

The false safety of three-wheelers: A study in the Sri Lankan Context

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Abstract— Three wheelers are the second highest registered vehicle category in the country. Though the transportation method is popular among general public, few studies have been carried out about the safety of the three wheeler transportation. The present study aims to critically assess five case studies where fatal accidents were reported in three cases. The analysis was done giving particular reference to the three main factors from which the crashworthiness is achieved, namely crumple zone, protective shell for passenger compartment and restrain systems. It was revealed that at present the three wheelers are not comply with the global safety standards. Moreover, the usage of non standard materials for manufacturing, absence of restrain systems were identified as the factors that hinder the crashworthiness of three wheelers.

Index Terms—Three Wheeler, Sri Lanka, Safety, Crash worthiness.

I. INTRODUCTION

The public bus service around the country can be considered as the predominant form of transportation. However due to lack of proper public transport system, and unreliability, the general public in Sri Lanka rely largely at private transport means. Out of many options, the three wheelers have become informal public transport mode in Sri Lanka. This is evident from the growth of number of three wheelers in the country. Sri Lanka had more than one million three-wheelers by 2016 and it has been predicted that the three wheeler market in Sri Lanka would grow at a compound annual growth rate of 7.2 from 2017 until 2030 [1]. In line with the number of three wheelers, the number of accidents involving three-wheelers and fatalities also has increased. According to WHO, 1.3 million people die each year as a result of road traffic accidents and between 20 to 50 million people suffer, non-fatal injuries. [2].

The reasons for such high number of fatal accidents are: Speeding, Driving under the influence of alcohol and other psychoactive substances, Nonuse of motorcycle helmets, seat-belts, and child restraints, Unsafe road infrastructure, Unsafe vehicles, Inadequate post-crash care, Inadequate law enforcement of traffic laws [2].

In a recent report, the Director General of the World Health Organization has mentioned that “ The problem is getting worse” [3]. Out of many, road traffic injuries account for about 2.3% and considered as the eighth cause of all global deaths.

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Of the 56.9 million deaths worldwide, the number of road traffic deaths has increased from 1.15 million in 2000 to 1.35 million in 2018 [3].

In Sri Lanka, the total deaths due to road accidents is 3,590 out of which 51% is Riders of motorized 2- and 3-wheelers in 2018. This accounts for 2.82% of total deaths [3]. The present study aims to critically investigate the case studies of accidents met with three whellers.

II. CASE STUDIES

Five number of selected accident footages have been analysed to assess the crash safety of three wheelers.

Case 1

A bus has been crashed onto a three-wheeler where the three wheel driver was killed on the spot while injuring a women who was in the three-wheeler [4]. Submit your manuscript electronically for review.



Fig.1 – Three wheeler crash case 1 [4]

The image depicts the crashing of the frontal part of the three wheeler into the driver compartment and severe damage to the hood. The analysis reveals that although the floor board of the three wheeler is strong enough to withstand loads, there is no protection at all from the hood. Further, there are no strong members to protect the passenger compartment and members in the front to absorb the crash energy.

Case 2

In this accident, all four people travelling in the three wheeler were killed when collided with a truck [5]. The wreckage clearly indicate the lack of a crumple zone to absorb the crash energy and lack of a strong hood cover and an A pillar to protect the passengers in a frontal collision is missing in the three wheeler. Had the three wheeler designed to accommodate the crash safety requirements, the fatality of the

accident could have been reduced and four lives could have been saved. The hood structure has been customized which was fabricated from stainless steel. However, even the new structure is not comparable to meet the requirements in terms of crash safety.



Fig.2 – Three wheeler crash case 2 [5]

Case 3

The case 3 is a crash on to the tank at the back of a cement carrying container due to loss of control by the three wheel driver. Three people were critically injured [6]. The image depicts that the frame of the three wheeler and hood are still intact due to the nature of the incident. However, injuring the occupants is a serious issue.



Fig.3 – Three wheeler crash case 3 [6]

Case 4

The case 4 is a three wheeler crashed onto a concrete post. Three people travelling in the three wheeler were severely injured.



Fig.4 – Three wheeler crash case 2 [5]

The image depicts that the frame of the vehicle including the hood is intact and no major crush forces have been imposed on to the three-wheeler. However, severely injuring the passengers compared to the small damage to the three wheeler is a serious issue.

Case 5

The three wheeler has fallen from a hill where the three wheeler driver and his son died on the spot and two others suffered injuries [8]. The image depicts the absence of a strong passenger compartment to protect the passengers during a collision or a rollover and absence of passenger restrain system is the major reason for such fatalities.

III. CRASH WORTHINESS

Generally, the ability of an automobile to protect its occupants during a crash is defined as the crash worthiness. In most of the parts of the world, in order for a vehicle to be sold in the market, it has to comply with certain standards including the crash worthiness. The crash worthiness is being achieved by means of a crumple zone, protective shell for passenger compartment and restrain systems.

A. Crumple zone (crush zone)

A crumple zone which will absorb the crash energy thus increasing the time taken for the vehicle to come to a complete stop after the collision. The Newton's second law can be written as:

$$F = m \frac{u - v}{\Delta t} \quad \text{---(1)}$$

Where the F is the crash force, U is the initial crashing velocity, V =0 since the crash bring the vehicle to a complete stop and Δt is the time taken for the crash event. According to the equation (1), higher the Δt, lower the F.

B. Protective shell

Protective shell to the passengers comprising of A Pillar, B pillar C pillar and side beams.

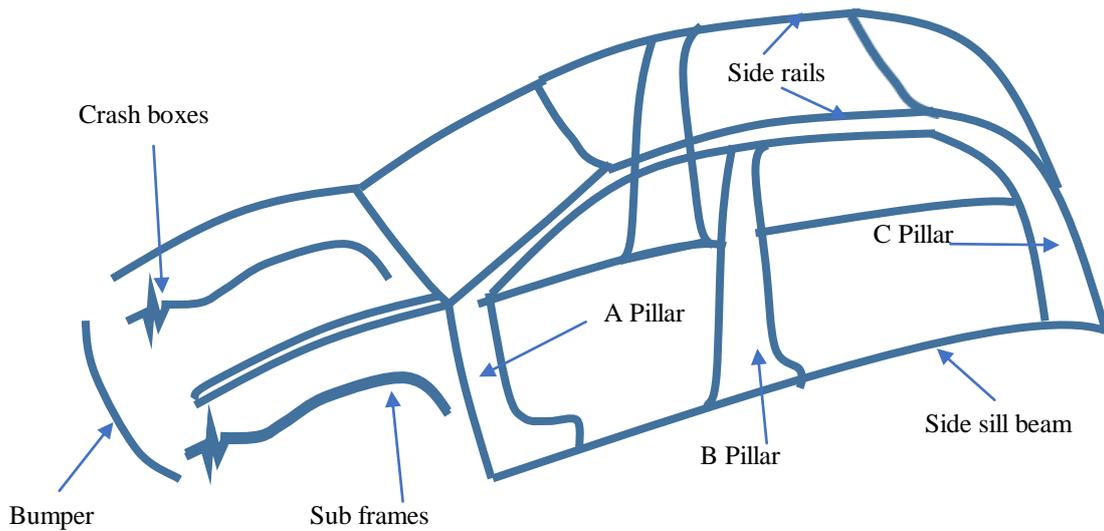


Fig.5- Structural designs of an automobile to ensure the crash worthiness

The common material used to construct the three wheel body and chassis is steel grade IS513 having yielding strength of 225 MPa [9] whereas Advanced High Strength Steels shown in Fig. 6 are being used in modern automobiles [10].

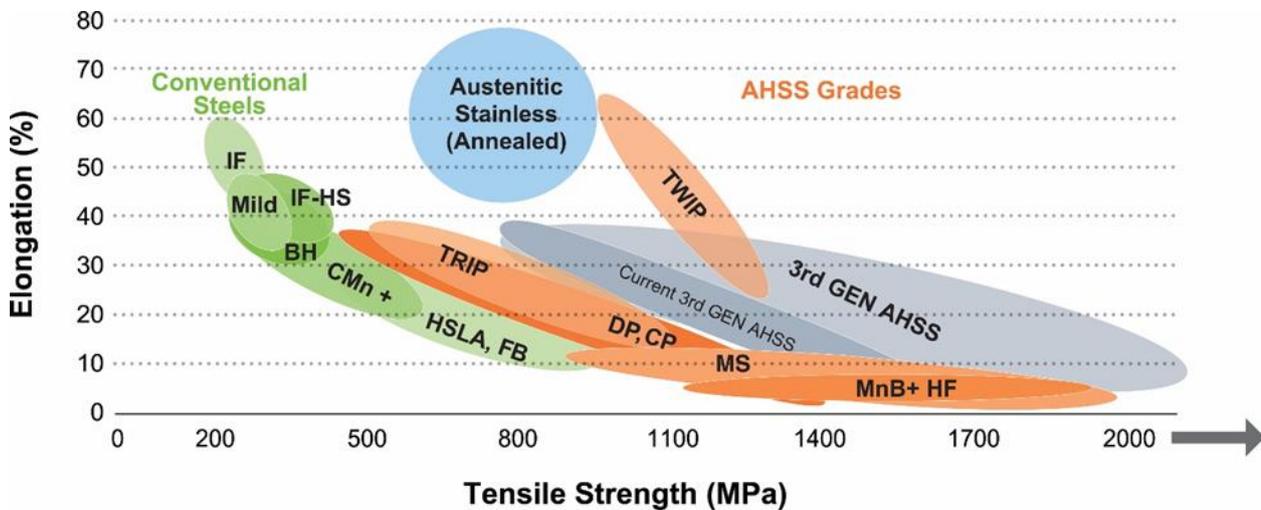


Fig.6 - Advanced High Strength Steels [10]

Source: WorldAutoSteel

C. Restrain systems

The two main restrain systems are the Airbag and the seat belt. The airbag is being activated during a collision whereas the seat belt is designed to restrain the occupants of the vehicle. The Fig. 7 show the Speed time diagram during a crash against a rigid barrier for Unrestrained occupant.

According to the Fig. 7, for a vehicle travelling at 50 km/h, during a crash against a rigid barrier, the deceleration of the vehicle would be 15.7 g, whereas the deceleration of the occupant is 140 g. If the passenger was restrained to the vehicle seat, the passenger would experience a deceleration of 15.7 g.

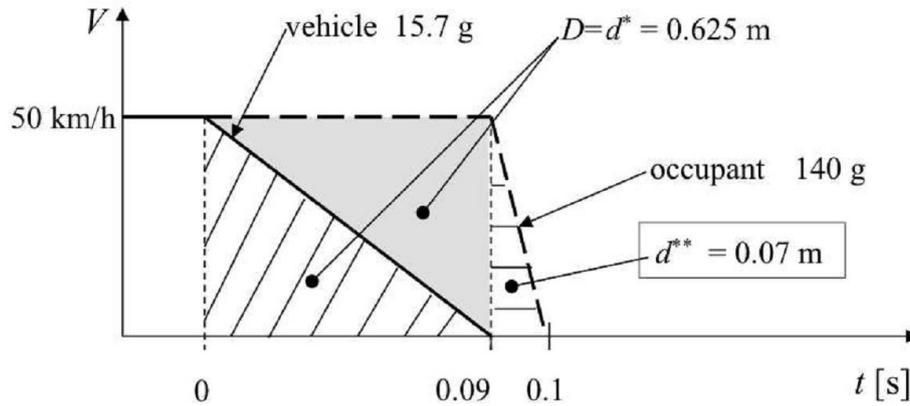


Figure 7 – Speed time diagram during a crash against a rigid barrier. Unrestrained occupant [11]

IV. FORENSIC DATA

Bandara et al [12] have carried out a study based on patients admitted after three-wheeler crashes to the Teaching Hospital Peradeniya from 2016 to 2018. This study excluded fatalities as the study was based on patients admitted to the Teaching Hospital only. A total of There were 310 patients have been analysed.

According to the study, 44% of the injuries were sustained due to an impact on an object inside the three-wheeler. The commonest injury seen was abrasion (63%) and the majority of injuries were non-grievous (68%). The most affected body part was Lower limb, which was accounted for 46%. According to authors, more rear passengers were injured than drivers. Sixty-nine percent victims had non-grievous injuries with 31% having

grievous injuries. Analyzing the Mechanism of causation of injuries, it was revealed that more passengers were thrown away compared to drivers. The authors have attributed this to drivers bracing themselves for the impact or due to holding on to the handlebar.

Adysinghe et.al [13] carried out a study based on medico-legal data available in three hospitals in Sri Lanka for occupants of three-wheelers succumbed from road traffic accidents. A total of 132 cases were studied including 57(43%) drivers and 75(57%) back seat passengers. The distribution of fatal injury site for back seat passengers and drivers are given in Fig 8. The site which caused highest number of fatalities is the head whereas the second was chest for both the driver and the passengers. As a percentage, the neck accounted for a total of 22.7 %.

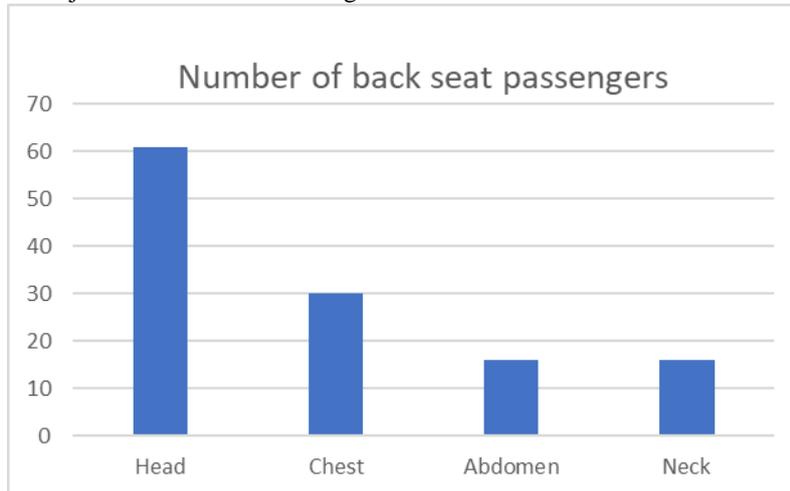


Fig.8 - Distribution of fatal injury site for back seat passengers

V. DISCUSSION

Out of five case studies, three were fatal accidents (case 1, 2 and 5). In all three cases the top part of the vehicle was severely damaged. The major reason for the fatality is absence of a crush zone (crumple zone), absence of a protective shell and restraint system. The main site of such victims was head and chest injury [13]. It has been observed

that during the collision, the hood part of the three wheeler collide with the external object which crush the upper body part of occupants.

Whiplash is also common fatal injury where the neck is injured during a crash as the passenger drastically decelerate during a crash. Common causes of abdomen and chest injuries are due to penetration by objects (metal parts) of the vehicle or external objects.

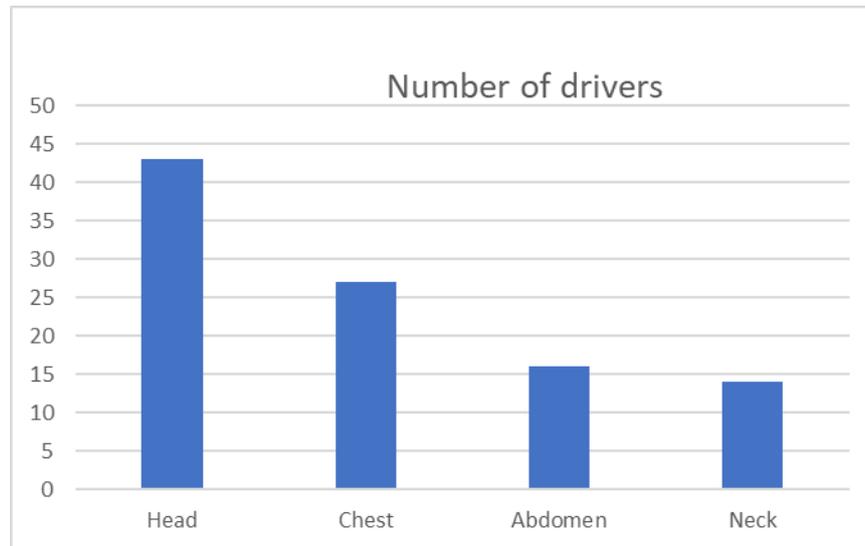


Fig.9 - Distribution of fatal injury site for drivers

The remaining two cases (case 3 and case 4) are nonfatal accidents where the body of the vehicles was intact compared to the fatal situation. Although the passengers sustained injuries, majority of them were in the lower part of the body [12]. Had the accident caused a damage to the top part of the vehicle, the situation could have been worst. However, 44% of such occupants sustained injuries due to an impact on an object inside the three-wheeler. This could have been averted if a proper restraint system was there. Further, the necessity of a restraint system is consolidated from the fact that that more passengers were thrown away compared to drivers and more passengers were injured compared to drivers.

VI. CONCLUSION

The general public is using three wheelers as a means of transport. However, three-wheeler is a vehicles that does not comply with globally accepted crash safety standards as Sri Lanka does not have such standards. The government has taken steps to discourage the three-wheeler by increasing the tax imposed to import three-wheelers. However, proper standard should be enforced in terms of crash safety in line with new car assessment programmes in other parts of the world. The usage of low cost material, absence of structural components that would enhance the crash worthiness and non availability of restraint systems has been identified as major contributing factors that lead to lack of crash safety.

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