Passengers' awareness and perceptions of way finding tools in a train station

Nirajan Shiwakoti [a,*], Richard Tay [b], Peter Stasinopoulos [a], Peter Jarrod Woolley [a]

[a] School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, Carlton, Victoria 3053, Australia
[b] School of Business, IT & Logistics, RMIT University, Melbourne, Victoria 3000, Australia

ABSTRACT

This paper examines the passengers' way finding in a train station under normal and emergency conditions, with a particular focus on the passengers' understanding and rating of the location of emergency exit signs, emergency buttons, evacuation maps and the assembly area. A questionnaire survey of 1127 passengers in a train station in Melbourne, Australia, shows that respondents are not homogeneous in their perceptions and understanding of evacuation information, tools and procedure.

Although the majority of respondents are familiar with the Melbourne train station and are of the opinion that it is easy to navigate the train station, they are not aware of the emergency evacuation way finding tools and procedure. More specifically, a significant proportion of the respondents do not know the emergency exit location (43.2%), evacuation plans/maps location (58.7%), the content of the evacuation plans/maps (56.8%), emergency red button location (41.6%), location of the assembly area (66.5%), and a quick way to the assembly area (66.3%).

In terms of demographic differences, results from the ordered logit and generalised ordered logit models demonstrate that there are some differences in the understanding of way finding tools between males and females as well as among the different age groups.

Our findings can assist managers of emergency response in developing appropriate strategies, design solutions, trainings, and education campaigns for effective and safe evacuation. Moreover, the results are a valuable resource in developing and verifying mathematical and theoretical models aiming to study passengers' evacuation in a train station.

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1. Introduction

Passenger crowd dynamics and safety have been a growing area of research in recent years. While the study of passengers' behaviour under normal conditions is important to assess the quality of service and overall efficiency of passenger crowd management (Daamen, 2004; Pender et al., 2013; TCRP, 2013), the study of passengers' crowd behaviour during emergency evacuation is critical from a safety perspective (Fridolf et al., 2013). In the recent past, there have been several natural or man-made disasters that have prompted the evacuation of passengers in major train stations, resulting in fatalities and injuries (Shi et al., 2012; Fridolf et al., 2013).

Previous studies on evacuation in train stations has shown that it is extremely important to provide information that aids way-finding and directs people to safe locations in an emergency situation (Fridolf et al., 2013) as the layout of train stations is often complex and confusing to the passengers. Therefore, critical way-finding tools such as evacuation maps and exit signs form an integral part of any effective emergency evacuation procedure, together with emergency alarm and succinct directions to assembly area. These way-finding cues, information and tools can influence passenger route choice and the evacuation process during an emergency situation (Verhoeff, 2014).

Despite its importance, little research has been conducted to understand passengers' awareness and perceptions of these way-finding information tools during an emergency evacuation. While there are several mathematical simulation models in the literature to predict the behaviour of passengers during normal and emergency evacuation (Shiwakoti et al., 2008; Duives et al., 2013), models on emergency evacuation rely on the assumption that people will start evacuating as soon as the threat arises. However, this assumption ignores the fact that passengers who are not aware of the emergency procedure can create a delay in the evacuation process, as noted from previous case studies (Fridolf, 2010), and

that this delay can severely impact the chances of injury and survival.

On the other hand, most of the evacuation drills and controlled laboratory experiments tend to examine mainly the operational aspects (under normal conditions), such as the dwell time, safety issues due to crowding and riding behaviour, along with evacuation behaviour, such as pre-evacuation times (Zhao et al., 2009; Li et al., 2011; Wan et al., 2015; Kim et al., 2015). Studies on human behavioural models by sociologists tend to focus on the psychological aspect of crowd behaviour, such as cooperative or competitive behaviour under emergency conditions (Mawson, 2007; Drury et al., 2009; Cocking et al., 2009).

In summary, there has been no systematic study on the passenger's awareness and perceptions of the way-finding tools in a train station. Understanding of this critical issue is crucial for the development of effective evacuation strategies and plans at train stations as confusion and delay in an emergency situation can result in injuries and fatalities.

Therefore, the objective of this study is to examine the passengers' way finding in a train station under normal and emergency conditions, with a particular focus on passengers' awareness and perceptions of the emergency way-finding tools. This objective will be accomplished by conducting a questionnaire survey at a major train station in Melbourne, Australia. Although questionnaire survey has been used extensively in transport mode choice analysis, we are not aware of any systematic study that has examined the passengers' understanding of emergency procedure in a train station. Hence, this pioneering study will provide valuable insights to supplement and extend the knowledge in evacuation modelling and the development of evacuation strategies.

The paper is organised as follows. The next section presents the relevant literature review. It is then followed by the description of the methodology used. Section four describes the results and section five provides some discussions. The final section presents the conclusions and recommendations for future research.

2. Literature review

In recent years, research had focused on developing mathematical models and simulations (both microscopic and macroscopic) for predicting passenger movements in major public infrastructure under normal and emergency conditions (Daamen, 2004; Klüpfel, 2007; Kretz, 2007; Shiwakoti et al., 2011, 2014; Shi et al., 2012; Bandini et al., 2014). For example, Shi et al. (2012) used an agent based modelling approach to study occupant evacuation behaviour, evacuation time, passage flow rate, and the strategy of using the escalator as an evacuation passage, while Srikukenthiran et al. (2014) modelled passenger route choice behaviour within a station where a passenger needed to choose between a lift and escalator located close together, using a standard binary and mixed-logic model in simulation programs.

Research had also been carried out to determine how people evacuate a virtual building given a set of simulated emergencies and conditions, and the impact it had on route choice in an enclosed environment (Bode and Codling, 2013). For example, Lovreglio et al. (2014) used discrete choice models to identify the exit that a passenger would take in an emergency. This study used a questionnaire survey to gather only basic demographic data for the model and the participants were then shown videos of different scenarios depicting two exits in a closed environment but varying the participant's position, the number of people around the two exits, and the number of people around the participant. The participants were asked to choose the exit that they were more likely to use and explain why they made that choice. However, the existing models did not explore the impact of passengers' perceptions and understanding of way finding tools and emergency procedure on evacuation time or other critical elements of the model.

Evacuation exercises in buildings and passenger vessels were also carried out by researchers in the past to provide empirical data for model validation. These exercises enabled researchers to observe evacuation times, occupants' response times and occupants' movements (Galea and Galparsoro, 1994; Olsson and Regan, 2001; Ko et al., 2007; Kretz, 2007; Xie, 2011; Fridolf et al., 2013), but they did not examine the occupants' understanding of the way-finding tools and evacuation procedure. Likewise, existing controlled laboratory walking experiments tended to focus on understanding only the flow rate and speed effects at those bottleneck points (Kretz, 2007; Asano et al., 2009; Zhang et al., 2008; Shiwakoti et al., 2015).

Some useful insights on the necessity of understanding passenger evacuation behaviour were gained from various documented evacuation studies. A study that investigated the fire incident in 2005 in a subway station in Rinkeby, Sweden, highlighted the importance of understanding passengers' behaviour and the training of station staff for safe evacuation (Fridolf, 2010). Moreover, several studies were carried out to evaluate the importance of the size and brightness of the exit signs, along with interaction of people with signage systems, for improving the performance of evacuation models (Yamada et al., 2004; Xie, 2011).

On the other hand, a study on the investigation of a fire incident in a train in the Zürich Metro in 1991 found that passengers seldom noticed the evacuation tools such as handrails in train tunnel as well as the emergency pictograms on the walls (Fermaud et al., 1995; Fridolf, 2010). It is recommended that emergency exit signs should be designed and placed in a way that would not create any confusion for the passengers and that would minimise the possibility of misinterpreting the exit signs (Fridolf, 2010). Similarly, several studies on evacuation in buildings also found that evacuees seldom notice emergency exit signs, which blend with the environment (McClintock et al., 2001; Xie, 2011).

In terms of questionnaire surveys, a post-fire survey on a multi-storey residential building in China revealed that the lack of understanding of emergency procedure was one of the factors that contributed significantly to increasing the pre-evacuation time (Zhao et al., 2009). In another study, a survey was conducted to gauge the passengers evacuation behaviour in general in train stations in China (Li et al., 2011) but the study did not specifically explore the passengers' understanding of way-finding tools and evacuation procedure.

Wan et al. (2015) conducted a survey of the station staff and passengers to identify the effects of different passenger behaviours (such as forcing train doors open or entering the train track area) on incident involvement (such as delays and accidents) so as to provide information to improve passenger safety. However, the focus of this study was on a normal congested situation in a train station rather than an emergency evacuation.

In summary, while there are several existing mathematical simulation models, evacuation drills, laboratory experiments and survey studies exploring the behaviour of people in congested and emergency situation, studies on passengers' awareness of way-finding information tools and procedure during an evacuation in a train station are still lacking in the literature.

3. Method

3.1. Survey

A questionnaire survey was designed to explore the passengers' way finding under normal and emergency conditions, with particular focus on their awareness and perceptions of the emergency