

FIRE SAFETY IN HIGH RISE RESIDENTIAL BUILDING IN MALAYSIA

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This project report is dedicated to My respected family
Thanks for your pray, attention and spiritual support

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ABSTRACT

With the increase in the high number of tall buildings being constructed in Malaysia, the building owners face many challenges. Not only the building owners will have to look after the maintenance of the buildings but they have also to consider the safety of the occupants, especially, in case there is a fire break out. The fire department will need the necessary equipment to 'fight' the fire and they need to be updated in the construction of these buildings. The aim of this study is to assess the fire safety regulation and also the factors taken into consideration in designing the fire safety requirements. The objectives of the study are to study the requirements of By-Laws 1984 (Malaysia) regarding the fire i.e. escape staircase, to identify the factors taken into consideration by building owners in term of fire regulation requirements, to assess the risk of fire in building and to evaluate the perception and behavior of occupants in case of fire outbreak. The study is focused on high-rise residential buildings with minimum of five storey's height. The data was gathered from observing five numbers of selected high-rise residential buildings in Kuala Lumpur. The data is also collected through questionnaires. From the study, the staircase width and intermediate floor depth are designed and constructed using different dimensions. There are five basic steps to carry out a fire safety risk assessment in buildings i.e. to identify fire hazards, identify people at risk, 'evaluate, remove, reduce and protect from risk', 'record, plan, inform, instruct and train' and review. The perception and behavior of occupants in case of fire outbreak is that they will immediately evacuate the building if the fire alarm goes off. The occupants wish to evacuate the building using the staircase instead of the elevator.

ABSTRAK

Dengan peningkatan dalam bilangan yang tinggi bangunan tinggi yang dibina di Malaysia, pemilik bangunan menghadapi banyak cabaran. Bukan sahaja pemilik bangunan perlu menjaga penyelenggaraan bangunan tetapi mereka mempunyai juga menimbangkan keselamatan penghuni, terutamanya, dalam kes kebakaran. Jabatan bomba akan memerlukan peralatan yang diperlukan supaya boleh memadamkan api dan mereka perlu sentiasa memeriksa pembinaan bangunan-bangunan. Tujuan kajian ini adalah untuk menilai peraturan keselamatan kebakaran dan juga faktor-faktor yang diambil kira dalam mereka bentuk keperluan keselamatan kebakaran. Objektif kajian ini adalah untuk mengkaji keperluan Undang-undang 1984 Malaysia mengenai kebakaran iaitu tangga kecemasan, untuk mengenal pasti faktor-faktor yang diambil kira oleh pemilik bangunan dari segi syarat peraturan kebakaran, dan menilai risiko kebakaran di bangunan untuk menilai persepsi dan tingkah laku penghuni dalam kes kebakaran. Kajian ini memberi tumpuan kepada bertingkat tinggi bangunan kediaman dengan sekurang-kurangnya ketinggian lima tingkat itu. Data yang telah dikumpulkan dari memerhatikan lima bangunan kediaman bertingkat tinggi terpilih di Kuala Lumpur. Dari kajian tersebut, lebar tangga dan reka bentuk lantai dibina menggunakan dimensi yang berbeza. Persepsi dan tingkah laku penghuni dalam kes wabak api adalah bahawa mereka akan segera mengosongkan bangunan itu jika penggera kebakaran padam. Penghuni ingin keluar dari bangunan dengan menggunakan tangga daripada lif.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

There have been numerous studies about fire safety in buildings and skyscrapers and have continued to be developed by many researchers for a considerable period of time, especially fire safety in the workplaces. Although there were some studies devoted on fire safety in tall buildings, there is still a gap on research about fire safety in high-rise buildings. Subsequently, the first seminar on human behavior in relation to fire incidents was held in 1977 at the University of Surrey, and eventually the seminar proceedings became the first published comprehensive book on human behavior relating to fire incidents [1]. Owing to the significance on the fire safety of building occupants, a second seminar was conducted in October 1978 by the National Bureau of Standards in the United States. Both meetings gave importance and focus on the examination and development of the various methods for the investigation of the occupants' behavior in times of fire incidents. Basically, the emphasis of this study is to define the behavior of the occupants during the occurrences of fire, the examination of the concept of *Panic Behavior*, and to explore the process of evacuation primarily on high-rise buildings [1]. In Malaysia, studies about fire safety of high-rise residential buildings are quite

new and very limited; thus, literature resources are scarce for review purposes in establishing a comprehensive assessment.

1.2 Background of study

There have been numerous studies about fire safety in buildings and skyscrapers and have continued to be developed by many researchers for a considerable period of time, especially fire safety in the workplaces. Although there were some studies devoted on fire safety in tall buildings, there is still a gap on research about fire safety in high-rise buildings. The first seminar on human behavior in relation to fire incidents was held in 1977 at the University of Surrey, and eventually the seminar proceedings became the first published comprehensive book on human behavior relating to fire incidents [1]. Owing to the significance on the fire safety of building occupants, a second seminar was conducted in October 1978 by the National Bureau of Standards in the United States. Both meetings gave importance and focus on the examination and development of the various methods for the investigation of the occupants' behavior in times of fire incidents. Basically, the emphasis of this study is to define the behavior of the occupants during the occurrences of fire, the examination of the concept of Panic Behavior, and to explore the process of evacuation primarily on high-rise buildings. In Malaysia, studies about fire safety of high-rise residential buildings are quite new and very limited; thus, literature resources are scarce for review purposes in establishing a comprehensive assessment.

1.3 Problem statement

In Malaysia, study on fire safety is very new, particularly research on provision of fire safety in high-rise residential buildings. The number of fire cases involved residential buildings is significantly high compared to other building types. Thus, escape routes in high-rise residential buildings should be designed and constructed to enable the occupants to evacuate the building as soon as fire has been detected.

By adopting observations approach, to investigate the issues and problems encountered in high-rise residential buildings. The numbers of high-rise residential buildings located in Kuala Lumpur observed so we should focus on the actual condition and problems encountered in escape routes in high-rise residential buildings in Malaysia.

However, discussion will be focused on the categorized issues which were highlighted during the research exploration, without mentioning a particular building where the problem was encountered. This is to avoid some degree of sensitivity in certain aspects especially when the rules and legislations are involved. Uniform Building By-Laws were used to consider the aspects of the requirements as they relate to escape route evaluate and fire safety in buildings. If we can understand the fire safety aspects, and we know what are the actual problems encountered in those buildings, appropriate measures can be taken to enhance fire safety standards.

1.4 Aim and Objectives

The aim of this study is to assess the fire safety regulation and also the factors taken into consideration in designing the fire safety requirements by means of following objectives:

1. To study the requirements of By-Laws 1984 (Malaysia) regarding the fire scape i.e.stair cases.
2. To identify the factors taken into consideration by building owners in term of fire regulation requirements.
3. To assess the risk of fire in building.
4. To evaluate the perception and behavior of occupants in case of fire outbreak.

1.5 Scope of study

The scope of this research is:

1. Only escape routes components i.e. staircase, corridor, fire door and intermediate floor are considered in analysis.
2. The study is focused on high-rise residential buildings with minimum of five storey's height.
3. Risk factors in building will be analysed according to the personal and damage hazards of fire as ruled out by Jabatan Bomba dan Penyelamat Malaysia.

REFERENCES

1. Chandrakantan, S., (2004), Human factors influencing fire safety measures, Disaster Prevention and Management, Vol. 13 N. 2, pp. 110-116.
2. Furness, A., and Muckett, M., (2007), Introduction to Fire Safety Management, Butterworth- Heinemann
3. Babrauskas, V., (1996), Fire Modelling: An Introduction for Attorneys, Fire Science and Technology Inc.
4. Henrik Johansson, (2001), Decision Making in Fire Risk Management, Report 1022, Lunds University, Lund, Sweden.
5. Angle, J.S., (2005), Occupational Safety and Health in the Emergency Services, 2nd Edition, Thomson Delmar Learning, N.Y. Avillo, A, (2002), Fireground Strategies, PennWell Corporation, pg. 223.
6. Bartlett, R.J., (1990), Fire Safety Evaluation System for Canadian Hospitals Phase 1 Report, International Federation Hospital Engineering 11th Congress – The Changing Scene of Health Care and Technology, Editor, R.G. Kensett, Chapman & Hall, London.
7. Christian, W.J.,(1974), The Effect of Structure Characteristic on Dwelling Fire Fatalities, Fire Journal, Vol.68, No.1 National Fire Protection Association, Quincy, MA.
8. Jones, B.K., and Hewitt, J.A., (1986), Leadership and Group formation in High Rise Building Evacuation, Fire Safety Science: Proceedings of the First International Symposium, Hemisphere Publishing Corporation, pp. 513 – 522
9. Bem, D.J., (1966), An experimental analysis of self-persuasion, Journal of Personality and Social Psychology, Vol..3, pp.707 -710.
10. Livesey, G.E., Taylor, I.R., and Donegan, H.A., (2001), A consideration of evacuation attributes and their functional sensitivities, 2nd International

- Symposium on Human Behaviour in Fire Proceeding, Interscience Communication, pp. 111- 122.
11. Bem, D.J., (1972), Self-perception theory, *Advances in Experimental Social Psychology*, Vol. 6, pp. 1 – 62, New York: Academic Press.
 12. National Fire Protection Association, Ma, USA.
 13. Benthorn, L., and Frantzich, H., (1998), Fire alarm in a public building: How do people evaluate information and choose evacuation exit? (1998), *Proceedings of the 1st International Symposium: Human Behaviour in Fire 1998*, University of Ulster, pp 213 – 222.
 14. Galea, E.R., Gwynne, S., (2001), Evacuation an Overturned Smoke Filled Rail Carriage, *Proceedings of the 2nd International Symposium on Human Behaviour in Fire*, Interscience Communication, pp.135-146.
 15. Berlin G.N., Dutt, A. and Gupta, S.M., (1982), Modeling emergency evacuation from group homes. *Fire Technology Journal*,. 18 pp. 38–48.
 16. Berndt, J.F., Richardson, J.K. (1982), “A Conceptual Approach to the Control of Fire Hazards”, *Canada Building Digest*.
 17. Sim, D., (1995), See how they run: modeling evacuations in VR. *IEEE Computer Graphics Apple* 15 2,pp. 11–13
 18. Bishop, S.R., Drysdale, D.D.,(1998), Fire in Compartments: the Phenomenon of Flashover, *Phil. Trans. Royal Society Journal* 356, pp 2855-2872.
 19. Bomba (Jabatan Bomba Malaysia), (2001), “Statistik Kes-Kes Kebakaran di Semenanjung Malaysia 1990 -1999”, Pusat Sumber Ibu Pejabat Bomba Malaysia.
 20. Bryan, J.L., (2002), A selected historical review of human behaviour in fire, *Fire Protection Engineering Journal*, No 16, www.sfpe.org.
 21. Canadian Wood Council (CWC), (2000), *Fire safety in Residential Buildings, Building performance bulletin, series 2*. Pg. 3.
 22. BSi, (2003), PD-7974-7:2003: Application of fire safety engineering principles to the design of buildings, British Standard Institution.
 23. Building Regulation 2006, Approved Document B: Fire Safety (Dwellings), ODPM, United Kingdom.
 24. Bukowski, R.W., (2004), Building regulatory systems in a post-September 11 world, *Proceedings 5th International Conference on Performance-Based Codes and Fire Safety Design Methods*, 2004, Luxembourg, (Society of Fire Protection Engineers) SFPE.

25. Churchman, C.W., Ackoff, R.L., and Arnoff, E.L., (1957), Introduction to Operational Research.
26. Clark F.R.S., (1988), Control ignition of buildings material, Canadian Building Digest, NRCC.
27. Tarada, F., (2005), Time For A Sharp Exit, Building Services Journal, 10/05, Pg 40 – 49, CIBSE, London.
28. Craighaed, G., (2003), High-Rise Security and Fire Life Safety – 2nd Edition, Elsevier Science,MA.
29. Wolski, A., Nicholas A. D., Brian J. M., (2000), Accommodation perceptions of risk in performance-based building fire safety code development, Fire Safety Journal 34, Elsevier, pp 297 – 309.
30. Davis, C., (1992), An Individual and Group Strategy for Research in Information System, Information systems research, issues, methods and practical guidelines, pp 230-250, (ed. Galliers, R.D.), Blackwell Scientific, Oxford.
31. Skinner, B.F., (1953), Science and Human Behaviour, New York, Macmillan.
32. Donald, I., Canter, D, (1990), Behavioural aspects of the King's Cross disaster, Canter, D, Fires and Human Behaviour, 2nd edition, David Fulton Publishers, London, pp.15-30.
33. FPA, (2003), Design guide for the Fire Protection of Buildings: Essential Principles, Fire Protection Association, London.
34. Douglas, J., (2002), Building Adaptation, Butterworth-Heinemann, Oxford.
35. Fahy, R., Proulx, G, (1996), A study of occupant behavior during the World Trade Center
36. Evacuation, Proceedings of Interflam `96, the 7th International Fire Science and Engineering
37. Conference, Cambridge, Interscience Communications, pp.793-802.
38. FPA, (3/2008), http://www.fpa-fireriskassessment.com/fire_risk.htm
39. FPEH (Fire Protection Engineering Handbook), (2002), Society for Fire Protection Engineering.
40. Thompson, iesve, Simulex: Simulation people have needs too, web.ww.iesve.com