COMPARISON ON BEHAVIOUR OF BOX GIRDER BRIDGES WITH DIFFERENT SHAPE

Karthika Santhosh[1], Prof. P Asha Varma[2]

[1]PG Student, Department of Civil Engineering, NSS College of Engineering, Palakkad, Kerala, India

[2]Professor, Department of Civil Engineering, NSS College of Engineering, Palakkad, Kerala, India

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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.*

***Key Words*: Box girder bridge, Radius of curvature, Torsion, Longitudinal bending stress, SAP Bridge.**

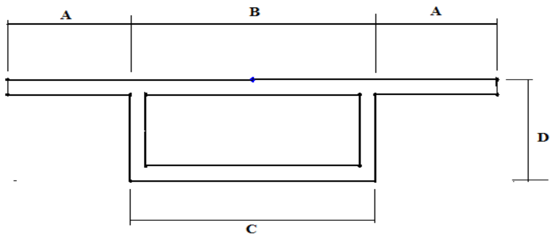
1. INTRODUCTION

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.

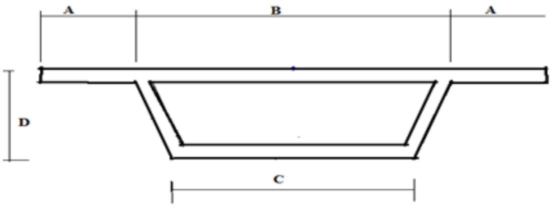
A box girder is particularly well suited for use in curved bridge systems due to its high torsional rigidity resulting in better transverse load distribution. High torsional rigidity enables box girders to effectively resist the torsional deformations encountered in curved thin-walled beams. Analysis 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.

2) PROBLEM DEFINITION

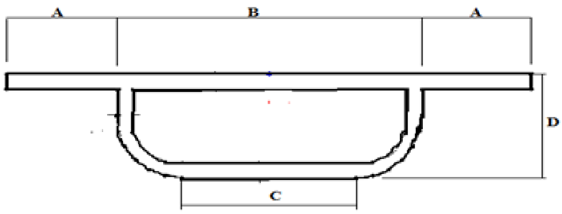
In this study mainly three types of box girder are used for analysis namely Trapezoidal, Rectangular and Circular. The details of the crossection are shown in figure 1 and table 1.



(a)



(b)



(c)

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

Table - 1 Geometries of Bridges Used For Study

Dimensions of Box Girder Bridge Used for Modelling									
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.

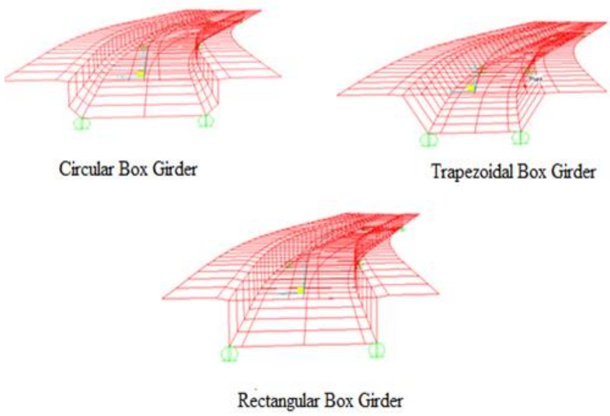


Fig - 2 Curved Box Girders Modelled in SAP Bridge

A graphical comparison of these box girder bridges of different cross sectional shape was studied in terms of vertical deflection, bending moment and 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.

3) METHODOLOGY

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.

- 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.

- A static analysis for dead load, moving load and prestressed load are performed. The bending moment, torsion, and deflection under all loading conditions, is recorded.
- The responses of a box girder straight and curved in plan and are compared.

4) 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 of deflection, bending moment and torsion of straight and curved box girders under different load combinations are presented.

4.1 **Variation of Bending Moment Under Dl+SIDl, Prestressed Load And Moving Load**

Bending moment parameter is recorded along the span of the box girder of different cross sectional shape under dead load and superimposed dead load, prestressed load and IRC Class A Tracked Vehicle Load.

Maximum bending moment 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 bending moment 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 bending moment due to dead load and superimposed dead load

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R=∞	18682	18498	17419
R=500	19002	18770	17577
R=400	19225	18780	17607
R=300	19301	18927	17609
R=250	19410	19157	17627
R=200	19411	19185	17631
R=150	19469	19283	18637
R=100	19510	19311	18650
R=90	20788	20315	18684
R=75	21314	20508	18697

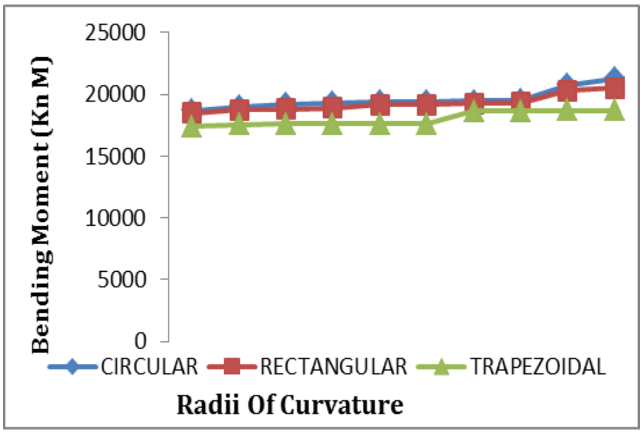


Fig -3 Variation of bending moment due to dead load

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

Table -3 Variation of bending moment due to Prestress load

Shape/radii (m)	Circular	Rectangular	Trapezoidal
R=∞	15889	14786	13728
R=500	15889	15027	13804
R=400	16070	15145	14515
R=300	16113	15556	15187
R=250	16320	15909	15269
R=200	16415	15914	15294
R=150	16558	15943	15799
R=100	16735	15948	15848
R=90	16794	15995	15873
R=75	19315	16821	15569

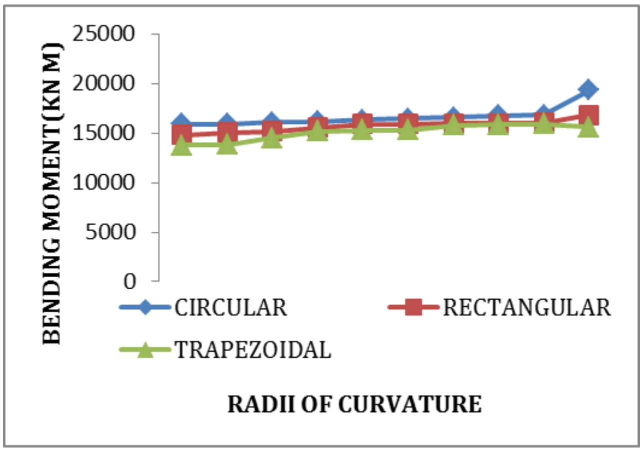


Fig-4 Variation of bending moment due to Prestress load

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

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

The variation of bending moment with change in shape for straight and curved box girder bridges under moving load are shown in graphs & table below.

Table-4 Variation of bending moment due to Moving Load

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R=∞	12012	5912	5948
R=500	12017	6015	5973
R=400	12037	6015	6010
R=300	12040	6021	6019
R=250	12041	6043	6029
R=200	12090	6067	6048
R=150	13148	6075	6063
R=100	14005	6133	6082
R=90	14056	6138	6116
R=75	15041	6173	6144

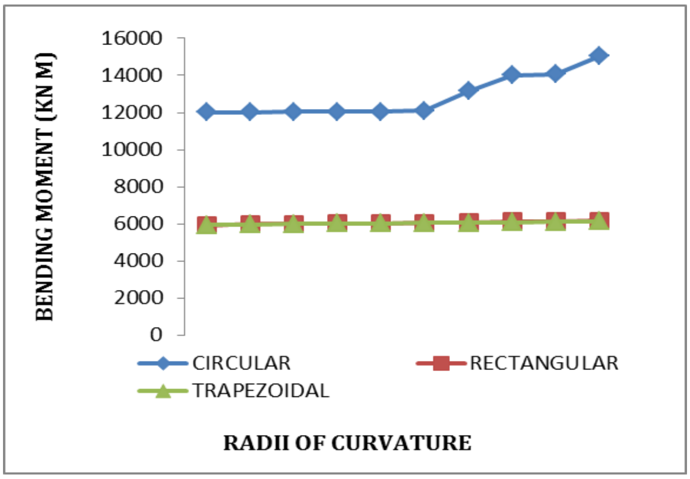


Fig-5 Variation of bending moment due to Moving Load

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

4.2 Torsion Under Dl+Sidl, Prestressed Load And Moving Load

Torsion is recorded along the span of the box girder of different cross sectional shape under dead load and superimposed dead load, prestressed load and IRC Class A tracked vehicle load.

Table 5 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

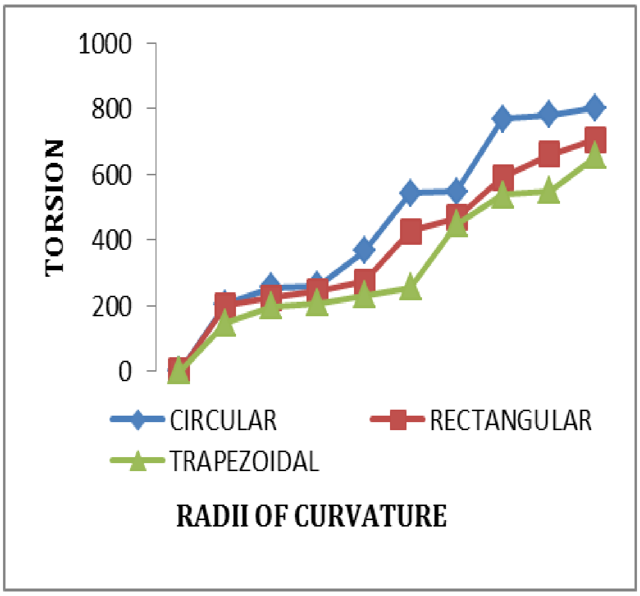


Fig-6 Variation of torsion under DL + SIDL

It is clear that trapezoidal cross section has the least bending moment under dead load and superimposed dead load for both straight box Girder Bridge and four other curved box girder bridges of different radius of curvatures

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.

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

It is clear that trapezoidal cross section has the least bending moment under dead load and superimposed dead load for both straight box Girder Bridge and four other curved box girder bridges of different radius of curvatures

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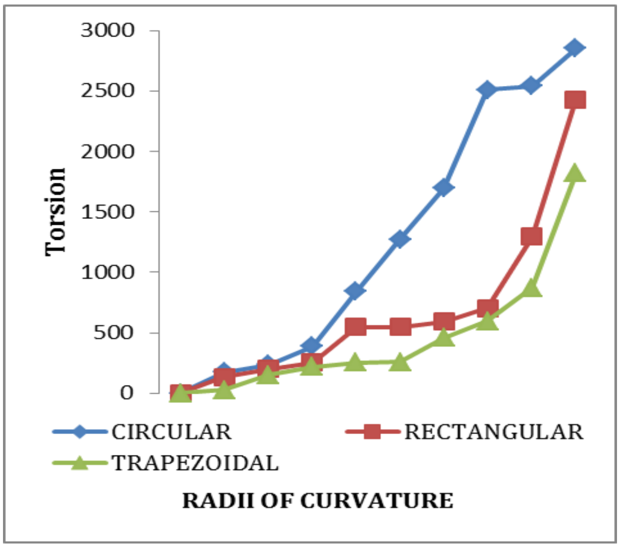

Fig -7 Variation of torsion due to Prestress load

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.

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

Table-7 variation of torsion due to moving load

Shape/Radii	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

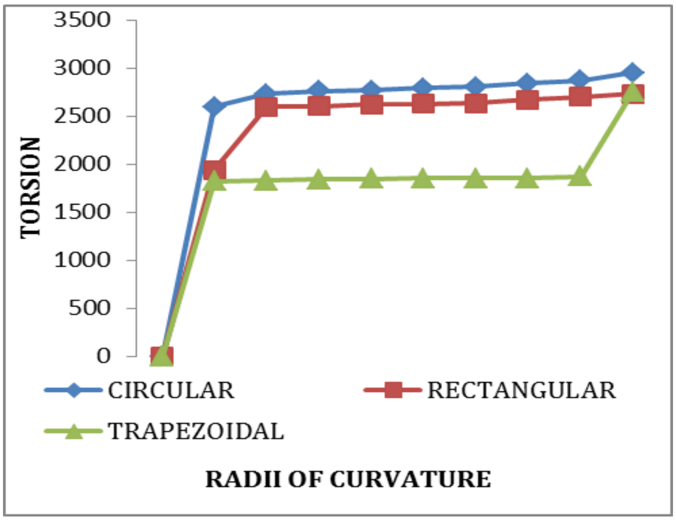

Fig-8 Variation of torsion due to moving load

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.

4.3 Deflection Under Dl+Sidl, Prestressed Load And Moving Load

Deflection is recorded along the span of the box girder of different cross sectional shape under dead load and superimposed dead load, prestressed load and IRC Class A Tracked Vehicle Load.

Maximum deflection under dead load and superimposed dead load is least for trapezoidal cross section both in case of both straight and curved box girder bridges

Table -8 Variation of deflection due to DL + SIDL

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R = ∞	0.00371	0.000044	0
R=500	0.004453	0.002669	0.001968
R=400	0.008681	0.005675	0.002009
R=300	0.009509	0.005872	0.002329
R=250	0.010969	0.006241	0.002437
R=200	0.011666	0.00636	0.005397
R=150	0.011765	0.00667	0.005699
R=100	0.011936	0.006722	0.005783
R=90	0.012858	0.006843	0.006316
R=75	0.012941	0.0103	0.007026

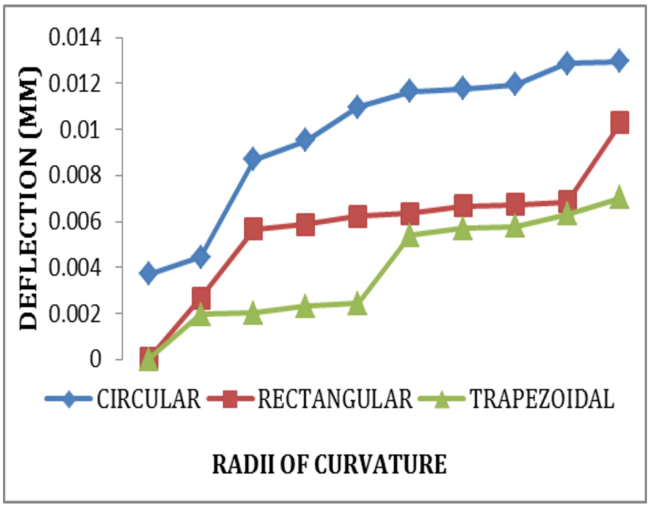

Fig-9 Variation of deflection due to DL + SIDL

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

Under prestressed load maximum deflection is least for trapezoidal cross section both in case of both straight and curved box girder bridges. The variation of deflection with change in shape for straight and curved box girder bridges under prestressed load are shown in graphs & table given

Table-9 Variation of deflection due to Prestress load

Shape/Radii (m)	Circular	Rectangular	Trapezoidal
R = ∞	0.012965	0.001301	0
R=500	0.013602	0.007692	0
R=400	0.013715	0.009373	0
R=300	0.014075	0.012189	0
R=250	0.014692	0.012207	6.29E-06
R=200	0.014911	0.012542	0.000301
R=150	0.015645	0.012705	0.000803
R=100	0.016097	0.013348	0.001284
R=90	0.017068	0.01429	0.003054
R=75	0.019184	0.014696	0.004933

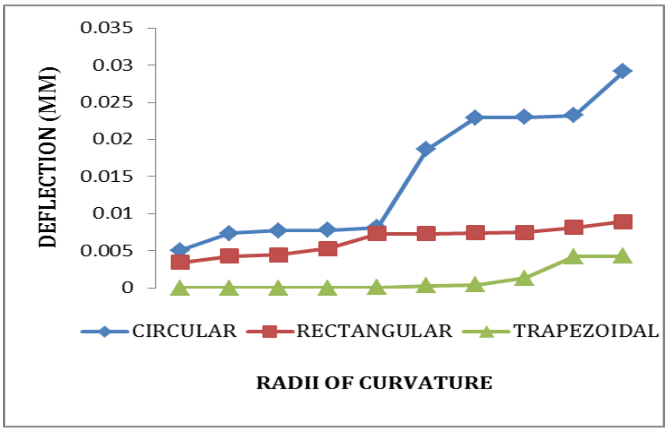

Fig-10 Variation of deflection due to Prestress load

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

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

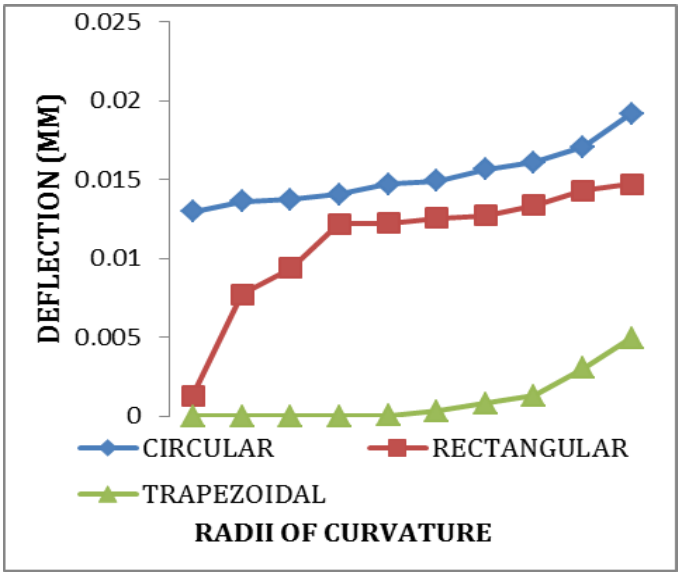

Fig-11 Variation of deflection due to moving load

Table 10 Variation of deflection due to moving load

Shape/Radii	Circular	Rectangular	Trapezoidal
R = ∞	0.005074	0.003453	0
R=500	0.007326	0.00428	0
R=400	0.007713	0.00444	0
R=300	0.007755	0.005326	0
R=250	0.008152	0.00728	0.000061
R=200	0.01866	0.007311	0.000302
R=150	0.022923	0.007422	0.000421
R=100	0.023021	0.007479	0.001335
R=90	0.02323	0.008148	0.004223
R=75	0.029134	0.008932	0.004249

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

5) CONCLUSIONS

The analysis of straight box girder and curved box girders of different radius of curvature are carried out in CSI 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 deflection, longitudinal bending stresses, and torsion. The conclusions that are drawn from the analysis of box girders of different radius of curvature are as follows

- Among rectangular, circular and trapezoidal box girders of all radii, the deflection and torsion is maximum for circular box girders and least for trapezoidal box girders.
- The trapezoidal section is the stiffest section and the most stable among the three sections.

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