IMPACT OF LATERAL LOAD ON BRIDGE GIRDER

AMIRA AZURA BINTI JALAL

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG
SUPERVISOR’S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of Bachelor of Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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IMPACT OF LATERAL LOAD ON BRIDGE GIRDER

AMIRA AZURA BINTI JALAL

Thesis submitted in fulfillment of the requirements for the award of the Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2018
ACKNOWLEDGEMENTS

Praise be to Allah, the Lords of the Worlds

First and foremost, thanks to god and his willingness, I have accomplished this final year project as a requirement to graduate and acquire a Bachelor Degree in Civil Engineering from Universiti Malaysia Pahang (UMP). There are number of people without whom this achievement might not have been done, and to whom I am greatly indebted.

I have to thank my research supervisor, Mr. Noram Irwan Ramli. Without his assistance and dedicated involvement in every step throughout the process, this paper would have never been accomplished. I would like to express my gratitude to him as for believing in my abilities, and giving me the foundation to be in this area of study, with his support and patience as I went through my journey in completing this study.

Also thank to Dr Lim Kar Sing. Thank you so much for your insight and guidance throughout this year, for assisting on my work and helping in getting sources and data.

Most importantly, none of this could happened without my mother. She has been a source of encouragement and inspiration to me throughout my life, a very special thanks to you. To my father, for providing support and for teaching me through the years, and also countless of ways in which, actively support me in my determination to find and realize my potential. To my family members who offered me unconditional love and support throughout my study, thank you.

Getting through my dissertation required more than academic support, and I have many people to thank especially to my friends for listening to and, at times, having to tolerate me over the past four years. For every memorable evenings in and out, I must thank to everyone which support during the time I spent at the university. To others, thank you very much for helping me throughout these four years of my study.

To all of you thank you for everything.
Dalam era globalisasi, pembinaan jambatan semakin bertambah baik dengan kemajuan sains dan teknologi. Walau bagaimanapun, jambatan perlu dibina mengikut keadaan semasa dan melakukan pemeriksaan bagi mengesahkan keselamatan jambatan dan tiada kerosakan yang ketara. Tujuan utama inovasi ini adalah untuk meningkatkan kualiti jambatan dan mengurangkan risiko yang mungkin berlaku. Seperti yang kita tahu, Malaysia mengalami intensiti hujan yang tinggi. Biasanya, banjir akan berlaku semasa Musim Monsun yang boleh menyebabkan kematian yang serius dan kehilangan harta benda. Malah, ia boleh menyebabkan kerosakan jambatan dan kegagalan apabila daya impak daripada banjir terlalu tinggi. Menurut kajian terdahulu, jambatan yang tenggelam dalam air banjir bergantung kepada kuasa hidrodinamik yang terhasil dari pemindahan air dan juga serpihan terapung. Terdapat empat jenis geomatri galang jambatan yang telah digunakan dalam ujian ini untuk mengenal pasti halaju akhir air dan juga tekanan yang dikenakan pada bahagian tersebut. Terdapat segi empat tepat, trapezoid, trapezoid terbalik dan bentuk bersegi enam. Dengan melakukan simulasi pada model jambatan, bentuk galang yang optimum dapat ditentukan supaya dapat mengukuhkan lagi jambatan yang berada di kawasan rawan banjir.
ABSTRACT

In this new era globalization, bridge construction has been improved extremely with the advancement in science and technology. However, bridge must be constructed according to the situation and do a regular inspection to validate the safety of bridge and no significant deterioration occurred. The main purpose of this innovation is to improve the quality of bridge and reduce risk that might be occurred. As we know, Malaysia had experienced a high rainfall intensity. Usually, flood will be occurred during a Monsoon Season which can cause a serious death and loss of properties. In fact, it can cause of bridge damage and failure when the impact force from flood is too high. According to previous study, bridge submerged in floodwater are subjected to hydrodynamic forces which created by moving of water and also floating debris. There are four types of bridge girder cross section have been used in this test to identify final velocity of water and also pressure that exerted on bridge girder. There are rectangle, trapezoid, inverted trapezoid and hexagon. By doing a simulation on the bridge model, the optimum cross section bridge girder can be determine to improve a bridge that located in flood prone area.
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<tbody>
<tr>
<td>m</td>
<td>meter</td>
</tr>
<tr>
<td>kg/m³</td>
<td>kilogram per meter cube</td>
</tr>
<tr>
<td>kg/m/s</td>
<td>kilogram per meter per second</td>
</tr>
<tr>
<td>m/s</td>
<td>meter per second</td>
</tr>
<tr>
<td>Y₀</td>
<td>Characteristic value</td>
</tr>
<tr>
<td>Y₁</td>
<td>Characteristic value</td>
</tr>
<tr>
<td>Y₂</td>
<td>Characteristic value</td>
</tr>
<tr>
<td>C₀</td>
<td>Drag coefficient</td>
</tr>
<tr>
<td>F₀</td>
<td>Drag force</td>
</tr>
<tr>
<td>P</td>
<td>Pressure</td>
</tr>
<tr>
<td>τ</td>
<td>Shear stress tangent</td>
</tr>
<tr>
<td>θ</td>
<td>Angle between the pressure vector and velocity vector</td>
</tr>
<tr>
<td>dA</td>
<td>Unit area</td>
</tr>
<tr>
<td>ρ</td>
<td>Fluid density</td>
</tr>
<tr>
<td>V₀</td>
<td>Average free stream approach velocity</td>
</tr>
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<td>A</td>
<td>Reference area</td>
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<tr>
<td>Fₐ</td>
<td>Lift force</td>
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<tr>
<td>Cₐ</td>
<td>Lift coefficient</td>
</tr>
<tr>
<td>Cₘ</td>
<td>Moment coefficient</td>
</tr>
<tr>
<td>Mₙₘ</td>
<td>Moment about the centreline</td>
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<tr>
<td>Lₚₚ</td>
<td>Reference length</td>
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<tr>
<td>V</td>
<td>Velocity</td>
</tr>
<tr>
<td>Fᵢ(t)</td>
<td>Impact force</td>
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<tr>
<td>Cᵢ</td>
<td>Correction factor</td>
</tr>
<tr>
<td>m</td>
<td>Effective mass</td>
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<tr>
<td>s</td>
<td>Stopping distance</td>
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<tr>
<td>g</td>
<td>Gravitational acceleration</td>
</tr>
<tr>
<td>h</td>
<td>Height</td>
</tr>
<tr>
<td>Fₙ</td>
<td>Resultant force</td>
</tr>
<tr>
<td>Cₚ</td>
<td>Centre of pressure</td>
</tr>
<tr>
<td>kPa</td>
<td>Kilo Pascal</td>
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<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tr>
<td>CFD</td>
<td>Computational Fluid Dynamics</td>
</tr>
<tr>
<td>SCDM</td>
<td>SpaceClaim Direct Modeller</td>
</tr>
<tr>
<td>UPL</td>
<td>Verification For Uplift</td>
</tr>
<tr>
<td>HYD</td>
<td>Hydraulic Ultimate Limit State</td>
</tr>
<tr>
<td>STR</td>
<td>Structural Resistance</td>
</tr>
<tr>
<td>GEO</td>
<td>Ground Resistance</td>
</tr>
<tr>
<td>FAT</td>
<td>Fatigue</td>
</tr>
<tr>
<td>EQU</td>
<td>Equilibrium</td>
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</table>
CHAPTER 1

INTRODUCTION

1.1 Background of Study

Bridge is one of the structure that people used to cross some form of barrier such as rivers or sea to travel from one place to another. Basically, there are many different design of bridge that have been constructed based on a particular purpose and apply to different situation. There are arch bridge, bascule bridge, beam bridge, cable-stayed bridge, cantilever bridge, suspension bridge and truss bridge.

Before bridges are constructed, the most important thing is to establish a good understanding about the week points of bridge design and also the failure. This can be very useful in focusing the inspection on the key elements of the design. In addition, quality materials, adequate design and good manufacturing techniques must be assumed to produce a safe bridge for public use. Plus, regular inspection is important to consider whether the bridge is safe and no significant deterioration has occurred.

Based on the study of bridge events in the US, which included four categories ranging from simple bridge distress, partial collapse, total collapse and unknown. These are the category shows a bigger cause of bridge problems during design or construction. There are flood, scour, collision, overload, deterioration and also earthquake (McLinn, 2009).

Malaysia is one of country that experiences very high rainfall intensity. Mostly, flood will be occurred during Monsoon season that usually happen from December until March. Due to these events, a few bridges in Malaysia collapse and most of them damaged due to excessive force from flood water. Unfortunately, it can cause a serious death, injuries, loss of properties and also loss of accessibilities. Prevention is better than cure. Based on that statement, it is reasonable for finding the best way by choosing the effective cross section bridge girder and design it properly to avoid this problem.
<table>
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<tr>
<td>Approaches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>signs and delineation- missing, damaged or obscured</td>
</tr>
<tr>
<td></td>
<td>guardrails – missing or damaged</td>
</tr>
<tr>
<td></td>
<td>road drainage – blocked inlets/ outlets</td>
</tr>
<tr>
<td></td>
<td>road surface – missing or damaged, settlement or depression</td>
</tr>
<tr>
<td>Bridge surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge surface – missing or damaged, scuppers blocked</td>
</tr>
<tr>
<td></td>
<td>Footpaths – damaged</td>
</tr>
<tr>
<td></td>
<td>Barriers/handrails – damaged, missing fixings, loose post base</td>
</tr>
<tr>
<td></td>
<td>expansion joints – loose or damaged, missing or damaged seal, obstructions in gap</td>
</tr>
<tr>
<td>Waterway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>debris against substructure</td>
</tr>
<tr>
<td></td>
<td>debris against superstructure</td>
</tr>
<tr>
<td></td>
<td>bank erosion</td>
</tr>
<tr>
<td></td>
<td>scour holes</td>
</tr>
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<td>damage to scour protection</td>
</tr>
<tr>
<td>Substructure (abutments)</td>
<td>Movement of abutments</td>
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<tr>
<td></td>
<td>Movement of wing walls</td>
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<td></td>
<td>Scour of spill through</td>
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<tr>
<td>Substructure (piers)</td>
<td>Movement of piers</td>
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<td></td>
<td>Rotation of piers</td>
</tr>
<tr>
<td></td>
<td>Scour around piers</td>
</tr>
<tr>
<td>Substructure (bearings)</td>
<td>Missing, damaged or dislodged</td>
</tr>
<tr>
<td></td>
<td>Poorly sealed</td>
</tr>
<tr>
<td>Superstructure (deck)</td>
<td>Damage</td>
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<tr>
<td></td>
<td>Debris on deck</td>
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<tr>
<td></td>
<td>Rotation of deck</td>
</tr>
<tr>
<td></td>
<td>Dipping of deck over piers</td>
</tr>
<tr>
<td>Superstructure (girders)</td>
<td>damage</td>
</tr>
</tbody>
</table>
1.2 Problem Statement

Load limit on bridges have been established by designers and the state departments of transportation during design stage to avoid bridge failure. Vertical loads are considered into two items which are dead load and dynamic load. Dead load consists of the static weight of the bridge itself that must be supported by the piers or cables. While total dynamic load is consider of the total weight of all vehicles on the bridge (McLinn, 2009). Wind causes two important loads, one called static and the other dynamic. Static wind load is the horizontal pressure that tries to push a bridge sideways. Dynamic wind load gives rise to vertical motion, creating oscillations in any direction. Like the breaking of an overused violin string, oscillations are vibrations that can cause a bridge to fail (Billington, Billington, & Shirley-Smith, 2017).

However, when floods occur, the bridge will be partially or entirely submerged in water and it is subjected to significant hydrodynamic and hydrostatic forces. In addition, there might be other additional force such as debris force. It also can be defined as anything that floats and may find its way into a waterway such as woody remains of trees, bushes and also grass. All of these forces will cause the failure of bridge components if there are not properly shaped and supported especially at the bridge girder and deck. This also could damage to cultural or asset heritage, loss of accessibility, life and injuries. It can cause of high cost and take a long time to rebuild and repair every part of bridge. From these problem statement, it is necessary to do some research and simulation on a bridge to increase the durability and exploring ways to strengthen the bridge in flood-prone area.

1.3 Objective

The objectives of this study are;

i. To study the effect of lateral impact due to flood.
ii. To identify the effectiveness of bridge girder cross-sectional geometry.
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