OPERATIONAL GAP ANALYSIS OF FIRE SAFETY APPLICATIONS IN SRI LANKAN HIGH-RISE BUILDINGS

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ABSTRACT

Life style confined with working and living in high-risers is a new concept to the Sri Lankan context. Scarcity of lands and urban development with the economic growth has accelerated the growth and popularity of tall and complex buildings in Sri Lanka. As such, in the conceivable future too, the progress of construction industry is likely to be dominated by high rise buildings. Fire safety is the most critical component within any type of building. High-rise buildings involve high-risk in fire emergencies due to the combination of three risk factors, which are high population density and various levels of mobility, design configuration of high-rise buildings, and excessive amounts of fuel load. The consequences of high-rise fires include the fatal and serious injuries to occupants, damage or loss of property and severe interruption to normal business activities. Hence, it is clear that significance attention on the fire safety is necessary to continue the operations of a building. Accordingly, this study aims to analyse the operational gaps in the fire safety applications in Sri Lankan high-rise buildings.

Case study method was selected as the most suitable research method for this study as it can be applied to explain presumed casual links in real life interventions. Furthermore, the primary source of data was collected through semi-structured interviews among professionals who involved with the fire safety management in Sri Lankan high-rise buildings. Data were analysed adopting content analysis. The research findings revealed that, in Sri Lankan context organisations were endeavouring within the bounds of possibility to fulfil the minimum requirements. Nevertheless, there is no considerable attention has given to achieve the acceptable standard for fire safety. Those differences were identified as operational fire safety gaps in high-rise buildings. Key reasons for the malpractices are inefficient fire safety systems, lack of knowledge and commitment of the management, design failures and lack of government's commitment. Therefore, organisations need to adopt a measured approach to minimise the gap and to achieve the acceptable standard.

Keywords: *Fire Safety; High-Rise Building; Operational Gap Analysis.*

1. INTRODUCTION

High-rise buildings have several characters and features that make them unique from other buildings (McGrail, 2007). ICTAD Fire Regulations (2006) defined high-rise building as "any building with more than ten floors including the ground floor, or whose height at any part of it above the ground level exceeds 30 meters excluding a lift or motor-room not exceeding 56 square meters". However, the existence of multiple occupied floors with the higher concentration of occupants creates comparatively a high potential for damages in case of a fire risk (Craighead, 2009). According to Pickard (1994), all buildings should incorporated with three broad fire safety objectives. At first is the Life Safety which requires adequate time and appropriate facilities to enable a safe escape. Secondly, Prevention of Conflagration which demands the prevention of fire spread from building to buildings. Thirdly, Property Protection which includes protection to contents such as furnishings fittings, objects of valve as well as the property itself. Moreover, safety system for a facility has to be designed in accordance with perspective regulations (Meacham, 1999).

During the last decade, the land values have risen up in Sri Lanka especially in Colombo and the high-rise culture became an inevitable reality that has to be faced by Sri Lankans (Aluthwala *et al*., 2007). Most of the Sri Lankan high-rise buildings do not pay considerable attention on fire safety applications which they deployed to prevent and control fire hazards (Aluthwala *et al*., 2007). Therefore, fire safety in high-rise buildings is a significant issue to be analysed in the Sri Lankan built environment.

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2. FIRE RISK AND SAFETY IN HIGH-RISE BUILDINGS

The fire risk in high-rise buildings has been special concerns to the fire community as long as there have been high-rise buildings (Ferguson and Janicak, 2005). The reasons being, natural forces affecting fire and smoke movement are more significant in high-rise buildings (National Fire Protection Association [NFPA], 1997). Furthermore, high-rise buildings affect the access of fire service personnel, fire apparatuses in reaching the upper floors of the exterior of the building. These unique features enhance the importance of fire safety in high-rise buildings. According to ICTAD Fire Regulations (2006), fire protection facilities are required to maintain by an organisation in a state of high operational efficiency at all times. Figure 1 shows some of the essential fire protection facilities.

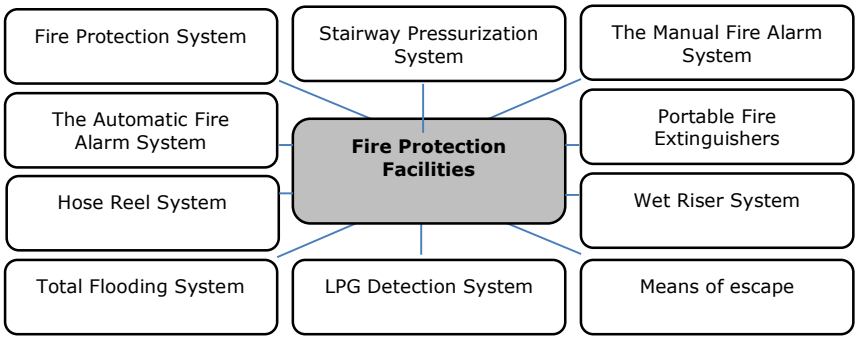

Figure 1: Essential Fire Protection Facilities
Source: ICTAD Fire Regulations (2006)

The fire protection measures are to curtail the danger to persons and property from fire. Two types of commonly used fire protection measures in high-rise buildings are active fire defence and passive fire defence (Daws, 1988). Active fire defences are devices or actions that must be receive a stimulus to act in a real or a perceived fire conditions (Fitzgerald, 2004). It includes fire detection systems and fire suppression systems such as smoke detectors, heat detectors, gas detectors, fire alarms, automatic sprinkler system, fire hose reels, stair pressurisation fire hydrants and fire extinguishers. As well as, passive fire safety defences defined as a building component that remains fixed in the building whether or not a fire emergency exists, it is the in-built feature of a fire precaution system which are fully available at all times in the building (Fitzgerald, 2004).

3. OPERATIONAL STANDARDS ON FIRE SAFETY

3.1. STRUCTURAL FIRE PRECAUTIONS

The purpose of structural fire precautions is to minimise the risk of spread of fire between adjoining buildings by a stable and durable form of construction, to prevent the untimely collapse of buildings in the event of fire and to prevent the spread of fire between specified parts of buildings by the division of such buildings into compartments (ICTAD Fire Regulations, 2006). Table 1 presents some of the structural fire precautionary requirements based on the ICTAD Fire Regulations (2006).

Table 1: Structural Fire Precautionary Requirements

Building Element	Requirement
Compartment wall / floor	Should be resistant to fire more than an hour
Staircases	Every staircase (including landing) which forms part of a building shall be constructed of non-combustible materials
Roof	All roof covering and roof construction shall be non-combustible

Source: ICTAD Fire Regulations (2006)

3.2. FIRE EXTINGUISHING APPLIANCES

A fire extinguisher is the basic fire protection device required to be in all type of buildings. SLS 831 (1988) defines, a portable fire extinguisher as a first aid firefighting appliance which can be carried by hand and the mess not exceeding 20 kg. Table 2 presents the classification of handheld extinguishers.

Table 2: Classification of Handheld Extinguishers

Standard	Type of Extinguisher	Definition	Capacity	Colour
SLS 815 (1988)	Water (stored pressure)	An extinguisher in which water is expelled by means of an inert gas or air, stored with, or dissolved in water under pressure	Not less than 9 litres	Red
SLS 704 (1985)	Water (gas cartridge)	An extinguisher which release on compressed gas from a cartridge to expel the water	Not less than 9 litres	Red
SLS 638 (1984)	Carbon dioxide	An extinguisher which expelled carbon dioxide as the extinguishing medium	Not less than 5 Kg	Black
SLS 785 (1987)	Powder	A portable fire extinguisher containing a powder as the extinguishing medium	Not less than 0.9 kg and not more than 14 kg	French Blue
SLS 831 (1988)	Foam (stored pressure)	An extinguisher in which foam is expelled by means of an inert gas, stored with or dissolved with in water under pressure	Not less than 9 litres	Pale Cream
SLS 724 (1985)	Foam (gas cartridge)	An extinguisher which release compressed gas from a cartridge to expel the form	Not less than 9 litres	Pale Cream

In addition at least one hydraulic hose reel need to be provided in every storey of a building and the hose reel should be of 19mm or 25mm diameter and not exceeding 45m in length (ICTAD Fire Regulations, 2006).

3.3. FIRE DETECTION AND ALARM SYSTEM

Every building or part of a building, shall be installed within a fire alarm system either automatic or manual type which shall be electrically supervised system. A fire alarm system of the automatic or manual type shall be provided with a fire indicator to indicate the location of the alarm which has been actuated or operated (ICTAD Fire Regulations, 2006). Further a manual alarm system shall be provided on every storeys of the building and shall be so located that no person need travel more than 30 m prom any position within the building in order to active the alarm (ICTAD Fire Regulations, 2006).

3.4. FIRE LIFTS AND FIRE FIGHTING SHAFTS

According to ICTAD Fire Regulations (2006), any building which floor level of any storey exceed 30m in height shall be provided at least one fire lift, which shall be contained within a separate protected shaft or a common protected shaft containing other lifts subject to such other lifts being served at each storey by the protected ventilated lobby. Figure 2 presents an illustration of a fire fighting shaft.

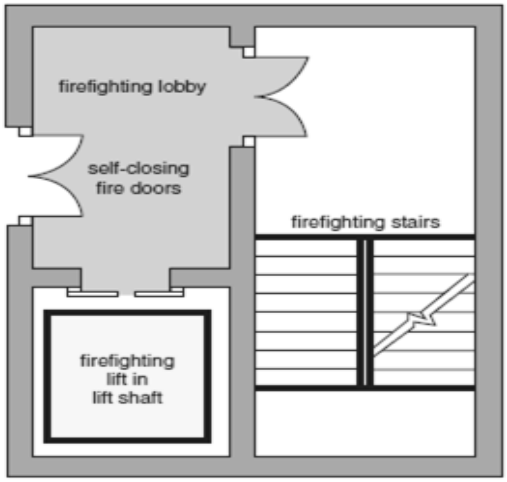

Figure 2: Fire Fighting Shaft
Source: Furness and Muckett (2007)

4. CURRENT STATUS OF FIRE SAFETY IN BUILDING ENVIRONMENT

According to Fire Service Department statistics (2012), fire calls from office building are in a considerable level compared to hotels and warehouses. Major issue for occurrences of fires in office buildings is lack of applicability of current Sri Lankan regulations. On the other hand growth of fire hazards in Sri Lanka implies the poor planning for fire safety in buildings. Summary of fire calls received by fire service department is presented in Table 3.

Table 3: Statistical Data of Fire Calls

Building Category	2007	2008	2009	2010	2011	Total
Office Buildings	12	14	09	15	11	61
Warehouses	6	10	13	8	10	47
Hotels	4	4	5	6	7	26

Source: Fire Service Department (2012)

5. RESEARCH METHOD

Case study was selected as the most suitable research method for this study as it provides an in depth understanding about the meaning of the subject being studied not usually offered by other qualitative methodologies, and as having the ability to capture many variables with the aim of identify how a complex set of conditions come together to produce a particular manifestation (Hancock, 1998).

Furthermore, Yin (2009) found that, the use of the case study methodology is appropriate when organisational and managerial issues need to be examined.

This research study was carried out based on high-rise office buildings that have been deployed fire safety applications, each considered as a single case as the target group of data collection. Three high-rise buildings were selected in order to collect data for the empirical study. Profiles of the selected three cases are given in Table 4.

Table 4: Profile of the Cases

	Building A	Building B	Building C
Constructed Year	1996	1976	1992
Number of Floors	36	12	14
Number of Occupants	4280	1260	840
Building Category	Commercial	Government	Government
Person In-charge for Fire Safety	Facilities Manager	Premises Manager	Fire and Safety Manager

For this purpose semi-structured interviews were considered as ideal because it elicits more elaborative and purposeful answers from the respondents to the questions raised. Being so, the interviews were carried out among professionals in the respective industry and content analysis was conducted to analyse the interviews. The QSR.NVivo; version 7 was used to analyse the data. Table 5 presents the list of interviewees.

Table 5: List of Interviewees

High-Rise Building Professionals			Fire Brigade Professionals	
Facilities Managers	Premises Managers	Fire and Safety Managers	Fire Officers	Firefighters
2	2	1	2	1
Total - 5			Total - 3	

6. DATA ANALYSIS AND FINDINGS

6.1. OPERATIONAL GAPS IN FIRE SAFETY APPLICATIONS

Interview results illustrated that, although the fundamental fire protection and firefighting requirements are fulfilled in all the selected cases, the intrinsic value of the fire safety is not attained effectually. Fire safety gap is referred as the difference between the existing fire safety applications and fire regulation and/or fire safety standards in this study. Standards are emphasising only on installation of fire protection devices. Proper maintenance of fire safety equipment to ensure the quality of such devices is not in need of any witness according to the standards. Fire alarm system of Case B has not been tested for a long time and it is not in a working condition. This situation can lead the building to take long time to respond in case of a fire. Similarly, sprinkler system is not installed in Case C. Consequently, the occupants will be subjected to danger when fire growth is unattended. Therefore, not deploying an automatic alarm system and sprinkler system can be recognised as fire safety gaps of a high-rise building.

One of the fire officers of Colombo fire brigade asserted, *"A portable fire extinguisher is a first aid firefighting appliance. However, in most of the cases portable fire extinguishers are not carefully maintained by the building management. Moreover, they are hidden in the corners of the building".* The statement of the fire officer revealed the ignorance of the building management on timely refilling and proper display of fire extinguishers. According to fire safety manager of Case C, the fire extinguishers of the particular building are not refilled due to budgetary issues. As a result, the building will lose the chances of immediate reduction of fire at an early stage.

According to the literature cited, if the floor level of any storeys exceeds 30m in height shall be provided at least one fire lift, which shall be contained within a separate protected shaft. However, two out of three selected high-rise buildings do not encompass a fire shaft. Furthermore, obstructed fire escape stair way was observed in Case B. These conditions will make the building more vulnerable in case of a fire. Based on the comments of a fire officer of Colombo fire brigade, a fire door should be resistant to fire for at least 30 minutes. However, fire doors were not installed in two of the selected cases. Moreover the exit sign boards are discoloured. These situations also can be recognised as fire safety gaps of high-rise buildings.

Standards on fire safety emphasises high-rise building to conduct fire drills since they accommodate a huge amount of occupants and the distance of evacuation is high. On the other hand, one of the selected buildings did not conduct a fire drill due to lack of trained staff and cost constrains. This may result in reducing the chances to identify weaknesses in emergency communications procedures and positive/negative reactions of staff with designated responsibilities.

Based on the above arguments it can be concluded that, operational fire safety gaps exist in the high-rise buildings of Sri Lanka even though the standards requires the optimum safety performance.

6.2. REASONS FOR MALPRACTICE

Organisations' performance on fire safety depends on several factors. A major cause for the gaps in the fire safety applications is malpractice of fire safety standards. The most common of the reasons for malpractice based on the responses are shown in Figure 3.

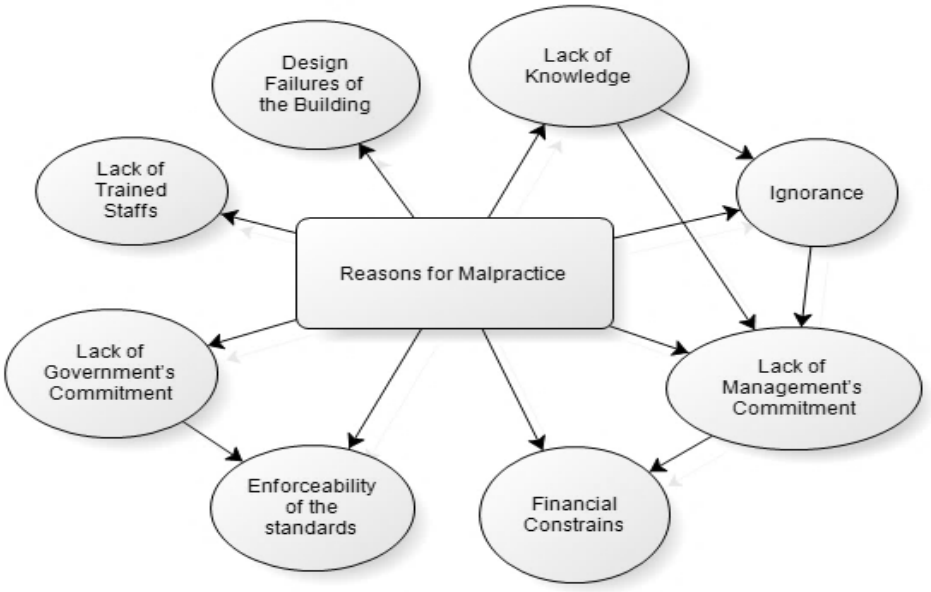

Figure 3: Reasons for Malpractice

Main reason pointed out by most of the interviewees is lack of management's commitment. Management's commitment depends on several factors including knowledge level, financial constraints and enforceability of the standards. As an assertion Fire and Safety manager of Case C mentioned "fire extinguishers of this building are not refilled due to budgetary issues". It shows the financial and other resource constraints of an organisation are one of the reasons for malpractice.

However, organisations are not solely responsible for malpractices by the reason of current standards do not require strict enforcement and continuous monitoring. However, organisations should improve their commitment towards fire safety in order to improve the performance of their building and to achieve their strategic objectives.

6.3. STRATEGIES TO MINIMISE OPERATIONAL GAPS IN FIRE SAFETY APPLICATIONS

In order to overcome from the identified gaps, building managers should adopt measured approaches. One of the fire officers of Colombo fire brigade stated that, *"organisations should give a special attention on available fire regulations to have all essential fire safety facilities to make the building safe".* Further he advice the managers of the buildings which are lacking with trained staff to appoint a third party as fire agents to install and maintain the fire protection system. As well as providing training to the existing staffs is equally important to monitor and coordinate the fire safety system. Another suggestion given by the fire safety officer of Case C is Fire Service Department and Urban Development Authority should take initiations to impose the standards on the buildings that are running with defective fire safety system.

According to the respondents, conducting a regular fire risk assessment with the assistance of Fire Service Department to identify fire safety gaps is another method which helps to develop the risk minimisation strategy. This will assist the organisation to identify the fire hazards, identify people at risk, valuate, remove or reduce the risks. Moreover, Facilities Manager of Case A suggested the high-rise building managers to maintain a fire plan and procedure manual to ensure the timely maintenance of firefighting equipment. One of the fire officers of the Colombo Fire Brigade stated that, *"if occupants do not given clear instructions they will automatically leave the building through the same route they have entered. Therefore the Public Addressing (PA) system should function in accordance with the intended evacuation strategy".* The statement reflects the importance of a good fire plan to a high-rise building.

Respondents further mentioned that, awareness of the building management have to be improved in order to adapt and maintain the required standards and to conduct fire drills. Because, the capabilities of the fire safety equipment will be assessed during the fire drills and it will enhance the communication with the Fire Services Department.

7. CONCLUSIONS

Based on the findings of the research study, various fire safety gaps were identified by means of comparisons based on compliance with fire regulations and relevant standards. According to the empirical findings, all the Sri Lankan high-rise buildings are not practicing all necessary fire safety procedures according to regulatory and standard provisions. Most common issues identified from the selected high-rise buildings are to lack of maintenance of means of escape, portable fire extinguishers, and directional fire safety signs and non-practicing of test evacuation drills. In order to avoid the losses that may result from a fire accident, organisations need to adopt a measured approach towards these gaps.

Based on the respondents' comments, several suggestions were presented to minimise fire safety gaps in high-rise office buildings. Improving the awareness level of building management and their commitment towards fire safety of the building, adapt emergency plans, take assistance of fire agents to rectify fire safety defects, and adhering to a proper maintenance system are some of the suggestions. A key suggestion for facilities managers is that they should recognise the importance of maintaining the fire related standards and should implement in their buildings.

This study was limited to fire safety applications in high-rise buildings in capital city of Sri Lanka. Case study samples were limited due to the scale of the study and the time constrains. Therefore this study can be continued to different types of buildings with a bigger set of sample. Furthermore, Facilities Managers' involvement on addressing these issues also can be studied through another research.

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