Comparative Analysis of Pretensioned Bridge Girder by Using Fem

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Abstract – Recently prestressing take place at every field in civil engineering one of them is Prestressed Metro girder. Structures are subjected to two types of loading one is static and other dynamic. I- bridge girder are one of the principal type of cast-in-place girder with stressed tendons. The FEM is general method of structural analysis. A simple span I-girder was analyzed by using IRC class AA type loading as a one dimensional structure using FEM method. Analyze same girder as 3-dimentional structural using Finite element plate as beam element for main beam element for main beam using software STAAD pro Vi8.The detailed study is carried out for I-beam box girder and Rectangular box girder for the span 24m under IRC class AA loading condition.

Keywords: I-beam, IRC loading, FEM, STAAD pro vi8.

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1. INTRODUCTION

Bridge is life line of road network; society has always relied on transportation over an obstacle to survive. And in all components of bridge, girders are the supporting members to deck slab. Girder bridges can have the span range of above 20m whereas the conventional bridge span is below that. The bridge deck structural system adopted is influence by factor like economy and complexity in construction. The aim of this paper is to analyze the girder in two different sections having same cross sectional area. The main objective to study this topic is to judge the variation in the results due to changed in cross-sectional area of girder.

In this study, for a post tensioned box girder bridge beam analysis is done for two different cross sections i.e. I- girder and rectangular box girder using finite element method (Staad Pro V8i). This two different cross-sections elements analyzed for IRC loadings cases Class AA tracked loading available from MMRDA (which is used for Mumbai Metro Rail Project for elevated station girders).Girder carries two lanes of metro lines. Bending moment and shear force for two different cross-sections observed.

1.1 Objectives

A comparative study of two different configurations of girders was performed. The loading consider for analysis were loadings cases Class AA tracked loading available from MMRDA (which is used for Mumbai Metro Rail Project for elevated station girders). FEM analysis is done using Staad Pro V8i SS6. In this study the objectives are achieved by following the underlying sequence:

1. Performing FEM analysis on prestressed I girder and Rectangular girder simply supported on pinned supports considering maximum Bending moment, shear force and deflections parameters of comparison.

2. To minimize the total cost in the design process of the bridge system considering the cost of fabrication and installation.

3. To judge the economy of section.

In this paper a comparative study on the behavior of simply supported I prestressed Bridge girder with respect to span of 24m. moments under standard IRC AA type loading. The study is based on the analytical modeling of Bridge girder by Finite Element Method for two different cross-sections.

1.2 Methodology

In this study we followed a particulars sequence in which we first used the cross-sectional dimensions of both box girders. An equivalent load of 9.7 kN/m and 4 kN/m was applied uniformly over the girder. A design thickness of 240mm was used for deck slab. This all information get from MMRDA for study.

We conduct FEM analysis on both configurations under the study and documented the results.

The analysis problem had the following details:

1. Span length (c/c pier) = 24.0 m
2. c/l of bearing from center of pier = 0.30 m
3. Overall width of the deck = 9.06 m
4. Spacing between beams = 3.00 m
5. Thickness of Deck slab = 0.24 m

2. LOADS ACTING ON BRIDGE

1) Dead Load

For general building structures, dead or permanent loading is the gravity loading due to the self weight structure and other items permanently attached to it. It is simply calculated as the product of volume and material density. Superimposed load is the gravity load of non-structural parts of the bridge. Such items are long term but may be changed during the life span of the structure. Thus, such superimposed dead loading is particularly prone to increases during the bridge life span. For this reason, a particularly high load factor is applied to road pavement. Bridges are extraordinary among structures in that a high proportion of the total loading is attributable to dead and superimposed dead load. This is mainly true of long-span bridges.

2) Live loads

Road bridge decks have to be designed to withstand the live loads specified by IRC (Indian Roads Congress i.e. I.R.C: 6-2014) in accordance with the specifications for the different and Various loads as well as stresses are consider in box girder bridge design. There are two types of typical loadings for which the bridges are designed specifically, IRC class A loading and IRC 70R. IRC class 70 R loading consists of either a tracked vehicle or a wheeled vehicle with dimensions and Class A loading consists of a train vehicle composed of a driving vehicle and two trailers of specified axle spacing's. The units in the figure are meters for length and tonnes for load. Normally, bridges on national highways are designed for IRC loadings. Bridges designed for class A should be checked for IRC class 70R loading for assured conditions, larger stresses may be obtained underneath class 70R loading. This loading is usually adopted on all highways on which permanent bridges are constructed.

3) Indian Road Congress bridge loading standards

Highway bridge decks have to be design to withstand the live loads specified by the Indian Roads Congress. The different categories of loadings were the first formulated in 1958 and they have not changed in the subsequent revisions of 1964, 1966 and 2000.

The standard IRC loads specified in IRC: 6-2000 are grouped under four categories are detailed below.

(a) For I.R.C. class AA loading-

Two different types of vehicles are specified under this category grouped as tracked and wheeled vehicles. The IRC Class AA tracked vehicle (simulating an army tank) of 700 kN and a wheeled vehicle (heavy duty army truck) of 400 kN. All the bridges located on National Highways and State Highways have to be designed for this heavy loading. These loadings are also adopted for bridges located within certain specified municipal localities and along specified highways. Alternatively, another type of loading designated as Class 70 R is specified instead of Class AA loading.

(b) IRC Class 70 R Loading-

IRC 70 R loading consists of the following three types of vehicles.

1. Tracked vehicle of total load 700 kN with two tracks each weighing 350 kN.
2. Wheeled vehicle comprising 4 wheels, each with a load of 100 kN totaling 400 kN.
3. Wheeled vehicle with a train of vehicles on seven axles with a total load of 1000 kN.

The tracked vehicle is somewhat similar to that of Class A A, except that the contact length of the track is 4.87 m, the nose to tail length of the vehicle is 7.92

m and the specified minimum spacing between successive vehicles is 30 m. The wheeled vehicle is 15.22 m long and has seven axles with the loads totaling to 1000 kN. The bogie axle type loading with 4 wheels tataling 400 kN is also specified. The details of IRC Class 70 R loading vehicles are shown in fig.

3. LITERATURE REVIEW

Literature available on stated theme can be classified as:

1. Studies dealing with analysis and design of bridge deck system using various combinations of span to depth ratio.

2. Studies dealing with analysis and design skewed box girder bridges.

3. Comparison among limit state method and working stress method.

4. Analysis of T-beam girder and box girder.

1) N. Krishna raju, (Design of Bridges) (4th ed.) et.al:

In Chapter 10th of Design of Bridges book author discuss about prestressed concrete and it's suitability as well as thumb rules like 7 wires strands are advantageous. We get design examples of Tee beam and I girder.

2) Praful N K, (June, 2015) et.al:

In this project report paper a comparative study on the behavior of simply supported RC T-beam Bridge with respect to span moments under standard IRC loading. It presented a comparative study of rectangular and trapezoidal concrete box girder using finite element method. In this study simply supported Tee bridge girder of spans 16m,20m,24m was analyzed for dead load and IRC: class 70R live load using Finite element Software Staad vi8.

3) Dr. Valsson Varghese, (July,2016) et.al:

In this research paper the effect of change in skew angles with normal bridge is studied. Longitudinal moment, shear force, deflection and transverse moment are computed by modeling using STAAD-PRO with IRC loadings and results are compared. Increasing the skew angle result, the planes of maximum stress are perpendicular to the centre line of the roadway and slab tends to twisted. This is an useful paper to compare normal and skew box girder bridge with parameter such as the Deflection, Support Reaction, Transverse Moment and Bending Moment by considering IRC Loading and Load Combination.

4) Mr. Deshmukh C. M.,(March, 2016) et.al:

In these three girders which can be determine which is effective and economical to bridges.Both models are subjected to I.R.C. Loadings to produce maximum bending moment.We know that the finite element method is a numerical method with powerful technique for solution of complicated structural engineering problems. It is mostly accurately predicted the bridge behavior under the truck axle loading. In this paper efforts will make to carry out the to check the strength of bridge by using software i.e STAAD Pro. According to various research papers, it has been found that composite bridge gives the maximum strength in comparison to other bridges.

5) Animesh Dutta.,(October, 2013) et.al:

In this paper is to compare the deformation results of simple and complex structures obtained using these products. The same structures are also analyzed by a MATLAB program to provide a common reference for comparison. STAAD is used by civil engineers to analyze structures like beams and columns.

6) Y. Yadu Priya.,(September 2016)et.al:

In this study a single span two lane t-beam bridge is analyzed by varying the span of 25m, 30m, 35m, 40m where the width is kept constant. The bridge models are subjected to the IRC class AA and IRC 70R tracked loading system in order to obtain maximum bending moment and shear force. From the analysis it is observed that with the increase in the span, shear force and bending moment in the girder increases. It is also observed that the results of bending moments and shear forces obtained from both courbon's method and finite element method have no significant variation. In this study Courbon's method and Staad Pro we analyzed the bridge deck by varying the span of the bridge deck, here I considered 25m, 30m, 35 and 40m spans, here I considered the class AA tracked load which is the worst case for any bridge and also 70R tracked load which gives the average result with respect to BM values in the longitudinal girder as compared to finite element method (STAAD.PRO) and there is significant difference for both methods.

4. FINITE ELEMENT METHOD OF ANALYSIS

FEM is best understood from its practical application, known as finite element analysis (FEA).

FEA as applied in engineering is a computational tool for performing engineering analysis It includes the use of mesh generation techniques for dividing a complex problem into small element, as well as the use of software program coded with FEM algorithm.

FEM is mostly accurately predicted the bridge behavior under the truck axle loading. The finite element method involves 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 and three-dimensional elements to represent the structure. The intersection between the elements is called nodal points in one dimensional problem where in two and three-dimensional problems are called nodal lines and nodal planes respectively. At the nodes, degrees of freedom (which are usually in the form of the nodal displacement and or their derivatives, stresses, or combinations of these) are assigned. Models which use displacements are called displacement models and models based on stresses are called force or equilibrium models, while those based on combinations of both displacements and stresses are called mixed models or hybrid models. Displacements are the most commonly used nodal variables, with most general purpose programs limiting their nodal degree of freedom to just displacements. In this way FEM works.

4.1 Advantages of FEM over classic methods:

1. Solutions obtained by classic methods are applicable only on particulars examples but FEM give universal solution applicable to all.
2. In classical methods if complexity arises like shape, boundary condition, loading then assumptions is assumed but in FEM problem take as it is.
3. FEM can able to handle anisotropic properties without any difficulty.
4. If structure content more than one material FEM is best method for analysis.
5. Problems with geometric non-linearities can be handled in FEM.

4.2 STAAD Model of girders:

For the modeling of the bridge structure STAAD PRO V8i is used. The bridge models are analyzed to conduct a comparative study of post-tensioned beams bridge girders with finite element method. The modeling involves the construction of I girder bridge model with single span. The bridge models are simply supported at the two ends. Staad Pro model has been created and illustrated in the following diagram. Analysis of Staad Model for 24m is shown in as follows:

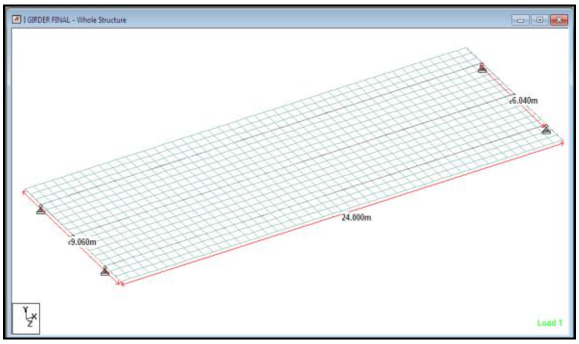

Fig. Grillage model of 3-girder system

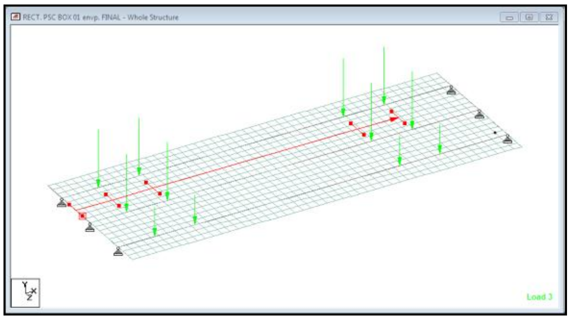

Fig. Both track loaded condition

5. RESULT AND DISCUSSION

The results are presented in the form of table.

Table: Comparison of results Obtained from FEM analysis by Staad Pro for Rectangular Box girder and I- girder.

Type of Girder	DEAD LOAD		LIVE LOAD		LOAD COMBINATION		
	SF (kN)	BM (kN.m)	SF (kN)	BM (kN.m)	SF (kN)	BM (kN.m)	DEFLECTION (mm)
END GIRDER :							
RECT. BOX	240	1438	164	986	606	3636	**167.09**
I - GIRDER	239	1435	164	986	605	3662	**60.98**
MIDDLE GIRDER :							
RECT. BOX	240	3442	164	928	606	**6555**	**328.04**
I - GIRDER	239	3615	164	964	605	**6869**	**126.21**

Parametric study is carried out on two lane metro bridge and bending moment, shear force, deflection values where arrive at by Finite element method i.e. staad pro for Class AA tracked vehicle. The values obtained from this comparative study are present in the tables and graphs.

1) Maximum BM occurs for dead load. Hence dead load case is the most critical for maximum BM in longitudinal girder.

2) Maximum SF occurs for dead load. Hence dead load case is the most critical case for maximum Shear force in longitudinal girder.

3) Use of load combinations to find maximum BM, SF and deflection and there is no very much variations in the values of bending moment and shear force.

4) There is 63.50% more deflection in the end rectangular box girder than I-shaped box girder.

5) There is 59.02% more deflection in the middle rectangular box girder than I-shaped box girder

6. CONCLUSION

The comparative study was conducted based on the analytical modeling of simply supported beam bridge girder by Finite element method using Staad Pro. In this study we analyzed the bridge girder by using the different cross-sections, here I considered 24m, here I considered the class AA tracked loading available from MMRDA (which is used for Mumbai Metro Rail Project for elevated station girders) which gives the average result with respect to BM values in the longitudinal girder. The design details can also be known clearly by finite element method of STAAD.PRO. Further we can check for different load combinations in STAAD.PRO. We get the results which shows that deflection occurs in I-shaped box girder is very less (i.e.63.5% less) as compare to deflection occured in rectangular box girder.

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