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Parametric Study on Behaviour of Box Girder Bridges with Different Shape Based On Torsion

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Abstract--- The present study focus on the behaviour of box Girder Bridge with different shape by keeping the span length constant. The bridge is modelled and analysed in SAP Bridge 2000 version 14. The cross section of the superstructure of the box girder bridge is in form of a single cell box. The curvature of the bridges varies only in horizontal direction. All the models are subjected to dead load and super imposed dead load, prestressed load and moving load of IRC class A tracked vehicle. Static analyses under different loading conditions are performed. From this study it is concluded that the trapezoidal section is superior to circular and rectangular section.
Keywords--- Box girder bridge, Radius of curvature, Torsion, Longitudinal bending stress, SAP Bridge.

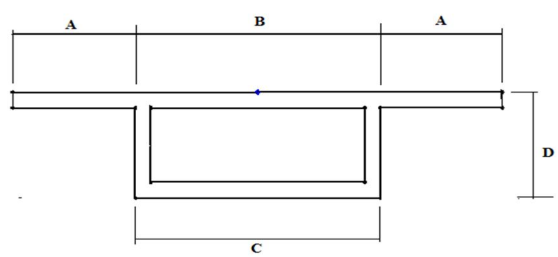
I. INTRODUCTION

A box girder bridge is a bridge in which the main beams comprise girders in the shape of a hollow box. The box girder normally comprises of either prestressed concrete, structural steel, or a composite of steel and reinforced concrete. The box is typically rectangular, trapezoidal or circular in cross-section. Box girder bridges are commonly used for highway flyovers and for modern elevated structures of light rail transport.

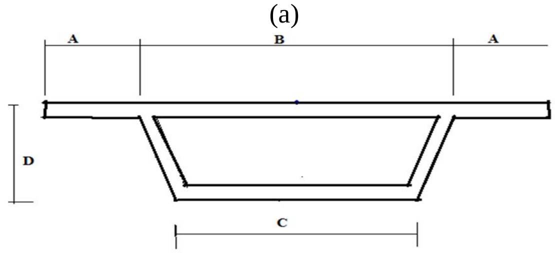
A box girder is particularly well suited for use in curved bridge systems due to its high torsional rigidity resulting in better transverse load distribution. High torsional rigidity enables box girders to effectively resist the torsional deformations encountered in curved thin-walled beams. Analysis and design of box-girder bridges are very complex due to its three dimensional behaviours consisting of torsion, and bending in longitudinal and transverse directions. Analysis and design of the box girder can be divided into two parts i.e. longitudinal analysis and transverse analysis. In each analysis method, the three-dimensional bridge structure is modelled by means of assumptions in the geometry, materials and the relationship between its components. The accuracy of analysis depends on the assumptions taken for bridge structure.

II. PROBLEM DEFINITION

In this study mainly three types of box girder are used for analysis namely Trapezoidal, Rectangular and Circular. The details of the crossection are shown in figure 1 and table 1.



(a)



(b)

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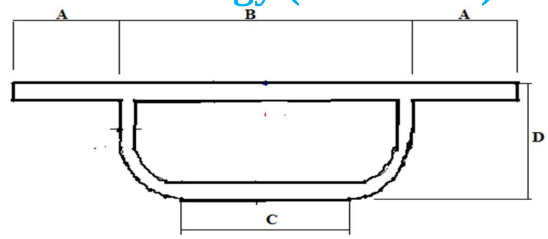

(c)

Fig.1 (a) Rectangular (b) Trapezoidal (c) Circular

TABLE: 1

GEOMETRIES OF BRIDGES USED FOR STUDY

Depth (m)	Rectangular			Trapezoidal			Circular		
D	A	B	C	A	B	C	A	B	C
2	3.2	5.6	5.6	2.6	6.7	4.5	2.2	6.6	4.3

The analysis of bridge is done for constant span of 70m having all the three models with same cross sectional area. The depth is made constant. The only changing parameter is the horizontal radii of curvature from R=∞, R=75m, R=90m, R=100m, R=150m, R=200m, R=250m, R=300m, R=400m, R=500m.

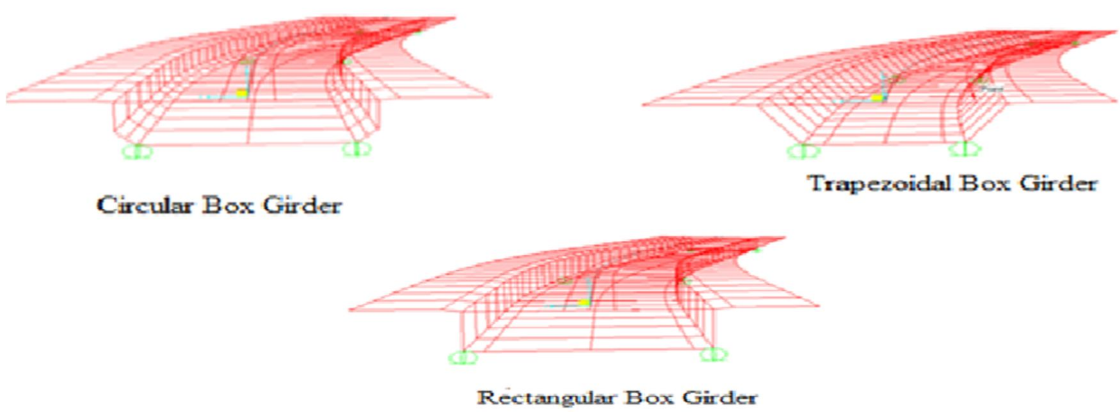

Fig. 2 Curved Box Girders Modelled in SAP Bridge

A graphical comparison of these box girder bridges of different cross sectional shape was studied in terms of torsion. The results obtained for various cross sections of the bridge are compared for different loading configurations, dead load and super imposed dead load (DL+SIDL), moving load of I.R.C Class A Tracked vehicle (ML) and prestressed load.

III. METHODOLOGY

A. Thirty models (ten of trapezoidal crossection, ten of rectangular crossection & ten of circular crossection) with same cross sectional details and different radii are also modelled in SAP Bridge software. Thus one straight and nine curved box girders (with constant span length, cross section and material properties but different radii) are modelled for three shapes in total are considered in the present investigation.

B. All the thirty models are subjected to dead load superimposed dead load, moving load (3 lanes of IRC Class A tracked vehicle) and prestressed load.

C. A static analysis for dead load, moving load and prestressed load are performed. The torsion under all loading conditions is recorded.

D. The responses of a box girder straight and curved in plan and are compared.

IV. RESULTS & DISCUSSION

A straight box girder and horizontally curved box girders of trapezoidal, rectangular & circular shape are modelled for different radii from R=75m, R=90m, R=100m, R=150m, R=200m, R=250m, R=300m, R=400m, R=500m are analysed and the graphs for torsion of straight and curved box girders under different load combinations are presented.

A. Torsion Under Dead Load & Super Imposed Dead Load

Torsion is recorded along the span of the box girder of different cross sectional shape under dead load and superimposed dead load(DL & SIDL), prestressed load and IRC Class A tracked vehicle load. Torsion under dead load and superimposed dead load is least for trapezoidal cross section both in case of both straight and curved box girder bridges. The variation of torsion with change in shape for straight and curved box girder bridges under dead load and superimposed dead load are shown in graphs & table below.

TABLE: 2

VARIATION OF TORSION UNDER DL + SIDL

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R = ∞	0	0	0
R=500	204	199	146
R=400	255	225	198
R=300	260	242	206
R=250	367	273	231
R=200	542	427	256
R=150	547	468	449
R=100	769	589	538
R=90	781	659	550
R=75	803	705	656

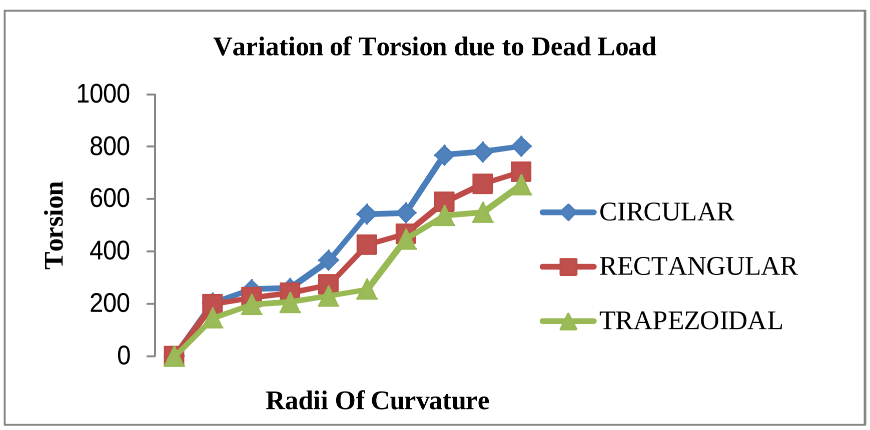

Fig 6: Variation of Torsion under DL + SIDL

B. Variation Of Torsion Under Prestress Load

Under prestressed load maximum torsion is least for trapezoidal cross section both in case of both straight and curved box girder bridges. The variations of torsion with change in shape for straight and curved box girder bridges under prestressed load are shown graphs & Table below.

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TABLE: 6

VARIATION OF TORSION DUE TO PRESTRESS LOAD

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R = ∞	0	0	0
R=500	173	133	27
R=400	234	202	150
R=300	389	252	217
R=250	843	545	252
R=200	1272	545	260
R=150	1694	590	458
R=100	2511	702	598
R=90	2542	1294	872
R=75	2851	2427	1819

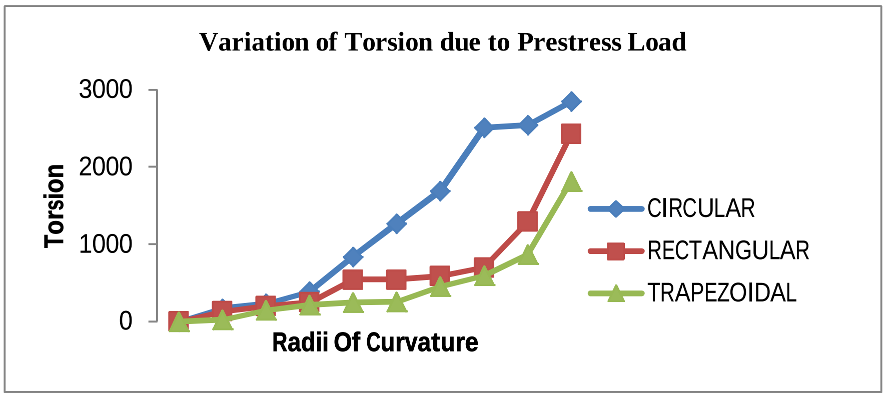

Fig :7 Variation of Torsion due to Prestress Load

Thus it is clear from the graph that trapezoidal cross section has the least torsion under prestressed load for both straight box Girder Bridge and nine other curved box girder bridges of different radius of curvatures.

C. Variation Of Torsion Under Moving Load

Maximum torsion under moving load (IRC Class A tracked vehicle) is least for trapezoidal cross section both in case of straight and curved box girder bridges.

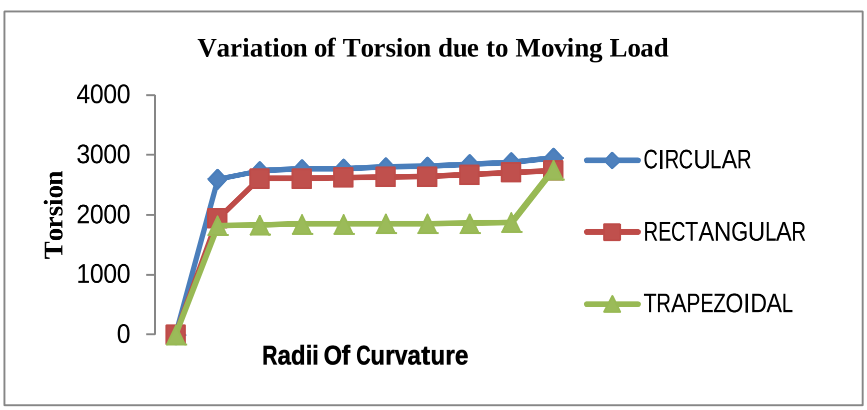

Fig :8 Variation Of Torsion Due To Moving Load

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TABLE: 7

VARIATION OF TORSION DUE TO MOVING LOAD

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R = ∞	0	0	0
R=500	2599	1940	1824
R=400	2736	2604	1833
R=300	2768	2607	1846
R=250	2771	2624	1848
R=200	2800	2631	1854
R=150	2810	2641	1855
R=100	2845	2673	1859
R=90	2878	2707	1873
R=75	2955	2738	2756

Thus it is clear that trapezoidal cross section has the least torsion under moving load for both straight box Girder Bridge and nine other curved box girder bridges of different radius of curvatures.

V. CONCLUSIONS

The analysis of straight box girder and curved box girders of different radius of curvature with different shape are carried out in SAP Bridge software. The results presented in this paper highlight the effects of shape with variation in radii of curvature for the box girder on the behaviour in terms of development of torsion. The conclusions that are drawn from the analysis of box girders of different shape are as follows.

A. Among rectangular, circular and trapezoidal box girders of all radii, the torsion is maximum for circular box girders and least for trapezoidal box girders.

B. The trapezoidal section is the stiffest section and the most stable among the three sections.

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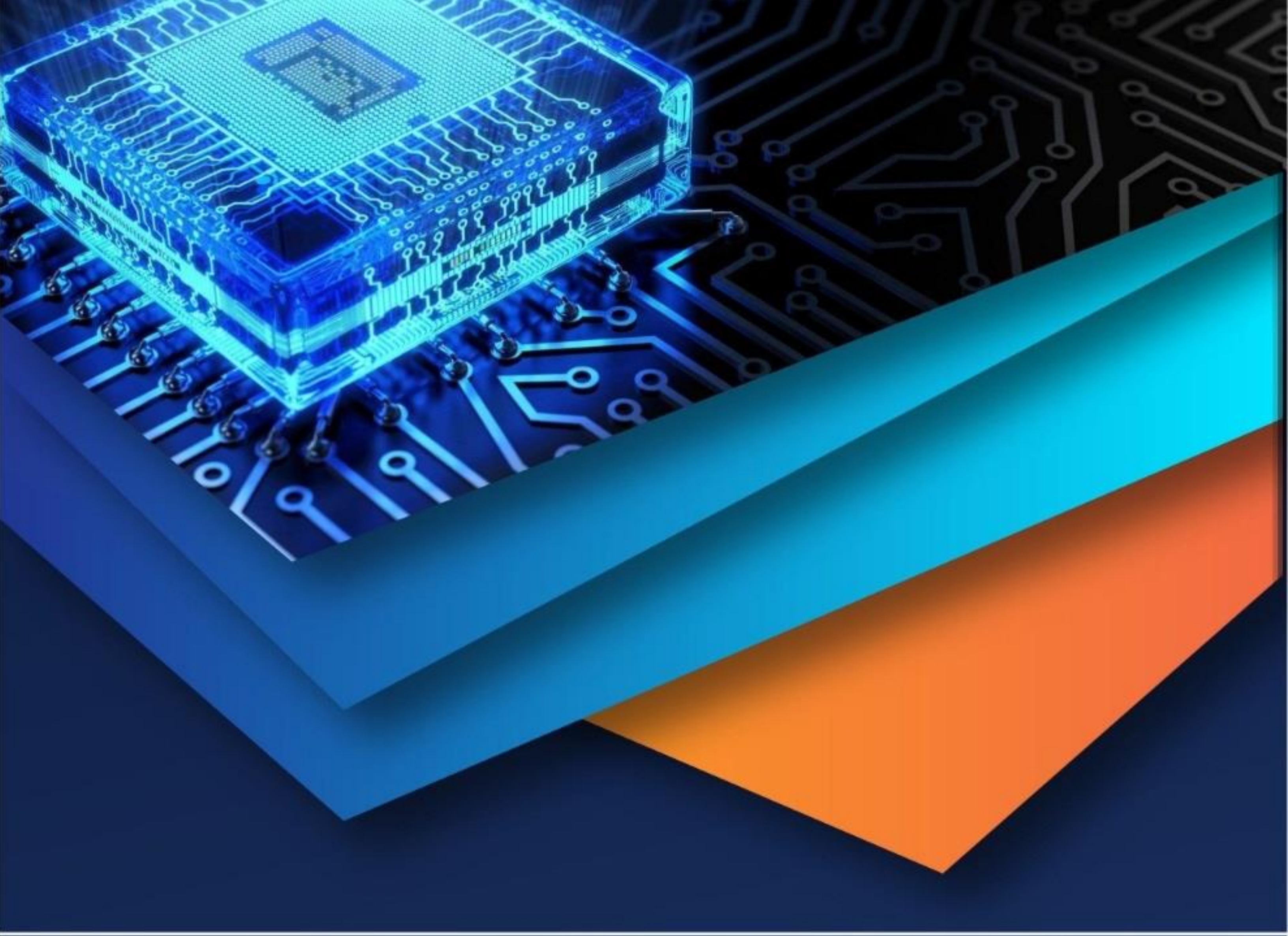

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