deal with accidental fires.

3. OLD TALL BUILDINGS

"Old" residential buildings usually refer [18,26] to those constructed on or before 1972. A typical example is shown in Fig. 1. Fire safety provisions were not specified clearly in the codes before that time. There are two types of such old residential buildings: conventional buildings and cage houses.

Fig. 1: A typical old tall building

These buildings used to have high occupancies but fire safety provisions were much less than those specified in current fire codes. Multi-tenants would give many electrical circuits of individual meters as in Fig. 2. Fire risk should be studied more carefully and surveying the amount of combustibles is the first stage of a long-term project on upgrading fire safety in old highrise residential buildings.

Fig. 2: Individual electrical meters

To understand the potential fire risk behind the old existing buildings, fire load density was surveyed in highrise buildings of age over thirty-three years [18]. The fire load density was found to be very high due to excess storage of domestic fuel. As individual occupants would keep different cooking appliances, large amounts of kerosene or liquefied petroleum gas LPG was stored. The fuel stored was surveyed to be up to 70% of the fire load density. Further, different families would have their own electrical appliances such as TV sets. Therefore, movable fire load in cage houses as in Fig. 3 is high. Fire load density is found to be over the upper limit 1,135 MJm^{-2} specified in the code [11-14] in most of these old tall buildings. With such high content of combustibles, it is more likely to have big accidental fires. Fire risks associated with storing too many combustibles were also studied [18]. The risk would be at the kitchen in storing excessive fuel for cooking.

(a) Outlook

(b) View 1

(c) View 2

Fig. 3: Cage houses

Occupant loading in the surveyed cage house was up to 0.8 person/m^2, i.e. 65 occupants in a unit of floor area 80 m^2.

4. COMMENTS ON THE ORDINANCE

It is not well-demonstrated that the fire safety requirements were recommended with in-depth scientific research. Such works were not reported in the literature, including the recent 4-year project on reviewing fire codes. Without such long-term sustainable research activities, regulations worked out might not be convincing, leading to queries.

Items specified follow basically the local prescriptive codes [11-14]. Those old highrise buildings would have different problems in satisfying the specifications. Taking upgrading fire safety in old offices as an example [19], items prescribed in the three practicing prescriptive codes on passive building construction which are difficult to comply are:

- MoA code [11]:
  - Access staircase: by using escape staircase as in the MoE Code.
  - Access to fireman's lift "fire service access point" at ground level facing open area.
  - Fireman's lift reaches any floor.
  - At least one fireman's lift serves the refuge floor.
  - Separate liftwell for fireman's lift.
  - Lobby to fireman's lift.
  - Openings for lighting and/or ventilation for the lobby.
  - Basements: firefighting and rescue stairway, one within 60 m of any part of the floor.

- MoE code [12]:
  - Place of ultimate safety, i.e. discharge to ground level open area.
  - Artificial lighting throughout exit route for emergency.
  - Transparent view panel for every exit door.
  - Self-closing mechanism for every door to a staircase and protected lobby.
  - Exit from room: number and width based on room capacity; exit allocation bounded by travel distance and/or direct distance.
  - Escape staircase: width based on discharge value and room capacity; staircase allocation bounded by separation between staircases and travel distance; riser height and tread depth are limited.
  - Protected lobby to every escape staircase.
  - Lift lobby connects to an unlocked exit route.
  - Basement to get at least 2 exits; staircase continued directly to ground and not connected to staircases serving above ground stories; at least one independent staircase to ground at each basement.
  - Refuge floor for every 25 floors; open sides above parapet height on two opposite sides for cross ventilation.

- FRC code [13]:
  - Fire compartmentation having fire resistance construction: separation between different uses; separation between every compartment exceeding 28,000 m^3 with the same usage; separation between different occupancies.
  - FRP depends on type of usage and compartment volume: above ground 1 to 2 hours; basement 4 hours.
  - Criteria on stability, integrity and insulation vary among different types of construction elements.
  - Fire rated external wall and roof for adjoining buildings within 1.8 m apart.
  - Fire rated fixed lights at external if within 0.9 m from adjoining building having an FR less than the internal element of construction.
  - Distance between unprotected openings of adjoining building not less than 1.8 m.
  - Fire rated external wall and roof if it is within 0.9 m from the common boundary of an adjoining site.
  - Lobby between fire compartments.
  - Drenchers in lieu of shutters for fire separation where installation of fire shutters is not practical.
  - Fire rated enclosure for combustible services installation passing through a compartment wall and floor.
  - Fire damper or fire stop at every opening for passage of services installation (non-combustible).
  - Fire rated vertical shaft including liftwell, escape staircase and lobby.
  - No unprotected opening (e.g. window) on external wall of escape staircase which is within 6 m from the opposite side of street, common boundary with an adjoining site; any other unprotected opening.
  - 450 mm downstand surrounding escalator void.
  - 900 mm spandrel at external wall (vertical or horizontal).

- Non-combustible materials for roof construction.
- Smoke vents for basement.
- Fire separation at each end of bridge/ tunnel connecting two buildings.
- Self-closing device for all fire rated doors.
- Fire separation for refuge on every refuge floor from the rest of building.
- No unprotected openings within 6 m of refuge floor open side.

• FSI code [14]:

- Audio and visual advisory systems for single occupancy with floor area greater than 2000 m^2 and transient occupants.
- Automatic actuating devices for actuation of fire equipment (e.g. fire shutter, smoke vent).
- Emergency generator.
- Fire detection system for area not covered by automatic fixed installation (e.g. plant room).
- Fireman's lift as required under MoA Code.
- Automatic fixed installation other than water to protect areas where the use of water is undesirable for the occupancy or trade.
- Sprinkler systems.
- Pressurization of staircase where there is no venting and the aggregate openable window area of the rooms is less than 6.25% of the floor area; the space volume of the building greater than 28000 m^3; and the design fire load is likely to exceed 1135 MJm^{-2}.
- Static or dynamic smoke extraction system for atrium fire compartment with space volume greater than 28000 m^3.
- Static or dynamic smoke extraction system for any fire compartment with space volume greater than 7000 m^3; the aggregate openable window area less than 6.25% of the floor area; and the design fire load is likely to exceed 1135 MJm^{-2}.

Painful experiences learnt from big fires such as the big Garley Building fire [2] led to updating fire codes [11-14] with more safety requirements imposed. But there are different views on interpreting the requirements. All buildings have to comply with the local codes at the time before getting the occupant permits. Normally, building spaces were optimized with fire safety provisions installed according to the codes at the time of construction. It is unfair to request new installations as existing residential buildings for the fundamental class of citizens would not have financial resources. There may be space limitations and impossible for owners of those older buildings to clear up the space for installation works. Apart from the restricted area for installations and managerial obstructions, there are limitations on structural loadings, water sources and electric power supplies. Difficulties for old buildings to satisfy the new codes are summarized as in above.

Many fire service installations were not provided in some old commercial buildings. It is now required to install and upgrade the fire safety provisions with reference to those systems specified in the code. However, the power supply system was not sufficient to operate such applications as surveyed [26]. The water source for the whole building could not meet the minimum requirements for fire services. The staircase was too narrow for installing hydrant outlets. Such cases are not found in new buildings due to the enforcement of new requirements imposed by FSD [15] and redevelopment by developers.

A total fire safety approach [10,20] should be considered by working out appropriate software fire safety management to control hardware fire safety provisions for both passive building construction and active fire protection systems under the constraints of the old buildings. Performance-based design through FEA is a solution [21,22].

5. TOTAL FIRE SAFETY CONCEPT

The concept of total fire safety [10,20] in buildings can be achieved by working out appropriate fire safety management [27] to control passive building construction and active fire protection systems. This is similar to using software for controlling hardware in computer science. The only feasible way is to introduce proper fire safety management. A fire safety plan can be worked out with the following:

- Maintenance plan including housekeeping.
- Fire action plan.
- Fire prevention plan.

Training is necessary for the occupants concerned. Fire safety awareness can be promoted more actively by the government. Blocking of exits as in Fig. 4 should be controlled.

Fire codes, prescriptive [e.g. 11-14,24] or performance-based [e.g. 21,22,28,29], should be established based on the concept of total fire safety. In fact, prescriptive fire codes are easier to implement. But it might not be viable for those old tall buildings which have been operating for a long time. Applying performance-based design with

FEA is feasible but the following should be clarified in FEA:

- Fire safety objectives (goals are life safety design for both occupants and firefighters, protection of property, non-disturbance to business and environmental protection) to comply with the prescriptive codes.
- Hazard level expected for the buildings concerned might be classified as high hazard, ordinary hazard or light hazard.

Management schemes on passive building construction and fire service installations can then be worked out.

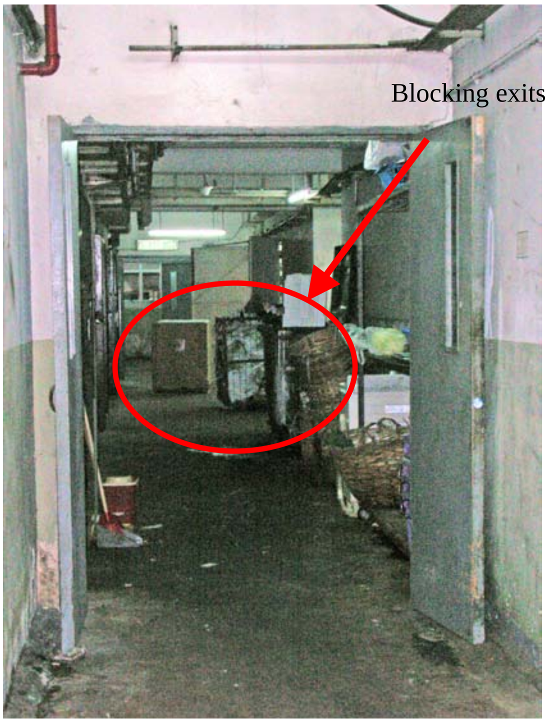

Fig. 4: Blocking of exit

6. CONCLUSIONS

With so many accidental fires [3-8] occurring since 1996 such as the one in Garley Building [e.g. 1,2], building fire safety is a concern. It is obvious that appropriate fire safety in old buildings should be provided. However, upgrading the fire safety provisions with reference to the current codes might not be appropriate. The fallback plan is a solution to the problems encountered. The specifications should be investigated to ensure that they are suitable for old buildings. The total fire safety concept can be applied by working out appropriate fire safety management.

'Technology', 'procedure' and 'behaviour' are the three key elements in safety engineering. Scientific research can give 'technology' and 'procedure' properly, say using the total fire safety concept [10,20] to work out appropriate software management to control the hardware system. However, 'behaviour' is the key point to achieve safety. This refers to not only the occupants' awareness on fire safety, but also the attitudes of the building owner and management to take actions as stated in the fire safety plan. Professionals in designing and installing workable systems should also be alert to the 'behaviour' element. Note that no temporary fire resisting construction was provided in the lift shaft before the big Garley Building fire [1,2]. The sprinkler system was shut off in two local recent fires in 2007 as reported in the news [6,8]. Responsibility of the owners, users and management should be watched.

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