PARAMETRIC ANALYSIS OF SINGLE-CELL BOX GIRDERS BRIDGE

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ABSTRACT

Bridges based on box girders concept are extensively utilized for their cost saving solution for different passages & viaducts that are seen in the present day highway systems. The behavior of box girder bridges is analyzed for stresses in longitudinal and transverse directions. In this paper, analysis of three different box girders has been carried out using SAP2000 as per Indian Road Congress (IRC) provisions for rectangular and trapezoidal sections. The behaviors of box girders with uniform depth and varying widths have been analyzed. A parametric study is conducted for various parameters like bending moments, axial force & shear force using SAP2000.

Keywords: Mechanical Properties, Silica Fume, Polyvinyl Alcohol Fibers, Water Absorption.

1. Introduction

The continuous increase of usage for highway networks in the world has resulted in a significant increase in population which tends to extensive metropolitan urban localities. Such expansion has tended to various changes in the utilization and development of different types of bridges. Box girder type of bridge is associated to provide construction techniques and maximal utilization of the material for specific span and its applications. As the increase in span leads to an increase of its dead load is an essential factor. In order to reduce dead load, usage of unnecessary materials to their total capacity is taken out of the section, which has resulted in the shape of cellular structures or box girders, considering whether to neglect the shear deformations or not.

The range of span is more for box girder than that of T-Beam Girder Bridge, which results in comparatively fewer piers for the equivalent valley width and thus resulting in terms of economy. The box girders have gained extensive range of acceptance in the bridging systems and freeways due to their greater stability, efficacy in terms of structural as well as serviceability, cost of construction and their pleasing aesthetics. The analysis and design of these box girder bridges is somewhat complex due to their 3-D behavior that includes bending, distortion and torsion in both the transverse and longitudinal directions. The box girder generally consists of structural steel, prestressed concrete or RCC and steel composites. Due to high torsional resistance, box beam structure is very much suited to bridges with significant curvature. They can be constructed as single, double or multi cell with various shapes of box girders like circular, trapezoidal and rectangular.

2. Concrete and steel parameters

2.1 Materials

Grade of Concrete: M40
Compressive strength of Concrete (fc): 4000
Grade of Steel: FE415

2.2 Methodology

In this study, 3 numbers of beam bridge models were considered having a constant span widths and lengths. In order to validate with the finite element modeling method, an example was taken from literature in order to perform the validation study. The considered beam is modeled and analyzed by
utilizing SAP 2000 and the responses are analyzed. The parameters like cross section span length and properties of materials remain unchanged. The variable parameters are girder width in the plan and loadings. A single cell box is considered within the cross section of the superstructure of the box girder. All the three models are subjected to self weight and dynamic loads of IRC class A-self wheeled vehicle and 70 R loading. Static and modal analysis were performed to identify the shear force, bending moment and axial force are analyzed. The responses for single, double and multi cell box beam bridges are recorded and compared. The responses from SAP are fairly matching with the experimental results.

2.3 Dimensional details of single, twin and multi-cell box girders

The span and depth are kept constant for all the different Box girders that have been analyzed SAP2000 is used to perform the analysis for class a type and 70r of loading.

**Single cell box girder model:**

Bridge span: 25m, Girder width =7.5m, Depth of box girder =2m

Type of loading considered: IRC class A(Truck) & 70R, Number of lanes =2

**Twin cell box girder model:**

Span of girder: 25m, Total width: 10m, Depth of girder =2m

Type of loading considered: IRC class A(Truck )& 70R, Number of lanes =03

**Multi-cell box girder model:**

Span of girder: 25m, Total width: 13m, Depth of girder =2m

Type of loading considered: IRC class A(Truck) & 70R, Number of lanes =03
Figure 1. Loading applied on a single, twin and multi cell box girder bridge

Figure 2. Members having a MMAX load on a single, twin and multi cell box girder bridge
Figure 3. Members having a MMIN load on a single, twin and multi cell box girder bridge

3. Result and discussion

COMPARISON OF SINGLE, DOUBLE & MULTI-CELL BOX GIRDERS

| TABLE-1 Results Of Single-Cell Of Class A-T |
|--------------------------------------------|
| Span                         | 25m            |
| Width                        | 7.5m           |
| Depth                        | 2m             |
| Class (as per IRC- 6:2000)    | A-T            |
| Number of Lanes              | 2              |
| Load Combination             | 1.35DL+1.75SIDL+1.5VLL |

| Results     | Maximum | Minimum |
|-------------|---------|---------|
| Axial Force | -20865.31 | -20865.31 |
TABLE-2 Results Of Double Cell Of Class A-T

| Results                           | Maximum   | Minimum   |
|-----------------------------------|-----------|-----------|
| Axial Force                       | -31205.5  | -31205.5  |
| Shear Force horizontal            | 1.87E-09  | 1.62E-09  |
| Shear force vertical              | 13998.87  | 0         |
| Moment at Y- axis                 | -1E-07    | -1.4E-07  |
| Moment at X- axis                 | 56796.15  | -23886.57 |

TABLE-3 Results Of Multi-Cell Of Class A-T

| Results                           | Maximum   | Minimum   |
|-----------------------------------|-----------|-----------|
| Span                              | 25m       |           |
| Width                             | 13        |           |
| Depth                             | 2m        |           |
| Class(as per IRC-6:2000)          | A-T       |           |
| Number of Lanes                   | 3         |           |
| Load Combination                  | 1.35DL+1.75SIDL+1.5VLL | |
### TABLE-4 Results Of Single Cell Of Class 70r

| Results                   | Maximum  | Minimum  |
|---------------------------|----------|----------|
| Axial Force               | -42195.3 | -421953  |
| Shear Force horizontal    | 1.352E-09| 9.637E-10|
| shear force vertical      | 18943.425| 0        |
| Moment at Y- axis         | -2.75E-07| -3.02E-07|
| Moment at X- axis         | 78201.05 | -38733.7 |

### TABLE-5 Results Of Multi-Cell Of Class 70r

| Span         | 25m  |
|--------------|------|
| Width        | 7.5m |
| Depth        | 2m   |
| Class(as per IRC-6:2000) | 70R        |
| Number of Lanes | 2              |
| Load Combination | 1.35DL+1.7SIDL+1.5VLL |

| Span         | 25m  |
|--------------|------|
| Width        | 13m  |
| Depth        | 2m   |
| Class(as per IRC-6:2000) | 70R        |
| Number of Lanes | 3              |
| Load Combination | 1.35DL+1.75SIDL+1.5VLL |

| Results                   | Maximum  | Minimum  |
|---------------------------|----------|----------|
| Axial Force               | -49536.9 | -49536.9 |
| Shear Force horizontal    | -7E-10   | -1.57E-09|
| shear force vertical      | 17579.25 | 0        |
Comparison For Irc Class A For Single, Twin And Multi-Cell Box Girders:

|                      | Moment at Y- axis | Moment at X- axis |
|----------------------|-------------------|-------------------|
| IRC Class A          | 5.681E-08         | 65109.76          |
| IRC Class 70r        | 3.16E-08          | -43404.1          |

Variation of bending moment and shear force

Comparison For Irc Class 70r For Single, Twin And Multi-Cell Box Girders:

Variation of bending moment and shear force
BENDING MOMENT:

- Twin cell box girder moment is 0.55 times that of the trapezoidal box girder for loading class A(T), whereas 1.67 times for the IRC loading 70R.
- The multi-cell box girder moment is 1.37 times the twin cell box girder and is 1.77 times for the IRC loading 70R.
- The multi-cell box girder moment is 2.749 times of trapezoidal box girder and is 2.97 times for the IRC loading 70 R.

SHEAR FORCE:

- Twin cell box girder shear force is 1.1042 times of the trapezoidal box girder for loading class A(T) whereas 1.53 times for the IRC loading 70R.
- The multi-cell box girder shear force is 1.35 times of the twin cell box girder and is 1.947 times for the IRC loading 70R.
- Multi-cell box girder shear force is 2.234 times of trapezoidal box girder and is 2.99 times for the IRC loading 70 R.

AXIAL FORCE:

- Twin cell box girder Axial force is 1.49 times of the trapezoidal box girder for loading class A(T) whereas 1.48 times for the IRC loading 70R.
- Multi-cell box girder axial force is 1.35 times the twin cell box girder and is 2.46 times for the IRC loading 70R.
- Multi-cell box girder Axial force is 2.022 times of trapezoidal box girder and is 3.658 times for the IRC loading 70 R.

3.1 Observations are summarized as follows:

- Bending moment in the single-cell box girder is smaller when compared to twin and multi-cell box girders, i.e., the bending moment developed in the single-cell trapezoidal section is less when compared to that in two cells and three cell rectangular sections that is 49.93% less than two-celled and 63.63% less than three cell rectangular sections for class A type of loading.
- Bending moment in the single-cell box girder is smaller when compared to twin and multi-cell box girders, i.e., the bending moment developed in the single-cell trapezoidal section is less when compared to that in two cells and three cell rectangular sections that are 40.13% less than two-celled and 66.33% less than three cell rectangular sections for class 70R type of loading.
- Shear force in the single-cell box girder is smaller when compared to twin and multi-cell box girders, i.e., the bending moment developed in the single-cell trapezoidal section is less when compared to that in two cells and three cell rectangular sections that are 39.44% less than two-celled and 55.25% less than three cell rectangular sections for class A type of loading.
- Shear force in the single-cell box girder is smaller when compared to twin and multi-cell box girders, i.e., the bending moment developed in the single-cell trapezoidal section is less when compared to that in two cells and three cell rectangular sections that are 34.86% less than two-
celled and 66.55% less than three cell rectangular sections for class A type of loading.

4. Conclusions

Single, Twin, and Multi-cell box girder bridges are considered for the analysis. Models are subjected under IRC class A loading and 70R conditions, and corresponding bending moments and shear force values are compared. Since the shear force and bending moment are less in Single-cell Girder Bridge, therefore it is more economical and effective when compared with twin and multi-cell girder bridge.

REFERENCES

[1] IRC: 6-2014, Standard Specifications and Code of Practice for Road Bridges, Section II, Loads and Stresses, The Indian Roads Congress, 2014
[2] IRC: 112-2011, Code of Practice for Concrete Road Bridges.
[3] Zakia B. “Analysis and Behavior Investigations of Box Girder Bridges”, M. Tech. thesis, Indian Institute of Technology Roorkee, India, 2010.
[4] Sennah K.M. and Kennedy J.B. “Literature review in analysis of box-girder bridges”, Journal of Structural Engineering ASCE, No. 10, 1061(2002) pp.1084-702.
[5] Analysis of multi-cell pre-stressed concrete box-girder bridge by B.Paval, Annamalai university.
[6] Behavior And Analysis Of An Instrumented Slab Bridge Sungki Jeon, 2009.
[7] Analysis of multi-cell pre-stressed concrete box-girder bridge by B.Paval, Annamalai university.
[8] Comparative Analysis Of Single Cell Box Girder For Different Code Jayesh Patil, Prof. R.S. Patil, Dr.G.R.Gandhe,2018.
[9] Analysis and Design of Segmental Box Girder Bridge MD TAUHEED REYAZ, SYEDA NIKHAT FATIMA,2018.
[10] Martin Alenius (2003) "Finite Element Modelling of Composite Bridge Stability" MSc. Thesis, Department of Mechanics, Royale Institute of Technology.
[11] P.K. Gupta, K K Singh and A. Mishra, (2010) "Parametric study on behaviour of box-girder bridges using finite element method" Asian journal of civil engineering (building and housing) vol. 11,Pages-135-148.
[12] SAP2000- Integrated Software for Structural Analysis and Design Structural modelling and analysis (2012), LRFD; Bridge Design Practice.
[13] Analysis of multi-cell pre-stressed concrete box-girder bridge by B.Paval, Annamalai university.