International Journal of Scientific & Engineering Research, Volume 6, Issue 12, December-2015
ISSN 2229-5518

Comparison of Rectangular and Trapezoidal sections of Post Tensioned Box Girder

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Abstract *:* The typical sections of box girder normally used are rectangular and trapezoidal. As compared to the rectangular box girder trapezoidal box girder has simple geometry and do not have sophisticate in construction.

This study deals with analysis and comparison of both sections of box girder and to shed light over the advantages of trapezoidal section. The objective of this paper is to analyze the rectangular and trapezoidal section for same span, loading and dimensional properties and compare both sections.

Key words : Girder, longitudinal, torsional, transverse.

INTRODUCTION

A box girder bridge is a bridge in which the main beams comprise girders in the shape a hollow box. Now a day box girder bridges are commonly used for highway flyovers and modern elevated structures of light rail transport because of its high torsional stiffness and strength as compared to an equivalent member of open cross section. It has gained wide acceptance in freeway and bridge systems due to its structural efficiency, better stability, serviceability and economy of construction. Maintenance of box girder can be easier, because the interior space can be made directly accessible.

There are two sections of box girder commonly used, rectangular and trapezoidal sections. In place of rectangular section if we talk about trapezoidal section, geometry is simple and do not have sophisticate in construction.

The purpose of this study is to focus over the advantages of trapezoidal section with respect to the structural efficiency over the rectangular section of box girder.

LITERATURE REVIEW

The study of detailed literature survey gives us an idea regarding different methodologies adopted for analysis and design of prestressed concrete box girders. Vishal U. Misal 2014 has mentioned in his paper that, ‘the box girder is costlier than I girder. It has also seen that losses are more in prestressed concrete I girder as compared to the prestressed concrete box girder’. Amit Saxena has done a comparative study of analysis and design of T-beam girder box girder in May 2013and he has mentioned that, ‘the T-beam girder has more moment carrying capacity and shear stress resistant than that of box girder for 25m span as well as the T-beam girder is more economical than the box girder.’ John R. Fowler 2007 has studied that, ‘the prestressed trapezoidal sections of girder bridge has becomes popular because of its more strength and pleasing appearance as compared to other sections of girder bridge.’

LOADING ON GIRDER

Dead load

The dead load carried by the girder or the member consists of its own weight and the portions of the weight of the superstructure and any fixed loads supported by the member. Dead load on girder = Dead weight of deck slab+ Dead weight of wearing coat + Self weight of girder.

Live load

Width of span for both sections is taken as 10.5m, the width of two lane carriageway shall be 7.5m as per clause 112.1 of IRC:5-1998. The Live Load is assumed as per IRC: 6-2000 vehicle is passing over deck. As per IRC:6-2000 live load combination for one lane of class 70R and for one lane of class A type loading are considered for this analysis.

Dead load bending moment

Dead load bending moment $M_g = W_d x\ l_e^2/8$
Where, W_d is total dead load and l_e is length of effective span.

Live load bending moment

The bending moment due to live load will be maximum for IRC class AA tracked vehicle. Impact factor for the class AA tracked vehicle is 25 percent for the 5m span, which decreases linearly to 10 per cent up to span 40m

Impact factor = 10 percent for a for all spans.

Impact factor = 10x effective span/100

The tracked vehicle is placed symmetrically on the span.

Effective length of load l = (3.6 + 2(overall depth of deck slab + thickness of wearing coat))

Effective width of the slab perpendicular to the span is expressed as,

$b_e = k\ (1 - X/L) + b_w$

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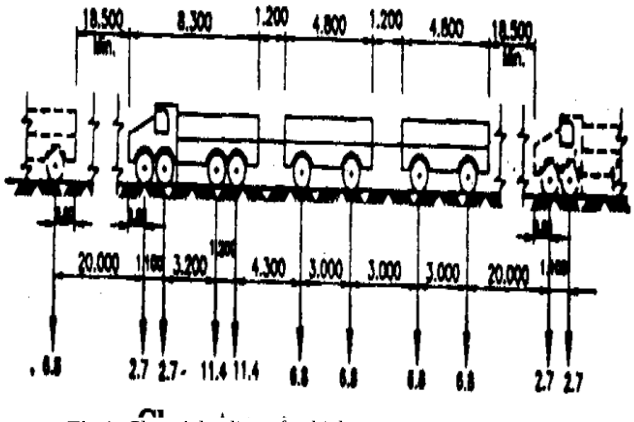

Fig 1: Class A loading of vehicle

PROPERTIES OF BOX GIRDER

Thickness of web

The thickness of the web shall not be less than d/36 plus twice the clear cover to the reinforcement plus diameter of the duct hole where'd' is the overall depth of the box girder measured from the top of the deck slab to the bottom of the soffit or 200 mm plus the diameter of duct holes, whichever is greater.
Thickness of web = Clear cover + diameter of duct hole + clear cover = 75 + 100 + 75 = 250mm ~ 300mm

Thickness of bottom flange

The thickness of the bottom flange of box girder shall be not less than 1/20th of the clear web spacing at the junction with bottom flange or 200 mm whichever is more. Thickness of bottom flange =500/20=250mm ~ 300mm

Thickness of top flange

The minimum thickness of the deck slab including that at cantilever tips be 200 mm. For top and bottom flange having prestressing cables, the thickness of such flange shall not be less than 150 mm plus diameter of duct hole. Thickness of top flange = 150+100=250mm

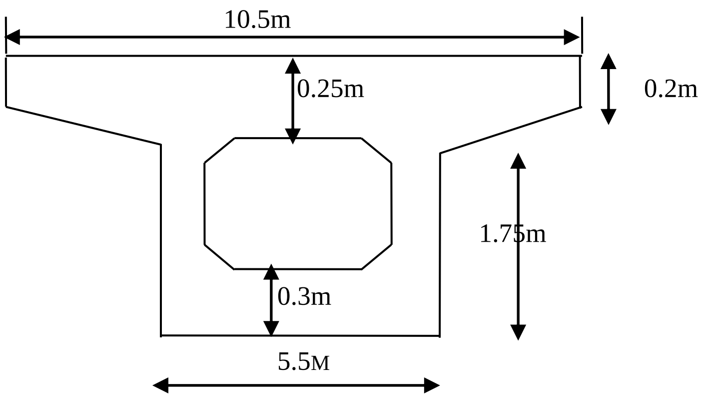

FIG 2: TYPICAL CROSS SECTION OF RECTANGULAR SECTION

LONGITUDINAL ANALYSIS

The analysis of box girder is done along the longitudinal section for 20m span of rectangular and trapezoidal sections. Width of span for both sections is taken as 10.5m; overall thickness of span and thickness of wearing coat are also taken same for both sections. Footpath width is kept as 1.5m and carriage way width is 7.5m. As per IRC:6-2000 live load combination for one lane of class 70R and for one lane of class A type loading are considered for this analysis.

The results of longitudinal analysis of SIDL, Class 70R loading and Class A type loading for both sections are nearby equal, but in case the shear force and bending moment due to dead load for rectangular section are slightly greater than that of trapezoidal section. The average shear force developed in rectangular section is 9.07% greater than that of trapezoidal section. The rectangular section of box girder is subjected to maximum shear force of 1380.382kN due to dead load but the value of maximum shear force in trapezoidal section is 1374.67kN.

Bending moment due to dead load for rectangular section is 7.65% greater than that of trapezoidal section. In case of rectangular section the maximum bending moment is 5768.664kN.m and that in trapezoidal section is 5213.034 kN.m.

TRANSVERSE ANALYSIS

Transverse analysis is carried out along the transverse section of girder. The torsional moment of box girder is resisted by the shear stresses on the components that make up the girder cross-section. Mostly in transverse analysis it has been observed that the torsional moment is nearby equal or less than 20% of bending moment along the longitudinal section up to 40m span of girder. For the span greater than 40m the torsional moment may be much more than 20% of bending moment. Therefore during the transverse analysis of span equal or less than 40m the torsional moment is taken as 20% of bending moment along the longitudinal section.

The difference between torsional moment in transverse analysis of rectangular section and trapezoidal section is same as difference in bending moment along the longitudinal section.

RESULT

The maximum shear force developed in rectangular box girder is 1380. 382kN and in trapezoidal section is 1374.67kN. Following table shows the shear forces developed in both sections at various distances from bearing.

Table 1: Difference in Shear force in kN of both sections

Distance from bearing	Shear force in kN Rectangular section	Shear force in kN Trapezoidal section
1m	1188.161	1126.372
2m	1023.529	878.072
5m	546.819	475.904
7.5m	195.39	178.464
10m	130.26	118.976

The maximum bending moment developed in rectangular box girder is 5768.664kN.m and in trapezoidal section is 5213.034kN.m. Following table shows the bending moments developed in both sections at various distances from bearing.

Table 2: Difference in bending moment in kN.m of both sections

Distance from bearing	Bending moment in kN.m Rectangular section	Bending moment in kN.m Trapezoidal section
1m	1263.069	1239.349
2m	2368.914	2241.571
5m	4707.25	4261.226
7.5m	5622.122	5079.186
10m	5153.546	5703.534

CONCLUSION

According to this analysis the trapezoidal section of box girder is subjected to less shear force and bending moment than that of rectangular section for same loading, span and dimensional properties due to its geometry. Torsional moment developed in trapezoidal section is also less as compared to that of rectangular section.

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