UNIVERSITI TEKNOLOGI MARA

CONFERENCE PROCEEDING

ICITSBE 2012

1ST INTERNATIONAL CONFERENCE ON INNOVATION AND TECHNOLOGY FOR SUSTAINABLE BUILT ENVIRONMENT

16 -17 April 2012

Organized by:

Office of Research and Industrial Community And Alumni Networking
Universiti Teknologi MARA (Perak) Malaysia
www.perak.uitm.edu.my

PAPER CODE: FM 24

A REVIEW OF BUILDING FACTORS CONTRIBUTING TO BUILDING SAFETY PERFORMANCE

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Abstract
This paper will present a review of literatures pertinent to the building factors contributing to the minimization of safety hazards in built living environment. Review of literatures shows that most property management organisations have not established regular safety inspection and maintenance of existing buildings. This scenario has led to a reduced number of existing buildings related to comfort and safety. Research shows that comfort and safety in a building are critical in order to protect occupants from hazards. Hence, to bridge this gap, this study aims to identify building factors affecting the safety performance of buildings. This research involved a literature search on the identification of the building factors affecting building safety based on the frequency of the factors identified by past researchers. From the mapping matrix, the highest frequency as indicated by most researchers is a means of escape and access that contributes to the minimization of safety hazards of buildings. Meanwhile, factors from each category are also determined. As a result, more effort is necessary to boost and further stimulate action towards a proposed building safety performance assessment framework towards a sustainable built environment.

Keywords: Building factors, Building Safety, Mapping Matrix.

1. Introduction

The creation of the sustainable construction became one of the main priorities of construction industry in Malaysia. Therefore, there is a need for a sustainable strategy especially towards building a safer and more sustainable built environment. Ministry of Works set a 10 per cent of the allocation under the Tenth Malaysia Plan for buildings and roads maintenance. Government also allocated a fund of 500 million ringgit for the repair and maintenance works of public and private low-cost housing (Government of Malaysia, 2010). Despite the government's commitment towards building maintenance, many issues reflected to safety and health of our buildings in Malaysia are reported. The problems of building damage seems to have no end even though many parties like Jabatan Kerja Raya (JKR) and the maintenance crew had presented the report to contain the same problems do not recur again (Chelladurai, 2008). In Malaysia, building problems are mainly caused by failure of design, structural, materials used and maintenance problems (Lai, 2011; Murali, 2010). A safe and healthy building must be carefully planned and orchestrated from the beginning of the design especially in architectural plans. This planning is a dynamic process that should be approached in a serious manner in order to provide a safe building from conception construction to grave demolition (Yau, 2006). All the safety and health design factors that have been learned over the years and have become required or regulated must be incorporated. Therefore, quality of buildings must be able to improve life quality into buildings, where high comfort must be guaranteed. The building had already exceeded the end of their design life of 50 years poses severe safety hazards problems to their occupants wellbeing (Ho, Yau & Poon, 2010). To reduce these safety hazards impacts, it needs a comprehensive understanding of the building factors for built environment hazards and for the purpose of the initial screening to evaluate building safety performance.

2. Conceptions Pertinent To Safety

Yau (2006), defined a safe building is a built environment that safeguards its occupants and the general public as a whole from physical, psychological, or material harms originating from the built environment, aims to reduce injuries and deaths, and hence, encourages the positive well-being of humanity. It should minimize potential losses from the five living built environment hazards, namely Structural Failures, Falling Objects, Fire Hazards, Building Services Failures, and Special Hazards. The concept of hazard is always interwoven with that of risk. Smith and Petley (2008), defined hazard a potential threat to humans and their welfare and risk the probability of a hazard occurring and creating loss. According to Lin and Michael (2010), risk factors that influence the building maintainability are design risk, construction (quality) risk, maintenance (quality) risk, environment and usage risk and risk from building's profile.

3. Performance Assessment Methods That Evolved After 1980

Building performance assessment methods evolved early since 80 an. Scale and scope of the assessment can be classified as fail type certification, simple additive and weighed additive. The aim of grading systems is to promote buildings with high maintainability through a structured risk assessment protocol (Lin and Michael, 2010). The R-2000 method developed 1981 in Canada proposed the systems to promote energy efficiency and reduction of greenhouse gas emissions of residential buildings. Upon fulfilment of mandates, certification is issued by the authority. With the industrial advancement and support from various government agencies, a number of assessment schemes have been developed with the simple additive systems. In 2000, the United States Green Building Council proposed LEED to assess a total of five major assessment areas namely sustainable sites, water efficiency, atmosphere, materials and resources and indoor environmental quality. The building is rated as Certified, Silver, Gold or Platinum based on a minimum score of 26, 33, 39 and 52, respectively, out of the total score of 69. In view to make more informed decisions of building performance assessment, a number of assessment schemes have been developed based on weighed additive. Determination of weightage mostly involves judgmental from expert opinion to rank the parameters and then weighingare allocated by analysing such data through various methods such as analytical hierarchy process and statistical correlation. These schemes are Building Environmental Assessment Method (HK-BEAM) in Hong Kong, Building Safety and Conditions Index (BSCI) in Hong Kong and the Standard of House Performance Appraisal (SHPA) in Mainland China.

Although the BSCI, SHPA and BQA are tailored to existing buildings, their scopes of assessment are either too specific or too wide. The BSCI is essentially an arithmetic weighted average of the ratings of all building factors that have a bearing on the safety of a residential building (Wong, Cheung, Yau, Chau, and Ho, 2006). In this regard, building factors are grouped into five categories, namely architecture, building services, external environment, operation and approach (as in figure 1). According to Wang, Ho, Daniel and Chen (2005), the assessment scope of the SHPA is wide, ranging from basic health and safety issues to environmental and functional performance. Wang et al. (2005) found SHPA is structured around five performance aspects, namely Applicability, Environment, Economy, Safety and Security, and Durability. In light to assess the actual performance of a building, the Building Quality Assessment (BQA) methodology has been widely used in Australia and New Zealand (Ho,1999). The BQA consists of 138 items relating to nine separate categories of quality namely Presentation, Space, Functionality, Access and Circulation, Amenities, Business Services, Working Environment, Health and Safety, Structural Considerations, and Building Operations (Clift, 1996). Green building assessment tool HK-BEAM, IBI and CEPAS are the most representative environmental performance assessments tools. HK-BEAM provides building users with a single performance label that assessed building will be safer, healthier, more comfortable, more functional and more efficient (HK-BEAM Society, 2004a). The number of building safety attributes that describe a building performance could often run into hundreds. However, not all of them are significant when considering the local conditions of the buildings. Hence, in identifying building safety attributes, historical building performance assessment data from a large pool of buildings would be useful. The development of Intelligent Building Index Version 2.0, attempted to cover holistic assessments for ten individual building elements to assess an intelligent building (Yiu et al., 2009). There were nine quality environment modules in the IBI framework, including Human Comfort and Safety and Structure. In order to further promote green buildings in a holistic manner, CEPAS was proposed as a standard yardstick to determine the environmental performance of buildings in Hong Kong (Wu and Yau, 2005). Assessment categories are grouped into eight categories, that is resources use, loadings, site impacts, neighbourhood impacts, indoor environmental quality (IEQ), building amenities, site amenities and neighbourhood amenities.

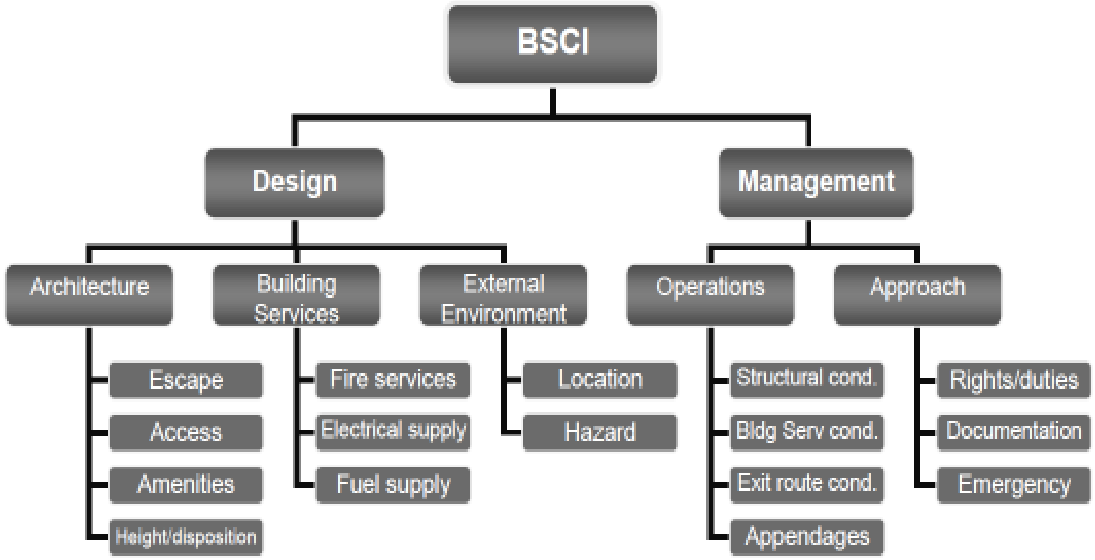

Figure 1: Building Safety and Condition Index (BSCI) framework
Source: Wong et al. (2006)

For many years, a variety of building performance evaluation models mainly focusing on the housing quality of inside and outside the residential buildings. The Housing Quality Indicator (HQI) is a housing quality certification system developed in 1998, in UK. According to Housing Quality Indicators (HQI) Form Version 2 (1998), assessments of quality of key features of a housing project in three main categories, which are design, location and performance. These three categories produce the ten section that measures quality includes location, visual impact, layout and landscaping, open space, routes and movement, size, layout, noise, light, services and adaptability, accessibility within the unit, sustainability and external environment. QUALITEL is a housing quality certification system of France to assess and measure of the global technical and environmental quality of buildings (Cunha and Daniel, 2010). The system is made up of eleven certification themes related to Organization and Information, Quality of The Shell and Common Areas, Housing Comfort and Performance, and Health and Fire Security. For ensuring the longevity of well-performing buildings in South Korea, the Housing Performance Evaluation Model (HPEM) was developed targeted for multi-family residential buildings. According to Kim, Yang, Yeo and Kim (2005), the criteria for performance evaluation includes structural safety, fire and life safety, human comfort, and the physical condition of building elements and service systems.

4. Matrix Of Building Factor

Mapping of building factors is to give preliminary idea on what past researchers had discovered the factors that contributed to the building performance. The building performance assessment schemes have been developed by past researchers around the world. All the focus of building performance assessments selected are relevance to assess building safety performance. This matrix analysis can identify the building factors affecting building safety based on the frequency of the factors identified by past researchers. There are 10 scholarly research papers selected for this study and 23 safety factors of building performance were found in the study. These factors are grouped into 5 categorized. Table 1 shows the mapping of the building factors taken from research articles around the world. Therefore, this input is useful for developing the questionnaire to determine the relevancy of these factors according to local design and construction quality, climate, environment conditions and the use of existing buildings.

Table 1: Matrix of Building Factor

GROUP	CATEGORY	BUILDINGS FACTORS	REFERENCES										
			BSCI	HK-BEAM 2004a	HK-BEAM 2004b	BQA	IBI	SHPA	CEPAS	HPEM	QUALITEL	HQI	F
DESIGN	ARCHITECTURE	Fire Resisting Construction	1		1	1	1	1	1	1	1		8
		Means of Escape	1	1	1	1	1	1	1	1	1	1	10
		Means of Access	1	1	1	1	1	1	1	1	1	1	10
		Microclimate Around Buildings		1	1				1	1		1	5
		Site Design Appraisal		1						1		1	3
		Amenities	1	1	1	1		1	1	1	1	1	9
	BUILDING	Fire Services	1	1	1	1	1	1	1	1	1		9
	SERVICES	Electromagnetic Supply		1	1	1	1	1	1		1	1	8
		Plumbing and Drainage	1	1	1	1		1	1		1	1	8
		Ventilation And Air Condition System				1		1		1	1	1	5
		Fuel Supply	1										
	EXTERNAL	Emergency Services	1	1	1					1			4
	ENVIRONMENT	External Hazards	1	1	1				1	1	1		6
MANAGEMENT		Structural and Finishes Integrity	1		1	1	1	1	1	1	1		8
		Building Services Condition	1	1	1	1	1		1	1	1	1	9
		Exit and Access Condition	1		1	1	1			1	1	1	7
	OPERATION &	Fire Compartment Integrity	1	1	1	1	1		1	1	1		8
	MAINTENANCE	Building and Site Operation			1					1		1	3
		Building Appendages	1										1
		Maintenance Policy				1							1
		Documentation &Evaluation	1			1	1		1				4
	MANAGEMENT	Emergency Preparedness	1				1			1			3
		Security and Access Control				1				1	1	1	1
		Financial Arrangements	1										1

Source: Summary from literature

5. Results And Discussion

The implementation of safety measures should be addressed in the design stage and building management process. Therefore, much literature (Al-Homoud, Abdou and Khan, 2004; McDermott, Haslam and Gibb, 2006; Reese, 2004) pointed out building design and management play an important role in building safety. Al-Hamoud and Khan (2004) highlighted the unnecessary hazards in buildings design can be reduce much more easily at the drawing board than would be the case after the fact corrective action. Yahya (2011) also suggested that strategic management approaches appears to be the most critical factor that should consider to improve the health and safety conditions across buildings. In this regard, building factors are grouped into two main categories, namely design and management. Based on table 1, the factor that has the highest frequency based on categories are discussed.

5.1 Means of Access and Escape

The engineered features of a building in connection with layout mainly relate to its escape route signage, the design of the escape routes and the design and location of the emergency exists and the emergency staircases (Kobes et al., 2010). The design of the means of escape and means of access for fire fighting is very important and should be kept in serviceable condition for their specified functions. The Al-Homoud and Khan (2004), suggested exit routes especially stairways of the buildings should be kept in good condition and free from obstructions for egress. Al-Homoud and Khan also found, lighting and maintenance floor surface are important safety consideration to decreased hazardous conditions.

5.2 Fire Services

According to Lai and Yik (2004), an assessment of building services conditions are important in the context of safeguarding the safety, health and well being of people, and protecting the environment. Systems of building services which are electricity, fire service, lifts and escalators, gas supply and ventilating systems tend to be maintained in serviceable condition if they are regularly inspected according to the legal requirements (Lai and Yik, 2004). With regard to for survival in the case of fire, a variety of models have been developed which aim to enhance the fire response performances of occupants. Sime (2001), proposed a fire response performance model that identified building features includes lay out, installation, materials, compartments and size of buildings has a direct and major influence on the degree of fire response performance. Further evidence of the need to consider building features is implemented by Yau (2006). In his building safety performance assessment framework, he concludes that fire services installations in a building are fire hydrants, hose reels, automatic detection devices, manual alarms, sprinkler, fire services control panels, exit signs, and emergency lighting.

5.3 External Hazards

In summary, the term environmental hazard refers to all the potential threats facing human society by events that originate in, and are transmitted through, the environment. External hazards mainly come from natural hazards (landslides, river floods), technological hazards (storage hazardous material) and context hazards (climate change) (Smith and Petley, 2008). This has been highlighted by Wong et al. (2006), who identified the external hazards mainly come from the landslide and flooding in the vicinity of the buildings. In addition, Yau (2006) also highlighted the external environment includes hazardous installations and slopes or retaining walls may dictate the safety of buildings by posing hazards to it.

5.4 Building Services Conditions

Lai (2005), suggested the building services installations for safety health and comfort should work together with the operation and maintenance parties to ensure the designed conditions of the installations be properly delivered and maintained in its life cycle. He suggested, the installations of building services includes electricity system, lighting, ventilation, air conditioning, water supply, drainage, fire services installation, gas supply, lifts and escalators. The relationship between overall health and safety and development scale has illustrated by Wong et al. (2006) in connection with building services. Wong et al. identified large developments performed better in terms of buildings services because the flexibility in adopting better building services design and adequate funding in building maintenance and management.

5.5 Documentation and Evaluation

Documentation and evaluation can affect the building management process, which led to reducing the existing building comfort and safety. This has been highlighted by Yau (2006), who identified that a records for building works and building services, maintaining incident records and seeking feedback from occupants on building safety issues should be assessed in order to be and effective building management. The records of building maintenance provide valuable information for future use, maintenance and transformation in the management of existing building maintenance (Wang, 2011).

6. Conclusion

Finally for the conclusion, hopefully at the end of this study a building factors affecting the safety performance of buildings will be used by researcher, contractor, building owners, maintenance and management services providers. For further study, these data will be model as an assessment framework, process and benchmarking tool for building performance evaluation in terms of safety.

Acknowledgement

The authors would like to thank to Prof. Madya Dr.Hj. Zainal Abidin bin Akasah and Prof. Mohd Idrus Bin Hj. Mohd Masirin as supervisor and the UTHM for supporting this study.

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