PERFORMANCE OF INTEGRAL BRIDGE WITH VARIOUS SPAN LENGTHS

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To my beloved wife, family, lecturers and friends

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ABSTRACT

An integral bridge may be defined as having no expansion joints or sliding bearings, the deck is continuous across the length of the bridge. Among the advantages of this type of bridge is reducing the cost of maintenance and bringing comfort to road users as there is no connection between the superstructure and substructure. However, this type of bridge is quite different in comparison to the conventional bridge in terms of the analysis and design. The aim of this study is to examine the performance, with respect to the terms of reference of the PWD Bridge Unit of integral bridges in excess of 60 m span length. This study is also intended to investigate and make a comparison between integral bridges with various span lengths in terms of the performance particularly for the reactions resulting from the applied load. A series of integral bridges with different span configurations and lengths have been designed and analyzed using STAAD Pro. The results show that when the span increases, the values of hogging moments at connection between beam and pier increase significantly. From the analysis and design that have been made, it can be concluded that for integral bridges with lengths more than 70 m (for example, configuration of bridge of 20m + 40m + 20m), the bridge can be designed as an integral bridge but the thickness of the deck slab should be increased in order to sustain the resulting negative hogging moment on the connections between the beams and piers. However, the cost incurred due to increasing the thickness of the deck slab should be calculated in order to assess whether a bridge should designed as an integral bridge or conventional bridge.

ABSTRAK

Jambatan integral boleh ditakrifkan sebagai tidak mempunyai sendi pengembangan atau gelongsor galas, yang mana pada bahagian papaknya adalah bersambung terus dari bahagian rentang kepada bahagian sub-struktur. Antara kelebihan jambatan jenis ini adalah dapat mengurangkan kos penyelenggaraan dan memberi keselesaan kepada pengguna jalan raya kerana tiada penyambungan antara sub-struktur dan struktur atas. Walaubagaimanapun, jambatan jenis ini adalah amat berbeza berbanding dengan jambatan konvensional dari segi analisis dan reka bentuk. Tujuan kajian adalah untuk mengkaji prestasi jambatan dengan merujuk kepada terma rujukan Bahagian Jambatan JKR Malaysia, bagi mengkaji jambatan integral yang melebihi 60 m panjang rentang. Kajian ini juga bertujuan untuk menyiasat dan membuat perbandingan di antara jambatan integral dengan pelbagai panjang rentang dari segi prestasi terutamanya bagi tindak balas yang terhasil daripada beban kenaan. Bagi tujuan tersebut, beberapa model jambatan integral dengan panjang dan konfigurasi rentang yang berbeza telah direka bentuk dan dianalisis dengan menggunakan perisian STAAD Pro. Keputusan yang diperolehi menunjukkan bahawa apabila span bertambah, nilai-nilai momen negatif pada sambungan antara rasuk dan tiang sambut meningkat dengan ketara. Daripada analisis dan reka bentuk yang telah dibuat, dapat dibuat kesimpulan bahawa untuk jambatan integral dengan panjang lebih daripada 70 m (sebagai contoh, konfigurasi jambatan 20m + 40m + 20m), ianya boleh direka bentuk sebagai jambatan integral tetapi ketebalan papak perlu ditambah bagi membolehkannya mengambil momen negatif yang terhasil pada sambungan antara rasuk dan tiang sambut. Walaubagaimanapun, perbandingan kos yang terhasil disebabkan oleh pertambahan ketebalan papak perlu dibuat bagi menilai samada sesuatu jambatan itu perlu direka bentuk sebagai jambatan integral atau jambatan konvensional.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

STAAD Pro	-	Structure software for analysis
S. Pro Beava	-	Software for live load analysis
WIM	-	Weight in motion
HA(UDL)	-	Distributed live load
HA(KEL)	-	Knife edge load
HB	-	Special vehicle live load
SW	-	Self-weight
DL	-	Dead load
Pa	-	Earth pressure
Ap.slab	-	Approach slab
Tr	-	Traction load
STC	-	Shrinkage, temperature and creep
TEM	-	Uniform temperature load
G_a	-	Self-weight of beam
G_c	-	Self-weight of slab
S_o	-	Earth pressure at rest
G_{fin}	-	Finishes load
K_s	-	Stiffness of soil (K-value)
I_{xx}	-	Second moment area about *x* axis
I_{yy}	-	Second moment area about y axis
A_{csbeam}	-	Cross-section area of beam
$A_{csdeckslab}$	-	Cross-section area of deckslab
$\gamma_{concrete}$	-	Density of concrete
γ	-	Density of soil
Ø	-	Angle of friction

f_{cu}	-	Strength of concrete
f_y	-	Strength of reinforcement
M_{max}	-	Maximum bending moment
V_{max}	-	Maximum shear force
Z	-	Lever arm
d	-	Effective depth
A_s	-	Area of reinforcement required
$A_{s\ prov}$	-	Area of reinforcement provided
A_{sv}	-	Area of reinforcement link
f_{yv}	-	Strength of link reinforcement
S_v	-	centre to centre of link spacing

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Integral Bridge is designed without any expansion joints in the bridge deck. They are generally designed with the stiffness and flexibilities spread throughout the structure/soil system so that all supports to accommodate all type of loads (primary and secondary loads). They are single or multiple span bridges having their superstructure cast integrally with their substructure. Generally these bridges include capped pile stub abutments and piers. In other words, these types of bridge are constructed without any movement joints between spans and abutments/piers.

One of the most important aspects in the design is that it can affect the life and maintenance cost structure with the reduction or elimination of road expansion joints and bearings. Unfortunately, this is too often overlooked or avoided. Joints and bearings are expensive to buy, install, maintain and repair and more costly to replace. The most frequently encountered corrosion problem involves leaking expansion joints and seal that permit salt-laden run-off water from roadway surface to attack the girder ends, bearings and supporting reinforced concrete substructures. Elastomeric glands get filled with dirt, rocks and trash and ultimately fail to function.

In the UK, the highways Agency Department Standard, BD57/01 and TOR Bridge Unit CKASJ JKR Malaysia "Design for Durability" requires designers to consider designing all bridges with length up to 60 meter and skew angles of less than 30 degrees as integral bridges. However, the basis of this requirement is yet to be justified.

The principal advantages of integral bridge include the following:

(i) Lower construction costs and future maintenance costs. In conventional bridges much of the cost of maintenance is related to repair of damage at joints.

(ii) Fewer piles are required for foundation support. No battered piled piles are needed.

(iii) Construction is simple and rapid. The integral bridge act as a whole unit.

(iv) Reduced removal of existing elements. Integral abutment and pier bridges can be built around the existing foundation without requiring the complete removal of existing substructure.

(v) The smooth, uninterrupted deck of the integral bridge is aesthetically pleasing and it improves vehicular riding quality.

(vi) Design efficiencies are achieved in substructure design. Longitudinal and transverse loads acting upon the superstructure may be distributed over more number of supports.

1.2 Aim and Objectives

The aim of the study is basically focus on the integral bridges capability with respect to the performance of the integral bridge is comparison to conventional simply supported bridges after the application of primary and secondary loads. Subsequently, the objectives of the study are as follows:

(i) To obtain the length limit for integral bridges in an analytical way, where the limit factors include capacity of abutments and piers due to primary and secondary loads.

(ii) To perform structural study on multiple spans integral bridge, through analysis to further understand the performance these types of bridges.

(iii) To perform analysis modeling using STAAD Pro software to determine the bending moment, shear forces, displacement for the whole bridge system.

(iv) To compare the results of integral bridges model with the various length.

1.3 Problem Statement

In general, integral bridges are designed for a range of less than 60 meters in length of span. If referred to the terms of reference from Bridge Unit, CKASJ JKR Malaysia, length of integral bridges not more than 60 meters and not more than 30 degrees of skew. This limit must be proved by theoretical studies of the behavior of an integral bridge.

This research is to find out and make a comparison of integral bridges with various span lengths in terms of the performance particularly for the reactions resulting (bending moments and shear forces) from the applied load. This study will also look at what is essentially an integral bridges should be designed not exceed 60 meters, and what happens if integral bridges designed beyond the limit particularly for the multiple spans bridge.

Generally, the overall problems of this study are:

(i) There is no solid basis for the limits of integral bridges.

(ii) The behavior of an integral bridge that exceeds the limit, particularly for the more than 60 meters long and what are the things to be considered in terms of how to design is limited.

(iii) There is no exact concept of loading that is correct for the analysis of integral bridges.

1.4 The scope of the study

One of the scopes of the study is to check the structural capacity of the design concept for beams, piers, abutments and foundation systems and make a comparison of the design for integral bridge and conventional type. This study is also includes the combination of load cases acting on the bridge and evaluate the behavior of the bridge and make a comparison between single span and multiple span.

In addition, studies to assess the key parameters to be considered in the analysis and design of integral bridges and evaluate the ability of integral bridge structure based on the theory by using the software to modeling the structure system. Results of the analysis will be considered in this study are such as bending moments and shear forces on the connection between the beam and abutment/pier and also the reaction force at the pile system due to soil interaction.

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