Finite Element Analysis of Different Types of Bridges Considering Vehicle Load as Per IRC Specification

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Abstract— In this research work the finite element method is used for the analysis of three different type of bridges i.e. cable stayed, cable suspension and deck slab bridge of constant width and length is considered. In this study analyze different bridge sections for same loading conditions and sections. The loading class considered is CLASS 70R from IRC 006-2014. A Finite Element model is formulated for this study using Staad beava software package. This model is then analyzed, for parameters like deflection, stress under the influence of moving vehicle load also to discuss the cost effectiveness of each type of bridge. The basis aim for this study is to give the best output for implementation of these results in future working conditions. In this study it is concluded that cable suspension bridge is comparatively more stable whereas cable stayed bridge is economical of all the types of bridge considered and deck Slab Bridge shows worst results overall.

Keywords: Structural Analysis, Bridge, Road Congress, Analysis Tool, Forces, Moment, Deck

I. Introduction

Bridge is an important structure required for the transportation network. Now a day with the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system.

In this research, vehicle load over different types of bridges (cable stayed, deck slab and cable suspension) analyzed using STAAD.Pro software based on finite element method.

The finite element method involves subdividing the actual structure into a suitable number of sub-regions that are called finite elements. The intersection between the elements is called nodal.

This has been considered to analyze the bridge having same IRC loading and span 200m for critical load.

After analyzing these critical loads, the results will be compared in terms of forces, deflection, weight and most importantly cost of each type to determine the most stable and economical section.

YEAR	AUTHORS	WORK & ANALYSIS	FINDINGS
2017	C Neeladharan et. al.	In this paper, All loading and unloading conditions is analysis and design as per codal specifications for Suspension Cable Bridge using SAP2000.	The output of the software presents results including moments, axial loads, shear force and displacements. Moreover, moments and axial load at each node and at any point within the element can be easily obtained from the software output.
2014	Rajesh F. Kale et.al.	In present study optimization technique for R.C.C. T beam girder is presented and explained, similar technique can be implemented to any bridge superstructure in order to economies it.	The cost of bridge superstructures increased rapidly with respect grade of concrete and grade of steel increases whereas cost reduces as the span of bridge shorten, alsoThe cost of girder is directly proportional to grade of concrete.
2014	Mulesh K. Pathak	In this paper, various behaviours like bending, shear, axial & torsion are presented for horizontally curved RCC box bridges considering 3-D FEM using SAP software..	This approach simplifies analysis & the preliminary design of curved bridge section and calculate bending moments, shear forces and axial forces which indicate that box section is having high torsional stiffness and is nonlinearly vary with degree of curvature.

II. Problem Identification

- In all of the previous work presented individual study of all type of bridges. There comparative study of these bridges is missing. It is not clear in past study about stability, force reactions and cost optimization of bridges in comparative way.
- In the work presented by C Neeladharan (2017), only the cable suspension bridges are analyses considering dead and live load using SAP2000.
- In this study we are comparing three different type of bridges to determine the most suitable type of bridge, for analysis and designing purpose staad.pro software is used. In this study we are providing vehicle loading as per IRC class 70R loading specifications and providing same span and geometry in all structures.

A. Objectives:

The main objectives of the present study are as follows:-

- To determine finite element analysis on different types of bridges.
- To determine most effective and stable bridge type.
- To determine the most economical type of bridge In cost comparison.
- To find out the implementation of STAAD. Beava for IRC specification

III. METHODOLOGY

1) Step-1: First step is to prepare a literature survey related to bridge, software implementation, vehicle load and structural analysis.
2) Step-2: second step is to select a geometry and model it in staad.pro.
3) Step-3 To assign section data and material properties.
4) Step-4 To Assign support conditions.
5) Step-5 To assign vehicle loading and hydraulic data as per provided toposheet.
6) Step-6: To perform finite element analysis.
7) Step-7 To prepare comparative result in M.S. excel.
8) Step-8: To design the cases for cost analysis as per S.O.R. 2017.

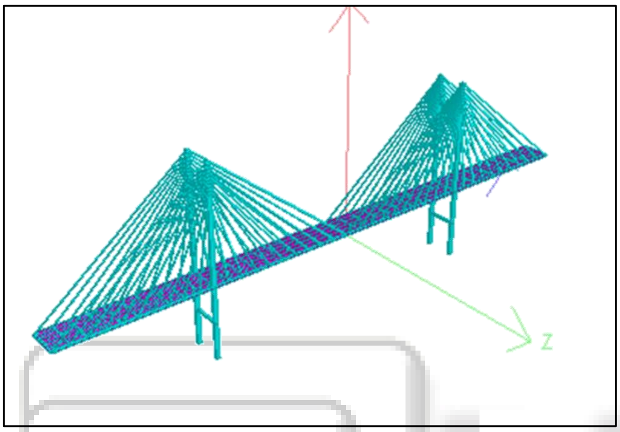

Fig. 1: Case cable stayed bridge

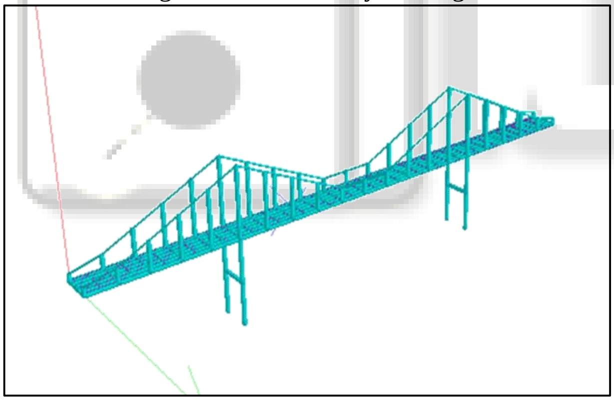

Fig. 2: Case cable suspension bridge

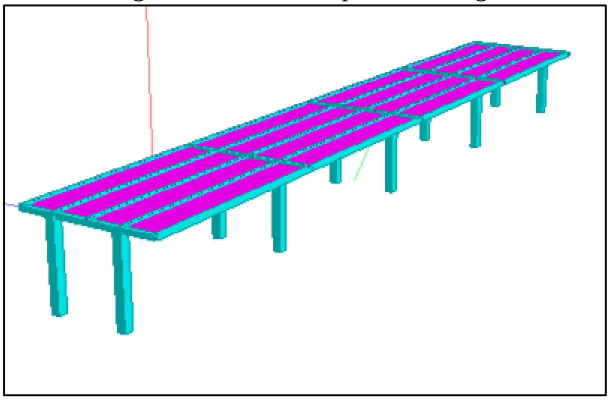

Fig. 3: Case Deck Type Bridge

S.NO	Description	Value
1	Length of Bridge	200 m.
2	Number of bays in X direction	40
3	Spacing bays in X direction	5m
4	Width of the bridge section	10 m
5	Bay width in Z direction	2 m
6	Support type	Pinned support

Table 1: Structure description

IV. ANALYSIS RESULTS & DISCUSSION

BENDING MOMENT IN KN-m		
Deck Slab	Cable Stayed	Cable Suspension
295	215	204.54

Cable suspension bridge shows lesser value of Bending moment as compared to other cases. Results shows that Deck slab bridge having more bending moment as compared to any of the type of bridge. In comparison of all the three cases results shows that cable suspension bridge is showing lesser value which determines that it is more stable and economical.

SHEAR FORCE IN KN		
Deck Slab	Cable Stayed	Cable Suspension
281.952	379.622	317.507

In this table comparative study of maximum sheer force of all bridges, whereas deck Slab Bridge shows minimum shear force value which results in balanced section, therefore maximum unbalanced forces are present in cable stayed bridge for same loading. In comparison of all the cases deck Type Bridge is proven more resistible to unbalance forces.

MAXIMUM DEFLECTION (mm)		
Deck Slab	Cable Stayed	Cable Suspension
7.948	7.666	2.935

In this table determined that deflection is maximum in Deck Slab Bridge whereas minimum in Cable suspension bridge which indicates that Deck bridge will require more supports as compared to other cases. Cable suspension bridge is more stable and economical.

Cost analysis:

S.no.	concrete volume in cu.m	S.O.R rates	Total cost of concrete
Deck slab	802.5	4200	3370500
Cable Stayed	705.695	4200	2963919
Cable suspension	784	4200	3292800

In this table Concrete cost analysis has been done and observed that Deck slab bridge structure will be more costlier In terms of concrete consumption for same loading as compared to other cases whereas Cable stayed bridge will be more economical.

V. CONCLUSION

- As India is a developing country there is a need of economical sections to have a cost effective design to bear same loading in lesser cost.
- Here in our study out of all three cases, cable suspension bridge shows least values for forces, stress and deflection which mean for the same loading it will be more stable and balanced.
- whereas cable stayed bridge is economical as compare to other types of bridge as per less weight of construction

material and deck slab bridge shows worst results overall in terms of forces and material cost.

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