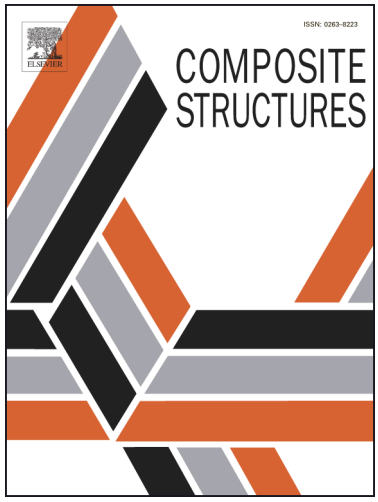

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Design Analysis of Hybrid Composite Anti-ram Bollard Subjected to Impulsive Loadings

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ABSTRACT: Series of terrorist attacks in Europe recently using vehicles lead to significant demands to improve the impact resistance of current anti-ram bollards by replacing conventional materials with composite materials. Composite bollards comprised of an outer steel hollow tube, an inner aluminium alloy hollow tube and a crushable foam core, are studied against conventional steel ones. The current design of bollard barrier systems is based on the crash-test certification, which often leads to an overly conservative design with excessively stiff bollards. In addition, the foundation of the bollard system is designed against unnecessarily high reaction forces. In this work, the performance of fixed bollard systems is optimised using the numerical approach which incorporates the rate-dependent effect of the hybrid metal/Divinycell H250 PVC foam cores. The bollard deflection is used as the indicator to quantify the relative impact resistance of the system along with the recorded peak reaction forces. The results indicate that an improvement, in the form of increased resistance and reduced reaction forces requirement, of the typical hollow tube system can be achieved by incorporating other energy dissipating materials in the bollard structure. This study highlights the importance of an optimised composite bollard by reducing the reaction force transfer requirement.

Keywords: Anti-ram bollard, impact resistance, hybrid composite, rate dependent, vehicle impact

1. INTRODUCTION

1.1 Bollard uses and design principles

Bollard systems are often used to prevent a moving vehicle from gaining access to restricted, secured areas. Vehicular assault and vehicle borne improved explosive devices are two typical examples of the risks which are mitigated by bollards. A high number of catastrophic terrorist attacks by vehicles have been recorded globally. This new and brutal form of terrorist attack is quickly becoming a popular terror approach that public safety experts fear the most: it can cause unpredictable carnage and seemingly come out of nowhere. January 20, 2017 saw 6 deaths in Melbourne, Australia due to a rampaging car driving in the pedestrian areas of the CBD. 4 people were killed in an attack in Jerusalem on January 8, 2017 in an intentional attack using a truck. A truck ran through crowds at a Christmas market in Berlin on December 19, 2016, killing 12 and injuring 48 people. Six months earlier on 14 July, 2016, 86 people were killed and 484 injured in Nice, France, when a truck drove through crowds celebrating Bastille Day. Following this attack, there was a move to shift security design in Australia to prevent vehicles from gaining access to civilian populated areas. Prior to these attacks, on 22 July 2011, in the Norway massacre, a car bomb exploded in Oslo, the executive government quarter of Norway, and killed 8 people. On September 9, 2010, a suicide car bomber hit the central market of a major city in North Caucasus, Russia, which killed at least 17 and wounded more than 130 people. On 30 June 2007, a Jeep