Movable fire load survey for old residential highrise buildings in Hong Kong

W. K. Chow, S. Y. Ngan & G. C. H. Lui
Research Centre for Fire Engineering,
Department of Building Services Engineering,
Area of Strength: Fire Safety Engineering,
The Hong Kong Polytechnic University, Hong Kong, China

Abstract

The fire safety of existing highrise residential buildings in Hong Kong over thirty-five years old is a concern. These buildings used to have high occupancies but with far fewer fire safety provisions than those specified in current fire codes. To understand the potential fire risk behind the old existing buildings, fire load density should be surveyed first. A sample of eight such old highrise buildings was selected and surveyed. Both fixed and movable fire loads were reviewed.

Fire load density was found to be high due to excess storage of domestic fuel. Movable fire load in cage houses is a concern. Four of the eight surveyed buildings have fire load density over the upper limit specified in the code. Fire risks associated with storing too many combustibles were also studied. With such a high content of combustibles, it is more likely that big accidental fires will happen.

Finally, occupant loading in each example building was also surveyed. This would provide important information for working out the evacuation strategy.
Keywords: fire risk, highrise buildings, fire load survey, residential buildings.

1 Introduction

Hong Kong is a densely populated city in the Far East with small quantity of usable areas. Highrise buildings have to be built closely together. Residential buildings are also very tall and half of the top 100 highrise residential buildings in the world are in Hong Kong [1]. Supertall buildings of height over 80 storeys are also erected as residential buildings.

WIT Transactions on The Built Environment, Vol 94, © 2007 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/SAFE070211

There is a concern on residential fires, especially in buildings constructed years ago. Statistical record from 2002 to 2003 [2] compiled by the Fire Services Department (FSD) indicated that there were more residential building fires than other building uses. One of the reasons for very few industrial fires is because most of the factories have moved to the Mainland.

Causes of residential building fires were identified as careless handling of flammable and combustible materials; children playing with matches; stove overcooking; leakage of flammable gas; and electrical appliance fault or overload as listed in that report [2] of FSD. Results compiled in 2003 are shown in Fig. 1. The total number of residential building fires is 30. The causes are:

A: Careless handling or disposal of flammable substances
B: Careless handling or disposal of cigarette ends, matches and candles
C: Stove overcooking
D: Electrical appliance fault or overload
E: Children playing with matches
F: Leakage of flammable gases
G: Careless disposal of joss sticks, joss paper and candles, etc.
H: Unknown

Over 50% of them were due to electrical appliance fault or overload.

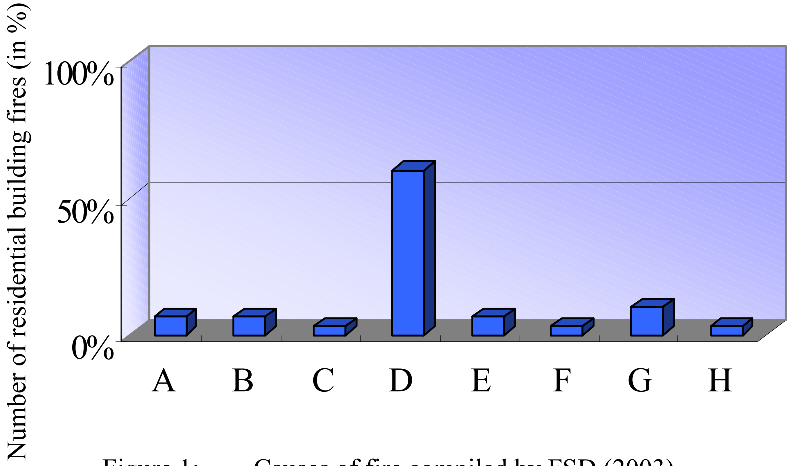

Figure 1: Causes of fire compiled by FSD (2003).

Preliminary studies on fire safety in old residential buildings in Hong Kong were reported [3–5]. Key parameters describing building characteristics and fire service provisions are identified. “Old” residential buildings commonly refer to those constructed on or before 1972, when the fire safety codes [6–9] were not yet well-developed. These old residential buildings can be classified into two types as conventional buildings and cage houses.

These buildings used to have high occupancies but with fire safety provisions much less than those specified in current fire codes. 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.

In this paper, fire risks in a sample of eight such old residential buildings were surveyed. Both the fire load and number of occupants were studied.

2 Fire load density

Fire load is defined [10] as:
"The sum of the calorific energies which could be released by the complete combustion and all the combustible materials in a space, including the facing of the walls, partitions, floors and ceilings".

Fire load is the total heat released when all combustibles are burnt. Fire load density FLD is the value normalized by the floor area. In a compartment of N combustible items, FLD (in MJ/kg) can be calculated by the mass of the i^{th} item M_i (in kg), its calorific value C_i (in MJ/kg) and the floor area A_f (in m^2) by:

$$FLD = \frac{\sum_{i=1}^{N} M_i \times C_i}{A_f} \tag{1}$$

Fire load can be classified as fixed fire load or those combustibles not likely to change frequently; and movable fire load which would be varied occasionally. To understand the potential fire risk, FLD should be surveyed first.

3 The survey

Eight typical old highrise residential buildings were selected on surveying their FLD. These buildings are mainly located at the older districts including Shamshuipo, Tai Kok Tsui, Mongkok, and Jordan as in Fig. 2. Two conventional buildings and six cage houses [11] were selected.

Visual inspections were carried out to identify the fire risks in the different target buildings. Reference was also made to some information based on published reports [12,13]. The possible accident fire scenarios can be identified once the FLD was surveyed.

In those eight selected sites, combustibles were located and stored in different partition areas such as bedroom, living room and kitchen. Calorific values of typical combustibles in residential buildings such as paper, polyvinyl chloride (PVC), kerosene/liquefied petroleum gas (LPG) are shown in Table 1. Key information of the eight buildings is shown in Table 2.

The flat concerned might have M partitioned areas and their FLDs were surveyed in these different areas. Values of FLD in each area (denoted by FLD_j for the j^{th} space of floor area A_{fj}) were estimated first, and then summed up to give the total FLD:

$$FLD = \frac{\sum_{j=1}^{M} FLD_j A_{fj}}{\sum_{j=1}^{M} A_{fj}} \tag{2}$$

Figure 2: Location of the sites.

Table 1: Calorific value of common combustibles in residential buildings.

Material	Wood	Metal	Paper	PVC	Cotton	Kerosene/ LPG	Rice	Cooking oil	Other food
Calorific value (MJ/kg)	18.59	8.0	16.28	22.10	16.74	48.78	14.71	39.92	12.61

Table 2: Survey result of fire load density.

Building	**Location**	**Type of flat**	**Flat area (M2)**	**No. of occupants**	**Fire load density (MJ/m^2)**		
					Fuel excluded	**Fuel only**	**Total**
1	Shamshuipo	Residential	60	3	96	98	194
2	Tai Kok Tsui	Residential	70	4	100	104	204
3	Shamshuipo	Cage House	120	88	349	818	1,167
4	Jordan	Cage House	80	58	307	842	1,149
5	Mongkok	Cage House	40	15	159	578	737
6	Mongkok	Cage House	60	50	397	739	1,136
7	Tai Kok Tsui	Cage House	80	65	343	932	1,275
8	Tai Kok Tsui	Cage House	70	28	162	570	732

4 Results

The surveyed FLD for the eight buildings are shown in Table 2. The FLD surveyed are split into two parts: with only fuel such as kerosene and LPG; and excluding fuel. All these are taken as movable fire load as plotted in Fig. 3.

It is observed that four surveyed buildings (3, 4, 6 and 7) have FLD higher than the upper limit of 1,135 MJ/m^2 specified in the local fire codes [6-9]. Fuel storage of kerosene or LPG is the main reason for having such high FLD in these four buildings.

All four buildings with high FLD are cage houses with high occupant loading. As individual occupants will keep different cooking appliances and store their own fuel, large amount of kerosene or LPG was found. Occupant loadings in the eight samples were also surveyed as in Table 2.

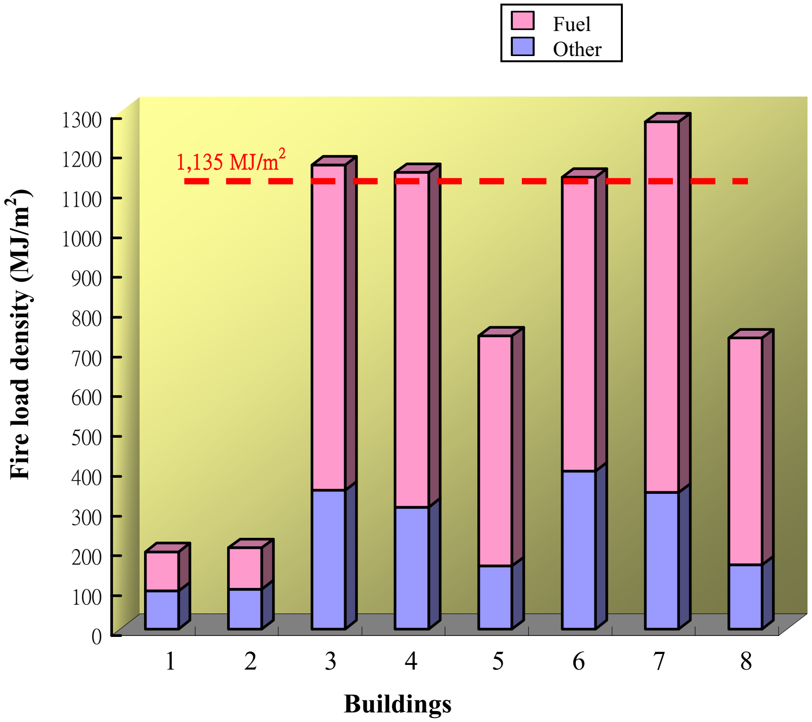

Figure 3: Fire load density surveyed.

5 Fire risks observed

In addition to surveying fire load, possible fire risk due to storing too many combustibles is also investigated. Fire risks identified are listed as follows:

In the bedroom:

- Storing too many combustibles such as cloths, papers.
- Too many electrical plugs connected to the same socket.
- Smoking risk.
- Aerosol spray placed too near to electrical appliances generating heat.
- Insufficient space behind TV set.
- Electrical appliances too close to combustibles such as papers, blankets and pillows.
- Placing electrical appliances on the bed.

In the living room:

- Storing too many combustibles such as papers, cooking oil, failed TV set.
- Smoking risk.
- Storing LPG linisters for fire pots.
- No fire resistance partition wall and doors between the kitchen and living room.

- Connecting too many electrical plugs to the extension cords of the same socket.
- Putting beds and combustible substances in the cage houses.

In the kitchen:

- Storing too many LPG containers or kerosene in cage houses.
- Connecting too many electrical plugs to the same sockets.
- Full of combustibles such as vegetable oil in the cage houses.
- Removing the fire door.

In the corridor and staircase:

- Rubbish bin at staircase.
- Storing too many combustibles.
- Blocking the emergency exit.
- Using passenger lifts for delivering fuel such as kerosene or LPG.

It is obvious that overheating would lead to ignition. Burning a small combustible might ignite adjacent items. Even explosion of LPG tanks might be resulted.

6 Fire safety management

From the survey on eight old highrise residential buildings, movable fire load is very high due to storing too much fuel. There is high fire risk associated with that. It is difficult to upgrade fire safety of the "old" residential buildings. Setting up codes to improve the hardware fire safety provisions such as active fire protection systems will be too disturbing. The only feasible way is to introduce proper fire safety management. A fire safety plan [14] can be worked out with the following:

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

Training is necessary on the occupants concerned. The government should take a more active role to promote fire safety education.

7 Conclusion

Fire load density, occupant loading and the associated fire risks were surveyed in eight typical old highrise buildings. Movable FLD due to fuel storage can be up to 50% of the total FLD, giving the value over 1,135 MJ/m^2. The main reason is due to excessive storage of fuel such as kerosene and LPG of individual tenants. Further, placing combustibles too near to electrical appliances, smoking and ignition of electrical appliances are possible fire risks.

Note that 60% of residential building fires recorded were due to overloading or faulty electrical appliances. All the eight surveyed buildings have electrical appliances placed close to the combustibles. Smoking is another issue and it is difficult to prohibit smoking in their own flat. Appropriate fire safety management should be worked out.

Acknowledgement

The work described in this paper was partially supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China for the project "The Skybridge as an Evacuation Option for Tall Buildings in Hong Kong" (PolyU 5147/05E) with account number B-Q916.

References

[1] *Property Times*, **447**, pp. 67-70, 10 January 2004.
[2] *Hong Kong Fire Services Review 2002~2003*. Fire Services Department, Hong Kong Special Administrative Region, 2003.
[3] Chow, W.K., Numerical studies on recent large high-rise building fire. *ASCE Journal of Architectural Engineering*, **4(2)**, pp. 65-74, 1998.
[4] Chow, W.K., Wong, L.T. & Kwan, Eric C.Y. A proposed fire safety ranking system for old highrise buildings in Hong Kong. *Fire and Materials*, **23(1)**, pp. 27-31, 1999.
[5] Chow, W.K., Chong, H.W. & Wong, L.T., Problems of the retrofit installation of sprinkler systems in old high-rise buildings: a case study. *Facilities*, **17(3/4)**, pp. 112-119, 1999.
[6] *Code of Practice for the Provision of Means of Access for Firefighting and Rescue Purposes*. Buildings Department, Hong Kong Special Administrative Region, 2004.
[7] *Code of Practice for the Provision of Means of Escape in Case of Fire*. Buildings Department, Hong Kong Special Administrative Region, 1996.
[8] *Code of Practice for Fire Resisting Construction.* Buildings Department, Hong Kong Special Administrative Region, 1996.
[9] *Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment.* Fire Services Department, Hong Kong Special Administrative Region, 2005.
[10] BS 7974, *Application of fire safety engineering principles to the design of buildings – code of practice*. British Standards Institution, UK, 2001.
[11] Chan, K.C., *Photo Album of Cages*, Society for Community Organisation (1993).
[12] Chow, W.K., & Cheung, K.C., Aspect of fires for factories in Hong Kong. *Journal of Applied Fire Science*, **5(1)**, pp. 17-32, 1996.
[13] Chow, W.K. & Lui, Gigi C.H., A fire safety ranking system for karaoke establishments in Hong Kong. *Journal of Fire Sciences*, **19(2)**, pp. 106-120, 2001.
[14] Lui, Gigi C.H. & Chow, W.K., Fire safety management of karaoke establishments in Hong Kong. *Journal of System Safety*, **37(4)**, pp. 10-15, 2001.