



Faculty of Mechanical Engineering

**DESIGN OF SAFETY FEATURES FOR HEAVY VEHICLES
IN MALAYSIA**

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Master of Mechanical Engineering (Product Design)

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DESIGN OF SAFETY FEATURES FOR HEAVY VEHICLES IN MALAYSIA

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**A report submitted
in fulfillment of the requirements for the degree of Master of Mechanical Engineering
(Product Design)**

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I declare that this report entitled “Design of Safety Features for Heavy Vehicles in Malaysia” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Master of Mechanical Engineering (Product Design).

Signature :

Name :

Date :

DEDICATION

This report is mostly dedicated to my beloved Mak and Abah.

Also to my family, friends, and also lecturers.

Not forgotten to dear self.

ABSTRACT

Often reported in newspaper or other mass media about accidents involving heavy vehicles in Malaysia. Hence, the safety features are capable to avoid unexpected things happen such as accident in particular. So, the design for safety features will be discussed where some of the existing safety features will be reviewed and improved. Besides, the performance of heavy vehicles to carry loads when climbing the hill also will be analysed. The methodology for this project consists of survey, analysis, calculation, and simulation. The survey is to investigate the use of current active safety as the warning signal which are lights, light reflection stickers, and the colour of canvas used on heavy vehicles. Therefore, the safety features that need to be emphasized in redesign or recommend change is light reflection stickers. This is because light reflection stickers can be an additional source of lights besides the lamp on heavy vehicles. Although the lights on heavy vehicles in not sufficient, light reflection stickers can be an aid to light the heavy vehicles. As for the canvas used, it is insignificant since the canvas is slightly up above the view of human eyes so this is no need to redesign in urgent. The speed required for the heavy vehicles to climb the hill with certain load have been identified where these required speed can be a guide to the driver where they need to drive exceeded those speed to pass the hill smoothly. Other road users also will move up the hill smoothly without the presence of heavy vehicles stranded at the hills and the usual congestion caused by heavy vehicles also can be reduced. In addition, the simulation on the impact analysis also have been made by using ABAQUS where the collision between car and heavy vehicle can be seen. This is also to simulate the use of safety speed between cars and heavy vehicles. Hence, the conclusion can be made as the slower the speed the higher the stress faced by the car's bumper and its condition will become worse. Besides, the heavier the heavy vehicles the slower it's moving and the more dangerous it could be to the other road users.

ABSTRAK

Sering dilaporkan di dalam akhbar atau media massa mengenai kemalangan yang melibatkan kenderaan berat di Malaysia. Oleh itu, ciri-ciri keselamatan mampu mengelakkan perkara-perkara yang tidak dijangka berlaku seperti kemalangan khususnya. Oleh itu, reka bentuk untuk ciri-ciri keselamatan akan dibincangkan di mana beberapa ciri keselamatan sedia ada akan dikaji semula dan ditingkatkan. Selain itu, prestasi kenderaan berat untuk membawa beban apabila mendaki bukit juga dianalisis. Metodologi untuk projek ini terdiri daripada tinjauan, analisis, pengiraan, dan simulasi. Tinjauan ini adalah untuk menyiasat penggunaan keselamatan aktif pada masa kini sebagai isyarat amaran seperti lampu, pelekat pantulan cahaya, dan warna kanvas yang digunakan pada kenderaan berat. Oleh itu, ciri-ciri keselamatan yang perlu ditekankan dalam mereka bentuk semula atau mencadangkan perubahan adalah pelekat pantulan cahaya. Ini kerana pelekat pantulan cahaya boleh menjadi sumber tambahan pencahayaan selain lampu pada kenderaan berat. Walaupun lampu pada kenderaan berat tidak mencukupi, pelekat pantulan cahaya boleh menjadi bantuan untuk mencerahkan kenderaan berat. Bagi kanvas pula, ianya tidak berapa penting kerana kanvas sedikit ke atas pada pandangan mata manusia jadi ini tidak perlu untuk mereka bentuk semula dengan segera. Kelajuan yang diperlukan untuk kenderaan berat untuk mendaki bukit dengan beban tertentu telah dikenalpasti di mana kelajuan yang diperlukan ini boleh menjadi panduan kepada pemandu di mana mereka perlu memandu melebihi kelajuan tersebut untuk melepasi bukit dengan lancar. Pengguna jalan raya lain juga akan bergerak dengan lancar tanpa kehadiran kenderaan berat yang terkandas di bukit-bukit dan kesesakan biasa yang disebabkan oleh kenderaan berat juga boleh dikurangkan. Di samping itu, simulasi analisis impak juga telah dilakukan dengan menggunakan ABAQUS di mana pelanggaran di antara kereta dan kenderaan berat boleh dilihat. Ini juga untuk mensimulasikan penggunaan kelajuan keselamatan antara kereta dan kenderaan berat. Oleh itu, kesimpulan boleh dibuat di mana semakin perlahan kelajuan semakin tinggi tekanan yang dihadapi oleh bumper kereta dan keadaannya akan menjadi lebih teruk. Selain itu, semakin berat kenderaan berat semakin lama ia bergerak dan lebih berbahaya kepada pengguna jalan raya yang lain.

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LIST OF ABBREVIATIONS

ABBREVIATE	TITLE
GVM	Gross Vehicle Mass
UN	United Nations
VTA	Transportation Type Approval
PDRM	Royal Malaysia Police
MIROS	Malaysian Institute of Road Safety Research
NSW	New South Wales
JPJ	Road Transport Department
RRMs	Retro-reflective markers
NHTSA	National Highway Traffic Safety Administration
ISA	Intelligent Speed Assist
GVW	Gross Vehicle Weight
GCW	Gross Combination Weight
SE	Special Edition
RP	Reference Point

CHAPTER 1

INTRODUCTION

1.0 Background

Generally, the definition of heavy vehicle or heavy transportation is a commercial transportations or goods transportations with Gross Vehicle Mass (GVM) exceeding 5,000 kilograms (5 tons). The types of heavy vehicles are distinguished by the axle and type of load that can be transported like liquid or non-liquid. Heavy vehicle also can be classified into two categories which are rigid transportation and articulated transportation. Based on the National Heavy Vehicle Regulator, heavy vehicles are divided into three classes which are Class I for special purpose vehicles, agriculture vehicle, Class II for freight-carrying vehicles and buses while Class III for heavy vehicles along with loads that do not comply with prescribed mass or dimension requirements. The class that will be discussed in this project is Class II where the heavy vehicles is transporting goods.

Meanwhile, it is often reported in newspaper or other mass media about accidents involving heavy vehicles in Malaysia. This is due to some factors which should be emphasized, with the highest percentage is human factor, followed by machine factor and lastly environment. Human factor is not only based on behaviour but also abilities, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use. International Leadership Speaker, Jim Bennett whose experts in the area of Human Factors in Major Accident Prevention and Response said that human factors is the connection of business goals to measure success that runs through integrated business management systems.

Studies have shown that a high percentage of major accidents are attributable in some degree to human failures. This includes technical failures that have a human error root cause. Usually, accident occurrence not only caused by the unconscious behaviour of human such as driving in drowsy state and emotionally, but also caused by the inability of human to see other vehicles on the road as well as the faulty in using safety features.

Therefore, each type of transportation has its own unique safety features. The safety features are capable to avoid unexpected things happen such as accident in particular. Among the safety features used are passive safety, active safety, general safety, and environment where all these features are contained in the UN Regulations. Malaysia has gazetted 100 of the UN Regulations into the rules of motor transportation (Construction and Use) 1959 which are implemented through the Transportation Type Approval (VTA) process. Although Malaysia have followed these regulation but there are some parties that compromise and ignore the safety features to gain advantages for their own. This attitude will affected disadvantages consequences which is accident occurrence not only to them but also to other road users.

Furthermore, heavy vehicles safety issue is a very serious situation that need to be taken care of by other road users although it is not classified as major accidents on the roads. However, heavy vehicles also contribute to the highest rate of fatal accidents. Besides, the increasing number of heavy vehicle on the roads contribute to the traffic congestion in Malaysia especially during festive season or peak hour. In addition, heavy vehicles are climbing slowly at the left lane up the hill is a sight that is commonly seen at any highway. This is due to the performance of engine which is the efficiency of its gearbox. So, in order to avoid this from getting worse, improvements to heavy vehicles design and safety features need to be contributed.

Thus, the design for safety features will be discussed where some of the existing safety features will be reviewed and improved for this master project. Among them is the use of active safety such as lights, light reflection stickers, and canvas that will be studied whether it is appropriate to use or not. Besides, the performance of heavy vehicle to carry loads when climbing the hill also will be analysed. The speed required for the heavy vehicle to climb the hill with certain load will be identified and calculated. Then a simulation to show how the collision occur with the different of speed and mass of the heavy vehicles also will be carried out.

1.1 Problem Statement

For years, there are so many accident that occurred involving heavy vehicle due to the weakness of the safety features on them. This not only endangers the passengers but also to other road users. If a big and long heavy vehicle want to enter the small junction at night especially, with limited light on it like the light is small or less light intensity which make the other road users may not see it clearly and thus, accident will occur. The appearance of the light reflection stickers that are dull and sometimes there is non-existent at all also can hamper the ability of other road users to see heavy vehicles. Similar observation can be said about the colour of canvas used which is dark or green. This might results heavy vehicles to be hit from behind because other road users cannot see if there is heavy vehicles in front of them especially in the dark environment. Besides, the heavy vehicle drivers might not be aware of the performance that the transportations can go as they just follow the instruction as long as the work is done. Maybe the truck is loaded beyond limit to go on the trip regardless of its performance. Hence, the truck could be stranded at the hill since it cannot move upward fast enough. This also can happen at the curvy road which make the traffic become slower than usual.

1.2 Objective

The objectives of this project are as follows:

1. To propose important safety features for heavy vehicle that have not been practiced in Malaysia.
2. To analyse the performance of heavy vehicle to maintain safety speed on the roads or highways.

Objectives will be carried out along this project as it will guide the processes of study until making the conclusion which will be related later. The first objective is to propose important safety features for heavy vehicle that have not been practiced in Malaysia. Then the second objective is to analyse the performance of heavy vehicles to maintain safety speed on the roads or highways.

1.3 Scope of Project

The scopes of this project are as follows:

1. To investigate the use of current active safety as the warning signal which are light, light reflection sticker, and the colour of canvas on heavy vehicles. The survey will be made to collect the views from respondents in Malaysia regarding this matter.
2. To recommend change in design of the most significant safety features for heavy vehicles by taking considerations on the human factor which focus on cognitive ergonomic in term of perception to convey message to other road users.
3. To analyse the performance of heavy vehicles to carry loads when climbing the hill by taking the Hino 300, 500 and 700 Series as the model types in the study. The speed required for the heavy vehicles to climb the hill with certain load will be identified.
4. To simulate the use of safety speed between cars and heavy vehicles by using ABAQUS/CAE with different parameters such as mass and velocity.

The scope of project will describe the topics covered in this master project. Firstly, this project is covered the investigation on the use of current active safety as the warning signal which are light, light reflection sticker, and the colour of canvas on heavy vehicles. This will be found out by doing the survey in order to collect the views from respondents in Malaysia regarding this matter. Then this project also cover on the recommended change in design of the most significant safety features for heavy vehicles by taking considerations on the human factor which focus on cognitive ergonomic in term of perception to convey message to other road users.. Besides, there is an analysis on the performance of heavy vehicles to carry loads when climbing the hill by taking the Hino 300, 500 and 700 Series as the model types in the study. The speed required for the heavy vehicles to climb the hill with certain load will be identified by calculation to find the hill-climbing ability of the vehicle. Last but not least, this project also cover the simulation on the use of safety speed between cars and heavy vehicles by using ABAQUS/CAE with different variables such as mass and velocity.

1.4 Report Organisation

Chapter 1 has already described the main ideas that need to be studied in this work. Next, Chapter 2 discusses the state-of-the-art in heavy vehicles safety features. It also highlights some of the related theory and concepts that will help develop the methodology for this work which discussed in Chapter 3. Chapter 4 then talks about the approaches in calculating an expected engine parameter for heavy vehicles to climb hills at safe speed and also brief introduction about the survey. The results and discussions are shown in Chapter 5. Last but not least, the conclusion and recommendation of this project work in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.0 Background

Literature review is a step of gathering information regarding the topic of the project. All the information can be accessed in the form of journal, reference book, webpage and also from existing research. This chapter will elaborate more about the safety features for heavy vehicles which consist of information on heavy vehicle crashes, road and heavy vehicles design, human factors, and speed management. Besides, brief explanation about ABAQUS/CAE will be made since this is the first time in using this software compared to CATIA, SOLIDWORKS and ANSYS.

2.1 Heavy Vehicle Crashes

Based on the statistics of general road accident in Malaysia (1997-2016) by the Road Safety Department of Malaysia, the number keep rising up to 500,000 which in 2016 was 521,466 (source: Traffic Investigation and Enforcement Department, PDRM Bukit Aman). The percentage of heavy vehicle crashes (2013) was 3%. Although the number is intangible, after that years, the estimated number of other vehicle crashes that involved with heavy vehicles is surely high especially motorcycles and cars. In depth road crash investigation conducted by the Malaysian Institute of Road Safety Research (MIROS) on high profile cases revealed that rear end collisions were the second highest crash configuration with 28.4%.

The heavy vehicles crash can occur in a single transportation crashes (heavy vehicles alone) such as out of the road or rolling over and also collide with other vehicle. The most common factors involved in heavy vehicle crashes are speed, the mechanical condition of the transportation especially the brakes, the characteristics of the load being carried that including overloading, and the surrounding either dark or bright which depends on weather and time.

Since the project is related to warning signal on the heavy vehicle, this can relate to the dark condition such as at night, rainy days and any other condition that has less light. These cognitive ergonomic will play an important role to convey the message to other road user to show there is heavy vehicle on the road. Table 2.1 below show previous research on the lighting condition which became the factor of heavy vehicle crashes.

Table 2.1: The lighting condition caused heavy vehicle crashes

Author	Year	Research	Finding
Craft	2007	Describes the incidence of rear-end crashes involving large trucks that are struck by other vehicles	In fatal crashes, trucks are struck more often by other vehicles. Around half of fatal crashes which another vehicle strikes the rear of a truck occur in dark
Sullivan	2005	Examine the factors that influence truck involvement in night time crashes	The crashing occurred in dark was greater in rural compared to urban areas
Sullivan & Flannagan	2004	Examine the influence of lighting conditions on rear end crashes with trucks	Rear end crashes between any vehicles were twice as likely during night. Fatal rear end crashes involving a truck were nine times more likely in darkness than in light
Williamson, Irvine, & Friswell	2003	Examine patterns of heavy vehicle crashes in NSW between 1996-2000	A higher proportion of crashes occurred between midnight and dawn

By referring to Craft (2007), this research is about explaining the incident of heavy vehicles involved with rear-end crashes by other vehicles that show most accident occurred resulted from another vehicles strike the rear of heavy vehicles and it happens in dark condition. This might be the driver of other vehicles cannot see there is heavy vehicles in front of them.

Then, Sullivan (2005) found from the research to examine the factors that influence truck involvement in night time crashes is the crashing occurred in rural areas is greater than urban areas. Rural areas usually have less light or insufficient streetlights compared to urban areas added with the presence of many other vehicles on the road that gives sufficient light to road users.

Before that, Sullivan and Flannagan (2004) had examine the influence of lighting conditions on rear end crashes of heavy vehicles where rear end crashes between any vehicles were twice as likely during night. They found that fatal rear end crashes involving heavy vehicles were nine times more likely in darkness than in light. The dark environment limited the view of road users to see clearly if there is insufficient light in the surrounding.

Besides, Williamson, et al. (2003) found that heavy vehicles has higher potential to involve in crashes between midnight and at dawn in their research to find pattern of heavy vehicles crashes in New South Wales (NSW) for four year. This happen because heavy vehicles usually start operating or moving on the roads at night to avoid congestion during daytime. So, due to the dark environment that have less light and maybe the driver cannot hold drowsiness, this may results to accident occurrence.

Based on a study conducted in Australia, crashes that occur during night time are more severe compared to daytime crashes (Monash University, 2003). In the dark, many heavy vehicles do not become visible to other road users until they are dangerously close. Thus, one of the essential elements of heavy vehicles safety is a good visibility in traffic.

Syukri (2013) found that the most common types of crash configurations for heavy vehicles are head-on collisions and rear impact collisions where the lighting condition of rear-end collision is mostly during daylight (51%) and followed with dark without lighting (27%), dark with lighting (13%) and at dawn or dusk (9%). This clearly show that the conspicuously of heavy vehicles to other road users plays a significant role in crashes occurrence. Besides, Chen, et al. (2011) stated the adverse road conditions contributing to crashes on mountain highway included icy road surface, windy conditions, and graded curves. Hence, the conditions of road also can cause accident occurrence to heavy vehicles.

The gap from these research is the crashes are always occurred at night and dark but there is no further explanation about any other dark condition such as rainy days, hazy, and any other condition that has less light. This might be other road user cannot see the presence of heavy vehicle clearly as well as the heavy vehicle driver does not see other vehicle too. Thus, the warning signal such as light, light reflection sticker and canvas are important as the safety feature of heavy vehicle.

2.2 Road and Heavy Vehicles Safety Design

Based on Masuri, et al. (2017), the road traffic crashes and their consequences are a significant burden to all societies in developed and developing country. Developed countries are typically more advanced in road safety interventions, so as for developing countries the use of road design and law enforcement in developed country should be applied actively and rigorously. Some issues such as the land use and town planning, mix population, country roads and use of vehicles, are important which needs to take into consideration. Thus, this will improve the safety of the road as well as preventing any accident occurrence. The horizontal alignment of curves and other design features of road represent safety hazard for heavy vehicle drivers. The provision of guard rail barrier is one of them which can benefit