

Comparative Study on Static Analyses of a Box Girder Bridge

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ABSTRACT: Finite element analysis is widely used by practicing engineers and researchers in design of bridges. Grillage method of analysis was practiced before the finite element analysis came into prominence. For many years, design of concrete bridge structures has been based on two dimensional frame analysis. Recently three dimensional elements have been employed in finite element analysis. Modelling of various components in the model needs to be given importance. The present study envisages modeling and analysis of a box girder bridge. Modeling of deck is studied in finite element software CSiBridge. The bridge deck is analysed by conventional manual calculations as well as grillage analysis and the results are compared with that of the finite element analysis using shell model. Comparison showed that the values for bending moment and shear force from finite element method gives the lowest value among the three methods making it more economical than the other methods. But the grillage model is easy to construct and use

KEYWORDS: finite element analysis; grillage analogy; CSiBridge; box girder bridge

I. INTRODUCTION

A finite element analysis is a numerical simulation of the behavior of a real-world structure which is intended to provide information that can be used by a designer to ensure a structural design is fit for its intended purpose. The finite element method consists of subdividing the actual structure into a suitable number of sub-regions that are called finite elements. These elements can be in the form of line elements, two dimensional elements or three-dimensional elements to represent the structure. Displacements are the most commonly used nodal variable, with most general purpose programs limiting their nodal degree of freedom to just displacements. A number of displacement functions such as polynomials and trigonometric series can be assumed, especially polynomials because of the ease and simplification they provide in the finite element formulation.

This is an important concept to understand because the focus of the analysis is the real world, which is not a mathematical model. It is, therefore a process that takes an actual structure, subject to its constraints including attachments to other structures. In the past structural analyses were often done with simplified models, for example two-dimensional equivalent beam or frame models. Such a model is not able to describe the distribution of forces in transversal directions.

The grillage analogy method for analyzing bridge superstructures has been in use for quite some time. The grillage idealisation consists of converting the bridge deck structure into a network of rigidly connected beams or into a network of skeletal members rigidly connected to each other at discrete nodes i.e. idealizing the bridge by an equivalent grillage. The deformations at the two ends of a beam element are related to a bending and torsional moments through their bending and torsion stiffness. The load deformation relationship at the two ends of a skeletal element with reference to the member axis is expressed in terms of its stiffness property. This relationship which is expressed with reference to the member co-ordinate axis, is then transferred to the structure or global axis using transformation matrix, so that the equilibrium condition that exists at each node in the structure can be satisfied. The moments are written in terms of the end-deformations employing slope deflection and torsional rotation moment equations. The shear force in the beam is also related to the bending moment at the two ends of the beam and can again be written in terms of the end deformations of the beam.

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II. METHODOLOGY

A. STUDY ON FINITE ELEMENT MODELLING

The box girder deck is modeled using beam and shell elements as shown in Fig 1.

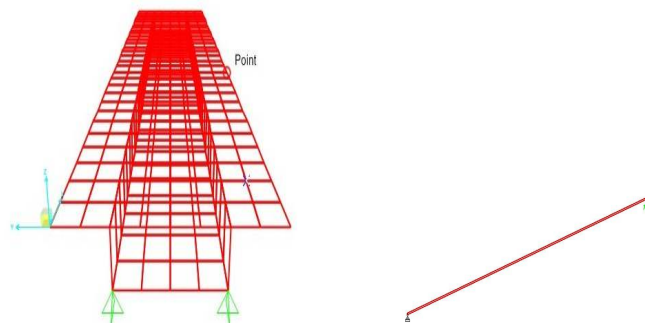


Fig 1. Box Girder deck shell and beam models

B. COMPARISON OF VARIOUS ANALYSES OF DECK

The box girder deck is analysed using manual calculations, grillage method and finite element method. The standard IRC loadings class A, class 70R tracked and wheeled are used. The grillage and finite element models are shown in Figures 3 and 4. The values of bending moment and shear force are compared for the three methods.

The manual calculations are done using Morice and Little method of distribution coefficients. The grillage method is done using STAADPro.V8i. It idealises the deck into a grid of beam elements with gridlines spaced according to positions of various components. Finite element analysis with CSiBridge is carried out using shell model of deck. Results are obtained and tabulated.

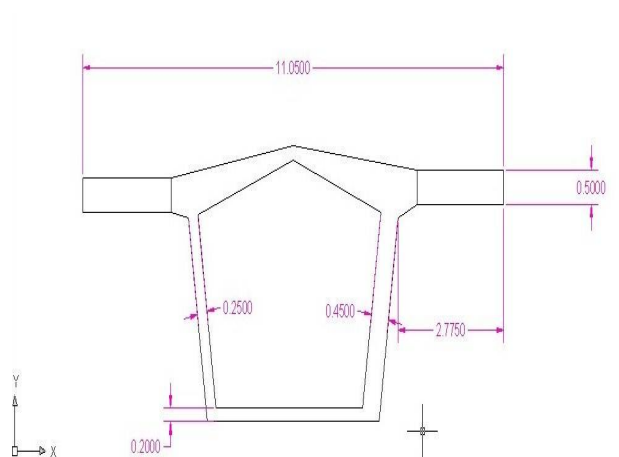


Fig 2.Box section used

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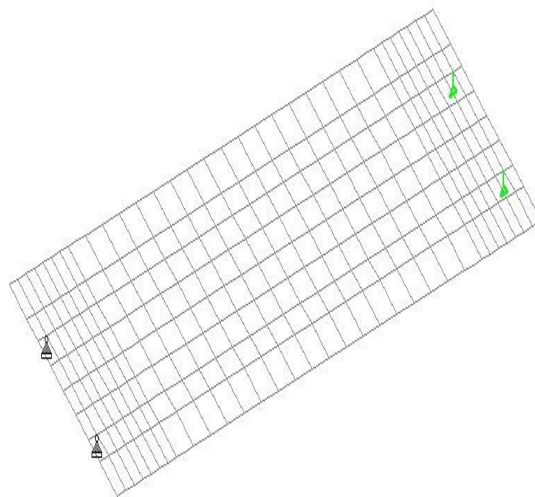


Fig 3. Box girder deck grillage model

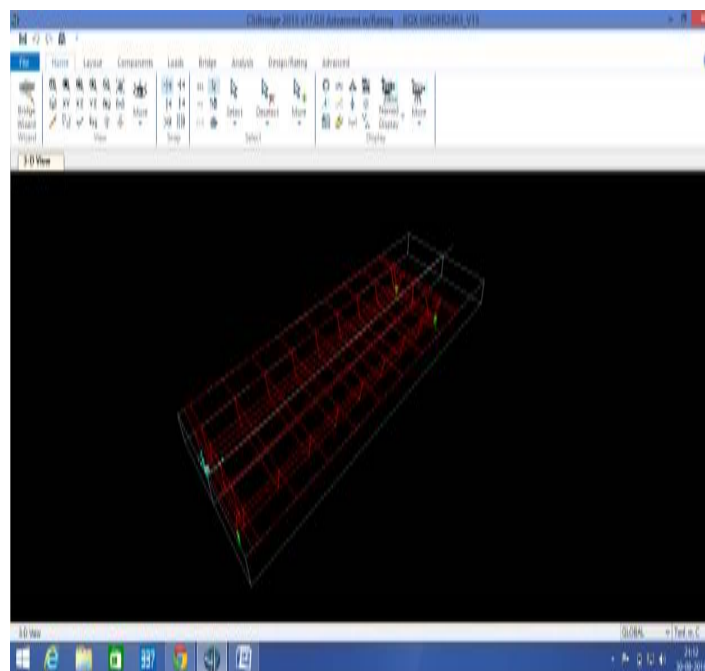


Fig 4.Box girder finite element model

III. RESULTS AND DISCUSSION

A. COMPARISON OF THREE METHODS OF ANALYSIS

- The comparison of three analysis methods for the box girder deck is shown in Table 1.
- The finite element method gives the lowest value among the three. It indicates that the finite element model resembles the actual structure more closely than other methods and it is more economical.
- But the grillage model is easy to construct and use and there is less probability of error.

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TABLE 1. COMPARISON OF THREE ANALYSES

Vehicle Class	Method	Support		L/8		L/4		3L/8		Midspan	
		BM	SF	BM	SF	BM	SF	BM	SF	BM	SF
		(KNm)	(KN)	(KNm)	(KN)	(KNm)	(KN)	(KNm)	(KN)	(KNm)	(KN)
Class A 2Lane	Manual	0	94	191	79	310	55	385	34	399	15
	Grillage	0	85	176	70	302	50	384	20	380	10
	FEM	0	67	154	61	276	44	273	16	377	8
Class 70R Wheeled	Manual	0	108	163	83	261	64	407	26	438	27
	Grillage	0	85	150	55	253	44	350	21	418	14
	FEM	0	79	143	39	242	30	341	20	400	14
Class 70R Tracked	Manual	0	79	166	68	285	57	356	46	380	40
	Grillage	0	67	100	65	250	50	351	40	377	35
	FEM	0	64	120	60	244	42	350	35	382	33

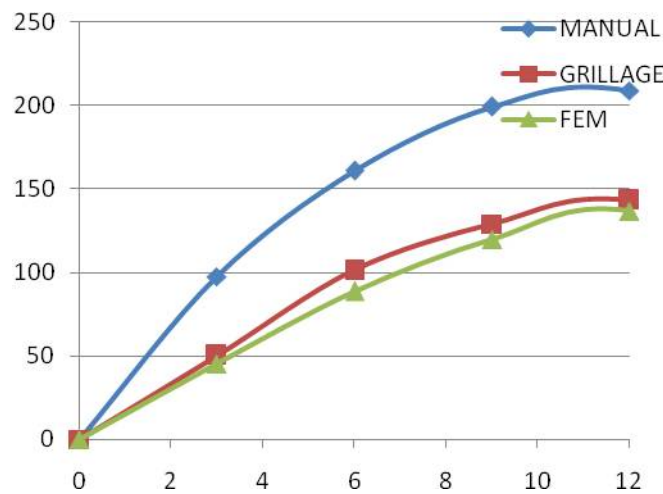


Fig. 5 Bending Moment Diagram for Class A 2 Lane

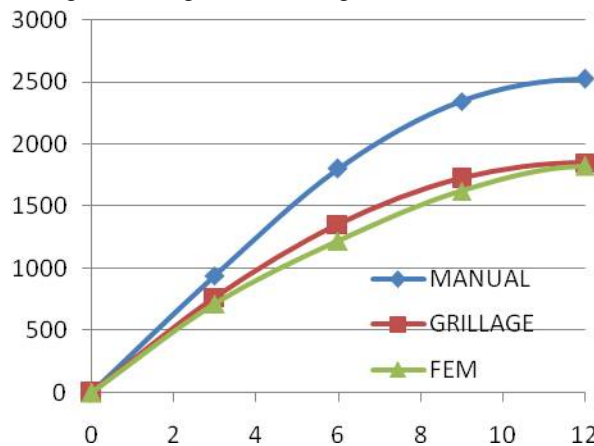


Fig. 8 Bending Moment Diagram for Class 70R Tracked

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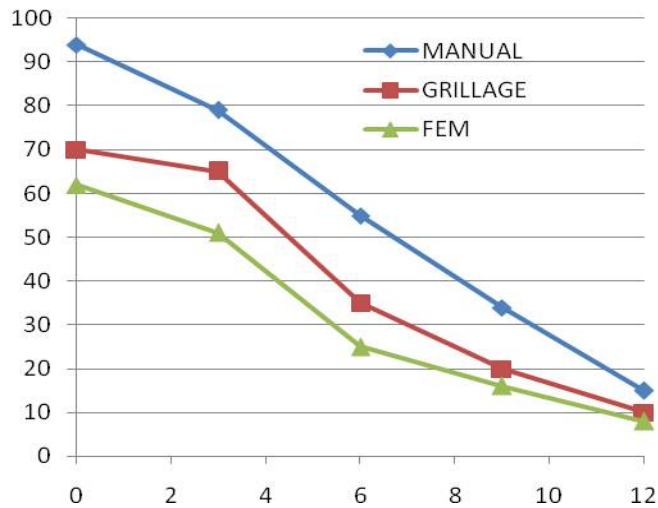


Fig. 6 Shear force Diagram for Class A 2 Lane

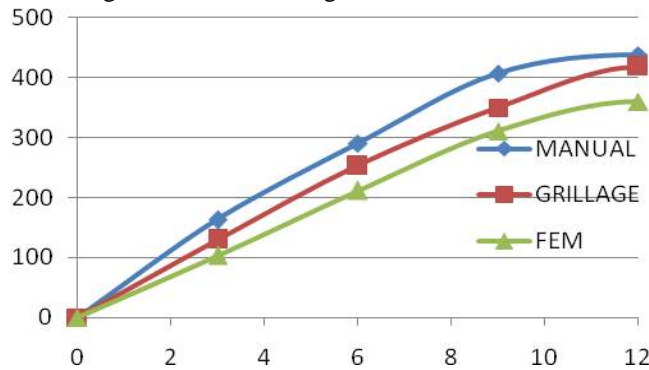


Fig. 7 Bending Moment Diagram for Class 70R Wheeled

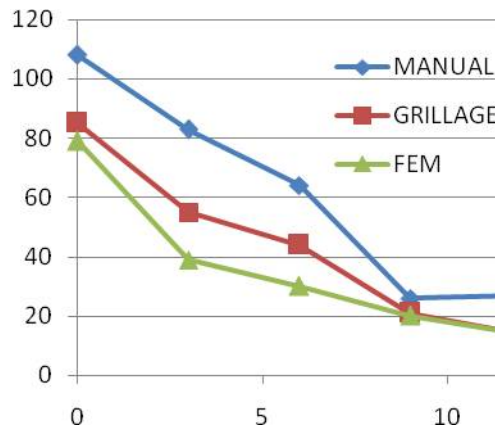


Fig. 9. Shear force Diagram for Class 70R Wheeled

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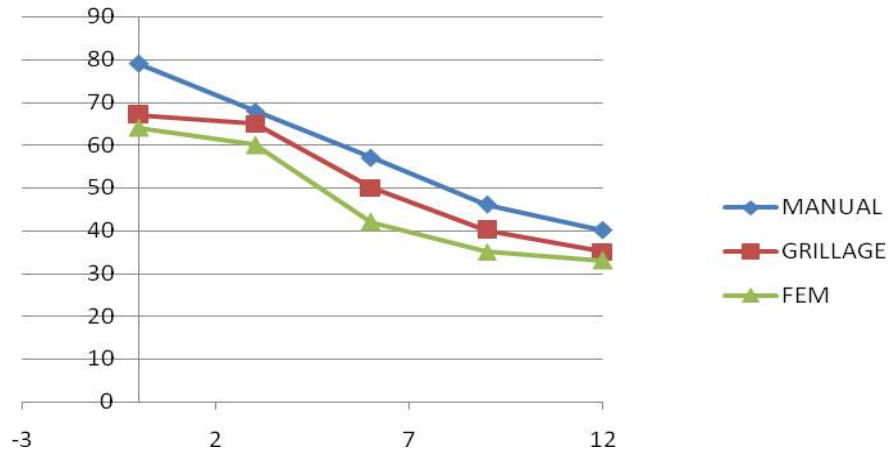


Fig.10 Shear force Diagram for Class 70R Tracked

IV. CONCLUSIONS

- Finite element packages are powerful tools to analyse structures but care should be taken to ensure no errors are introduced anywhere in the process.
- Results of finite element analysis have been found to be compatible with the values obtained from conventional and grillage methods.
- The Finite element models yield the lowest value for bending moment and shear force than the other two methods. Hence it is more economical.
- The grillage method is easy to use and comprehend because of its simplicity and ease of constructing a grillage model but is less accurate.

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