An Overview of Heavy Vehicle Accidents Characteristic on Expressways in Malaysia

N Manap¹², M N Borhan¹*, M R Mat Yazid¹, N Manap³ and N A Wahid⁴

¹Department of Civil Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia;
²Department of Polytechnic & Community College Education, Ministry of Education Malaysia;
³Faculty of Mechanical Engineering, Universiti Teknologi MARA, Terengganu Branch, Bukit Besi Campus, Dungun, Malaysia
⁴Department of Project Management, Malaysian Highway Authority, Malaysia
*Corresponding author: mnazri_borhan@ukm.edu.my

Abstract. Heavy vehicles play a vital role in the economic wellbeing of a country. Safety measures are necessary to ensure the safety of heavy vehicles and other vehicles since the majority of crashes involving heavy vehicles are frequently severe crashes. This study utilized the data provided by Malaysian Highway Authorities (MHA) to investigate the accidents involving heavy vehicles on the expressways in Malaysia. Result of the analysis shows that most of the heavy vehicle accidents on expressways occurred during the day (54.8%) and clear weather (88.1%). Most night-time accidents and fatal accidents occurred on roads without street lights, where a total of 22.2% of the heavy vehicle accidents occurred on roads without street lights with 28.2% are fatalities cases whereas 16.8% of the accidents occurred on roads with street lights with 17.6% are fatalities cases. Heavy vehicle accidents frequently occur in flat areas, and they also cause 32.5% of the deaths in multi-vehicle accidents. The Chi-Square test was also performed in order to identify the relationship between accident severity and type of vehicle (in MVA and SVA) and the relationship between heavy vehicle accident severity and type of topography of road profile. The result shows that there was a significant association between accident severity and type of vehicle in MVA and SVA. It is also revealed type of topography of road profile affects the heavy vehicle accident severity. The finding of this study can help safety planners to develop a safety management plan for heavy vehicles, especially for heavy goods vehicles.

1. Introduction
Heavy vehicle accidents are often associated with severe injuries due to the high impact during accidents. Most accidents involving heavy vehicles result in deaths to other vehicle users compared to heavy vehicle users themselves [1-2]. Heavy vehicles in Malaysia contributed only 4.40% of total registered vehicles which comprises of 4.20% heavy good vehicles and 0.20% buses [3]. According to the Road Safety Department of Malaysia, the 3.67% death rate of heavy vehicle occupants is low in comparison to the total death caused by road accidents [3-4]. However, there is scarce information regarding the accidents associated with heavy vehicles and the fatalities that resulted from these accidents. In 2014, 57,430 of the road accidents involved lorries, buses, and taxis [5]. Heavy vehicle accidents are also found to cause 1,000 deaths per year [1]. Of this number, 80% of the deaths involve
the occupants of the other vehicles [1]. The accidents involving heavy vehicles are more likely to occur on expressways and more likely to cause fatalities compared to other types of road [1].

Road accidents involving heavy vehicles are also a concern in other countries. For example, in the United States, up to 3% of the registered vehicles are heavy vehicles, which accounts for 7% of the total vehicle per mile. However, heavy vehicles are involved in approximately 11% of fatal accidents [6]. Similarly, in Australia, 3% of all registered vehicles are heavy vehicles but account for 18% of all severe and fatal accidents [7]. The accidents and fatalities involving heavy vehicles have highlighted the need for a better understanding of the impact of these vehicles on other road users. As most roads in Malaysia have mixed traffic flows, the design of these roads must ensure the safety of all road users. An in-depth understanding of accident risk factors by type of vehicle is critical in formulating the policies for road design and road safety. This study focuses on the characteristics of heavy vehicle accidents and the associated factors on the expressways in Malaysia.

2. Study area
The study area for this research includes all open toll system and closed toll system expressways in Malaysia under administration of Malaysian Highway Authority (MHA). Most of the highway in Malaysia are controlled-access highways and built following JKR R6 rural highway standard. The design speed limit for this type of route is 120km/hr however, the allowing speed limit on this type of road is 110 km/hr, and 80-90km/hr for heavy vehicles. According to the Malaysian Highway Authority (MHA), in 2018, the total paid traffic is 1,726.57 million vehicles [8].

3. Research methodology
The accident data that occurred at all highways under the administration of the Malaysian Highway Authority (MHA) in 2018 were used in this study. The data were provided by MHA and extracted from the Malaysian Highway Road Accident Analysis & Database System (MHROAD). MHROAD is a database to record the accidents that occurred on the highway. The data are keyed in by patrolling officers at the accident scenes. For this study, the accident data were examined and filtered, and only accidents involving heavy vehicles were prioritized. 11 types of vehicles were considered as heavy vehicles in this study, namely trucks, trailers, tankers, crane trucks, low loaders, express buses, transit buses, shuttle buses, tour buses, school buses, and mini busses.

The heavy vehicle accident data were then analyzed in terms of accident severity by type of heavy vehicle, accident severity of heavy vehicles by the time of accident, light and weather condition, and type of heavy vehicle collision. The descriptive analysis of road accidents was generated for all variables to observe the pattern. The Chi-square test of independence was also performed to examine the relationship between accident severity and type of vehicle in multi-vehicle accident (MVA) and single-vehicle accident (SVA), and the relationship between heavy vehicles accident severity and topography of road profile by using Statistical Package for the Social Sciences 23.0 (SPSS 23.0).

4. Results and discussion
The result of the analysis shows that 4,637 or 17% of all accidents (27,476 cases) involved heavy vehicles. Of the 940 fatal accidents, 245 (26%) are accidents involving a heavy vehicle, indicating that heavy vehicle accidents are more likely to cause deaths compared to accidents involving cars. Even though cars are involved in a significantly higher number of accidents (54%), most of these accidents are non-fatal. It is also observed that motorcyclists are the most vulnerable users of the expressways where 42% of the fatal accidents involved motorcyclists even though they make up only 19% of all road accidents. Figures 1 and 2 presents the breakdown of the percentage of accidents cases by vehicle and the percentage of fatalities by vehicle.
Figure 1. Percentage of accidents by vehicle

Figure 2. Percentage of fatalities by vehicle

4.1. Accident severity by type of heavy vehicles

Given that there are different types of heavy vehicles plying the highways daily, there is a need to identify the types of heavy vehicles involved in most of the accidents to allow for the formulation of effective measures to prevent accidents in the future. Figure 3 shows the breakdown of accident severity for all types of heavy vehicles considered in this study and Table 1 shows the distribution of accident severity by vehicle type. Lorries are involved in the highest number of heavy vehicle accidents on the expressways (58.3%) and contribute to the highest number of fatal cases (51%), severe injuries (61.7%), minor injuries (38.2%), and property damage (58.6%). Trailers make up 28.1% of the accidents, causing 32.2% of the fatal cases, 26.4% of the severe injuries, 20.4% of the minor injuries, and 27.8% of the property damage. Other types of heavy vehicles contribute to less than 6% of all accident cases. Only a small percentage of accidents involving buses result in injuries. It is noteworthy that of all the accidents involving buses, most of the accidents and fatal accidents involved express buses since they are the type of buses most frequently on the expressway for commercial activities. The percentage of express buses involved in accidents is 3.8%, of which 5.3% were involved in fatal accident cases, 3.7% in serious injuries, 2.5% in minor injuries, and 3.7% in property damage. In this study, a fatal case is one accident case and not the total number of deaths in a single accident, which means that whether an accident causes...
one death or ten deaths it is considered as one fatal case. However, the total number of deaths for each type of accident is not available in this study.

![Figure 3. Accident severity by type of heavy vehicle.](image)

**Table 1. Distribution of accident severity by type of heavy vehicle.**

| Type of Severity | Type of Vehicle | Lorry | Trailer | Crane | Tank Truck | Low Loader | Express Bus | Transit Bus | Shuttle Bus | Tour Bus | School Bus | Mini Bus |
|------------------|-----------------|-------|---------|-------|------------|------------|-------------|-------------|-------------|---------|-----------|----------|
| Fatal            | 125 (51.0%)     | 79 (32.2%) | 3 (1.2%) | 13 (5.3%) | 5 (2.0%) | 13 (5.3%) | 0 (0.0%) | 1 (0.4%) | 5 (2.0%) | 1 (0.4%) | 0 (0.0%) |
| Severe Injury    | 398 (61.7%)     | 170 (26.4%) | 3 (0.5%) | 22 (3.4%) | 10 (1.6%) | 24 (3.7%) | 4 (0.6%) | 9 (1.4%) | 1 (0.2%) | 0 (0.0%) |
| Minor Injury     | 340 (38.2%)     | 182 (40.4%) | 7 (1.4%) | 40 (9.1%) | 1 (0.1%) | 22 (5.1%) | 4 (0.6%) | 9 (1.4%) | 1 (0.2%) | 0 (0.0%) |
| Property Damage  | 1840 (58.6%)    | 872 (27.8%) | 12 (0.4%) | 186 (5.9%) | 54 (1.8%) | 117 (3.7%) | 7 (0.2%) | 37 (1.1%) | 7 (0.2%) | 0 (0.0%) |
| Unknown          | 1 (100%)        | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) |
| Total            | 2704 (58.3%)    | 1303 (28.1%) | 25 (0.5%) | 261 (5.6%) | 70 (1.5%) | 176 (3.3%) | 12 (0.3%) | 61 (1.3%) | 10 (0.2%) | 0 (0.0%) | 0 (0.0%) |

4.2. Accident severity of heavy vehicles by the time of accident, light and weather condition

The percentage of accidents cases involving heavy vehicles in 2018 range between 14 to 17% on weekdays and the number of accidents is lower on weekends (figure 4). Heavy vehicle accidents tend to occur on working days as most of the trips are on these days. It is also observed that the percentage of heavy vehicle accidents is much lower at 3% on public holidays. The regulation prohibiting heavy vehicles on the road during public holidays seems to have a positive effect in reducing heavy vehicle accidents when there is heavy traffic on the expressways.
Figure 4. Percentage of heavy vehicle accidents by day.

Heavy vehicle accidents also tend to occur more often during the day (54.8%) and clear weather (88.1%), see table 2. Of all the fatal heavy vehicles accidents, 47.8% occurred during the day and 91.4% occurred during clear weather. A previous study of motorcycle fatalities in Malaysia, also found that the fatalities occur more often during clear weather and during the day [9]. Even though, most heavy vehicle accident cases tend to occur during the day, however, the study also found, the fatal accidents during night-time are higher. The night-time accidents make up 39.0% of the total accident whereas the fatal accidents are 45.8% compared to day time where the total of accidents cases is 54.8% and the fatal cases are 47.8%. Of all the night-time accidents, 22.2% occurred on roads without street lighting, which is 5.4% higher than the percentage of accidents on roads with street lights. The fatality rate of night-time accident on roads without street lights is 28.2% whereas the fatality rate of night-time accidents on roads with street lights is 17.6%. Similarly, most of the accidents in other categories of severity (severe injuries, minor injuries, and property damage), occurred during the day, and most of the night-time accidents occurred on roads without street lights.

Table 2. Accident Severity of heavy vehicle by light condition and weather.

| Severity      | Light Condition | Weather |
|---------------|-----------------|---------|
|               | Day            | Dawn/Dusk | Night with street light | Night without street light | Clear | Rain | Foggy | Windy |
| Fatal         | 117 (47.8%)    | 16 (6.5%) | 43 (17.6%) | 69 (28.2%) | 222 | 21 (8.6%) | 0 (0.0%) | 0 (0.0%) |
| Severe        | 319 (49.4%)    | 51 (7.9%) | 103 (16.0%) | 172 (26.7%) | 579 | 61 (9.5%) | 0 (0.0%) | 0 (0.0%) |
| Injury        | 306 (50.5%)    | 41 (6.8%) | 82 (13.5%) | 177 (29.2%) | 532 | 71 (11.7%) | 1 (0.2%) | 1 (0.0%) |
| Minor Injury  | 1801 (57.4%)   | 177 (5.6%) | 549 (17.5%) | 613 (19.5%) | 2753 | 365 (11.7%) | 0 (0.2%) | 0 (0.0%) |
| Property Damage | 1801 (57.4%)  | 177 (5.6%) | 549 (17.5%) | 613 (19.5%) | 2753 | 365 (11.7%) | 0 (0.2%) | 0 (0.0%) |
| Total         | 2543 (54.8%)   | 285 (6.1%) | 777 (16.8%) | 1031 (22.2%) | 4086 | 518 (11.9%) | 6 (0.1%) | 1 (0.0%) |

a one unknown case for light condition
b 26 unknown cases for weather condition

4.3. Type of heavy vehicles collisions
Most of the heavy vehicle accidents on the expressways are rear-end collision (43%), followed by out of control (28%), swirl (10%), hitting objects (6%), sideswipe (4%), overturn (3%), and other types of
collision making up one per cent or less of all accidents (figure 5). Similarly, past study also found that rear-end collision is the most type of accident involving heavy vehicles [1].

![Figure 5. Heavy vehicle accident by type of collision.](image)

### 4.4. Relationship between accident severity and type of vehicle in multi-vehicle accident (MVA) and single-vehicle accident (SVA)

Table 3 presents the percentage of vehicles involved in multi-vehicle accidents (MVA). Even though heavy vehicles are involved 21.3% in multi-vehicle accidents, they accounted for 32.5% of fatal cases. Motorcycles, on the other hand, are found to be involved in most of the fatal accidents in MVA (36.1%) despite only 18.6% were involved in MVA. Cars are found to be involved in 50.7% of MVA and accounted for only 25.7% of fatal cases. These results would seem to suggest that the accidents involving heavy vehicles and motorcycles are more likely to result in death compared to other types of vehicle.

Only 11.9% of the single-vehicle accidents (SVA) cases involving heavy vehicles resulted in death while 55.4% of motorcycles and 25.5% of cars in SVA resulted in death as shown in table 4. The findings of this study suggest that heavy vehicles are less involved in SVA compared to cars and motorcycles, and SVAs involving heavy vehicles also are not likely to result in death. It also showed that heavy vehicles are more likely to involved in MVA compared to SVA.

In this study, Chi-Square test was performed in order to identify the relationship between accident severity and type of vehicle in MVA and SVA. According to the Chi-square test results (sig. < 0.001) between accident severity and type of vehicle in MVA, the null hypothesis that there is no relationship between accident severity and the type of vehicle can be rejected. There was a significant association between accident severity and type of vehicle in MVA, $\chi^2(9, N=12653) = 2510.15$, p<.05. Similarly, the result of Chi-square test of independence (sig. < 0.001) between accident severity and type of vehicle in SVA showed that there was significant association between the variables, $\chi^2(9, N=14241) = 6367.79$, p<.05. The findings of this study suggest that, there are significant association between accident severity and type of vehicle vehicles.
Table 3. Type of vehicle involved in MVA.

| Severity          | Type of vehicle | Total of accident |
|-------------------|-----------------|-------------------|
|                   | Car             | Motorcycle        | Heavy Vehicle | Others | Unknown cases |               |
| Fatal             | 166             | 233               | 210           | 37     | 0             | 646 (5.1%)    |
| Severe Injury     | 1105            | 1224              | 544           | 196    | 13            | 3082 (24.2%)  |
| Minor Injury      | 973             | 721               | 423           | 169    | 10            | 2296 (18.0%)  |
| Property Damage   | 4220            | 191               | 1543          | 698    | 62            | 6714 (52.7%)  |
| Unknown only      | 2               | 0                 | 1             | 0      | 4             | 7 (0.1%)      |
| Total number of Accident | 6466 | 2369              | 2721          | 1100   | 89            | 12745         |

Table 4. Type of vehicle involved in SVA.

| Severity          | Type of vehicle | Total of accident |
|-------------------|-----------------|-------------------|
|                   | Car             | Motorcycle        | Heavy Vehicle | Others | Unknown cases |               |
| Fatal             | 75              | 163               | 35            | 15     | 6             | 294 (2.0%)    |
| Severe Injury     | 425             | 1238              | 101           | 48     | 13            | 1825 (12.4%)  |
| Minor Injury      | 761             | 1073              | 183           | 91     | 14            | 2122 (14.4%)  |
| Property Damage   | 7223            | 227               | 1597          | 986    | 446           | 10479 (71.1%) |
| Unknown only      | 5               | 2                 | 0             | 0      | 4             | 11 (0.1%)     |
| Total number of Accidents | 8489 | 2703              | 1916          | 1140   | 483           | 14731         |

4.5. Relationship between heavy vehicles accident severity and topography of road profile

Table 5 presents the breakdown of heavy vehicle accident severity at different topography of road profile. Heavy vehicles are more likely to be involved in accidents in flat areas (76.3%) followed by mountainous area (14.3%) and rolling area (9.4%). Similarly, most fatal accidents (73.9%) occurred in flat areas, followed by mountainous areas (15.1%) and rolling (11%) areas. In contrast, a previous study conducted by [10] reported that heavy vehicle accidents involvements were higher along the mountainous than the non-mountainous road. There are several possible explanations for this result. This rather contradictory result may be due to the percentage of mountainous road compare to flat road in highway. The higher percentage of flat road may cause the higher accidents in this type of road. However, this study did not analyze the exact location of the accident and the geometry of the road. This study used the entire data provided by MHA. Another reason that may affect the outcome is, information about the accident is recorded by the patrolling officer and it depends on their assessment at the location of the accident. A more in-depth study of this matter should be conducted in the future.

The Chi-Square test was performed in order to identify the relationship between heavy vehicle accident severity and type of topography of road profile. According to the Chi-square test results (sig. =
0.002 < 0.05) between the two variables, the null hypothesis that there is no relationship between heavy vehicle accident severity and type of topography of road profile was rejected. There is a significant relationship between heavy vehicle accident severity and type of topography of road profile $X^2$ (6, N=4636) = 21.10, $p<.05$. The result of this study revealed that the type of topography of road profile affects the heavy vehicle accident severity.

5. Conclusions

The interaction of heavy vehicles with other road users (especially vulnerable users such as pedestrians, motorcyclists and cyclists) may have adverse consequences, especially in the absence of adequate facilities and controls. Hence, there is an urgent need for a more in-depth understanding of the characteristics of accidents involving heavy vehicles. This study has provided an overview of heavy vehicle accidents on the expressway. Compared to buses, heavy goods vehicles, especially lorry, are involved in a higher number of accidents that are more likely to result in fatal. Heavy vehicle accidents frequently occur during daytime and clear weather. Accidents involving heavy vehicles are more likely to occur on roads without street lights than on roads with street lights. The impact of heavy vehicles involved in multi-vehicle accidents is higher and heavy vehicle more likely to involved in multi-vehicle accidents compared to single-vehicle accident. Heavy vehicles accidents occurred more frequently in flat areas compared to rolling and mountainous area.

6. References

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