

# Transverse Analysis on PSC Box Girder Bridge

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**ABSTRACT:** Bridges are the key elements in any road network. Bridges are nation's lifelines and backbones in the event of war. Bridges symbolize ideals and aspirations of humanity. They span barriers that divide, bring people, communities and nations into closer proximity. They shorten distances, speed transportation and facilitate commerce. Use of prestress box girder type bridges gaining popularity in bridge engineering fraternity because of its better stability, serviceability, economy, aesthetic appearance and structural efficiency.

In this project, a Box Girder Bridge made up of prestressed concrete which is analyzed for moving loads as per Indian Road Congress (IRC:6) recommendations and code of practice for concrete bridges (IRC:112) specifications. The analysis of box girder is to be performed by using CSI Bridge Wizard. The various types of response are plotted, discussed and results are tabulated.

**KEYWORDS:** Box girder bridge, Prestressed Concrete, IRC loading, CSI Bridge

## I. INTRODUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it. Bridge construction today has achieved a worldwide level of importance. Bridges are the key elements in any road network and use of prestress girder type bridges gaining popularity in bridge engineering fraternity because of its better stability, serviceability, economy, aesthetic appearance and structural efficiency. Bridges are nation's lifelines and backbones in the event of war. They span barriers that divide, bring people, communities and nations into closer proximity. They shorten distances, speed transportation and facilitate commerce. Bridge construction constitutes an importance element in communication and is an important factor in progress of civilization, bridges stand as tributes to the work of civil engineers.

### Basics of prestressing

Prestressed concrete is ideally suited for the construction of medium and long span bridges. Prestressing is the application of an initial load on a structure, to enable it to counteract the stresses arising from subsequent loads during its service period. Prestressing has been practiced from ancient times the behaviour of spokes of the bicycle when it is loaded, is also example of prestressing. Prestressed concrete is basically a concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to desired degree. In reinforced concrete members, the prestress is commonly the steel reinforcement.

Box girders are more suitable for larger spans and wider decks. They are elegant and slender. Economy and aesthetics further lead to evolution of cantilevers in top flanges and inclined webs in external cells of box girder. The dimension of cell could be controlled by prestressing. The box girder normally comprises either prestressed concrete,

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structural steel, or a composite of steel and reinforced concrete. It typically rectangular or trapezoidal in cross section. Fig. 1.1 and Fig.1.2 shows the cross section of rectangular and trapezoidal box girder bridge respectively.

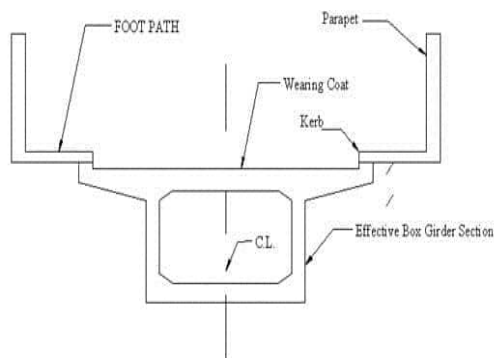


Fig. 1.1 Cross section of rectangular box girder

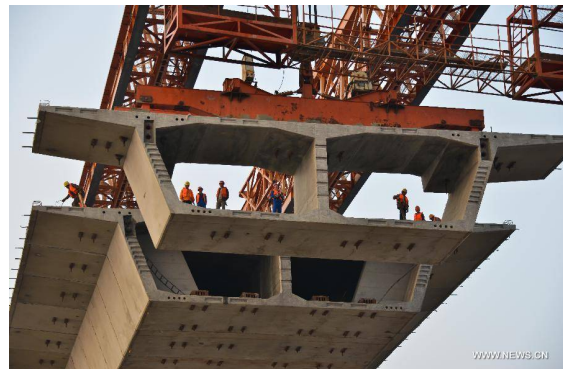


Fig. 1.2 Cross section of precast trapezoidal box girder

## Advantages of box girder

The box girder often is more advantageous than t-beam due to its high bending stiffness combined with a low dead load, yielding a favorable ratio of dead load to live load. Its high torsional stiffness which allows freedom in the selection of both the supports and bridge alignment.

- In case of long span bridges, large width of deck is available to accommodate prestressing cables at bottom flange level. The maintenance of box girder is easier in interior space is directly accessible without use of scaffolding.
- It has high structural efficiency which minimizes the prestressing force required to resist a given bending moment, and its great torsional strength with the capacity this gives to re-center eccentric live loads, minimizing the prestress required to carry them.

## II. LITERATURE SURVEY

The scope of the review is to get an overview of various studies done so far related to the topic of box girder bridges. The main purpose is to get an idea of work already carried out and to form the basis for formulating objectives and methodology in this design.

1. ALI R. KHALOO AND M. KAFIMOSAVI (Sept.2007): has studied the flexure behavior of curved prestressed box bridge by using finite modeling models and analysis. From result it is proposed that the distribution of tendons across the width should be varying for optimizing the bridge capacity. Also it is concluded that the reduction in resultant stress is possible because of prestressing.
2. P.R. BHIVGADE: In her study, a two lane simply supported Box Girder Bridge made up of prestressed concrete which is analysis for moving loads as per Indian Road Congress recommendations, Prestressed Code and also as per IRC: 18 specifications. The analyzed of box girder using SAP 2000 14 Bridge Wizard and prestressed with parabolic tendons in which utilize full section.
3. SUREN CHEN et al (2014): has analyzed comprehensive performance on eight bridge configurations of various degrees of skew and curvature with low to moderate seismic excitations which are characteristics of mountain west region. The result of this paper gives the impact on seismic performance due to the effect of skew and curvature with combined geometries.

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4. HARDIK R. TRIVEDI (2014): In this paper reports to understanding of how to make the design process somewhat easy by providing automatization with the use of the programming languages. And he conclude that most economical and safe section can be achieved by taking numbers of trials with minimum of time.
5. PHANI KUMAR.CH et al (2016): Carried out research on analysis and design of prestressed concrete bridges (Deck Slab, T-Girder and Box Girder) are carried out using IRC:112-2011. The unified concrete code (IRC:112) published by the Indian Road Congress in November 2011 combining the code for reinforced concrete and prestressed concrete structures represents a new generation code, which is significantly different as compared to previous codes (i.e. IRC:21 for RCC structures and IRC:18 for PSC structures).
6. J. RIMAL et.al. (2002): worked on the thermal behaviour of a Composite Box-girder Railway Bridge, The behaviour of a composite box-girder railway bridge subject to environmental thermal effect such as solar radiation, air temperature and wind speed, was presented. The temperature measure of temperatures was performed on the railway bridge in KralovskePorici.

### III. METHODOLOGY

The prestressed concrete box girder bridge is analyzed in this project by using a software. The software using in this project is CSI Bridge. The various inputs required were taken from the IS codes for the modeling of prestressed box girder bridge and the trial section is taken from the Public Works Department, Trivandrum. The fig. 3.1 shows the typical schematic diagram for methodology.

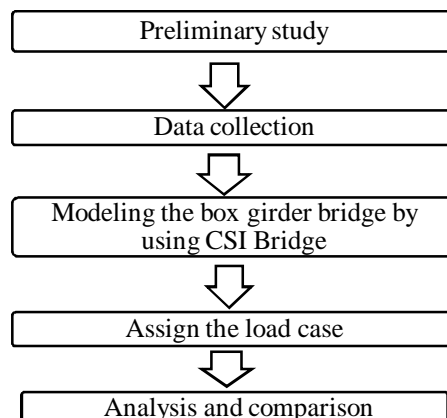


Fig 3.1 schematic diagram of methodology

### IV. GEOMETRY AND PROPERTIES

The prestressed box girder bridge of 50 m clear span and width of carriage way 11 m is considered. The overhang face of the girder is 1.7 m and deck slab thickness is 0.25 m. Bottom slab thickness and girder thickness is 0.6 m. The thickness of wearing coat is 80 mm. Material properties used are M40 grade of concrete and Fe415 grade steel. The tendon profile considered is parabolic in nature. The cross section of box girder, cross section properties and the material properties are shown in fig 4.1, fig 4.2 and fig 4.3 respectively.

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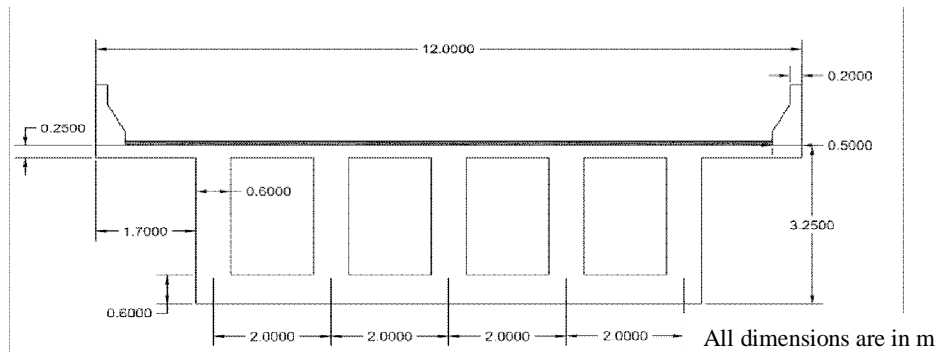


Fig 4.1 cross section of box girder

Table 4.1 Cross section properties of box girder bridge

span	Width	Area	$I_{xx}$	$Z_{top}$	$Z_{bot}$
50 m	12 m	15.36 m <sup>2</sup>	19.58 m <sup>4</sup>	13.59 m <sup>3</sup>	10.81 m <sup>3</sup>

Table 4.2 Properties of Materials

Properties	Value
Concrete grade(M40)	
Characteristic strength, fck	40 Mpa
Young's modulus, Ec	5000√40 Mpa
Density of concrete	25 kN/m <sup>3</sup>
Steel reinforcing bar (Fe 415)	
Yield stress, fy	415 MPa
Ultimate tensile strength, fu	485 MPa

## V. MODELLING AND ANALYSIS

### Modelling

Modelling is carried out using CSI-Bridge 2017 (Structural Analysis Programming) software of version 17.2.0 this software is basically finite element method software and Finite element method is the most versatile method, which can easily handle structures of complicated shapes, and boundary conditions. It involves subdivision of the whole structure into number of small elements. Before modelling all the parameters of box girder structure has to be decided based on

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the IRC standards. In modelling of box girder, main parameter is input of the sizes of box girder and its supporting property and after assigning section property parameter next step part is loading part where lane justification live load application and super imposed dead load application on box girder, different live load application is done to get worst case of live load.

### Analysis

In this case, as per IRC, one 70R loading and class A or 3 class A whichever is maximum, will govern the live loading, once all loading is done analysis proceeds as per standard practice. Fig 5.1 shows full view of box girder as a wire mesh model and fig 5.2 shows the 3D view of box girder.

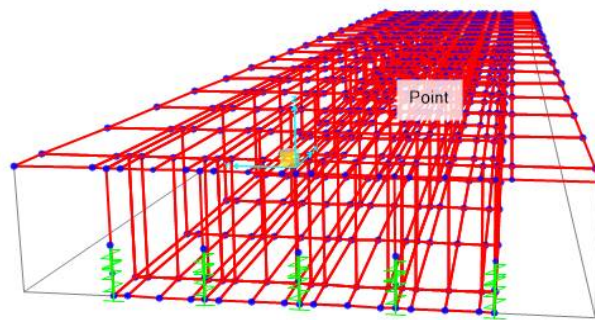


Fig 5.1 Frame element of multy cell box girder bridge

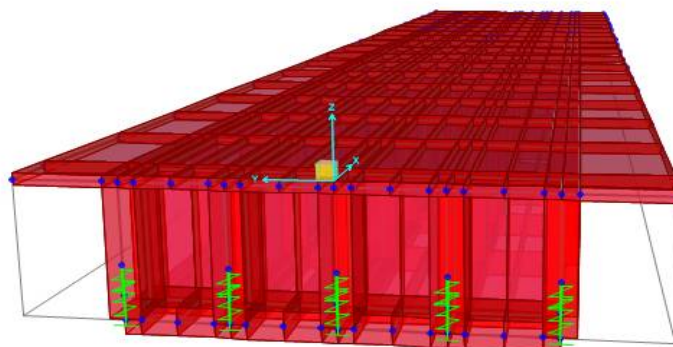


Fig 5.2 3dimensional view of box girder bridge

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## VI. RESULT AND DISCUSSION

### Bending Moment And Shear Force

Variation of bending moment and shear force in full span is shown in fig 6.1, 6.2, 6.3, 6.4 respectively and the values of bending moment and shear force are tabulated in table 6.1 and 6.2. For dead load the bending moment and shear force value will be more, the box girder is analysed as a simply supported and maximum moments will be at midspan and there will be negative moments at supports and maximum shear force at support and there will be minimum shear force at midspan.

Table 6.1 Total Midspan Bending Moment (tm)

DL BM	Mg	12638
LL BM	Mq	3466
TOTAL	(Mg+Mq)	16105

Table 6.2 Total Shear force (KN)

DL	10202
LL	2745
TOTAL	12947

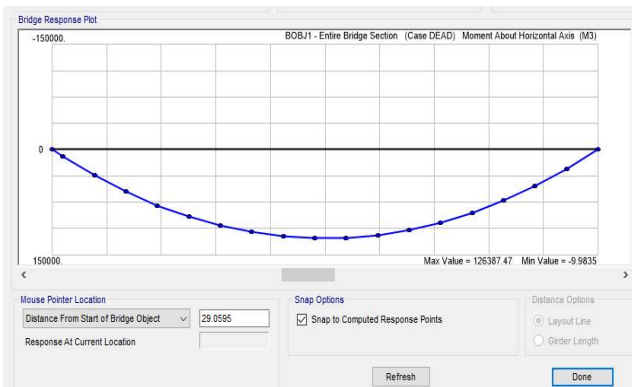


Fig 6.1 Dead load Bending moment

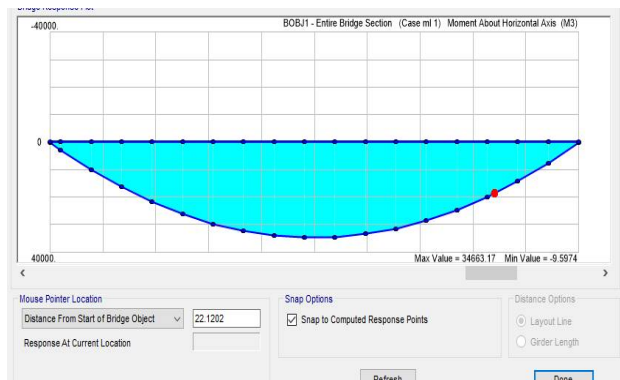


Fig 6.2 Live load Bending moment



Fig 6.3 Dead load Shear force

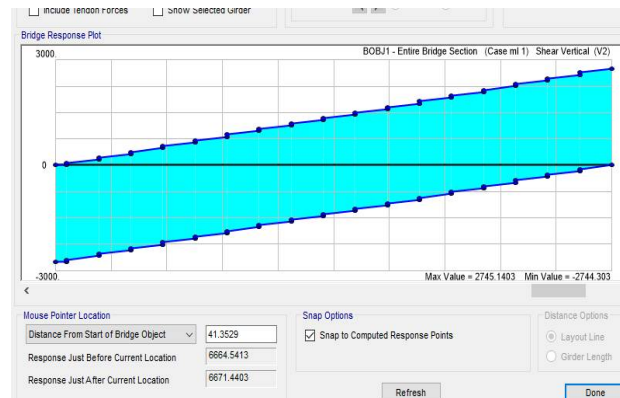


Fig6.4 Live load Shear force



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## Deflection At Midspan

Deflection check is done for the centre of the span which is critical, the net downward deflection is 49.8 mm and net upward deflection due to PSC is 32.2 mm and resultant will be 17.6mm downward which is within the limits as per IRC standards( $L/800=62.5\text{mm}$ ) and which is within the limit of 62.5mm.

## VII. CONCLUSION

1. Finite Element Analysis of Box Girder from CSI Bridge modeler software is found to be more effective.
2. For Dead load, the bending moment and shear force is maximum compare to other loadings.
3. Under the live load analysis, one lane of IRC 70 R and Class A is found to be more critical than 3 lane of Class A.
4. It is found that the deflection obtained due to various loading conditions is well within permissible limits as per IRC. The maximum vertical deflection is found to occur near mid-span location of the girder.

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