DETAILING CONCEPTUAL DESIGN OF MULTI-PURPOSE MOVEABLE FENCE NEAR THE HIGHWAY

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DECLARATION

I declare that this work report entitled “Detailing Conceptual Design of Multi-Purpose Moveable Fence Near the Highway” is the result of my own work except as cited in the references.

Signature : .....

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Date : .....

SUPERVISOR'S DECLARATION

I hereby have read this report and found that its content and form meet acceptable presentation standards of work for the award of Bachelor of Mechanical Engineering with honors.

Signature	:	.....
Name of Supervisor	:	Dr. Ernie binti Mat Tokit
Date	:	.....

DEDICATION

To my beloved mother and father.

ABSTRACT

The existed moveable fence barrier at exit toll highway Ayer Keroh, Melaka is a ground reinforced cable wire barrier with the length of 2 meter is used to mitigate the vehicle impact at the highway area from any errant vehicles from crossing each opposite lane. However, there are few liabilities with the existed design of the barrier that needs to be improved in the future development of fence barrier system such as ease of handling in moving the fence, reduce the impact force, heavy enough in composition to resist wind pressure, and act as a road divider to prevent reckless driver from making a U-turn. A conceptual design is utilized in this study in analyzing and selecting the best ideal design for the substitution of the existing moveable fence. A 3D geometrical model had been generated from the selection process in the final concept improvement by using Solidwork 2018 and went through simulation process by using Finite Element Analysis (FEA) structural analysis in studying the maximum allowable stress of the created design. The analysis included for the barrier inspection are structural analysis, impact force analysis and wind force analysis. The simulation stages thoroughly examined three types of barriers opening from the final proposed reinforced barrier design. Hence, the results gathered were 10 kN allowable stress limits for maximum opening setup,10 kN and 15 kN allowable stress limits, respectively for medium opening setup and minimum opening setup. For the impact force analysis, few vehicles that are commonly used is chosen to evaluate the predicted force output of each vehicle on the highway condition, and the forces range were from 1.736 kN to 20.833 kN. Meanwhile, the wind force resultant that had been calculated were 390 N from the maximum opening setup of the barrier. The deviation of maximum deformation, maximum stress, and factor of safety were compared to the maximum deformation, material properties and allowable factor of safety at 7.461e-04 m, 2.5e+0.8 MPa and 2, respectively. The required parameters of the expected results settled in allowable range value. As for the conclusion, the generated design for this study of moveable fence near highway has achieved the standard safety guidelines and requirement needed. For future study, the increment of rail thickness should be determined in order to achieve factor of safety above 2 for all load condition of 10, 15, and 20 kN. However, the weight would be an issue for this adjustment. Thus, a cheaper material selection with less weight should be examined if this product were to be commercialized.

ABSTRAK

Penghalang pagar sedia ada yang boleh bergerak di lebuh raya tol keluar Ayer Keroh, Melaka adalah penghalang dawai kabel diperkuatkan tanah dengan panjang 2 meter digunakan untuk mengurangkan impak kenderaan di kawasan lebuh raya dari mana-mana kenderaan yang hilang kawalan dari melintasi lorong yang bertentangan. Walau bagaimanapun, terdapat sedikit kekurangan dengan reka bentuk penghalang semasa yang perlu diperbaiki dalam pembangunan sistem penghalang pagar pada masa akan datang seperti kemudahan pengendalian dalam menggerakkan pagar, mengurangkan daya hentaman, komposisi yang cukup berat untuk menahan tekanan angin, dan bertindak sebagai pembahagi jalan untuk mengelakkan pemandu ceroboh membuat putaran-U. Reka bentuk konseptual digunakan dalam kajian ini dalam menganalisis dan memilih reka bentuk ideal terbaik untuk penggantian pagar bergerak yang sedia ada. Model geometri 3D telah dihasilkan dari proses pemilihan pada peningkatan konsep akhir dengan menggunakan Solidwork 2018 dan melalui proses simulasi dengan menggunakan analisis struktur Finite Element Analysis (FEA) dalam mengkaji tekanan maksimum yang dibenarkan dari reka bentuk yang dihasilkan. Analisis yang disertakan untuk pemeriksaan penghalang adalah analisis struktur, analisis daya impak dan analisis kekuatan angin. Tahap simulasi meneliti dengan teliti tiga jenis penghalang yang dibuka dari reka bentuk penghalang diperkuatkan yang dicadangkan pada bahagian terakhir. Oleh itu, hasil yang dikumpulkan adalah had tekanan 10 kN yang dibenarkan untuk penyediaan pembukaan maksimum, dan had tekanan yang dibenarkan 10-15 kN untuk penyediaan pembukaan sederhana dan penyediaan pembukaan minimum. Untuk analisis daya impak, beberapa kenderaan yang biasa digunakan dipilih untuk menilai ramalan output daya setiap kenderaan pada keadaan lebuh raya, dan daya diperolehi adalah antara 1,736 kN hingga 20,833 kN. Sementara itu, hasil kekuatan angin yang telah dihitung adalah 390 N dari penyediaan pembukaan maksimum penghalang. Hasil daripada penyimpangan ubah bentuk maksimum, tekanan maksimum, dan faktor keselamatan dibandingkan dengan ubah bentuk maksimum, sifat material dan faktor keselamatan yang dibenarkan masing-masing pada 7.461e-04 m, 2.5e + 0,8 MPa dan 2. Parameter yang diperlukan dari hasil yang diharapkan diselesaikan dalam nilai julat yang dibenarkan Kesimpulannya, reka bentuk yang dihasilkan untuk kajian pagar bergerak berhampiran lebuh raya ini telah mencapai garis panduan keselamatan dan keperluan yang diperlukan. Untuk kajian masa depan, peningkatan ketebalan rel harus ditentukan untuk mencapai faktor keselamatan melebihi 2 untuk semua keadaan beban 10, 15, dan 20 kN. Walau bagaimanapun, berat akan menjadi masalah untuk penyesuaian ini. Oleh itu, pemilihan bahan yang lebih murah dengan berat yang lebih rendah harus diperiksa jika produk ini akan dikomersialkan.

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CAD	Computer Aided Design
FEA	Finite Element Analysis
HOQ	House of Quality
TRIZ	Theory of Invective Problem Solving
ANP	Analytic Network Process
LCA	Life Cycle Assessment
PDA	Platform Deployment Arm
CRPP	Convergence Controlled Pugh Method
PVC	Polyvinyl Chloride
ANSYS	Analysis System
IQRF	Communication Via Radio Frequency
SQL	Structured Query Language
LS-DYNA	Ansys Type
AASHTO	American Association of State Highway and Transportation Officials
YCB	Yellow Colored Guardrail Belt
GFRP	Glass Fiber Reinforced Polymer
ISO 9001	International Organizations for Standardizations 9001
ASTM	American Society for Testing and Materials
SIRIM	Standard and Industrial Research Institute of Malaysia

LIST OF SYMBOLS

μ	=	Coefficients of friction
α	=	Angle of Alpha
β	=	Angle of Beta
F	=	The equivalent impact load,
v	=	The object velocity on impact,
d	=	The collision distance or deformation distance of the object
m	=	The mass of the colliding object.
K_z	=	Velocity Pressure Coefficient
K_{zt}	=	Topographic Factor
K_d	=	Wind Directionality Factor
V	=	Basic Wind Speed in Mph
I	=	Importance Factor
G	=	Gust Effect Factor
C_f	=	Force Coefficient of The Sign
A_f	=	Area of The Sign

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Generally, a fence is a solid arrangement that encircles a chosen area, and commonly constructed from posts that are linked together with wire, rails, board, or netting. The purpose which mainly applied to the housing fence is to provide a secure safe ground from the outside of the barrier by establishing the boundaries. One of the alternative fences that have been developed in the past years is the temporary fence or portable fence that are built with the couplers that coupled the panels together making it flexible and supported by counter-weighted feet for variety of occasion as a countermeasure of a fixed fence. Thus, this study is focusing on constructing a detailed moveable fence design for highway and traffic management that can act as a safety barrier for road users. Often used as an effort to physically segregate the traveled path and the work area and as to resist and redirect the impact of an errant mobile. For certainly, safety barrier is one of the most vital tools in the road restraint system.

Considering most of the future technology that keeps developing nowadays in terms of manufacturing and engineering, numerous categories of safety barrier have been produced with an aim to enhance the safety performance for the traffic management. An optimum design of a safety

barrier is supposedly able to resist the impact of any errant vehicle despite the size variances and minimize the damage of the mobile and most importantly the road users.

Subsequently, few researchers have undergone their studies with an objective of improving the safety aspects of the road restraint system by evaluating the performance of the safety barrier and its limitation. The steps taken by the researchers are involving the design, installation, and maintenance of each proposed design accordingly as to maximize its full potential and reliability. This is due to the current existing problems of traffic barrier which includes the unavailability of safety barrier in certain area which expose to the risk of out-of-control vehicle, lack of integrity in the installment of the barrier that could lead to the potential of barrier failure, and lack of standard requirement followed by the workers. As of results, the numbers of severe damage injuries and road fatalities is increasing for both the mobile's occupants and road users.

The current moveable fence used for exit toll Ayer Keroh is a flexible cable barrier comprises of 4 core cable wire that linked together with the end post and bolted into tar foundation and weight supported by stainless steel base. With the dimensional length of 1.5 meter to 2 meters apart between the post and 600 mm in height above road pavement, this present fence used is less favors in term of movability as it is complicated to be moved and the fence design is too heavy in composition. The purposes of the constructed cable barrier are to reduce the impact of lost control vehicle, act as a barrier to prevent road users from making risky U-turn and high in durability to restrain the pressure difference cause by the nearby passing mobile. Consequently, further study needs to be done to enhance the performance of the current barrier system used at the highway exit toll Ayer Keroh, Melaka by examine the current constraint of the design and providing a new improved design which is more reliable and durable in the safety performance perspective.

Figure 1.1: Current moveable fence at exit toll Ayer Keroh, Melaka

Therefore, the study aims are to assist the installment condition of safety barriers in Malaysia and the compliance of the installment process with the safety requirements and specifications (Hamid, 2017). The present study consist of the guidance of conceptual design stage is being used to create an ideal design for the moveable fence near highway with its movability value from the variance of designs established in the modelling stage. A Computer Aided Design (CAD) tool is used to modelized an actual 3D presentation of the fence and then would be analyze in Finite Element Analysis (FEA) tool to determine its performance as required for this study.

1.2 Problem Statement

A moveable fence specifically for exit toll Ayer Keroh, Melaka highway traffic system are expected to be able to withstand and reduce the impact of the errant mobile, heavy enough in term of weight composition to resist the pressure difference that can be caused by the passing vehicle at high speed, and as a road divider to avoid any mobile from making a U-turn after or before taking an exit at the highway toll. Moreover, the movability of the fence is also one of the important aspects in this study as the new required design is to create a portable fence that could be used to substitute the current highway guardrail cable fence which is fixed to the ground as a safety system.

Therefore, the need of further study to improve the performance of the safety barrier system for the traffic management in designated area, which is exit toll Ayer Keroh, Melaka by enhancing the current barrier design should be implemented to create a new portable barrier system and to evaluate the performance of the design.

1.3 Objective

The objectives of this study are mainly:

i. to conceptually design the moveable fence near highway
ii. to run the Finite Element Analysis on a conceptual design of moveable fence near highway.
iii. to compare the final design of the moveable fence with the standard safety guidelines and requirements.

1.4 Scope of Study

To accomplish the purpose of this project, this study covers the conceptual design concept which includes the designing of a product by using the Morphological Chart, House of Quality and Pugh methods. This conceptual design is established in order to choose the ideal design of a moveable fence near highway that are complying with the requirement needed. Solidwork2018 as a Computer Aided Design (CAD) modelling tool is utilized after the finalize design proposal is confirmed on the stage of conceptual design. The dimension and the mechanical features of the fence will be integrated from the literature study and proposed design. Thus, numerical analysis of

a new moveable fence near highway is examined by using Finite Element Analysis (FEA) Ansys tool for the purpose of simulate the design constraints and performance that are able to resist and redirect the impact of the vehicle on the road and highway environment.

1.5 General Methodology

The general stage and explanation that are required to be done to achieve the objectives of the study are briefly discussed in this section as shown below:

1. Literature Review

   Any relevant data from the journals, articles, books and papers are collected and reviewed as a study material.

2. Conceptual Design

   Utilize the methods of Morphological Chart, House of Quality, and Pugh Method in the purpose of choosing the ideal geometric design of study.

3. CAD Modelling

   Draw a new moveable fence near highway using SolidWork2018 as concluded in the conceptual design.

4. FEA Analysis

   The constructed design is transferred to FEA to be analyzed with the resolve of finding the suitable design.

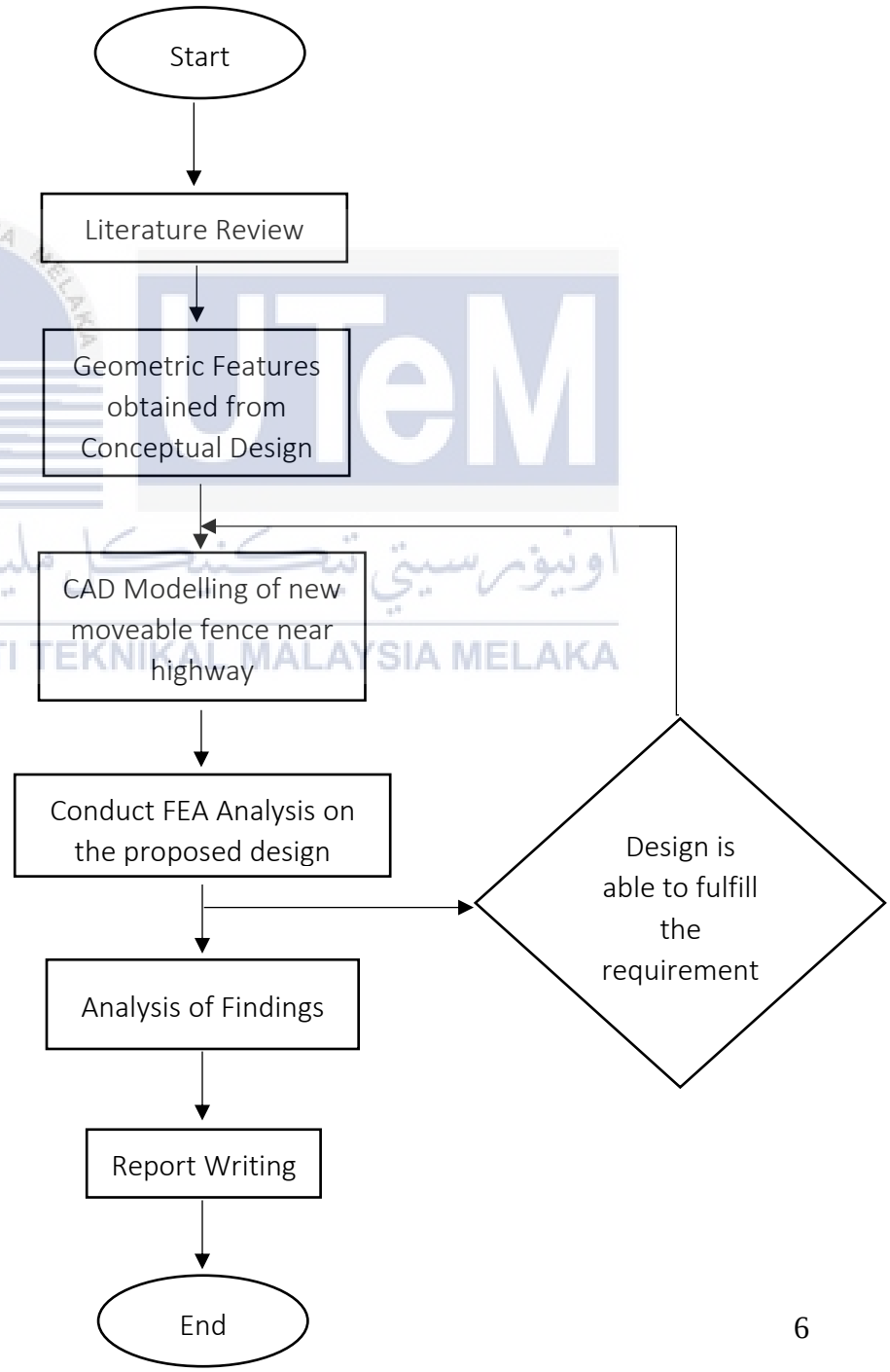
5. Analysis of Findings

   The analysis results will be gone through investigation that are complying with the required new design.

6. Report Writing

   A written report will be created at the end session of the study to show the finding and the results obtained.

Figure 1.2: The summarization of constructed methodology for this study is shown in the flowchart below



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the previous research and studies that are related to the conceptual design of moveable fence near the highway. The sources are including the articles and journal reports that are used as a parameter to complete this study by using the relevant information, knowledge and results that were obtained from it. This chapter summarizes the past research about the application of conceptual design, the analysis used and the current fence.

2.2 Conceptual Design

In the new product development process, conceptual design is considered to be a conclusive phase as its also accountable in the uniqueness and the originality of a product. As this stage where technical feasibility becomes serious issue in time. Instantaneously, the increasing pressure for producing product at faster rate is demanded by its practical, original and faster solution by using conceptual design stage as stated by (Delgado-Maciel, 2020).

The paper discusses the research study on the development and choosing the optimum conceptual design of the component that complying to the requirement of the product design with the help of certain application which are the morphological chart, Analytical Network Process