

**CRASH SIMULATION FOR THE EVALUATION OF SAFETY BARRIER
AGAINST VEHICLE IMPACT AT DIFFERENT ANGLE AND TONNAGE**

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JUNE 2015

SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant and Maintenance)”

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Date : JUNE 2015

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**The report submitted in partial fulfilment of the requirement for the award of
Bachelor of Mechanical Engineering (Plant and Maintenance)**

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STUDENTS DECLARATION

“I admitted that this thesis is truly mine except the summaries and extraction where both I clearly knew its sources”

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ABSTRACT

Road safety barrier is function to absorb the impact during the crash. It also functions to keep the vehicle at safe side of the road. During the crash, there were severity that will be produced, and it will cause some damage to the vehicle and the obstacle. The purpose of this project is to determine the effect of the crash at different angle. To accomplish the objective, the computational aided design (CAD) software will be used to draw 3D geometry modelling. Then, the 3D model, the analysis is conduct at several different angles and 2 type of truck. From the analysis, several results will be obtain and will be used as comparison parameters. The comparison will be done between the angles, type of truck, type of analysis and previuos study. From the static analysis it was found that the critical component of road safety barrier was w – beam guardrail while in dynamic analysis, it was found that the critical component of road safety barrier when velocity applied were guardrail post and spacer channel. It show that the critical component was different for different type of analysis. It also found that the safety factor of road safety barrier that installed at our roadways is less than 1 which for static analysis was 0.26237 and for dynamic analysis was 0.058942. This means that the installation of road safety barrier nowadays was not applicable anymore unless the current design is redesign in order to make it can withstand the impact from a bigger force.

ABSTRAK

Penghadang keselamatan jalan raya berfungsi untuk menyerap impak semasa kemalangan. Ianya juga berfungsi untuk memastikan kenderaan selamat dan sentiasa berada di laluan yang betul. Semasa terjadinya pelanggaran, terdapat tahap keterukkan yang akan dikeluarkan, dan ia akan menyebabkan kerosakan kepada kenderaan dan halangan. Tujuan projek ini adalah untuk mengkaji kesan pelanggaran pada sudut yang berbeza. Untuk mencapai objektif tersebut, perisian komputer dibantu reka bentuk (CAD) akan digunakan untuk melukis 3D model geometri. Kemudian, model 3D akan digunakan sebagai bahan untuk analisis dari beberapa jenis sudut dengan menggunakan 2 jenis trak. Daripada analisis tersebut, beberapa keputusan akan diperolehi dan akan digunakan sebagai parameter perbandingan. Perbandingan akan di buat berdasarkan sudut yang berbeza, jenis – jenis truck, jenis – jenis analisis dan kajian lepas. Daripada analisis statik yang telah dijalankan, didapati bahawa komponen kritikal bagi penghadang keselamatan jalan raya adalah pada w – bar manakala untuk analisis dinamik, komponen kritikal adalah “guardrail post” dan “spacer channel”. Ini menunjukkan bahawa komponen kritikal adalah berbeza untuk setiap analisis. Kedua – dua analisis telah menghasilkan faktor keselamatan kurang daripada 1 iaitu untuk analisis statik adalah 0.26237 dan analisis dinamik adalah 0.058942. Ini bermaksud pemasangan penghadang keselamatan jalan raya sekarang adalah tidak sesuai lagi kecuali rekabentuk yang sekarang ini di ubahsuai bagi membolehkan ia menampung kesan pelanggaran daripada daya yang lebih besar.

LIST OF TABLES

Table 2.1: Road safety barrier deflection.....	10
Table 2.2: Road safety barrier categories.....	11
Table 2.4.1: Summary of crash test results and simulation results.....	24
Table 2.4.2: Materials Used for Test model 2.....	27
Table 2.4.3: Comparison NCAC model and Test models.....	28
Table 2.4.4: Simulation result summary.....	29
Table 4.1.1: Element Quality	44
Table 4.1.2: Aspect Ratio.....	44
Table 5.1: Two Tonnes.....	73
Table 5.2: Ten Tonnes.....	73

LIST OF FIGURES

Figure 2.3.1 : Individual truss element.....	17
Figure 2.3.2 : Component of nodal force.....	18
Figure 2.1.1 : Curb simulations conducted using under-integrated shell elements.....	24
Figure 2.4.2 : Deformation of vehicle side rails.....	26
Figure 2.4.3 : Top view of deformation of vehicle side rails.	26
Figure 2.4.4 : FE model of a Chevrolet C-1500.....	27
Figure 2.4.5 : Crash sequence of Test model.....	28
Figure 3.1 : Flowchart of FYP.....	31
Figure 4.1.1: W – Beam Guardrail Drawing.....	41
Figure 4.1.2: Guardrail Posts.....	42
Figure 4.1.3: Spacer Channel.....	42
Figure 4.1.4: Fastener (Bolts and Nut).....	42
Figure 4.1.5: Truck Frontal Bump.....	43
Figure 4.1.6: W-Beam Safety Barrier Full Assemble.....	43
Figure 4.1.7: Mesh by default.....	43
Figure 4.1.8: Total Displacement.....	46
Figure 4.1.9: Equivalent Plastic Strain.....	46
Figure 4.1.10: Equivalent Stress.....	46
Figure 4.1.11: Safety Factor.....	47
Figure 4.1.12: Total Displacement.....	48
Figure 4.1.13: Equivalent Plastic Strain.....	48
Figure 4.1.14: Equivalent Stress.....	48
Figure 4.1.15: Safety Factor.....	49
Figure 4.1.16: Total Displacement.....	50
Figure 4.1.17: Equivalent Plastic Strain.....	50
Figure 4.1.18: Equivalent Stress.....	50

Figure 4.1.19: Safety Factor.....	51
Figure 4.1.20: Total Displacement.....	52
Figure 4.1.21: Equivalent Plastic Strain.....	52
Figure 4.1.22: Equivalent Stress.....	52
Figure 4.1.23: Safety Factor.....	53
Figure 4.1.24: Total Displacement.....	54
Figure 4.1.25: Equivalent Plastic Strain.....	54
Figure 4.1.26: Equivalent Stress.....	54
Figure 4.1.27: Safety Factor.....	55
Figure 4.1.28: Total Displacement.....	56
Figure 4.1.29: Equivalent Plastic Strain.....	56
Figure 4.1.30: Equivalent Stress.....	56
Figure 4.1.31: Safety Factor.....	57
Figure 4.1.32: Total Displacement.....	59
Figure 4.1.33: Equivalent Plastic Strain.....	59
Figure 4.1.34: Equivalent Stress.....	59
Figure 4.1.35: Safety Factor.....	60
Figure 4.1.36: Total Displacement.....	61
Figure 4.1.37: Equivalent Plastic Strain.....	61
Figure 4.1.38: Equivalent Stress.....	61
Figure 4.1.39: Safety Factor.....	62
Figure 4.1.40: Total Displacement.....	63
Figure 4.1.41: Equivalent Plastic Strain.....	63
Figure 4.1.42: Equivalent Stress.....	63
Figure 4.1.43: Safety Factor.....	64
Figure 4.1.44: Total Displacement.....	65
Figure 4.1.45: Equivalent Plastic Strain.....	65
Figure 4.1.46: Equivalent Stress.....	65
Figure 4.1.47: Safety Factor.....	66

Figure 4.1.48: Total Displacement.....	67
Figure 4.1.49: Equivalent Plastic Strain.....	67
Figure 4.1.50: Equivalent Stress.....	67
Figure 4.1.51: Safety Factor.....	68
Figure 4.1.52: Total Displacement.....	69
Figure 4.1.53: Equivalent Plastic Strain.....	69
Figure 4.1.54: Equivalent Stress.....	69
Figure 4.1.55: Safety Factor.....	70

LIST OF GRAPHS

Graph 4.1.1:Element Quality.....	44
Graph 4.1.2: Aspect Ratio.....	44
Graph 5.1: Total Displacement against Time.....	74

TABLE OF CONTENTS

SUPERVISOR DECLARATION	ii
STUDENTS DECLARATION	iv
ACKNOWLEDGEMENT	i
ABSTRACT	ii
ABSTRAK	iii
LIST OF TABLES	iv
LIST OF FIGURES	v
LIST OF GRAPHS	viii
INTRODUCTION	1
1.1 BACKGROUND STUDY.....	1
1.2 PROBLEM STATEMENT.....	2
1.3 OBJECTIVE.....	2
1.4 SCOPE.....	2
1.5 PROJECT PLANNING.....	3
1.5.1 Gantt Charts.....	3
1.6 REPORT ORGANIZATION.....	4
CHAPTER 2	6
LITERATURE REVIEW	6
2.1 INTRODUCTION OF ROAD SAFETY BARRIER.....	6
2.1.1 FUNCTION OF ROAD SAFETY BARRIER.....	7
2.1.2 TYPE OF ROAD SAFETY BARRIER.....	9
2.1.3 SPECIFICATION OF ROAD SAFETY BARRIER.....	12
2.2 STRUCTURAL IMPACT.....	13
2.3 FINITE ELEMENT ANALYSIS (FEA).....	14
2.3.1 THEORY OF FINITE ELEMENT ANALYSIS.....	16
2.3.2 APPLICATION OF FINITE ELEMENT ANALYSIS.....	19
2.3.3 SOFTWARE OF FINITE ELEMENT ANALYSIS (FEA).....	20
2.4 PREVIOUS STUDY.....	23
CHAPTER 3	30
METHODOLOGY	30

3.1 FLOWCHART.....	30
3.1.1 PROJECT FLOWCHART	32
3.2 DATA COLLECTION	33
3.3 DETERMINATION OF SPECIFICATION.....	33
3.4 GEOMETRY MODELLING.....	34
3.5 STATIC ANALYSIS.....	36
3.6 DYNAMIC ANALYSIS	38
3.7 COMPLETING THE REPORT	40
CHAPTER 4	41
RESULTS AND ANALYSIS.....	41
4.1 RESULTS	41
4.1.1 3D Geometry Modelling by Using SOLIDWORKS	41
4.1.2 Meshing Quality.....	43
4.1.3 Specification Of Road Safety Barrier	45
4.1.4 Static Structural Analysis.....	46
4.1.5 Explicit Dynamic Analysis	59
CHAPTER 5	72
DISCUSSION.....	72
CHAPTER 6	76
CONCLUSION AND RECOMMENDATION.....	76
6.1 CONCLUSION.....	76
6.2 RECOMMENDATIONS.....	76
REFERENCE	78
APPENDIX	80
Gantt Chart for FYP 1.....	80
Gantt Chart for FYP 2.....	80
Project	81

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

A crash can be said as violent collision, that normally occur between the vehicle and another vehicle or between vehicle and any obstacle such as building and boulders. After the crash occur, there were severity that will be produced, and it will cause some damage to the vehicle and the obstacle. To prevent the vehicle from collide with the obstacle, the road safety barrier will be installed at the road side. Road safety barrier or we can called as traffic barrier or crash barrier will be function to keep the vehicle at safe side of the road. Besides that, road safety barrier are also installed at the middle of divided highways to prevent the vehicle from entering the opposing traffic flow [1].

A crash simulation is a virtual recreation of a destructive crash test of a vehicle or a road safety barrier. The virtual recreation will be done by using computer simulation in order to measure the level of safety of the vehicle and its occupants and also determine the type of road safety barrier that suitable to install at certain place. To run the simulation, some Computer – Aided Design (CAD) will be used to produce 3D model geometry. In this study, a crash simulation will be run for the evaluation of road safety barrier against vehicle impact through several angle. To complete this study, 3D model geometry for road safety barrier and and lorry will be produce by using SOLID WORKS software. Then, the static analysis will be done at the impact for three different angle.

Usually, a crash simulation that already run from the previous study only for the frontal impact which is at the angle 90^0 . It only valid for one angle only. So this

study will be cover about the impact at three different angle which is 25° , 45° and 90° .

1.2 PROBLEM STATEMENT

The main function of safety barrier is to improve road safety for all road users by reducing the consequences of crashes into potentially hazardous environments [2]. Nowadays the maximum speed at the highway is limited to 110 km/h but the safety barriers installed on our roads now was outdated and only can withstand 100 km/h impact at certain angles. This will make the safety barrier not being able to withstand the crash impact and it will cause catastrophic event when the crash occurs. To show the problem statement is true, a test and research should be done to investigate the crash performance of road safety barrier when it receive the impact from the vehicle.

1.3 OBJECTIVE

- i. To produce 3D model geometry for the safety barrier and the standard vehicle.
- ii. To stimulate crash from different impact angles and car weight (in tonnes).
- iii. To investigate the crash performance of road safety barrier when it receive the impact from the vehicle at different angles.

1.4 SCOPE

- i. During the computational analysis, thermodynamical aspects will not be included. This analysis will include mechanical aspects only.
- ii. This study will be focused in the relationship between mechanical aspects and the geometry of the barrier.
- iii. This study also focus on the angle of the impact. The angle that will be use are 25° , 45° and 90° .

1.5 PROJECT PLANNING

Every successful project needs a planning to ensure that all the parts of the project will be complete on time and to make sure that the objective can be achieved in the target period. It also can be used as a reminder. To remind us, what next job to do. It describes the plan and reports progress with clear through schedules such as a Gantt chart to provide a flow of the project.

1.5.1 Gantt Charts

As described above, a Gantt chart is one of the methods to schedule the plan of the project. A Gantt chart is a type of bar chart that is used to illustrate a project schedule. It will give some visual about the start and finish dates of the terminal elements and summary elements of a project. The Gantt chart for this project can be seen in Appendix.

From the Gantt chart that have been created, the overview of the flow project schedule for this project which will cover and explain about all the activity or task that should be done for FYP 1 and FYP 2. For both FYP, the duration to complete all the task until the submission report is 14 weeks. The project planning for FYP 1 was starting with the briefing session and followed by confirmation of the title of the project with supervisor. This is the starting line in the flow of the project. Then, the problem statement, objective and the scope that related to this project is identified. All the data and information is gathered and collected from many sources. For this task, it takes three weeks, which is from week 1 until the week 3.

Then, the next task is to find the project specification for 3D geometry modelling. The specification that has been determined is for current road safety barrier and truck frontal bumper. The process of 3D geometry modelling by using SolidWorks started after all the data and specification of the project was determined. The material of the model also was defined. After the drawing is complete, the structural analysis will be done to validate the product performance and safety factors. The duration for this task takes about six weeks which started at week 4 until the week 9. The flow of the project then continued with a poster submission at week 9. The balance of the week is used for result analysis and preparation of draft report.

1.6 REPORT ORGANIZATION

For final year project 1 (FYP 1) report, the organisation of the report is divide into three chapter which is Chapter 1 (introduction), Chapter 2 (literature review) and Chapter 3 (methodology). All the contents for each chapter will be explained in detailed below.

Chapter 1 is a general introduction to this project. All the information and data is collected to get the knowledge about the project. In this project, we will be introduced to the main components which is road safety barrier. In this chapter also provide about the problem definition. It is includes the background of study, problem statement, objective and the scope of the project.

Chapter 2 is a introduction of literature review of the project. Literature review is done in order to gained and obtained the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. For this project, it will explain about the detailed of the road safety barrier, the structural impact, angle of impact, and the tools (software) that will be used to complete the project.

Chapter 3 is a methodology of the project. It will explain about the chronology of the project flow. It also tell how to collect and find the road safety barrier specification for drawing. For this project, it will use the computational aided design (CAD) software to draw the 3D geometry modelling. Besides, it will show how to do the analysis and what parameters that should be considered during run the analysis.

Chapter 4 is a data and results of the project. In this chapter, the data and the result will be presented. The data and results will be obtained from 2 type of analysis which is static structural analysis and explicit dynamic analysis. The results will be include the safety barrier specification and 3D geometry modelling. Besides that, the factor of safety, the displacement, equivalent elastic strain and equivalent stress from both analysis will be tabulate. The picture of result from the analysis also will be show in this chapter.

Chapter 5 is a discussion of the project. This part will be discuss about the result that obtained from the analysis. The result from the analysis will be compare between the angles, type of truck, type of analysis and previous study. The parameters that will be use as a comparison are total displacement, strain, stress and factor of safety (FOS).

Chapter 6 is the last chapter of this study which is conclusions. This chapter will conclude that whether the objective of this study is achieve or not.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF ROAD SAFETY BARRIER

Barrier is anything that obstruct passage or to maintain separation, such as a fence or gate. It will prevent the any unwanted objects from entering or go through the protected or harmful place. In other meaning, it is a structure or object that hinder the free movement. At the highways or roadways, it also need the barrier to protect and to prevent the vehicle from go to the dangerous place or crash with hazardous roadside objects. The hazardous roadside objects can be classified into two group which is man made objects (signs, abutments, culverts, embankments, ditches, electricity substations, retaining walls, poles and etc.) and natural objects (trees, rock outcrops, bodies of water, cliffs and etc.) [1]. This type of barrier is called road safety barrier or traffic safety barrier. A road safety barrier is considered to be a hazard and should only be used when the consequences of hitting it are less than the hazard or object which it is shielding. To install the safety barrier, there were standard that should be followed. The standard will be based on the National Cooperative Highway Research Program Report 350 (NCHRP 350) [3]. It will provides standerdised procedures for crash testing and evaluation of both permanent and temporary road safety features, including barriers.

2.1.1 FUNCTION OF ROAD SAFETY BARRIER

Road safety barriers are therefore used to contain and redirect errant vehicles so as to prevent them from leaving the roadways or entering the worksite or dangerous place. Sometimes, it also be used to protect pedestrians, bystanders or property. However, installing the road safety barrier may increase the target area for an errant vehicle, reduce lateral clearance on roadways, and pose special problems at its end. So the road safety barrier will be install only if they reduce the severity and adverse consequences of potential crashes, as they are a hazard in themselves [4]. When problems with roadside objects arise, the following options should be considered:

- Improve the road environment to reduce the likelihood of errant vehicles.
- Remove or reduce the hazard so that it no longer requires shielding.
- Leave the hazard unshielding.
- Install a barrier.

There are four type of road safety barriers, which is roadside barriers, median barriers, bridge barriers and work zone barriers [5]. Each type have it is own function as shown below.

1. **Roadside barriers** are used to protect traffic from roadside obstacles or hazards, such as slopes steep enough to cause rollover crashes, fixed objects like bridge piers, and bodies of water. Roadside barriers can also be used with medians, to prevent vehicles from colliding with hazards within the median.
2. **Median barriers** are used to prevent vehicles from crossing over a median and striking an oncoming vehicle in a head-on crash. Unlike roadside barriers, they must be designed to be struck from either side.
3. **Bridge barrier** is designed to restrain vehicles from crashing off the side of a bridge and falling onto the roadway, river or railroad below. It is usually higher than roadside barrier, to prevent trucks, buses, pedestrians and cyclists from vaulting or rolling over the barrier and falling over the side of the structure. Bridge rails are usually multi-rail tubular steel barriers or reinforced concrete parapets and barriers.

4. **Work zone barriers** are used to protect traffic from hazards in work zones. Their distinguishing feature is they can be relocated as conditions change in the road works. Two common types are used: temporary concrete barrier and water-filled barrier. The latter is composed of steel-reinforced plastic boxes that are put in place where needed, linked together to form a longitudinal barrier, then ballasted with water. These have an advantage in that they can be assembled without heavy lifting equipment, but they cannot be used in freezing weather.

2.1.2 TYPE OF ROAD SAFETY BARRIER

According to Ashghal Public Works Authority (PWA) (2015), road safety barriers can be classified into three types, which is rigid barriers, semi – rigid barriers and flexible barriers. These three type of barriers were classified based on the amount they deflect when struck by a vehicle and the mechanism the barrier uses to resist the impact forces. Rigid barriers are usually constructed of reinforced concrete. A permanent concrete barrier will only deflect a negligible amount when struck by a vehicle. Instead, the shape of a concrete barrier is designed to redirect a vehicle into a path parallel to the barrier. This means they can be used to protect traffic from hazards very close behind the barrier, and generally require very little maintenance. Impact energy is dissipated through redirection and deformation of the vehicle itself. Jersey barriers and F-shape barriers also lift the vehicle as the tires ride up on the angled lower section. For low-speed or low-angle impacts on these barriers, that may be sufficient to redirect the vehicle without damaging the bodywork. The disadvantage is there is a higher likelihood of rollover with a small car than the single slope or step barriers. Impact forces are resisted by a combination of the rigidity and mass of the barrier. Deflection is usually negligible. An early concrete barrier design was developed by the New Jersey State Highway Department. This led to the term Jersey barrier being used as a generic term, although technically it applies to a specific shape of concrete barrier. Other types include constant slope barriers, concrete step barriers and F-shape barriers. Concrete barriers usually have smooth finishes. At some impact angles, coarse finishes allow the drive wheel of front wheel drive vehicles to climb the barrier, potentially causing the vehicle to roll over. However, along parkways and other areas where aesthetics are considered important, reinforced concrete walls with stone veneers or faux stone finishes are sometimes used. These barrier walls usually have vertical faces to prevent vehicles from climbing the barrier. Semi-rigid barriers include box beam guide rail, heavy post blocked out corrugated guide rail and thrie-beam guide rail. Thrie-beam is similar to corrugated rail, but it has three ridges instead of two. They deflect 3 to 6 feet (0.91 to 1.83 m): more than rigid barriers, but less than flexible barriers. Impact energy is dissipated through deformation of the rail elements, posts, soil and vehicle

bodywork, and friction between the rail and vehicle. Box beam systems also spread the impact force over a number of posts due to the stiffness of the steel tube. Flexible barriers include cable barriers and weak post corrugated guide rail systems. These are referred to as flexible barriers because they will deflect 1.6 to 2.6 m (5.2 to 8.5 ft) when struck by a typical passenger car or light truck. Impact energy is dissipated through tension in the rail elements, deformation of the rail elements, posts, soil and vehicle bodywork, and friction between the rail and vehicle. That's only the average of the deflection. The table below will describe about the deflection.

Table 2.1: Road safety barrier deflection. (Ashghal Public Works Authority (PWA) (2015))

Barrier type	System type	Deflection
Cable barrier or beam guardrail	Flexible	Up to 12 feet (face of barrier to object)
Beam guardrail	Semi - rigid	3 feet (face of barrier to object)
Two – sided W – beam guardrail	Semi – rigid	2 feet (face of barrier to object)
Permanent concrete barrier, unanchored	Rigid unrestrained	3 feet (back of barrier to object)
Temporary concrete barrier, anchored	Rigid unrestrained	2 feet (back of barrier to object)
Precast concrete barrier, anchored	Rigid anchored	6 inches (back of barrier to object)
Rigid concrete barrier	Rigid	No deflection