

**COMPARISON BETWEEN GRILLAGE MODEL AND FINITE ELEMENT  
MODEL FOR ANALYZING BRIDGE DECK**

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## ABSTRACT

Since its publication in 1976 up to the present day, Edmund Hambly's book "Bridge Deck Behaviors" has remained a valuable reference for bridge engineers. During this period the processing power and storage capacity of computers has increased by a factor of over 1000 and analysis software has improved greatly in sophistication and ease of use. In spite of the increases in computing power, bridge deck analysis methods have not changed to the same extent, and grillage analysis remains the standard procedure for most bridges deck. In this study analysis bridge deck using grillage model are compared with the analysis of the same deck using finite element model. A bridge deck consists of beam and slab is chosen and modelled as grillage and finite element. Bending moment, Shear force, Torsion and Reaction force from both models are compared. Effect of skew deck is also studied. In general for practical skew bridge deck results from finite element model give lesser value in terms of displacement, reaction, shear force, torsion, bending moment compare with the results from grillage model. It can be concluded that analysis of bridge decks by using finite element method may produce more economical design than grillage analysis. This is due to the fact that the finite element model resembles the actual structure more closely than the grillage model.

## Abstrak

Semenjak publikasinya dari 1976 ke hari ini, buku Edmund Hambly berjudul “Bridge Deck Behaviors” merupakan sumber rujukan paling berguna kepada jurutera-jurutera jambatan. Semasa tempoh ini kuasa pemprosesan dan kapasiti penyimpanan komputer-komputer telah bertambah dengan satu faktor melebihi 1000 dan perisian analisis telah banyak meningkat dalam kecanggihan dan penggunaannya. Meskipun bertambah dari kuasa pengkomputeran, cara-cara menganalisis geladak jambatan masih dalam takat yang sama, dan kekisi analisis kekal sama untuk kebanyakan jambatan-jambatan bertingkat. Dalam analisis kajian geladak ini, analisis geladak jambatan menggunakan model kekisi dibandingkan dengan analisis bagi geladak yang sama menggunakan model unsur terhingga. Geladak jambatan yang mengandungi rasuk dan papak dipilih dan menjadi model sebagai kekisi dan unsur terhingga. Momen lentur, Daya Ricih, Kilasan dan Daya Tindakbalas daripada kedua-dua model adalah dibandingkan. Kesan geladak pencong adalah juga dikaji. Secara keseluruhannya keputusan analisis daripada model unsur terhingga memberi nilai yang kurang dalam soal anjakan, tindak balas, daya ricih, kilasan dan momen lentur berbanding dengan keputusan-keputusan daripada model kekisi. Di sini dapat disimpulkan bahawa analisis dengan menggunakan kaedah unsur terhingga mungkin menghasilkan reka bentuk yang lebih berekonomi daripada kekisi analisis. Ini memandangkan model unsur terhad lebih menyamai struktur sebenar berbanding model kekisi.

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

Even though the finite element method has developed to the maturity and numerous computer software that use the methods are relatively cheap and easily available. Engineer still prefer to use grillage method for their analysis of bridge decks. Hambly (1991) listed out reasons why grillage method is a more popular choice than finite element method. Firstly the finite element method is much more complicated and expensive than the grillage method. Though the finite element is thought to be more accurate, in reality does not produce significant different results as compared with the grillage. According to Hambly (1991), finite element is cumbersome to use and the choice of element type can be extremely critical and, if incorrect, the results can be far more inaccurate than those predicted by simpler models such as grillage or space frame [Hambly 1991].



However, perhaps the greatest drawback at present is that while the finite element technique is developing so rapidly, the job of carrying out finite element computations is a full time occupation which cannot be carried out at the same time by the senior engineer responsible for the design. He is unlikely to have time to understand or verify the appropriateness of the element stiffness's or to check the large quantity of computer data. This makes it difficult for him to place his confidence in the results, especially if the structure is too complicated for him to use simple physical reasoning to check orders of magnitude [Jenkins, 2004].

## **1.2 Problem Statement**

Grillage method is a fast and simpler approach compared to the finite element method, and has been used by engineers to analyses bridge deck over a long time on the other hand the finite element method is thought to be better model for the slab analysis because of its capability to represent the structure more realistically.

As such there is a need to conduct a thorough comparison between the two models to gain better idea on which model may produce more economical design.

## **1.3 Objectives of Study**

The objectives of this study are as follows:

- To compare the performance between grillage and finite element model for analysing bridge deck.
- To conduct analysis of bridge deck using grillage and finite element model using LUSAS software.

- To study the effect of deck skew on the analysis result for both models.
- To propose which model can provide more conservative design.

#### **1.4 Scope and Limitations of the Study**

In this study, LUSAS software will be used to model and analyse the bridge deck. Only grillage and finite element using 3D beam and shell elements are considered. Bending moment, Shear force, Torsion and Reaction force will be compared.

#### **1.5 Significant of the Study**

Grillage method consists of members lying in one plane only while the finite element method lying in 3D plane. Both of these planar methods of analysis are used to model a range of bridge forms. Planar methods are among the most popular methods currently available for the analysis of slab bridges. They can, with adaptation, be applied to many different types of slab as will be demonstrated. Further, their basis is well understood and results are considered to be of acceptable accuracy for most bridges.

However, grillage model and finite element model can also be considerably more complex and can take much longer to set up. For this reason, planar grillage and finite element models are at present the method of choice of a great many bridge designer for most bridge slabs [O'Brien, 1999].

The research significance to be obtained from this study will be the results and analysis of the behaviour of bridge deck. It is necessary to compare between two models to see which model gives more economical result.

## **1.6 Methodology**

- a) The steps adopted in this study are
  - Identify problem and scope of study, obtain realistic bridge deck plan.
  - Literature review of the grillage and finite element model. (Books, Previous studies, Journal, Case studies)
  
- b) In order to achieve the second objective we have to
  - Choose a realistic a bridge deck section with a different skews.
  - Analyze the bridge deck section properties using each of grillage and finite element models for each skews in LUSAS software.
  - Application of load cases and vehicles loading.
  - Analysis and result processing.
  - Graphical and report output.
  
- c) Compare between the two models (Grillage and Finite element) by using the results of first and second objectives.
  
- d) Recommendation & Conclusion.

The methodology that will be used for this study is shown in Figure 1.1.



Figure 1.1: methodology