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An analysis of the emergency response system of the 1996 Channel tunnel fire

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ABSTRACT

The paper presents the results of an analysis of the 'emergency response system' at the time of the 1996 Channel tunnel fire accident. In particular, the analysis focuses on the events that unfolded once the incident train had stopped; i.e., the evacuation of the passengers and the train crew. The approach has been the use of a 'Tunnel Fire Safety Management System' ('TFSMS') Model as a 'template' for comparison with the 'emergency system' in place at the time. In particular, responding to the following question being addressed: could the time of evacuation of the incident train crew and passengers be less that the time it took? The answer is Yes. Some relevant findings associated with the deficiencies in the existing 'system' have been highlighted by the model.

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1. Introduction

Rail and road tunnels have been built and are on the increase worldwide (Beard, 2009); further, the length and complexity of tunnel infrastructure is increasing. An effective 'emergency response system' becomes an essential component of 'tunnel fire safety management systems' when accidents occur (Santos-Reyes and Beard, 2012; Beard and Cope, 2008; Beard and Carvel, 2012).

Recently, there have been a number of serious tunnel fires; for example those that occurred in the Viamala Tunnel, Switzerland (2006), the Burnley Tunnel, Melbourne (2007), and in California (2007) (Beard, 2009; Beard and Carvel, 2012). In more recent years, there has been an incident involving smoke detection in the Channel tunnel that lead to the cancellation of all trains from France to the UK (Malnick, 2015); there have been also high speed railway accidents, although none of them involved tunnels; i.e., the 2013 Spain railway accident (Tremlet, 2013), and the Marseille-Madrid high speed train fire near Lunel, France, 2015 (ABC, 2015).

In order to understand tunnel fire safety a vast amount of research has been conducted on the subject; for example, in relation to design fires (Li and Ingason, 2015; Beard and Carvel, 2012; Heidarinejad et al., 2016; Carvel, 2004), risk assessment (Beard and Carvel, 2012; Weyenberge et al., 2016), ventilation systems (Beard and Carvel, 2012; Ang et al., 2016; Wang and Wan, 2016; Stolz and Ruiz-Ripoll, 2016; Amouzandeh et al., 2014; Carvel, 2004), evacuation and fire fighting (Seike et al., 2016; Fridolf et al., 2016; Hue-Pei et al., 2016; Beard and Carvel, 2012), fire dynamics (Ingason et al., 2015), experimental tests (Chang-Kun et al., 2016; Beard and Carvel, 2012).

Also, research has been conducted on railway accident analysis (Zhou and Irizarry, 2016; Ouyang et al., 2010; Zhou et al., 2014, 2015). However, there is very little reported in the literature regarding fire accident analysis in rail tunnels. This paper intended to address this gap. An analysis of the 1996 Channel tunnel fire has been conducted by applying a 'Tunnel Fire Safety Management System' (TFSMS) model (Santos-Reyes and Beard, 2012). The results associated with the unfolding events since the departure of the incident train until it stopped in-tunnel have been reported by Santos-Reyes and Beard (2016). This paper presents the results of the second part of the analysis; i.e., an analysis of the 'emergency response system' in place at the time of fire (the events that unfolded once the incident train had stopped). In particular, the paper addresses the following question: could the time of evacuation of the incident train crew and passengers be less that the time it took? The paper gives an account of the analysis.

2. The Channel tunnel system

Fig. 1 shows the key components of the 'Channel Tunnel' system which are the following (CTSA, 1997): (a) the "Running Tunnel North" ('RTN') which usually handles traffic from the UK to France; (b) the "Running Tunnel South" ('RTS') from France to the UK; and (c) the "Service Tunnel" ('ST') that is intended to achieve three

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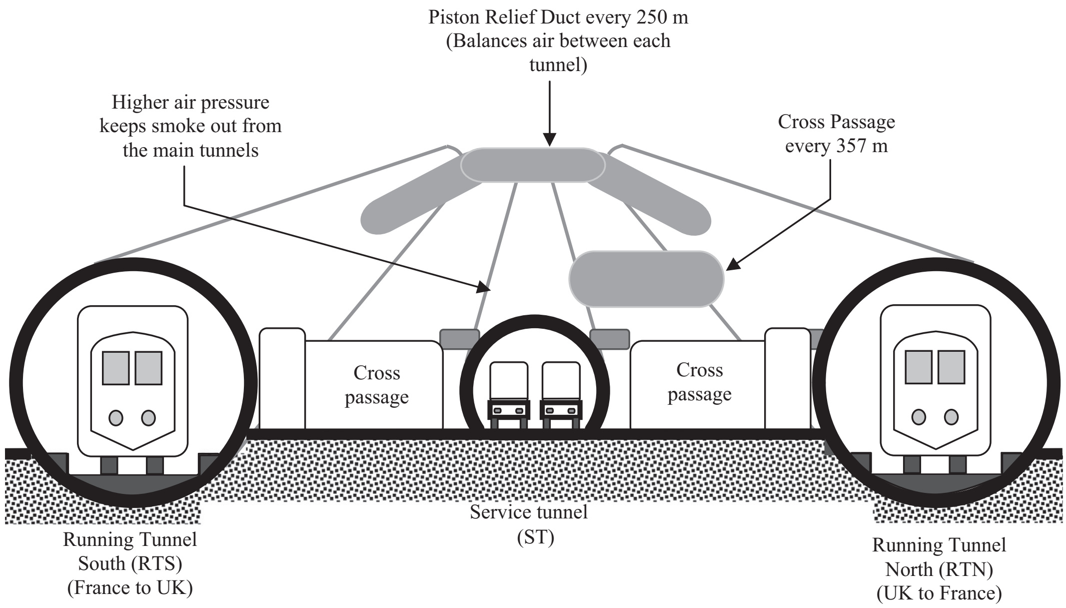

Fig. 1. The Channel Tunnel system. (Adapted from CTSA, 1997).

objectives according to CTSA (1997): {a} "to provide normal ventilation for the running tunnels"; {b} "to provide a 'safe haven' for passengers and crew members in the case of an emergency; i.e., evacuation in case of a fire"; and {c} "to facilitate the speedy arrival of emergency teams." (The figure also shows other components of the system; e.g., the cross-passages which were installed every 357 m along the tunnel; similarly, "Piston Relief Ducts" were also installed every 250 m along the tunnel. These, amongst others, played an important role in the emergency response to the tunnel fire.)

2.1. The 1996 Channel tunnel fire

A fire on a HGV on the shuttle train No. "7539" occurred on November 18th 1996. The shuttle train travelled from France to England; the fire forced the train to stop 19 km from the French side of the tunnel entrance (Figs. 2 and 3).

Some of the key events of the fire accident are thought to be the following (CTSA, 1997):

- The HGV shuttle train "7539" left the French terminal at about 21.42 h. (Fig. 2).
- At 21:48 h, the train (involved in the accident) entered the "Running Tunnel South" ('RTS'); it is believed that security guards saw a fire beneath one of the lorries and reported it to the "Terminal Control Centre" ('TCC') at the French terminal.
- At 21:53 h, a fire was confirmed by the onboard fire detection system and the fire detection system in tunnel. The train had travelled 10 km into the "Running Tunnel South" ('RTS').
- At 21:56 h, a team of the "French First Line of Response" ('FR-FLR') left the "French Emergency Centre" ('FEC').
- At 21.58 h, the incident train ("7539") made a controlled stop at "PK-4131" which was next to the 'ST' ("Service Tunnel"); see Fig. 3.
- At 22:01 h, the train driver could not organize the evacuation of the passengers due to dense smoke; Fig. 3.
- At 22:02 h the French team of eight fire fighters entered the 'ST'. It is believed that soon after the "UK First Line of Response" ('UK-FLR') team also entered the 'ST'.
- At 23:39 h, a confirmed fire was detected in between cross-passage doors "4163" and "4201".

The combined fire fighter forces of the UK and the French attacked the fire for about 5 h. The fire accident severely damaged the concrete lining and tunnel facilities but fortunately there were no fatalities (CTSA, 1997).

3. A TFSMS model

Fig. 4 shows the 'structural organization' of the 'Tunnel Fire Safety Management System' ('TFSMS') model that has been employed in the analysis. A detailed account of the features of the model is being described in Santos-Reyes and Beard (2012). The feature of the model associated with the 'structural organization' is being reproduced below:

> *"Overall, systems 2–5 facilitate the function of system 1, as well as ensuring the continuous adaptation of the systems as a whole; i.e. (the 'Eurotunnel system'). Systems 2–5 are described briefly in what follows: System 2, tunnel fire safety coordination, ensures that the various operations of system 1 operate in agreement. System 3, tunnel fire safety functional, ensures that system 1*

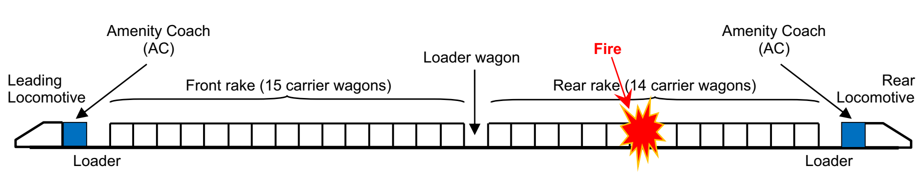

Fig. 2. The incident train "7539". (Adapted from CTSA, 1997).

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