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EFFECTS OF IMPACT LOCATION, IMPACT ANGLE AND IMPACT SPEED ON HEAD INJURY RISK OF VIETNAMESE PEDESTRIAN HIT BY A SEDAN

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ABSTRACT–This paper employed finite-element simulation together with a human body model (HBM) - THUMS to study the head injury risk of a pedestrian involved in a frontal impact with a sedan car. While previous studies have gained an intensive understanding of the effects of various factors on pedestrian injury, their results were mainly based on standard-sized HBMs. Hence, a scaling procedure was first applied for the THUMS to obtain a model that possesses Vietnamese anthropometry. A total of thirty simulations were conducted to investigate the effect of various parameters, including impact angle, impact location, and impact speed, on the head injury criterion (HIC) of the scaled THUMS. Besides, each simulation covered not only the car-to-pedestrian impact but also the pedestrian-to-ground impact. Thus, the head injury of the pedestrian in both primary impact and secondary impact could be evaluated. Results showed that HIC increased consistently with impact speed for primary impact. An impact at the center of the car was more critical than that at the corner. Whereas, the effect of impact angle varied depending on the impact location. Regarding the secondary impact, HIC value was found to be highly sensitive to the posture of the pedestrian before impacting to the ground. In most cases, HIC was much higher in secondary impact than in primary impact. In other words, secondary impact poses a high risk of fatality to pedestrians in a traffic accident.

KEY WORDS : Head injury criterion, Pedestrian, Sedan, Collision, Injury risk

SUBSCRIPTS

HAV	: highly automated vehicle
HBM	: human body model
FE	: finite element
BrIC	: brain injury criteria
MPS	: brain maximum principal strain
Nij, Nkm	: neck injury indices

1. INTRODUCTION

Pedestrians are among the most vulnerable road users (VRUs) and constantly bear a high injury risk when involved in collisions with other road users. Pedestrians are reported as the largest group of road fatalities, accounting for approximately 40,000 deaths annually worldwide (Naci *et al.*, 2009). The statistic is predicted to increase (World Health Organization, 2004). Pedestrians are 1.5 times more likely to die in a car crash than a car occupant per trip (Beck *et al.*, 2007). In Vietnam, pedestrian safety is among the contributors to very serious traffic safety issues and has been voiced widely by the media (Dinh *et al.*, 2020). This issue received great attention from the government and a lot of effort has been made in search for countermeasures and improvements. Nevertheless, the statistics of road fatalities and injuries during a period of five years (2011 ~ 2016) remained alarmingly at 48,000 and 162,000, respectively (In Vietnam, traffic accidents kill more people than pandemic diseases, 2016). As reported in 2017, the number of road fatalities was still over 8,000 (The Government of the Socialist Republic of Vietnam, 2018; National Transportation Safety Committee of Vietnam, 2018). Various factors that have influence on pedestrian fatality risk under a vehicle crash have been identified, e.g. impact speed (Kröyer *et al.*, 2014; Pok *et al.*, 2012), age (Tay *et al.*, 2011), vehicle geometry (Desapriya *et al.*, 2010; Kim *et al.*, 2010), or roadway environment (Mansfield *et al.*, 2018). Pedestrian orientation and location relative to the hitting vehicle prior to the impact are also important factors. Chen *et al.* (2015) found that a pedestrian facing away from the

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