COMPARISON OF ANALYSIS MODELS FOR SEMI CICULAR CURVED BOX-GIRDER BRIDGE DECK

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This project report is dedicated to my beloved parents,
supportive wife and my lovely children for their endless support and encouragement

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ABSTRACT

With the quick development of transportation infrastructure, there is an increase in the number of construction of curved bridges, particularly in the construction of highway interchanges and overpasses. The most popular type of curved bridges structure being used is Box-Girder. This is due to its efficiency, high strength to weight ratio and aesthetic appealing, and occasionally the use of straight beam is not possible. The LUSAS analysis software was used in this study to simulate and analyze the box-girder curved bridges in various models, namely Grillage, Beam, Finite Element Solid Element and Finite Element Thick Shell models. The study examines and compares the maximum displacement, shear force, bending moment and torsional moment for each model. The results demonstrated that the beam and grillage model produce moment, shear force and torsional moment that can be used directly for design. On the other hand, finite element model gives only stresses which is much more difficult to be used in the design, but useful for local effect analysis. The finite element model with solid element suffered the largest displacement while the beam model had the least amount of displacement.

ABSTRAK

Seiring dengan pembangunan pesat infrastruktur pengangkutan darat, pembinaan lebuhraya, jambatan dan overpass giat dijalankan. Struktur jambatan melengkung yang paling popular dibina adalah rasuk kekotak. Struktur ini dipilih kerana kecekapannya, nisbah kekuatan dengan berat yang kecil dan boleh memberi pemandangan yang cantik. Ia juga serngkali dipilih apabila rasuk lelurus tidak dapat dibina kerana kelengkungan yang kecil. Perisian LUSAS telah diguna dalam kajian ini untuk menganalisis rasuk kekotak terlengkung dengan pelbagai model, iaitu model rasuk, model grillage, model unsur terhingga padu dan model unsure terhingga permukaan. Perbandingan nilai maksimum pesongan, daya ricih, momen lentur dan momen kilasan telah mendapati bahawa model rasuk dan grillage telah dapat memberikan nilai daya dalaman yang boleh diguna secara terus untuk rekabentuk manakala model unsure terhingga, walaupun lebih tepat, hanya memberikan nilai tegasan di mana nilai ini tidak sesuai untuk diguna dalam rekabentuk, tetapi lebih sesuai untuk analisis kesan tempatan. Model unsur terhingga dengan element padu mengalamai pesongan terbesar manakala model rasuk jaluh lebih kukuh dengan memberikan pesongan maksimum paling kecil.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

There was an alteration in the philosophy of bridge design and analysis around twenty years ago. Essentially, the fact that the principle of resistance for the structure must be more than the employed load still remains unaltered. To acquire the right modeling, being not dangerous as well as a cost-effective bridge design to be used in the future, the bridges must be able to resist all loads when employed to it (Doerrer and Hindi, 2008).

The curved bridges are made up of reinforced concrete cast in situ or precast, pre-stressed, steel and composite concrete deck and are built in the form of a single cell (one box), double cell, multi-cell and individual or together cells.

But, the curved beam theory was created by (Sakai, 1980) even though the theory of thin–walled beam by (Vlasov, 1965) mentioned analysing and designing straight and curved box-girder bridges (Sennah and Kennedy, 2002).

The small radius of box-birder curve bridges have been extensively used due to the rapid progress of transportation, rising numbers of highway interchanges, overpasses, urban roads and U-turns to lessen traffic congestions. The function of the box-girder is to crosswise shear force and torque and will have distortion of cross section(Li and Sun, 2011).

Box-girder is very rigid and hardy in brute torsion and distortion causes more of the twisting in the deck. But, the box-girder can be built without diaphragms or cross-bracing.

As it is sensitive to variances in settlement and compression of bearing when it has two bearings near to one other at a support, the box-girder will be very rigid against torsion and distortion. Due to this, it may require a minor variance in settlement or minor twisting of the structure (Hambly, 1991).

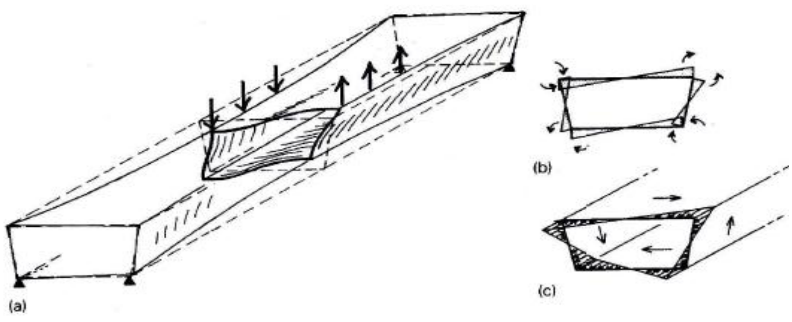

Figure 1.1: (a): Distortion of box-girder; (b) out-of-plane Bending Moment and (c) in plane Bending Moment(Hambly, 1991).

Box-girder is very stiff and strong in pure torsion and more of the twisting in the deck is due to distortion. However, the box-girder can construct without diaphragms or cross-bracing.

Box-girder will be very stiff against torsion and distortion because it is sensitive to differential settlement and compression of bearing when it has two bearings close to each other at a support. In the case, it may needs a small differential settlement or small twisting of the structure (Hambly, 1991).

The advantages of box-girder bridge are:-

1- The box-girder bridge is usually used for long span, the flexural and torsion capacity rigidity are large.
2- They have low self-weighted, due to hollow.
3- Box-girder aesthetically pleasing.
4- The void may be used for utilities and services installation.
5- Reduces the number of beams translate to economical system.
6- The box-girder can be constructed from variable materials; separate or together, such as steel, concrete, or composite.
7- No needs to construct expansion joints at the interior support because . it is continuous
8- The box-girder is more stable compared to other type of bridge Deck.

In this study are using a layout of the curved bridge as shown in Figure 1.2 as a model for a continuous curved bridge deck with two spans. The length of each span is 42.42m and with a radius of 30m. The deck is supported by two bearings at each support.

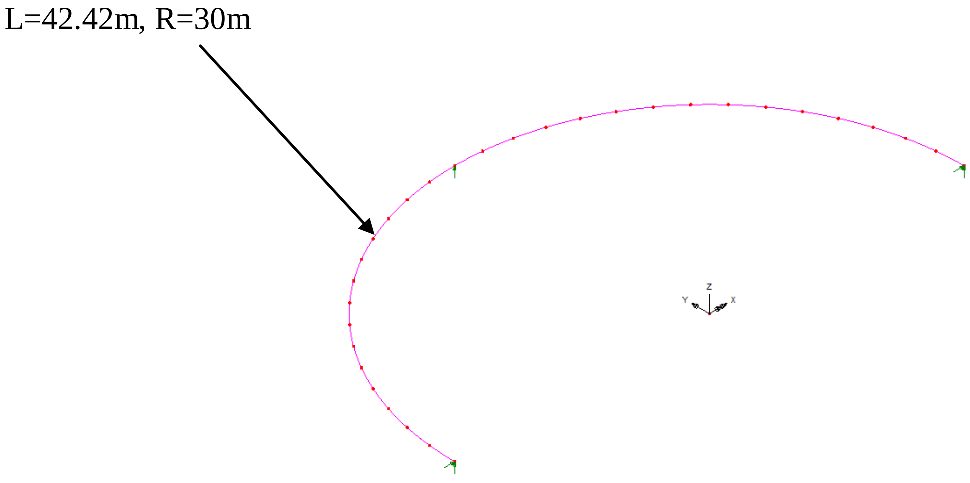

Figure 1.2: Layout of the Bridge

Although, for previous layout of the bridge assuming Figure 1.3 as a cross section.

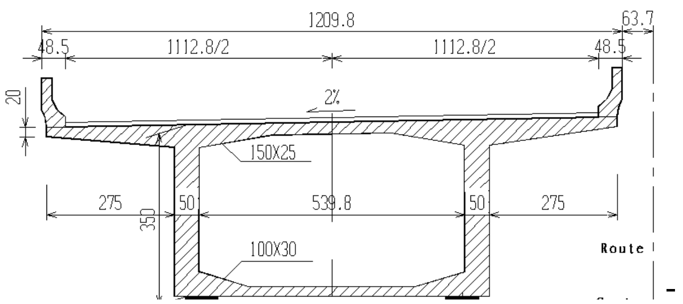

Figure 1.3: Box girder cross section (dimension is cm) Kang *et al*. (2011)

1.2 Problem Statement

Where the radius of semi-circular is small, uses straight beams or girder for bridge deck structure system is not possible. Hence, box-girder is the most efficient structure in bridge construction.

1.3 Aim and Objectives

The aim of this study is to determine an efficient model, for analysis of semi-circular continuous span box- girder bridge deck.

In order to achieve the aim several objectives are set:

1- To analyze for displacement, moment, torsion and shear in semi-circular continuous box-girder bridge deck using different modeling methods :

- Beam modeling.
- Grillage modeling
- Finite element modeling using solid element.
- Finite element modeling using thick shell element.

2- To investigate the largest deflection, moment, torsion and shear stress along the curved bridge deck by comparing between the results.

1.4 Significant of the study

The significant of this study is to use this type of the bridge, continues curved bridge in the semi-circular curve radii, because in current practice solid slab is used as structural system for small turning radius curve bridge. In this project, box girder is proposed in replacement of pre stressed beam.

1.5 Scope of Study

The scope of this study is to develop and analyse the semi-circular curve single -cell box–girder bridge deck. Four type models will be investigated: beam modelling, grillage modelling, finite element modelling using solid element and thick shell element with continuous two span constructions.

- This type of bridge typically used in the U-turn or flyover interchange.
- Use LUSAS Software.
- Assuming homogenous isotropic concrete material. Where the data is not assessable.
- Effect of temperature change, horizontal load, concrete creep, shrinkage is neglected.
- The analysis will be carried out base on uniform load (UDL load only).
- Single cell right web box-girder will be used.

1.7 Methodology

In order to achieve the objective of this study the research application is start with searching and finding information and references related to the main proposed study that helps to obtain the objectives. The sources of information are obtained from journal, books, internet and the related to continuous curved box girder bridge deck.

To starting the study, analysing software is needed. There are many computer software are available for finite element analysis such as ANSYS, LUSAS.

LUSAS is chosen in this study because it has bridge module function, which is easy to apply vehicle loading.

The main steps in this study are as following:

- Identify and limitation of problem and scope area of the study, to obtain the proper model for continuous curved bridge deck.
- Choose box girder section for curved bridge deck.
- Simply support will be used
- Model the bridge deck section properties using: beam, grillage and finite element, solid element and thick shell element using LUSAS.
- The element types which will be used are BMS3, Grill, HX8M and QTS4.
- Only uniform loading type UDL is used.
- Linear analysis will be used.
- Analysis and result processing.
- Graphical output of displacement, shear, bending moment and torsion will be showed a largest value of the efficiency of the model which is determined by looking at the deflection value where small value indicates the model is stiff.
- Output reporting

- Comparing analysis results for each term.

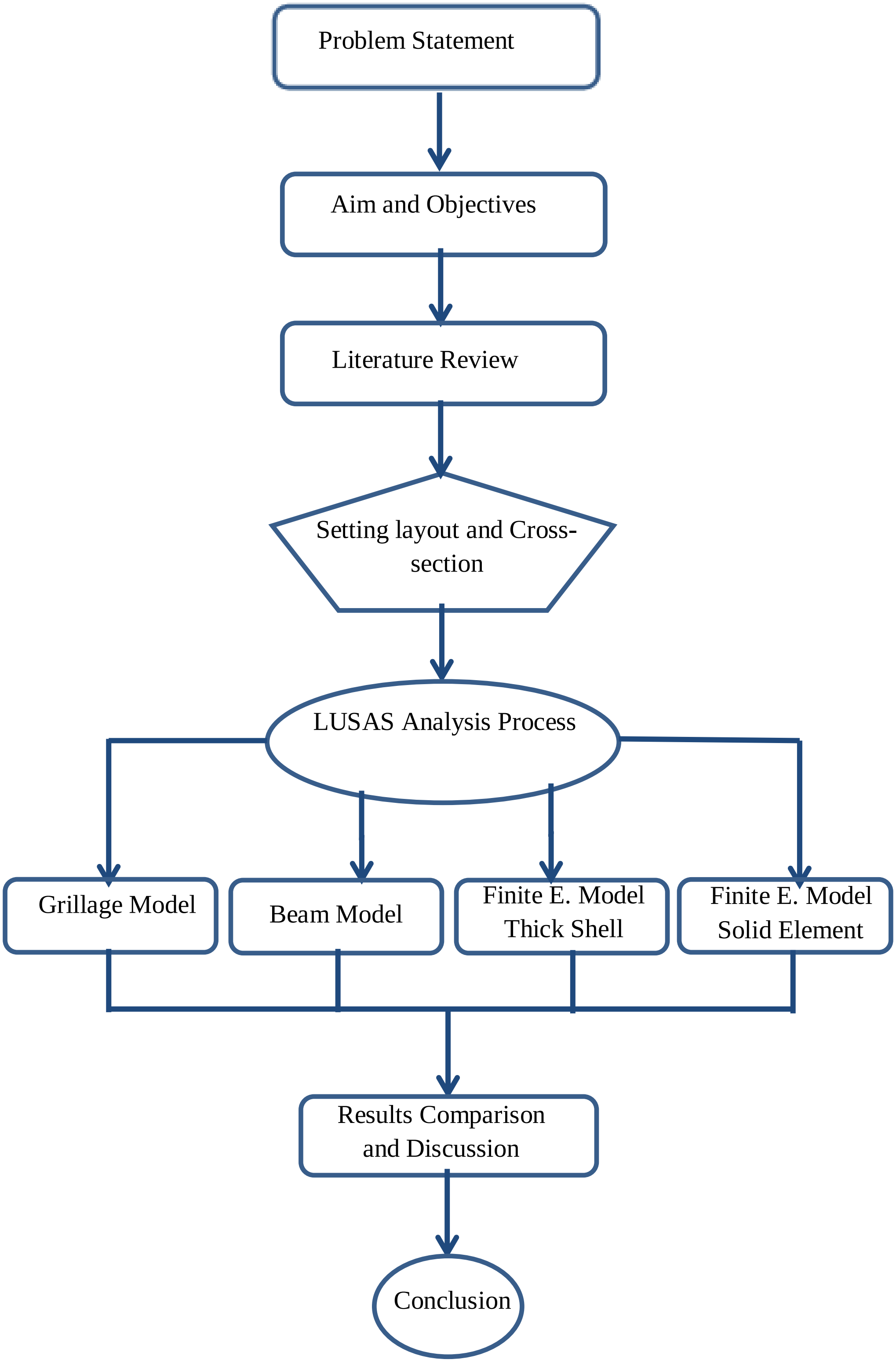

Figure 1.4: Methodology

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