IMPACT OF LATERAL LOAD ON BRIDGE GIRDER

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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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ABSTRAK

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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LIST OF SYMBOLS

m	meter
kg/m^3	kilogram per meter cube
kg/m/s	kilogram per meter per second
m/s	meter per second
Y_0	Characteristic value
Y_1	Characteristic value
Y_2	Characteristic value
C_D	Drag coefficient
F_D	Drag force
P	Pressure
τ	Shear stress tangent
θ	Angle between the pressure vector and velocity vector
dA	Unit area
ρ	Fluid density
V_0	Average free stream approach velocity
A	Reference area
F_L	Lift force
C_L	Lift coefficient
C_M	Moment coefficient
M_{GS}	Moment about the centreline
L_{REF}	Reference length
V	Velocity
Fi(t)	Impact force
C_F	Correction factor
m	Effective mass
s	Stopping distance
g	Gravitational acceleration
h	Height
F_R	Resultant force
C_P	Centre of pressure
kPa	Kilo Pascal

LIST OF ABBREVIATIONS

CFD	Computational Fluid Dynamics
SCDM	SpaceClaim Direct Modeller
UPL	Verification For Uplift
HYD	Hydraulic Ultimate Limit State
STR	Structural Resistance
GEO	Ground Resistance
FAT	Fatigue
EQU	Equilibrium

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 1.1 Inspection data for Damaged Bridges

Inspection element	Type of damage
Approaches	signs and delineation- missing, damaged or obscured
	guardrails – missing or damaged
	road drainage – blocked inlets/ outlets
	road surface – missing or damaged, settlement or depression
Bridge surface	Bridge surface – missing or damaged, scuppers blocked
	Footpaths – damaged
	Barriers/handrails – damaged, missing fixings, loose post base
	expansion joints – loose or damaged, missing or damaged seal, obstructions in gap
Waterway	debris against substructure
	debris against superstructure
	bank erosion
	scour holes
	damage to scour protection
Substructure (abutments)	Movement of abutments
	Movement of wing walls
	Scour of spill through
Substructure (piers)	Movement of piers
	Rotation of piers
	Scour around piers
Substructure (bearings)	Missing, damaged or dislodged
	Poorly sealed
Superstructure (deck)	Damage
	Debris on deck
	Rotation of deck
	Dipping of deck over piers
Superstructure (girders)	damage

Source: (Lebbe, Lokuge, Setunge, & Zhang, 2014)

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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