# Study the behavior of the Trapezoidal PSC Box Girder by using Single and double cell with the help of IRC and AASHTO Codes

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**Abstract -** *Bridges are an essential part of the infrastructure of any city. Now a days Bridges are designed by the different software such as Staad pro, Medas Civil, Sap2000 etc. The latest Practice for designing the bridge shows the number of Consultants is preferred box girder bridges instead of regular bridges, where prestress box girder is most suitable option because of its economy, stability, structural efficiency and serviceability. This paper presents an investigation on behaviour of curved PSC box girder bridge by the use of IRC and AASHTO code. This analysis is carried out by using CSI-bridge software. The analysis part explains the different behaviour of the PSC curved box girder by using single and double cell and response is recorded, plotted in table for all two girders and the results are discussed in graphs with code comparison.*

***Key Words***: Horizontally Curved Psc Box Girders, Aashto Code, Irc: 6-2014 Code, Csi Bridge Software.

## 1.INTRODUCTION

The Importance of Bridges as Vital Elements of Transportation Lifelines Cannot Be Over Emphasized. Bridges and Tunnels Are the Costliest and Strategic Elements of Highways and Railways. Horizontally Curved Concrete Box Girder Are Widely Used in Construction of Highway Bridges. Horizontally Curved Bridges Are the Most Feasible Options at Complicated Interchanges or River Crossings Where Geometric Restrictions and Constraint of Limited Site Space, Make Difficult the Adoption Of Standard Straight Superstructures. Usually These Bridges Are of Cellular Cross-Section So That High Torsional Moment Can Be Well Resisted Economically. Contrary to Straight Bridges. Finite Element Method Is Most Suitable for Analysis of Such Type of Problem, But Looking to The Complexity Involved In Use Of Finite Element Method, The Designer Involved In The Process Of Bridge Designing Need Some Simplified Solution To Solve The Problem. Prestress Concrete Bridge Is Good Option to Have Higher Durability with Minimum Maintenance As Compared To Other Bridges. Box Girder Is Ideally Suited for Longer Span In Prestress Bridge. However, Sometimes Due To Highway Alignment Layout And Site Restrictions, It Becomes Necessary To Provide Supports For The Curved Bridges And These Bridges Are Referred To As Curved Bridges. In Addition To Overcoming These Geometrical Constrains, Construction Of Curved Box-Girder Bridges Is Becoming Increasingly Popular For Economic And Aesthetic Reasons.Most of The Prestress Concrete Bridges in India Are Designed for The Loading by Indian Road Congress Which Is Recently Revised In 2014. It Is Necessary to Check Reliability of Irc With American Association of State Highway and Transportation Association (Aashto-LRFD) Code as It Is Mostly Used and Accepted by Many Parts Of The World. The Present Study Is About Comparative Analysis and Design of Various Box Girders For 45m Span Using Irc:6-2014 And Aashto- LRFD. Typical Post-Tensioned Prestressed Concrete Box Girders as Single Cell & Double Cell, Single Cell Rectangular Are Taken for Study with Same Span, Depth, Intensity of Loading and Material Properties in This Paper. Csi Bridge Software Which Is Based on Finite Element Is Used for Analysis And All Girders Are Manually Designed. Loadings Considered in Irc:6-2014 Are as Per Class-A And Class-Aa Whereas Loadings Considered In

Aashto- LRFD. Analytical Comparison Of Shear Force, Bending Moment And Torsion Has Been Done For Box Girders.

## 2.Preliminary Data Considered for the Analysis:

Total width = 8.5 m
Total Depth = 2.3 m
Exterior Girder Thickness = 0.305

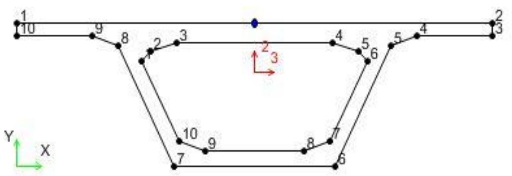

FIG-01 **SINGLE CELL TRAPEZOIDAL BOX GIRDER SECTION**

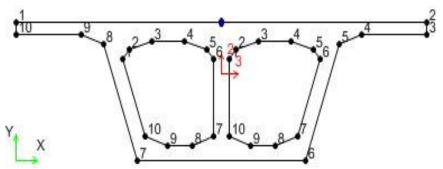

FIG-02 **DOUBLE CELL TRAPEZOIDAL BOX GIRDER SECTION**

## 3. FOLLOWING ARE LOADING ON BOX GIRDER BRIDGE

3.1 **Dead Load (DL)-**Which consist of self-weight of the member on bridges which is calculated by the software itself.

3.2 **live Load (DL)-**Which consist of all the loads acting over the bridge span in the form of Vehicle load such as Trucks, Trailer, Trains etc. of the member on bridges.

These all types of live load consist the following loadings in the form of IRC and Ashto.

a) Indian Roads Congress Bridge Loading

A. **IRC Class AA Loading**

B. **IRC Class A Loading 1.2**

b) **AASHTO** (American Association of State Highway Transport Official) Loading.

## 4. RESULTS: -

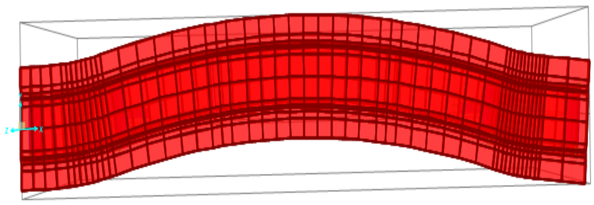

**FIG: SHOWS THE TOP VIEW OF BOX GIRDER BRIDGE**

**Table1. Displacement**

| SR.NO | LOAD CASE | SINGLE CELL TRAPEZOIDAL GIRDER (MM) | DOUBLE CELL TRAPEZOIDAL GIRDER (MM) |
|---|---|---|---|
| 1. | DEAD | 33.6 | 25.2 |
| 2. | IRC A | 7.7 | 3.5 |
| 3 | IRC A-A | 10.5 | 4.9 |
| 4 | ASHTO HL 93 | 9.8 | 4.9 |

As the result indicate that the when we considered the single cell box girder in that case for the Dead load the displacement value is 33.78 while comparing with the Double cell the double cell box girder having the displacement value is less than that of single cell. While from the results shown in the tabular form it is showing that the displacement value for the all loading cases are less in the double cell while comparing with the single cell box girder bridges.

**Table2. Bending Moments**

When we consider the different load combinations for the measurement of B.M we can say that after the analysis the bending moments value is more in case of Double cell box girder bridges while comparing with the single cell.

| SR.NO | LOAD CASE | SINGLE CELL TRAPEZOIDAL GIRDER (KNM) | DOUBLE CELL TRAPEZOIDAL GIRDER (KNM) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1. | DEAD | 16060.00 | 15694.073 |
| 2. | IRC A | 2653.78 | 2687.95 |
| 3. | IRC A-A | 4447.59 | 4311.60 |
| 4. | ASHTO HL-93 | 3722.79 | 3551.7 |
| 5. | 1.25(DL)+1.75LL (IRC A) | 24719.87 | 28056.33 |
| 6. | 1.25(DL)+1.75LL (IRC A-A) | 27859.05 | 29748.7 |
| 7. | 1.25(DL)+1.75LL (ASHTO) | 26590.65 | 29670.75 |

**Combinations: For single cell box girder & Single Cell Trapezoidal box girder**

**A. SINGLE CELL BOX GIRDER**

**01: -1.25(DL) +1.75LL (IRC A)**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3126.88 | 533.7024 | -804.167 | -18801.9 |
| 5 | -2276.89 | -380.428 | 194.0469 | -1403.42 |
| 10 | -1436 | -357.252 | 879.0736 | 10563.27 |
| 15 | -712.5 | -28.423 | 1303.34 | 17534.82 |
| 20 | 47.676 | 826.5538 | 1514.169 | 20771.57 |
| 25 | 818.844 | 1918.634 | 1479.945 | 20141.45 |
| 30 | 1654.11 | 2938.392 | 1171.718 | 15052.74 |
| 35 | 2415.52 | 3460.834 | 718.4163 | 7237.517 |
| 40 | 3295.991 | 3587.313 | -84.0617 | -6771.22 |
| 45 | -2370.39 | 3022.192 | -851.842 | -17561.9 |

**02: 1.25(DL) +1.75LL (IRC A-A)**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3117.56 | 894.4 | -804.382 | -18507.4 |
| 5 | -2222.11 | -114.9 | 203.8689 | 174.4763 |
| 10 | -1335.9 | -137.1 | 938.0829 | 12836.69 |
| 15 | -544.2 | 136.60 | 1394.21 | 20262.31 |
| 20 | 272.869 | 965.90 | 1619.464 | 23819.91 |
| 25 | 1096.8 | 2168.9 | 1582.64 | 23104.79 |
| 30 | 1983.3 | 3256.1 | 1252.788 | 17599.12 |
| 35 | 2770.6 | 3794.5 | 767.832 | 9349.617 |
| 40 | 3681.1 | 3888.9 | -83.9252 | -5638.77 |
| 45 | -2264.5 | 3497.5 | -935.581 | -15727.1 |

**03: 1.25(DL)+1.75LL (ASHTO**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3125.45 | 763.8104 | -804.239 | -18759.5 |
| 5 | -2261.69 | -268.349 | 209.9683 | -967.939 |
| 10 | -1410.33 | -267.87 | 957.3237 | 11518.14 |
| 15 | -649.816 | 93.7912 | 1422.818 | 18976.85 |
| 20 | 140.103 | 1004.499 | 1652.44 | 22502.96 |
| 25 | 946.526 | 2155.659 | 1614.102 | 21806.17 |
| 30 | 1825.459 | 3224.549 | 1276.031 | 16314.37 |
| 35 | 2622.841 | 3780.234 | 781.9081 | 8028.268 |
| 40 | 3572.774 | 3911.346 | -85.2558 | -6525.16 |
| 45 | -2363.72 | 3340.209 | -851.746 | -17456.9 |

**B. DOUBLE CELL BOX GIRDER**

**01: -1.25(DL)+1.75LL (IRC A)**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3363.4 | -4227.7 | 11216 | -23150 |

| | | | | |
|---|---|---|---|---|
| 5 | -2345.9 | -4059.5 | -1554 | -4955.5 |
| 10 | -1345.3 | -3143.8 | -9537 | 6829.28 |
| 15 | -489.27 | -1838.7 | -14373 | 12849.7 |
| 20 | 406.723 | 123.642 | -16767. | 14411.3 |
| 25 | 505.269 | 2877.84 | -16291. | 14423.9 |
| 30 | 1487.13 | 4948.49 | -12692 | 10855.5 |
| 35 | 2384.40 | 6434.09 | -7447 | 3653.80 |
| 40 | 3421.86 | 7744.57 | 2201 | -10468.6 |
| 45 | -1881.4 | 7503.24 | 10751 | -110.643 |

**02: 1.25(DL)+1.75LL (IRC A-A)**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3362 | -3995 | 11215 | -23107 |
| 5 | -2330 | -3945 | -1541 | -4525 |
| 10 | -1319 | -3052 | -9470 | 7776 |
| 15 | -426 | -1714 | -14271 | 14283 |
| 20 | 499 | 302 | -16648 | 16134 |
| 25 | 632 | 3115 | -16176 | 16080 |
| 30 | 1658 | 5234 | -12603 | 12109 |
| 35 | 2591 | 6752 | -7394 | 4438 |
| 40 | 3698 | 8068 | 2201 | -10225 |
| 45 | -1875 | 7822 | 10749 | -8.27 |

**03: 1.25(DL)+1.75LL (ASHTO)**

| DISTANCE | V2 | T | M2 | M3 |
|---|---|---|---|---|
| 0 | -3125.45 | 763.84 | -804.29 | -18759.5 |
| 5 | -2261.69 | -268.349 | 209.93 | -967.939 |

| | | | | |
|---|---|---|---|---|
| 10 | -1410.33 | -267.87 | 957.32 | 11518 |
| 15 | -649.816 | 93.79 | 1422 | 18976 |
| 20 | 140.103 | 1004.4 | 1652.44 | 22502 |
| 25 | 946 | 2155 | 1614 | 21806 |
| 30 | 1825 | 3224 | 1276 | 16314 |
| 35 | 2622 | 3780 | 781 | 8028. |
| 40 | 3572 | 3911 | -85 | -6525 |
| 45 | -23632 | 3340 | -851 | -17456 |

**Table No.5** Prestress Calculation Comparison of Single Cell and Double Cell Trapezoidal Box Girder

| *Parameter* | **Single Cell Trapezoidal Box Girder** | **Double Cell Trapezoidal Box Girder** |
|---|---|---|
| *fbr* | *0.8X18-0 =* *14.4 N/mm²* | *0.8X18-0=* *14.4N/mm²* |
| *finf* | *43574.17xE6* *0.8x2.83xE9* =19.24 N/mm² | *45005.19xE6* *0.8x3.65xE9* =15.41 N/mm² |
| *Pre stress Force* | *4.36XE6X19.24X2.83XE9* *2.83XE9+(4.36XE6)X700* *=4036.168 N/mm²* | *5.2XE6X15.41X3.65XE9* *3.65XE9+(5.22XE6)X700* *=40198.073N/mm²* |
| *FORCE IN ONE TENDON* | *1.703X10^3* | *1.703X10^3* |
| *NO OF TENDON* | *24* | *24* |

## Graph:

**DISPLACEMENT DETIALS:**

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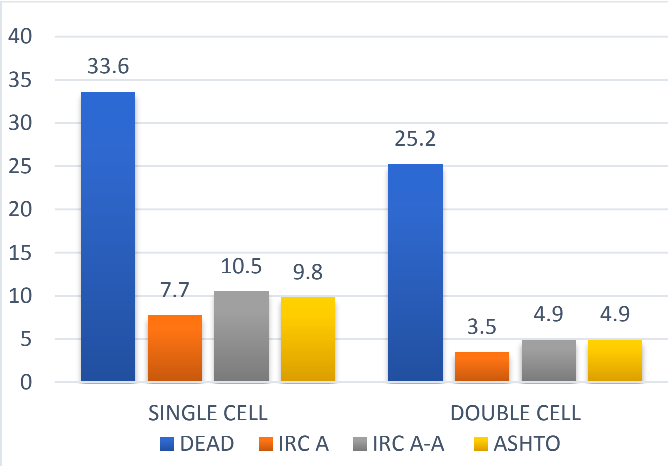
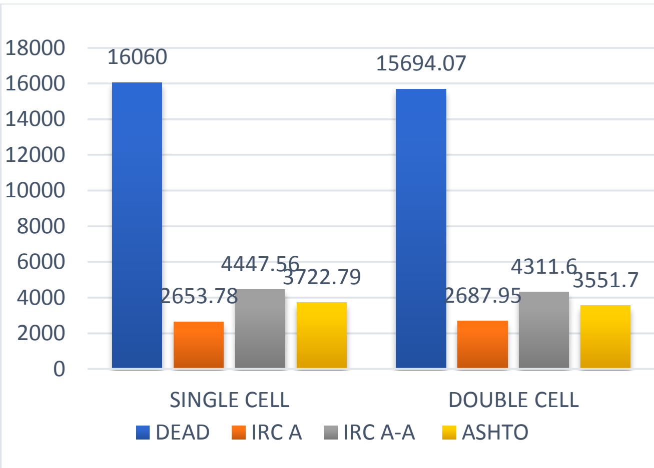


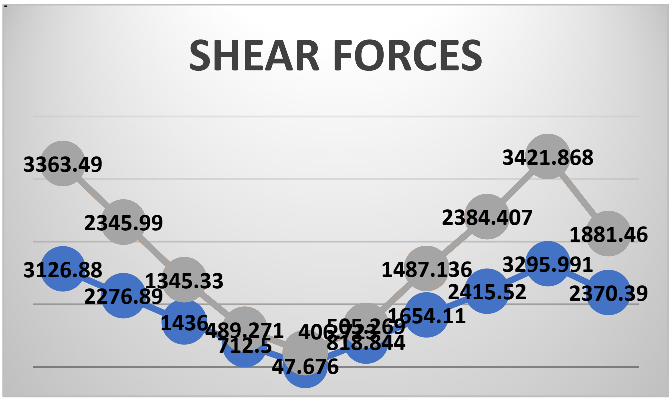

The above graph shows the displacement values for the all four load cases such as Dead load, IRC A , IRC A-A & Ashto codes.

### BENDING MOMENTS DETIALS:



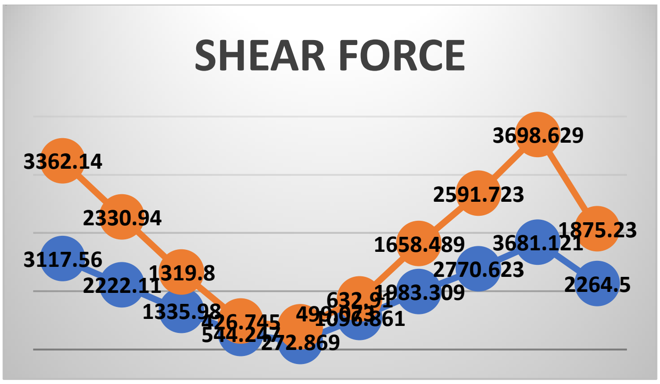

The above graph shows the Bending moments values for the all four load cases such as Dead load, IRC A, IRC A-A & Ashto codes.

### SHEAR FORCE RESULTS FOR DIFFERENT LOAD CASES:



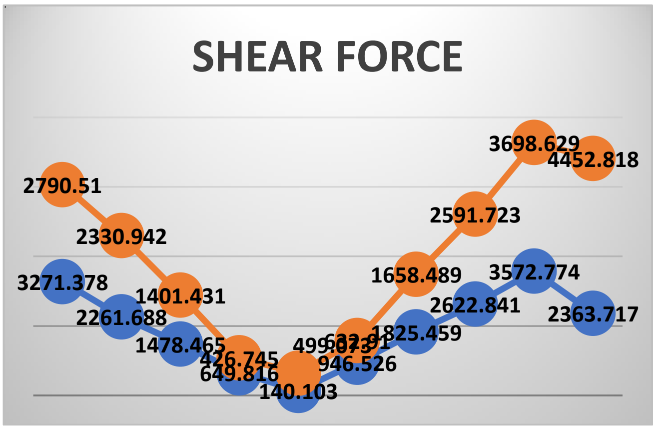

(BLUE – SINGLE CELL, GREEN – DOUBLE CELL)

COMBINATION-(1.25(DL)+1.75LL (IRC A)




(BLUE – SINGLE CELL, RED– DOUBLE CELL)

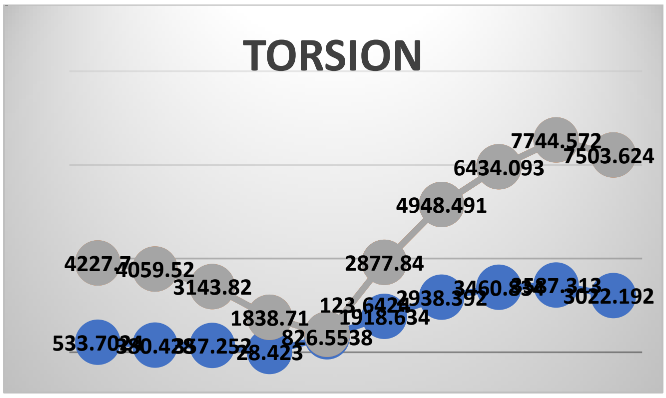
COMBINATION-1.25(DL) +1.75LL (IRC A-A)




BLUE – SINGLE CELL,RED – DOUBLE CELL

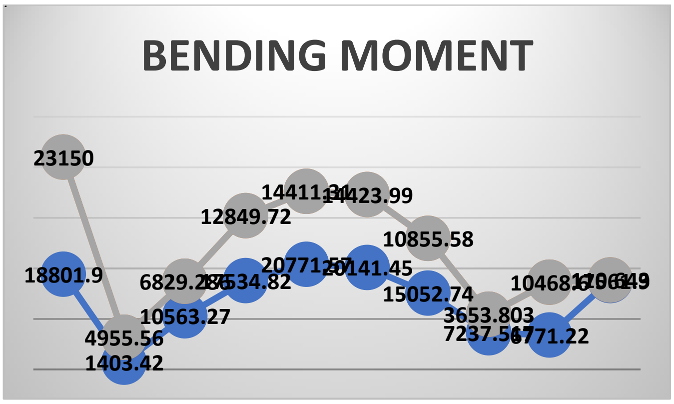
COMBINATION-1.25(DL) +1.75LL (ASHTO)

### TORSION RESULTS FOR DIFFERENT LOAD CASES:



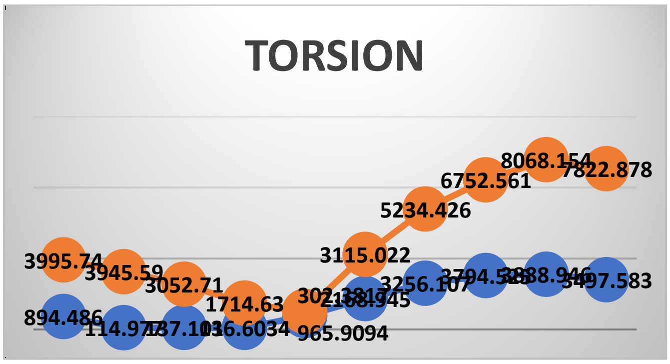

BLUE – SINGLE CELL,GREEN – DOUBLE CELL

COMBINATION-1.25(DL)+1.75LL (IRC A)



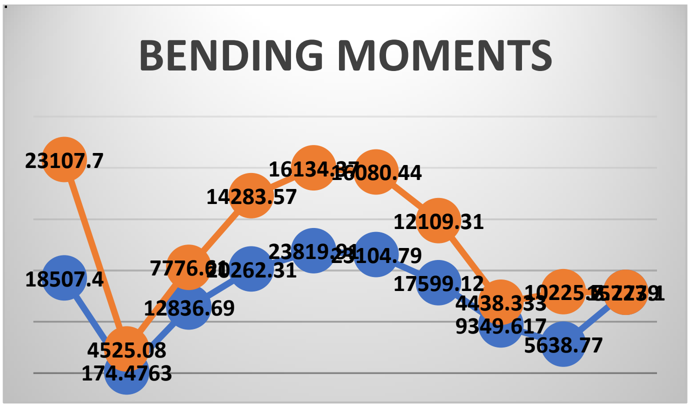

BLUE – SINGLE CELL,GREEN – DOUBLE CELL

COMBINATION-1.25(DL)+1.75LL (IRC A)



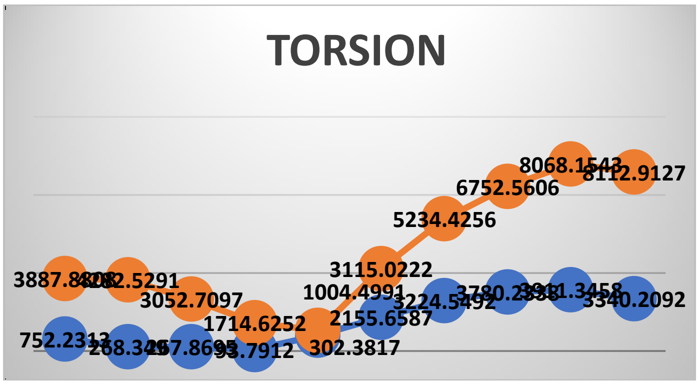

BLUE – SINGLE CELL,RED – DOUBLE CELL

COMBINATION-1.25(DL) +1.75LL (IRC A-A)



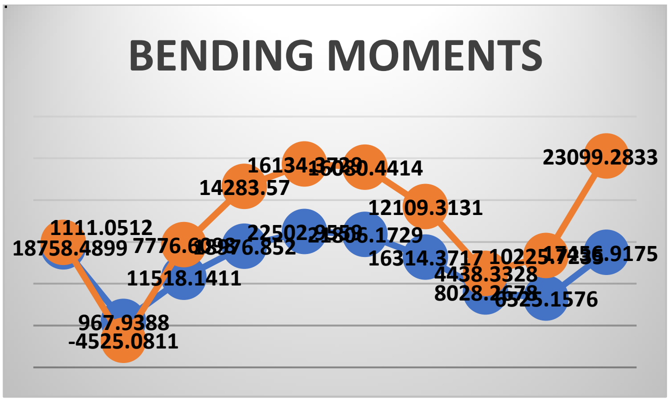

BLUE – SINGLE CELL,RED – DOUBLE CELL

COMBINATION-1.25(DL) +1.75LL (IRC A-A)




BLUE – SINGLE CELL,RED – DOUBLE CELL

COMBINATION-1.25(DL) +1.75LL ASHTO)




BLUE – SINGLE CELL,RED – DOUBLE CELL

COMBINATION-1.25(DL)+1.75LL (ASHTO)

**MOMENTS RESULTS FOR DIFFERENT LOAD CASES:**

## 3. CONCLUSIONS

Following are the conclusion we have obtained from above analysis results are:-

1. In case of single cell curved box Girder bridge the Displacement, value is getting higher when it will be compared with the Double cell Curved box girder bridge.as shown in above tables
2. But in case of Bending moment the value of curved single cell box Girder bridge is going to be increasing slightly as compared with the Double cell box girder. Refer table for bending moments.
3. The results for AASHTO Loading is very less then the IRC A and IRC A-A loadings.
4. IRC A-A loading gives the significant required results for which the bridge can be design.
5. The behavior of Double cell curved girder is Economical and effective against the different loading for which these bridges are analysis.
6. 24 no of tendons are required to resist the moment which are acting due to the self weight and the live load coming from the vehicals.
7. The central portion going to be sag when vehical is passing from one location to the another location.

   And the prestress tendons are give its resistance to the bridge to get into its original position.

## REFERENCES

[1] Gourav Gajrani, Dr. L. M. Gupta, "Behavior and Analysis of Horizontally Curved Composite Steel Girder Bridge System".

[2] Mozhdeh Amani, M.M. Alinia, "The flexural behavior of horizontally curved steel I-girder bridge systems and single-girders".

[3] Mulesh K. Pathak, "Performance of RCC Box type Superstructure in Curved bridges".

[4] Shruti G Kulkarni, Pradeep A R, "Guruprasad T N, "Static Analysis of RC Box Girder Bridge with skew angles using finite element method".

[5] Cagri Ozgur, "Behaviour and analysis of a horizonatally curved and skewed I-girder bridge".

[6] Mohammed Ameen Zaki, "Live load distribution factors for horizontally curved concrete box girder bridges".

[7] Jose J. Oliveira pedro, Antonio J. Reis, "Nonlinear analysis of composite steel-concrete cable-stayed bridges".

[8] S.J.Fatemi, M.S. Mohamed Ali, A.H. Sheikh, "Load distribution for composite steel-concrete horizontally curved box Girder Bridge.

[9] Tanmay Gupta, Manoj Kumar, "Flexural response of skew-curved concrete box-girder bridges".

[10] Fatmir Menkulasi, Dinesha Kuruppuarachchi, "Development of alternative concrete bridge super structure system for short and medium span bridges".

[11] R.Shamass, K.A. Cashell, "Analysis of dtsinless steel-concrete composite beam".

[12] R.L.Pedro, J.Demarche, L.F.F.Miguel, R.H.Lopez, "An efficient approach for the optimization of simply supported steel concrete composite I girder bridges.

[13] Rodek Wodzinokski, Khaled, Hamdy M.Afefy, "Free vibration analysis of horizontally curved composite concrete-steel I-girder bridge".

[14] Teng Tong a , Zhao Liu b , Jie Zhang a , Qiang Yu, "Long-term performance of prestressed concrete bridge under the intertwined effect of concrete damage,static creep and traffic-induced cyclic creep".

[15] Quang-Viet Vu, Duc-Kien Thai, Seung-Eock Kim, "Effect of intermediate diaphragms on the load – carrying capacity of steel – concrete composite box girder bridges".