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ANALYSIS OF PRE-STRESSED BOX GIRDER BRIDGE WITH DIFFERENT NUMBER OF CELLS

Praveen Patil[1] and Prashant.M.Topalakatti[2]

[1]*Postgraduate student, Department of Civil Engineering, BLDEA's CET, Vijayapur, Karnataka, India, 586103*
[2]*Professor, Department of Civil Engineering, BLDEA's CET, Vijayapur, Karnataka, India, 586103*

Abstract : ***Pre-stressed concrete box girders have become increasingly popular as bridge superstructures because of its high torsional stiffness and strength. Most of the study is concentrated only on varying the span and depth of the box girder bridge.***

In the present study the effect of number of cells is considered In this paper work an attempt have been made to study the behavior of the pre-stressed multi-cell box girder bridges and a comparison is made between two cell, three cell and for cell girders of span 50 m. The analysis software used is CSi Bridge v18.2.0 and the loading considered was IRC class A loading as per IRC guidelines. After the completion of the analysis a comparative study is carried out with respect to Bending moment, Shear Force & Displacement variation of the of number of cell.

Keywords - Pre-stress, Box girder, Deck, FEM, CSi bridge v18.2.0.

I. INTRODUCTION

A multi-cell box girder bridge is a bridge type in which a hollow box shape houses the main beams. Generally structural steel or pre-stressed concrete or composite sections are adopted. Its cross section is most of the time trapezoidal, rectangular or square. Normally pre-stressed box girders are adopted for longer spans only (span range 30 to 90m) due to the fact that pre-stressed concrete box girder. The depth of the girder can be reduced drastically when compared to usual I shaped girders.

The depth of the box girder is depending upon the number of webs provided. As the number of webs increases the depth of the box girder also reduces. Box girders a most suitable for spans in curved alignment due to their high torsional rigidity. The box girder in general consists of pre-stressing concrete, structural steel or reinforced cement concrete. The section of box girder may be taken in the form of single cell or multi-cell with a common bottom flange. The box girder achieves its stability mainly because of shape and pre-stress tendons.

1.1. OBJECTIVES OF THE STUDY

To study the behavior of PSC box Girder Bridge with IRC loadings at various locations of the girder. Determining the variation in deflection values, bending moment values, shear force values of the models at different location on the bridge span.

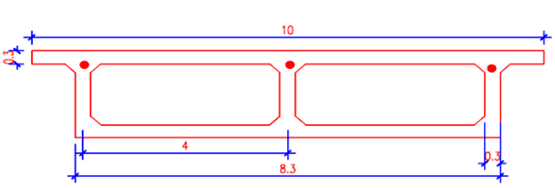
II. MODELLING AND ANALYSIS

To study the behavior of cells in PSC box Girder Bridge, two-cell, three-cell and four-cell box girders are considered. Total width of top slab of the deck is considered constant for all the girders is 10m consisting of a 7.5m carriageway and 1.25m footpath on either side. The l/d ratio considered is 25 for span of 50m which gives depth of girder as 2m. Figure 1, 2 and 3 shows the finite element model of two-cell, three-cell and four-cell rectangular box girder bridge deck modeled in CSi bridge v18.2.0**.**

Basically 3 models of 2 cells, 3 cells and 4 cells are modeled and loaded with IRC class A live load and analysed. Other loads considered are dead load, pre-stressing force, super imposed dead load. Concrete grade of M60 is considered for dead load analysis. The material properties taken are shown in table 1.

Table 1: Material Properties

Material Properties	**Values**
Grade of concrete	M60
Weight/unit volume	25 kN/m2
Young's modulus (E)	38729833 kN/m2
Poisson's ratio (υ)	0.2
Shear Modulus (G)	16137430 kN/m2
Coefficient of thermal expansion (A)	9.900E-06
Specific compressive strength of concrete (fc')	60 N/mm2



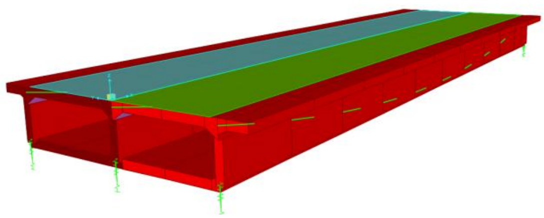
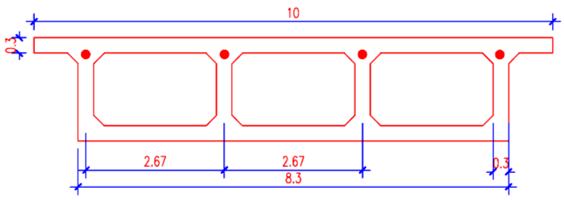


Fig.1 Cross section of 2 cell girder at start of the span

Fig.2 3D model of two cell box girder



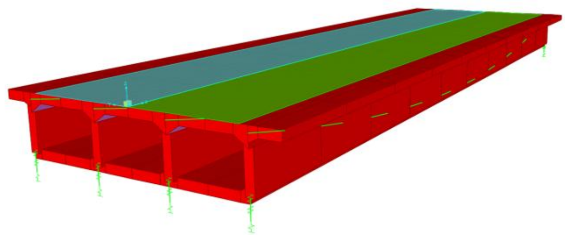
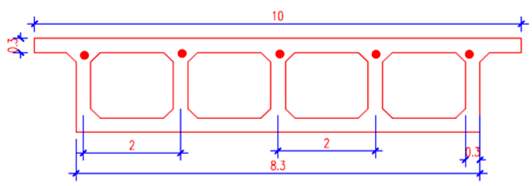


Fig. 4.3 Cross section of 3 cell girder at start of the span

Fig.4 3D model of three cell box girder



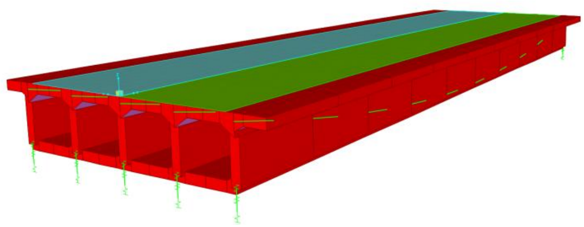


Fig.5 Cross section of 4 cell girder at start of the span

Fig. 6 3D model of four cell box girder

III. RESULTS AND DISCUSSION

A. Shear Force

The maximum shear force of various numbers of cells for dead load, live load and combined load case (DL+LL+Prestress) is presented in table.

Table 5.12 Maximum Shear force for different cells of box girder bridge in kN

Load Case	Dead load	Live load	DL+LL+Prestress
Two	4623	867	719
Three	5072	867	2051
Four	5866	867	3038

Figures 7, 8 and 9 shows the shear force variation of different number of cells for DL, LL and combined case. SF is maximum near support, which was increased by 9% and 21% for three-cell and four-cell box girder compared to two-cell box girder bridge. In live load case there is no variation in the shear force for different number of cells. For combined load case, it is observed that the shear force has increased in four-cell and three-cell box girder bridge by large percentage compared to two-cell box girder bridge.

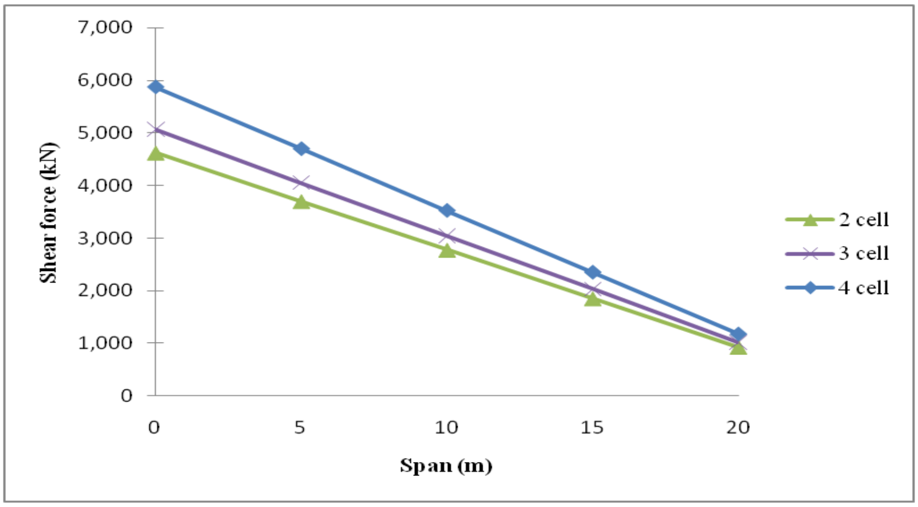


Fig. 7 Dead load shear force for various cells

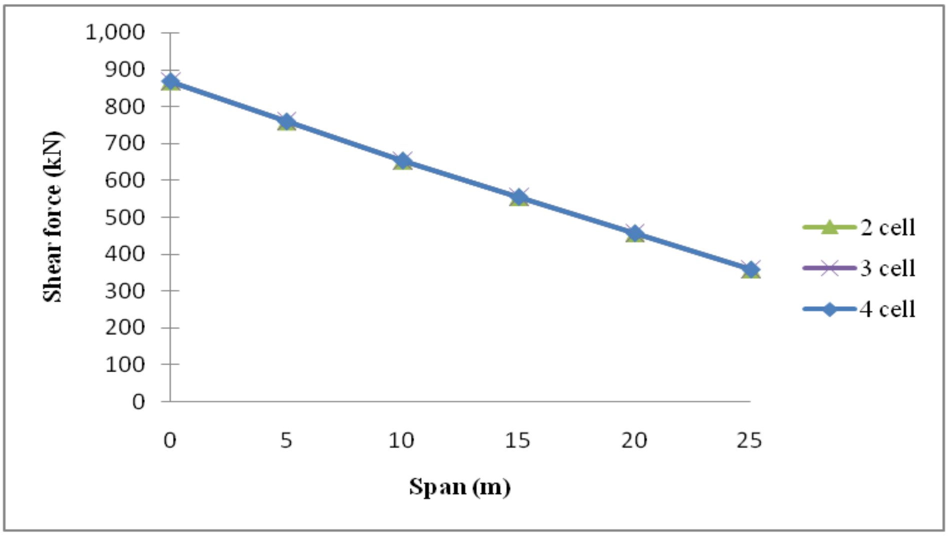


Fig. 8 Live load shear force for various cells

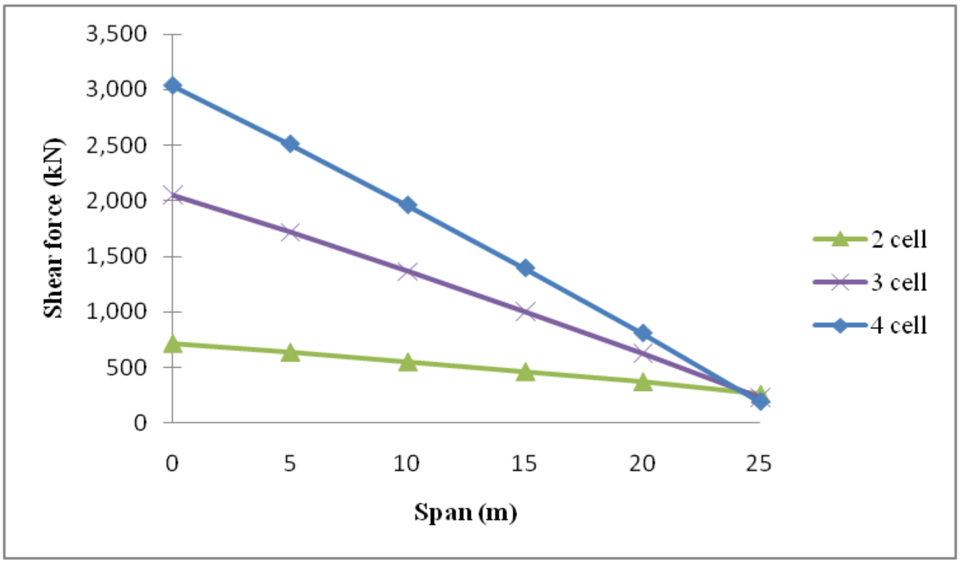


Fig. 9 Combination load shear force for various cell

B. Bending Moment

The maximum bending moment of various numbers of cells for dead load, live load and combined load case (DL+LL+Prestress) is presented in table.

Table 5.8 Maximum bending moment for different cells of box girder bridge in kN-m

Load Case	Dead load	Live load	DL+LL+Prestress
Two	57792	10838	30869
Three	63406	10838	41164
Four	73333	10838	51471

Variation of bending moment for different cells is shown in figure 10, 11 and 12 for dead load, live load and combined load case. Due to increase in the number of girders the self weight of the bridge is increased. Therefore the dead load bending moment of three-cell and four-cell box girders increased by 9% and 21% compared to two-cell box girder. Whereas for live load case, there is no variation in entire bridge bending moment on increasing the number of cells but the bending moment of interior girder changes

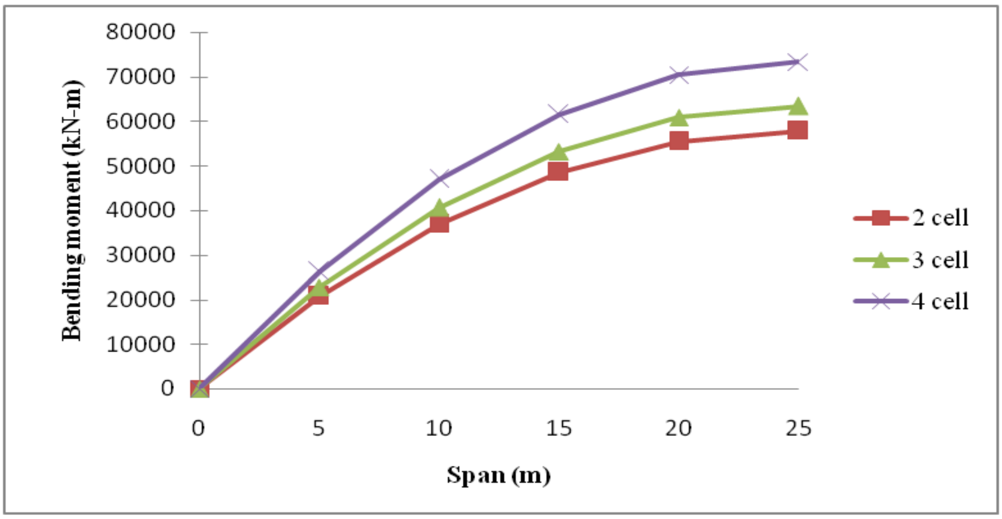


Fig. 10 Dead load bending moment for various cells

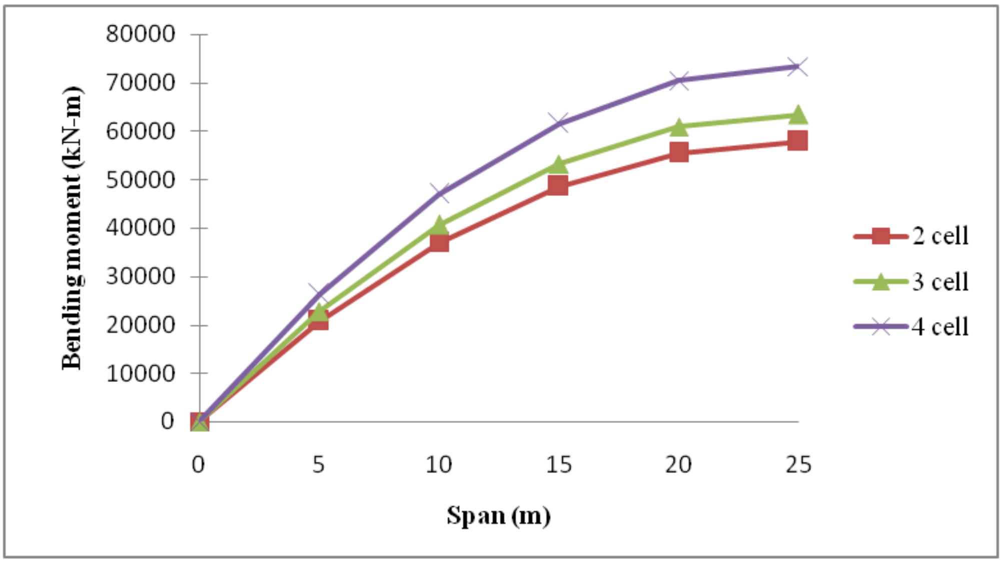


Fig. 11 Live load bending moment for various cells

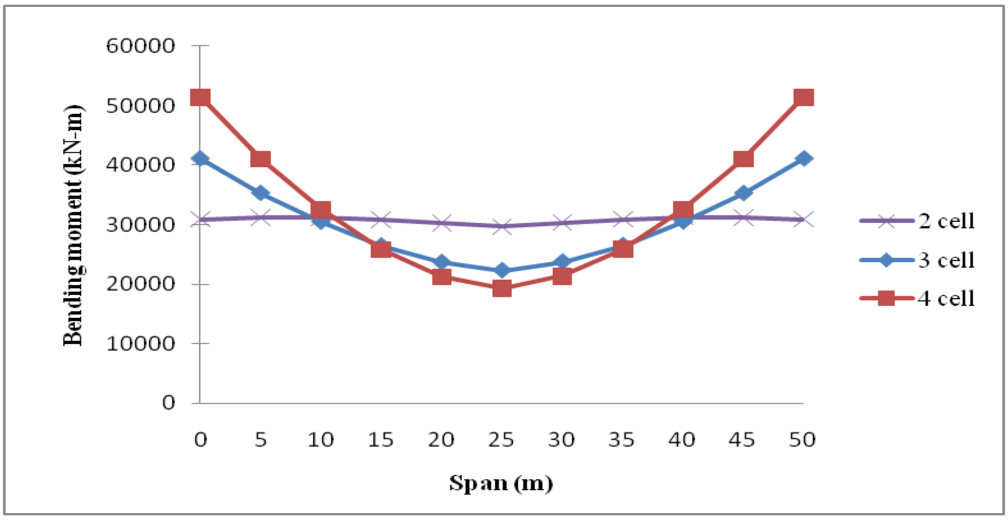


Fig.12 Combination load bending moment for various cells.

C. Deflection

The maximum deflection of various numbers of cells for dead load, live load and combined load case (DL+LL+Prestress) is presented in table.

Table 5.4: Maximum deflection for different cells of box girder bridge in mm

Load Case	Dead load	Live load	DL+LL+Prestress
Two	90.6	16.31	37.23
Three	94.19	15.37	27.22
Four	100.21	14.1	22.66

Figure 13, 14 and 15 shows the deflection of different cells for dead load, live load and combined load case respectively. In two-cell box girder bridge the deflection is less due to lesser dead load. The deflection is reduced in two-cell box girder by 4% and 11% compared to three and four-cell box girder bridge respectively. For live load case there is no much variation. Due to which for combined load case the deflection of three-cell and four-cell box girder is increased by 27% and 39% compared to two-cell box girder bridge.

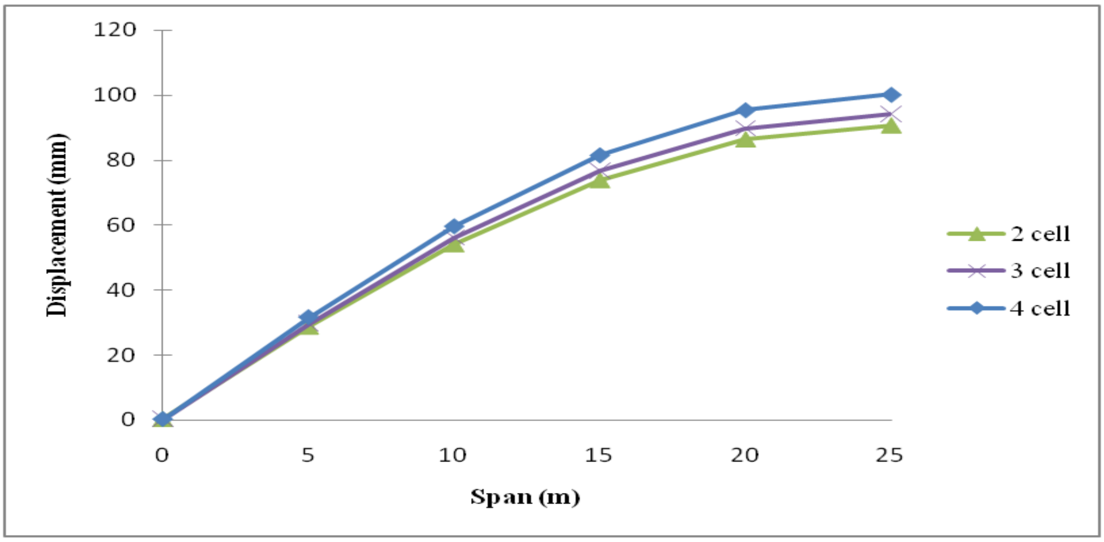


Fig. 13 Dead load deflection for various cells

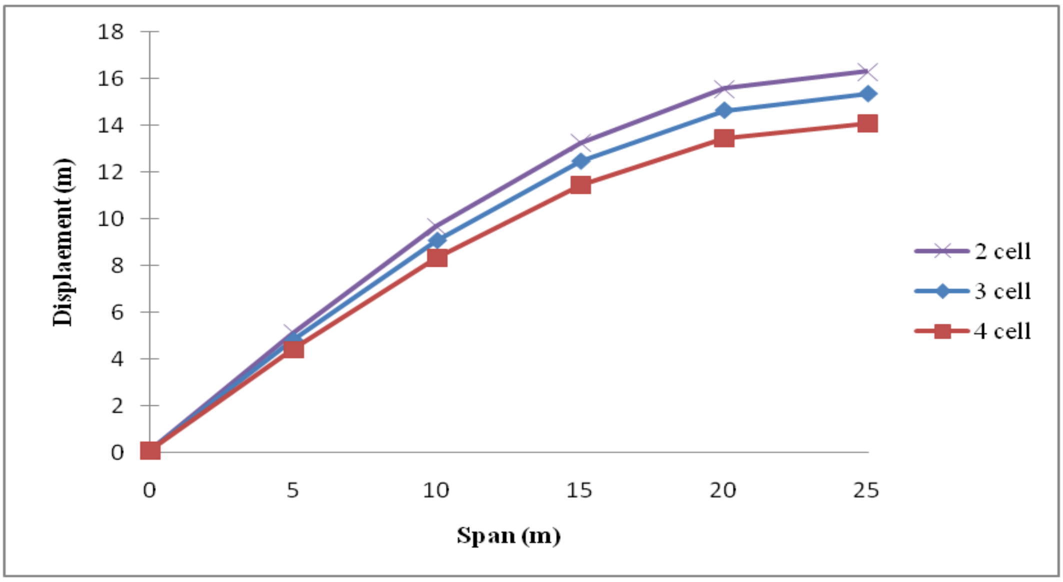


Fig. 14 Live load deflection for various cells

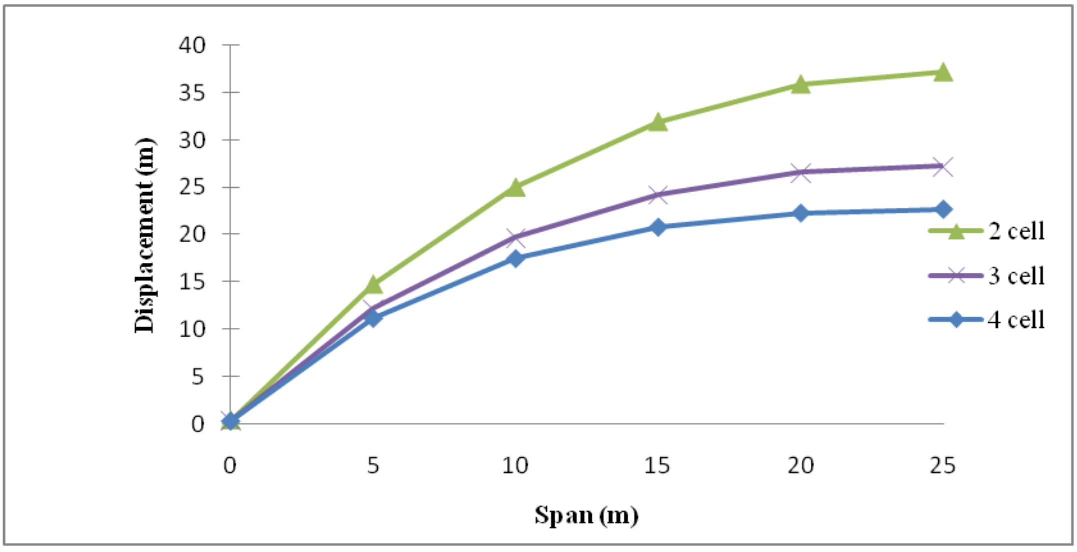


Fig. 15 Combination load deflection for various cells

IV CONCLUSION

1. In the multi span bridge the mid support section bending moment is about 22% more compared to the bending moment at mid span section.
2. Deflection is increased as the number of girders is increased. The deflection is reduced in two-cell box girder by 4% and 11% compared to three and four-cell box Girder Bridge respectively.
3. Due to increase in the number of girders the self weight of the bridge is increased. Therefore the dead load bending moment of three-cell and four-cell box girders increased by 9% and 21% compared to two-cell box girder.
4. SF is maximum near support, which was increased by 9% and 21% for three-cell and four-cell box girder compared to two-cell box Girder Bridge.
5. For live load case there is no change deflection, moment, and shear values in any of the sections.
6. It is observed that the deflection for various loading conditions and at service condition is within the IRC limits. Near mid span location the maximum deflection is occurred.
7. It is observed that the results obtained by manual and software shows good agreement.
8. The bending moment and shear force is maximum for dead load compared to other loadings.

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