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Risk management: The effect of FIST on perceived safety in crowded large space buildings

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ABSTRACT

Facilities management within large space buildings used by large crowds must involve effective risk management as a key component. Poor risk management within large space buildings such as sports stadiums, concert halls, and religious buildings have resulted in crowd disasters in various venues across the world. Fruin suggested that Force, Information, Space and Time (FIST) are the main factors that influence the occurrence of crowd disaster. Within the built environment, safety is considered in two main parts: objective safety (normative and substantive) and subjective safety (perceived). This paper theorised that poor perceived safety alone could result in crowd disaster, and by using the FIST model, it investigates the relationship between the four critical FIST factors and perceived safety in crowded large space buildings. The research chose to use the Holy Mosque in Makkah as a case study, a building where large crowd always use on a continuous basis all year round with its peak occupancy usually reached during the Hajj (an annual pilgrimage to Makkah that is undertaken by Muslims from all over the world). The Holy Mosque is a large building of 356,800 square metres with a maximum capacity of two million users (pilgrims). Data was collected using iPad devices via a group-administered questionnaire distributed to 1940 pilgrims of 62 different nationalities. The results were analysed using SPSS for descriptive analysis and AMOS 22 for Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM). The fitness of the model was tested, and the unidimensionality, convergent validity, discriminant validity, and reliability were assessed. The findings confirmed that there is a significant relationship between the FIST factors and perceived safety in crowded large space buildings. These findings will assist the facilities managers by making them aware of the users' safety perception and the factors that make them feel unsafe.

1. Introduction

Safety in the built environment is made of objective safety and subjective safety (perceived safety) (Sorensen and Mosslemi, 2009). In an organisational context, objective safety is measured as the actual number or risk of incidents or injuries occurred in an organisation. While subjective safety is intangible, and it refers to the feeling or perception of being safe or unsafe within a specified period. Numerous studies have been undertaken on objective safety in the built environment (Sagun et al., 2013; Wieringa et al., 2016; Sagun et al., 2008; Alkhadim et al., 2018). However, there has been a lack of research on the subjective safety (perceived safety) particularly in large space buildings where large numbers of users attend at the same time for an event or congregation.

Research has concluded that safety is the inverse of risk- the lower risk the higher is the safety (Moller et al., 2006). It means safety can be achieved through mitigating risk to a tolerable level by using risk management approaches. Dickie (1995) confirmed that poor risk management in large space buildings during an event has led to many crowd disasters across the world. Booty (2009) stated that each large space building used by a large number of people (crowd) is normally surrounded by diverse types and levels of risk requiring effective management. Leopkey and Parent (2009) defined risk management as a proactive approach to eliminate threats to an organisation through anticipating, identifying, assessing and mitigating the possible risks. The British Institute of Facilities Management (BIFM, 2014) have classified Risk Management (RM) as one of the 24 key components of Facilities Management (FM). FM covers all aspects of planning, managing space, designing, environmental control, health and safety and support services (Alexander, 1996). It significantly contributes to the delivery of strategic and operational objectives on a day-to-day basis (Nazali et al., 2009). When events are held in large space buildings, Ali et al. (2011) highlighted that facilities managers must be involved before, during and after the event to reduce risk and enhance safety. Chotipanich (2004) mentioned that organisations that own large space assets for public use often make the strategy to reduce risks as a top

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priority to enable them to gain an advantage over their competitors.

It is therefore conclusive that FM of large space buildings used by a large number of people (crowd) must involve effective risk management as a key component. In current practice, the emphasis is placed on addressing objective safety. Fruin (1993) has studied this issue and established some of the key factors that influence objective crowd safety that he referred to as crowd disaster. As mentioned earlier, there is a lack of understanding of the same issue as it relates to subjective safety. This study, therefore, has adopted the factors used by Fruin to investigate whether they affect subjective safety in large space buildings. The factors are referred to by the acronym FIST: Force, Information, Space, and Time. The paper argued that there is a strong relationship between FIST and perceived safety in crowded large space buildings by studying the extent to which perceived Force, perceived poor Information, perceived insufficient Space, and perceived poor Time management influence perceived safety. For the research to investigate this hypothesis, the Holy Mosque in Makkah, Saudi Arabia has been chosen as a sample large space building for the research project.

2. The Holy Mosque as a large building

Hajj is a religious event which includes a large number of pilgrims with diverse cultures, ages, genders, nationalities and languages. It is one of the five pillars of Islam and an obligation for Muslims who are capable financially and physically of performing Hajj at least once in their lifetime (Khan, 2012; Alsolami et al., 2016). Annually around two million pilgrims, visit Makkah (also called Mecca) to perform the Hajj, at the same place and time in a period ranging from 4 to 6 days. This has been considered one of the largest gatherings in the world (Alnabulsi and Drury, 2014), and the number of people who wish to perform Hajj is increasing yearly. The rituals of the pilgrimage are mainly concentrated in four holy places: Holy Mosque, Mina, Muzdalifah and Arafat. These are situated in different parts of the city and its neighbourhood (Ascoura, 2013). The pilgrims arrive in Mecca on the 8th Dhul-Hijjah Arabic calendar when the Hajj starts, and they leave after completing their rituals by the end of Hajj on the 13th Dhul-Hijjah. The first holy place the pilgrims visit when they arrive in the Holy Mosque to perform Tawaf and Saee. Tawaf is a movement of the pilgrims around the Kaaba (circumvention), which is situated in the centre of the Holy Mosque. In Tawaf, pilgrims move around the Kaaba seven times in an anticlockwise direction. While in the Saee, pilgrims walk seven rounds between two points in the Holy Mosque called Safa and Marwah, where each round is around 0.5 km in the distance (Khan, 2012). On completion of the welcome Tawaf and Saee at the Holy Mosque, the pilgrims then travel to Mina to camp for a night. They then start moving from Mina to Arafat, where they camp again until sunset. They then move to another location called Muzdalifah, to camp until midnight. After that, they move to Jamaraat Bridge to perform another ritual before they return to the Holy Mosque for another Tawaf and Saee. It is usually at this event that the Holy Mosque is full to its maximum capacity.

The Holy Mosque is a large space building which can accommodate around two million worshipers at the same time. It includes indoor (covered) and outdoor (open) type spaces that makes it more complex to manage and control effectively. The Holy Mosque is considered one of the largest mosque in the world. Throughout the Kingdom of Saudi Arabia history, numerous expansion projects have been carried out. The first major expansion began in 1956 and lasted for ten years to complete. This expansion was done by King Saud when the area of the Holy Mosque was about 28,000 square meters with a capacity of 50,000 worshipers. Since then the area of the Holy Mosque has been expanded to accommodate the number of the worshipers who are increasing yearly. The current area of the Holy Mosque has reached up to 356,800 square meters and still increasing (Alnabulsi and Drury, 2014).

Fig. 1 shows the aerial view of the Holy Mosque with the Kaabah situated centrally and the Safa (at the top) and Marwah (bottom right) points are connected by clearly visible long straight lines.

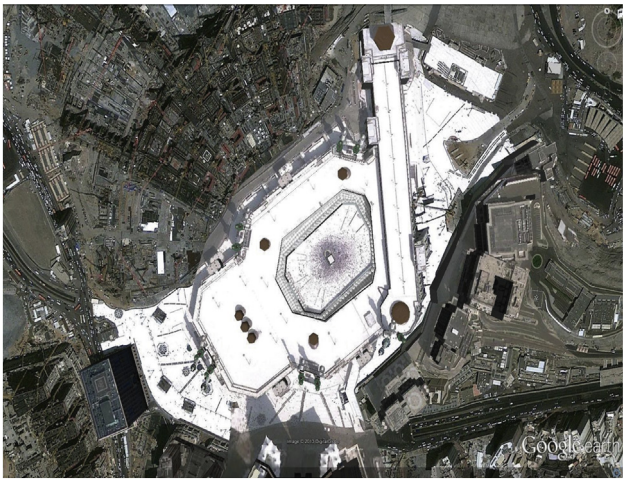

Fig. 1. Holy Mosque in Makkah.

Several incidents have occurred during the Hajj that caused the loss of hundreds of lives (Miller, 2015; BBC, 2015). Still (2000) identified the safety limit for crowd density as 40 people in 10 square meters for a moving crowd and 47 for standing areas. The level of the density at the Holy Mosque in its full capacity reaches 6–8 people per square meter, which is considered extremely high because having such density has the potential for the occurrence of crowd disaster. This research is primarily focusing on preventing such incidents from occurring in the Holy Mosque. The safety of the users is the priority at this stage to reduce the risks and avoid disaster in the future. Hajj authorities are investing a lot of resources in crowd management and crowd control and continuously modifying and adjusting the physical environment of the Holy Mosque based on objective safety considerations.

This study is focused on the risk perception rather than other emotions. Other studies such as Barhamain (1997) investigated the level of satisfaction of users based on their experience with regards to the facilities and services provided during the Hajj event. It was found that six critical factors of facilities and services have an apparent influence on the users' perceptions. The findings emphasised that the security and safety in crowded large space buildings are ranked the highest essential factors. This research is providing data for additional issues that must be considered in order to ensure a safe physical environment and crowd protection measures based on subjective safety. The research is not about modeling the movement of the crowd or the physical space, it is about the perception of the pilgrim and how can that perception affect the safety of the environment.

3. The conceptual model

This study investigates the relationship between the four FIST factors with perceived safety. It chose the Fruin (1993) theoretical framework to propose a simple model made up of four hypotheses for the research inquiry. Imenda (2014) defined a theoretical framework as "the application of a theory, or a set of concepts drawn from the same theory, to offer an explanation of an event, or shed some light on a particular phenomenon or research problem".

According to Fruin (1993), the FIST elements were derived from personal experiences, analysis of major crowd incidents and traffic flow principles. The FIST model has been established to demonstrate that the crowd characteristics, prevent and mitigate the crowd disasters through developing efficient guidelines. Indeed, it was developed based on the real conditions and objective safety. The proposed conceptual model used in this research replaces the tangible items used by Fruin with the perceived situation and its effect on perceived safety. The conceptual model is shown in Fig. 2, which includes one dependent variable