A Brief Discussion on Fire Safety Issues of Subdivided Housing Units in Hong Kong

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ABSTRACT

Subdivided unit (SDU) is a new type of residential housing affordable to the fundamental class citizens of Hong Kong. A flat is subdivided into smaller units in both domestic buildings and industrial buildings without government approval. Fire hazard of SDUs is a public concern, which should be assessed properly.

In this paper, fire hazards of SDU will be discussed. Fire regulations for SDUs by the local government will be summarized. Fire accidents happened in SDUs will be briefly reported. A survey was carried out on the potential fire hazards of SDUs located in eight residential buildings and two industrial buildings. Based on the surveyed results, recommendations were made along four areas on fire safety auditing; upgrading the design, installation and maintenance of appropriate fire safety provisions; raising the awareness of occupants on fire safety and providing suitable training; and the establishment of a Building Fire Warden System.

INTRODUCTION

Hong Kong is a densely populated big city with over 7 million registered residents, and another million of transient visitors. About 60% of the population stay in 80 km^2 of usable land (Grange 2004). Economics in Hong Kong is growing rapidly and so housing cost is very high. A residential flat cannot be cheaper than HK\$100,000/m^2 (about US\$13,000/m^2) of floor area. However, citizens prefer to stay close to their working areas to avoid having long traveling time.

Subdivided units (SDUs) then appear in downtown to provide low-cost housing. A residential or industrial flat is divided into many small units. There are about 280,000 SDUs (Platform of Concerning Subdivided Flats and Issue in Hong Kong 2012) with over 170,000 residents. Many problems were identified in SDUs, such as poor ventilation, fire safety and even overloading of the structure. After the fire accident in the Fa Yuen Street involving SDUs in 2011 (South China Morning Post 2011), citizens are alerted to the fire hazards in those buildings with SDUs. Problems on fire hazards have to be solved urgently as most of the SDUs do not comply with the fire safety codes (Buildings Department 2011; Fire Services Department 2012).

The fire hazards identified in buildings with SDUs include poor electrical wiring, unregistered electric meter installation, high amounts of combustibles stored with high fire load density (FLD), inadequate evacuation paths and blocked escape route. Illegal electrical wiring systems with unregistered electric meter installation can give (and had given) accidental fires due to electricity leakage or overloads.

In this paper, fire safety provisions in SDUs will be studied. The potential fire hazards in an SDU will be identified first. The amount of combustibles in a selected SDU will be surveyed. The current situation of SDUs in Hong Kong will be reviewed. Results of the study will be analysed. Recommendations will then be made for improving the fire safety in buildings with SDUs.

SDUs IN HONG KONG

SDU is defined (Buildings Department 2013a) by the government Buildings Department (BD) of Hong Kong as a unit that is subdivided into two or more separated rooms, and usually there is individual toilet or cooking place in each of the flat. SDUs without individual toilet or cooking place are known as 'cubicle apartments' or 'bedspace apartments' not defined in the Buildings Ordinance (BO) following the legislative council quota (LCQ11) (News.gov.hk 2012). Cubicle apartments are generally defined as a flat subdivided by wooden cubicles of simple construction and enable a unit to accommodate more than one tenant or sub-tenant. Bedspace apartments are known as 'caged homes' according to the BO, meaning that there are 12 or more bedspaces used as sleeping accommodation for individuals under rental agreements.

Statistics compiled by the government reported (Legislative Council Secretariat 2013) that there are at least 66,900 SDUs; and every subdivided flat is approximately subdivided into 3.6 units, with about 171,300 residents or 2.4% of the total population in Hong Kong. Over 55.4% of the 171,300 residents are living in SDUs with 7 to 14 m^2 floor area, and 10.8% are living in SDUs below 7 m^2. Housing shortage in downtown areas might be addressed by increasing the number of SDUs after sorting out the problems identified. Note that the main reason why citizens live in SDUs is for convenience, not travelling between their working or studying areas for over 2 hours a day with heavy traffic. The ordinary class of citizens cannot afford to drive, and the fares for public transport are high. SDUs are also found in industrial buildings which are not designed for domestic use. Some factories are in operation in industrial buildings with SDUs. Such SDUs have a higher risk to the household and are not suitable for domestic use (Buildings Department 2013b). Fire safety requirements on ventilation, open space, means of escape and other fire service installations of industrial buildings are different from the regulations of residential buildings and composite buildings.

The average area of an SDU per capita was about 6.3 m^2 for those staying at SDUs (Policy 21 Limited 2013). Note that for public rental housing (PRH), the actual usable floor area per person is about 13 m^2 as compiled in end-September 2013. SDU households have a much crowded living environment than the PRH households. According to the accepted standards for floor space of World Health Organization (Wikipedia 2013), the range of floor area for one person is 7 m^2 to 9 m^2.

There are many problems on indoor environment quality, structural stability and others to be addressed separately (Leung 2014). In this presentation, fire safety in SDUs will be pointed out. Note that an accident occurred in 2011 with 4 dead and 19 injured. The top 10 most serious fires happened in the last two years are listed in Table 1. As observed from the table, fires were mainly caused by electrical short-circuit and electric meter overload. Poor fire safety management in blocking escape routes is the main reason for casualties and injuries. Case 4 as listed in Table 1 is the most disastrous case with serious consequences. The fire was caused by electrical short-circuit. As reported in the news (e.g. South China Morning Post 2011), many occupants could not escape from the building because the escape routes were either blocked or altered.

Table 1. Ten fire accidents with SDUs from 2011 to 2013

Case	Date	Cause of the fire	Number of deaths	Number of injuries	Cause of the deaths or injuries
1	15 June 2011	Cigarette or incense	4	19	The floor layout changed because of building SDUs. Evacuation was difficult.
2	19 July 2011	Electrical short-circuit	0	3	• Many objects were put in the fire escape route. • Smoke door opened to spread fire and smoke fast. • Many people felt irritating after inhaling smoke.
3	3 November 2011	Circuit overload	-	-	No casualty and injury reported.
4	30 November 2011	Electrical short-circuit	9	34	Many objects were put in the fire escape route.
5	11 January 2012	Electrical short-circuit	-	-	No casualty and injury reported.
6	2 August 2012	Circuit overload	-	-	No casualty and injury reported.
7	26 August 2012	Circuit overload	0	5	The exit door was locked, people could not escape.
8	5 October 2013	Circuit overload	1	2	Many objects were put in the fire escape route and staircase.
9	1 December 2013	Electrical short-circuit	0	2	Many objects were put in the fire escape route and staircase.
10	29 December 2013	Arson	0	25	Many construction materials placed at the exit of the building, extending evacuation time.

A leaflet on fire safety regulations of SDUs was issued (Buildings Department 2013b) as shown in Appendix A. Common fire safety problems of SDUs identified from a survey carried out by the Institute of Surveyors (2011) are listed in Appendix B.

SURVEY ON SDUs

A total of 10 buildings including 8 residential buildings and 2 industrial buildings were surveyed with their potential fire hazards inspected (Leung 2014). These buildings are distributed in different districts in the downtown areas of Hong Kong, including Yau Ma Tei, Fanling, To Kwa Wan, North Point, Sham Shui Po, Mongkok, Tai Po and Hung Hom labelled as R1 to R8 for residential buildings; and labelled as I1 and I2 for industrial buildings in Kwun Tong in Tsuen Wan respectively.

The floor areas of the eight residential flats with SDUs are shown in Table 2, ranging from 3.7 m^2 to 6.5 m^2. Pictorial views of SDUs in the eight residential buildings are shown in Figure 1.

Table 2. SDUs surveyed in residential buildings

Building number	District	Room area	Combustibles	FLD (MJm^{-2})
R1	Yau Ma Tei	3.7 m^2	a single bed, clothes, small wardrobe, newspaper, carton	556
R2	To Kwa Wan	4.6 m^2	Paper, plastic wardrobe, bunker bed, television, an air conditioner, fan, clothes, table, refrigeration	949
R3	Fanling	4.2 m^2	Paper, plastic wardrobe, bunker bed, table, clothes, fan, curtain	1024
R4	North Point	5.6 m^2	bunker bed, refrigeration, paper, clothes, wardrobe	1326
R5	Sham Shui Po	3.7 m^2	bunker bed, table, clothes, paper, wardrobe, chair	1563
R6	Mong Kok	6.0 m^2	Wardrobe, television, double bed, air-conditioner, small wardrobe, clothes	767
R7	Tai Po	3.7 m^2	Single bed, fan, radio, small wardrobe, newspaper, clothes	576
R8	Hung Hom	6.5 m^2	Bunker bed, table, clothes, wardrobe, computer	787

(a) SDU in R1 at Yau Ma Tei

(b) SDU in R2 at To Kwa Wan

(c) SDU in R3 at Fanling

(d) SDU in R4 at North Point

(e) SDU in R5 at Sham Shui Po

(f) SDU in R6 at Mongkok

(g) SDU in R7 at Tai Po

(h) SDU in R8 at Hung Hom

Figure 1. Combustibles inside SDUs of residential buildings

The FLD (in MJ/m^2) at each SDU was surveyed (Fire Services Department 2012) by inspecting the total number N of different combustibles, the mass of each combustible m_i (in kg) and its calorific value E_i (in MJ/kg), and the floor area A (in m^2) of the building concerned:

$$FLD = \frac{\sum_{i=1}^{N} m_i E_i}{A} \quad (1)$$

The combustible items observed in buildings R1 to R8 are listed also in Table 2 with their FLD estimated. Values of FLD measured from 556 MJm^{-2} to 1563 MJm^{-2}. High FLD observed at each unit is found in small units.

In Hong Kong, the upper limit of FLD allowed (Fire Services Department 2012) is 1,135 MJm^{-2}. In these eight surveyed domestic buildings, 25% of those SDUs have fire loads exceeding the upper limit. For the SDUs in R2 at To Kwa Wan and R3 at Fanling, the FLDs are very close to the upper limit. The FLD of those SDUs are only estimated, based only on the dead fire load. There are many combustible objects stored in some SDUs not allowed to enter. The FLDs estimated are only minimum values. SDUs would have a much higher FLD. The percentage of those SDUs with FLD exceeding the upper limit should be more than 25%.

From the survey in eight residential buildings and SDUs, high FLD over the upper limit of the code requirement (Fire Services Department 2012) is a concern. A flat subdivided into several SDUs will have higher FLD; if a fire occurs, it will be more dangerous than a fire in a building without any SDUs. Storing large amounts of combustibles will give a big fire in the SDU with a long duration.

SDUs IN RESIDENTIAL BUILDINGS

Fire safety problems surveyed are shown in Figure 2. Basically, the problems are:

- The corridor width is less than 0.75 m.
- Many combustibles are placed in the escape route.
- Escape routes are blocked.
- Too many electric wires and electric meters are installed in the public escape staircase.
- Electric wires are not connected orderly because of addition and alteration works.

Local regulations (Buildings Department 2011) require that for a flat with less than 3 persons, the clear width of the internal corridor serving the SDUs should not be less than 0.75 m. Narrow corridor violates the regulations and would give difficulty in evacuation. However, narrow corridors are observed in the unit in R1 at Yau Ma Tei and R2 at To Kwa Wan as shown in Figure 3. Since one floor may contain several SDUs, the population density on a floor with SDUs should be much higher than the

population density on a floor without SDUs. A flat with narrow internal corridors and high population density would give (Reax Fire Protection Engineering Services 2014) long evacuation time.

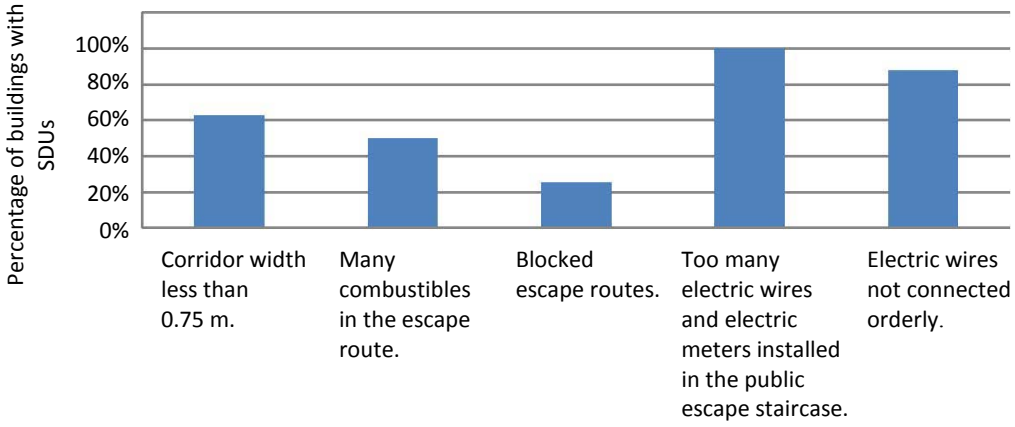


Figure 2. Observed fire safety problems in SDUs

(a) R1

(b) R2

Figure 3. Narrow corridor observed

Many combustible objects are placed in the escape route as in R5 at Shum Shui Po and R4 at North Point as shown in Figure 4. Putting objects in the escape route will not only block the corridor, but it may also increase the rate of fire spread (Cheng and Hadjisophocleous 2011). Most of the objects placed on the corridors and staircases are combustible. Upon igniting those objects, the fire may spread easily and rapidly from one unit to another unit, or from one floor to another floor. Large amount of smoke will be produced to reduce the visibility (Klote and Milke 2002). People might die due to inhaling too much smoke.

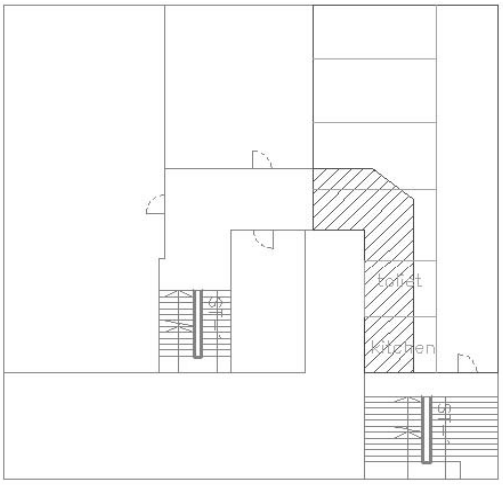
Some escape routes are blocked as in R1 at Yau Ma Tei and R2 at To Kwa Wan as shown in Figure 5 on the floor layout plans. As in Figure 5a, the three SDUs can reach both staircases in the original building design. However, another SDU was built

with an illegal partition wall, which blocked the escape route from the other two flats to the staircase. For the case in Figure 5b, the floor in that building was originally built with two large units. However, the two large units are subdivided into several SDUs. The escape route is blocked due to the added doors and partition walls. Although there are two staircases, occupants cannot use the nearby staircases. Blocking the escape route would give long evacuation time which might lead to fatality and injuries. Units with only one staircase are very dangerous.

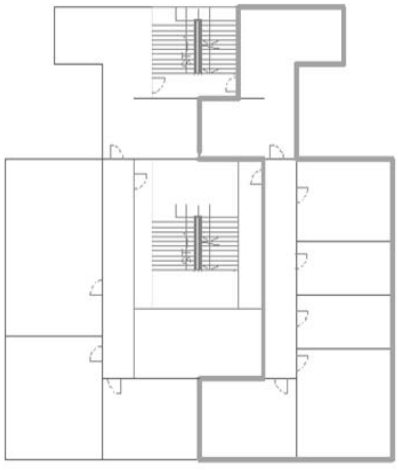
(a) R5 at Sham Shui Po

(b) R4 at North Point

Figure 4. Combustibles placed in SDUs



(a) R1 at Yau Ma Tei



(b) R2 at To Kwa Wan

Figure 5. Blocking of escape route

(a) R1 at Yau Ma Tei (b) R6 at Mong Kok

Figure 6. Electrical meters

All the eight buildings with SDUs surveyed have many electric meters and electric wires installed in the escape routes or staircases as in R1 at Yau Ma Tei and R6 at Mongkok shown in Figure 6. As observed from the figure, each SDU has its own electric meter for paying the electric bill. Those electric meters may not be installed by registered persons or companies. Further, too many users as indicated by the number of electric meters would cause overload as occupants are having many low quality electrical appliances, such as pirated cellular phones with explosion reported in the past. Note that electrical overload is the main cause of fire as reported in the past fire accidents in SDUs. It can be observed from Figure 6a that electric wires are not connected orderly. Protective coating of electric wires might be ruined to cause electricity leakage.

SDUs IN INDUSTRIAL BUILDINGS

Many SDUs are built in industrial buildings because of the relatively cheaper price. However, industrial buildings are not suitable (Buildings Department 2013b) for domestic use because the designs of the provision of ventilation and natural lighting and means of escape for industrial buildings are different from those for domestic buildings. Industrial buildings would store dangerous and inflammable goods.

It can be observed that electric wires are not connected orderly in I2 at Tsuen Wan on some floors with SDUs as in Figure 7a. The escape route in an industrial building is wider than that in a domestic building as shown in Figure 7b for I1 at Kwun Tong.

The corridor and escape route for SDUs in industrial buildings are better than those in domestic buildings. In the industrial building, the corridor of the floor with SDUs complied with the requirement of minimum clear width of the internal corridor. The width of the corridor is more than 1.5 m as shown in Figure 7b. No objects were placed in the escape route.

However, the escape route design did not satisfy the requirement (Buildings Department 2011; Fire Services Department 2012) that the length from any living unit to the escape staircase should not be longer than 18 m. As the industrial building has a large floor area, some SDUs have escape route over 18 m (Cherwell Fire Safety Limited 2011). As in Figure 8 on the SDU at Kwun Tong, the floor is separated into two parts, each with 33 SDUs. The population of the floor is high. On that floor, the escape route in some SDUs is more than 18 m. The required evacuation time will be extended for high occupant loading. Although the situation of the public corridor of the floor with SDUs in industrial building is better than that in domestic building, the escape route design failed to comply with local regulations.

(a) Electric wires in I2 at Tsuen Wan

(b) Corridor of SDUs in I1at Kwun Tong

Figure 7. Industrial buildings with SDUs

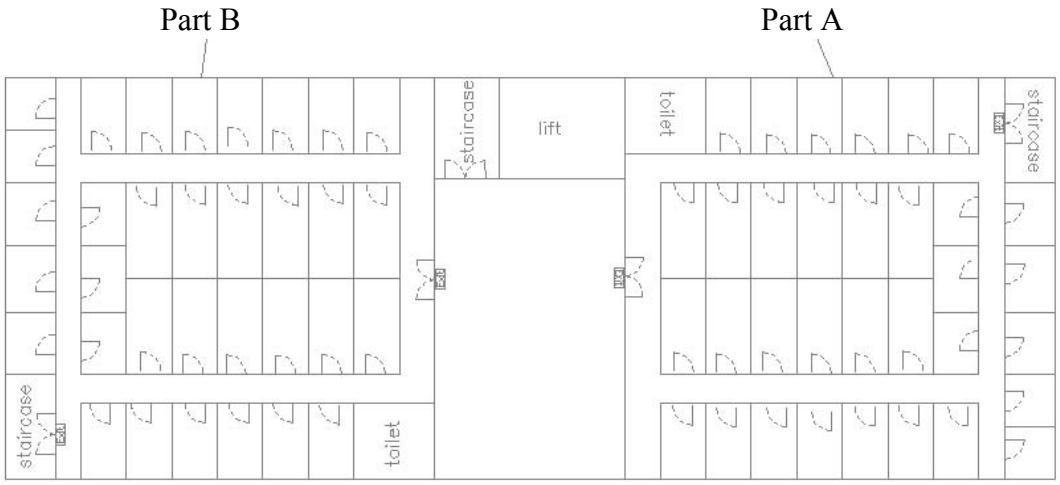


Figure 8. Layout plan of a floor with SDUs in the surveyed industrial building I1 at Kwun Tong

RECOMMENDATIONS

From the above study, recommendations are made along four areas to upgrade fire safety in buildings with SDUs. These are on fire safety auditing; upgrading the design, installation and maintenance of appropriate fire safety provisions; raising the awareness of occupants on fire safety and providing suitable training; and the establishment of a Building Fire Warden System.

- **Fire safety auditing**

Local government encourages building owners to pay more attention to the fire safety in their building, particularly in SDUs. A fire safety checklist for the general use of building owners or occupiers was devised by Fire Services Department (FSD) (2010). The purpose of the checklist is to facilitate building owners or occupiers to carry out routine inspections on fire safety provisions of their own buildings, and to rectify minor irregularities identified. After the survey visit on the ten buildings with SDUs, most of the SDU owners are not concerned with fire safety. The government should pay a more active role requesting building owners to conduct regular fire safety checks. Mandatory fire safety check is good for monitoring SDUs with a high potential fire risk. Officers must be sent to inspect fire safety regularly. Sudden inspection must be practised.

Further, monthly fire safety check by SDU owners themselves is suggested. A group can be established to take responsibility for the fire safety of the building with SDUs.

- **Fire safety provision**

Fire safety provision includes the passive construction elements such as fire escape route and fire resisting constructions; and active fire service installations (FSI) (Fire Services Department 2012). As surveyed, FSI in the ten buildings with SDUs did not comply with the local requirements (Fire Services Department 2012). The government FSD and BD have already reinforced the inspection of target buildings, and taken follow-up actions if potential fire hazards caused by obstructions to fire escapes or structural problems are identified, or if there are problems associated with FSI. However, action must be taken to control and ensure new SDUs are built with appropriate fire safety provisions.

Items of works found in SDUs are included in the Minor Works Control System (MWCS) (Buildings Department 2013c). The government should consider incorporating the fire safety provisions in the MWCS to upgrade fire safety in SDUs.

Additional FSI such as residential sprinkler should be installed as FLD in buildings with SDUs is high.

- **Fire safety awareness and training**

Occupants living in SDUs are mostly fundamental class of low educational level and low income. All the ten surveyed buildings with SDUs have a high FLD and with combustibles put on the public area staircase. Many combustibles such as newspaper and old electrical appliances are stored. In view of these, knowledge of fire safety and appropriate training must be provided to the occupants.

Occupants must be alerted to the hidden fire hazards. The fire safety awareness among the household should be strengthened. District Fire Safety Committees (Legislative Council 1999) in crowded districts with SDUs such as Yau Ma Tai, Sham Shui Po and Mongkok, should promote more on the importance of fire safety. More leaflets, pamphlets and posters should be distributed to the public, owners of the buildings with fire safety problems and people of different races.

It is difficult to alert occupants to the fire risks of SDUs. More talks must be arranged by the District Fire Safety Committees to the building owners with SDUs. The purpose of these talks is to provide training for the building owners, so that they know how to increase the fire safety awareness of the households in their buildings.

- **Building fire warden system**

Fire wardens and building households can assist the management of fire safety by reporting any issues or problems that they may identify. The government should encourage SDU owners to designate a warden responsible for fire safety in the building. Occupants in SDUs can be grouped together to take care of fire safety.

The FSD should control the fire warden system and ensure the responsible person has adequate knowledge on fire safety management, including not to build illegal structures such as partition walls.

CONCLUSIONS

Fire safety in the buildings with SDUs is reported in this paper. From the site survey, common fire safety problems in those buildings with SDUs are identified. Problems for SDUs in residential buildings are narrow corridor, combustible objects put in the escape route, blocked escape routes, and large number of electric wires and meters improperly installed in the public escape staircase. These may increase the fire risk to the inhabitants in the building with SDUs and may cause higher numbers of deaths and injuries in a fire.

The situation is better for SDUs in industrial buildings. However, the industrial building is not suitable for establishing SDUs because there are still factories operating. Dangerous and inflammable goods stored can bring fire hazards to the occupants concerned.

The FLD in SDUs is much higher than the maximum FLD requirement (Buildings Department 2011; Fire Services Department 2012) of domestic flats in Hong Kong. Therefore, the FLD of SDUs must be controlled. Based on the survey result, recommendations are made to upgrade fire safety in SDUs.

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APPENDIX A: FIRE SAFETY LEAFLET BY BUILDINGS DEPARTMENT (2013)

http://www.bd.gov.hk/english/documents/pamphlet/SFIBe.pdf

- Do not remove existing fire rated doors or replace them by doors not meeting the required fire resistance rating.
- When the original fire rated door at the entrance of the flat is maintained. The width of the corridor should not less than 0.75 m if the total number of occupants is not more than 30persons and should not less than 0.85 m if the total number of occupant is more than 30 persons and not more than 200 persons.
- When the original fire rated door at the entrance of the flat is removed or replaced by a door not meeting the requirement of the fire resistance rating, the

width of the corridor should not less than 1.05 m.

- The partition walls between the subdivided unit and corridor and the door of each subdivided unit should be fire resistance. The door should be able to close automatically and smoke-sealed.
- The exit route should have a clear headroom of not less than 2 m.
- In the enclosures of exit staircase, there should not exist any new door and ventilation opening.
- For the fire rated wall separating the unit and the means of escape, there should not exist any new opening for ventilation or for installation of air-conditioners and exhaust fans.
- If there are installed any metal gate, those should not obstruct the means of escape.
- The subdivided unit should not block or obstruct the means of escape leading to any exit staircase.

APPENDIX B: FIRE SAFETY PROBLEMS SURVEYED BY THE INSTITUTE OF SURVEYORS (2011)

http://www.legco.gov.hk/yr10-11/chinese/panels/dev/papers/dev0620cb1-25782-c.pdf

- Escape routes are often blocked or are inaccessible due to the illegal construction of partition wall, it increases the difficulty of fire escape.
- There are leak of fire resistance wall and door, it encourages the fire spread.
- There are leak of emergency lighting.
- New installed metal gate obstruct the means of escape.
- Too many electrical equipment which cause electric overload, increase the fire risk.
- Too many electric wire and electric meter installed in the public escape staircase and the electric wire is messy.
- The escape route is more than 18 m, too long escape route may over the required safety egress time, high risk to people from fire.
- The electric meter for each SDU is not installed by registered electric company or any certified people, therefore, the handling load of the electric meter may not meet the required standard.