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Structural Behaviour on Concrete Box Girder Double Cells (RDBG & TDBG) Bridges using STAAD PRO

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Abstract—Bridge construction today has achieved a worldwide level of importance. Extension development today has accomplished an overall dimension of significance. Extensions are the key components in any street system and utilization of strengthened support type spans picking up notoriety in scaffold building organization in light of its better security, functionality, economy, stylish appearance and auxiliary effectiveness. By and large for long range Box brace spans are progressively basic proficient. Box support opposes the torsional unbending nature and appropriate for critical bend.

For this investigation, four distinctive scaffold supports are viewed as specifically Rectangular Single and Double cell Box Girder (RSBG and RDBG), Trapezoidal Single and Double cell Box Girder (TSBG and TDBG) of ranges 20 m, 30 m, 40m and 50m. Direct Static and Modal Analysis are performed on all the considered extension supports utilizing Staad Pro connect wizard. IRC Class AA Tracked Loading framework is considered for the examination. A near give an account of dynamic Characteristics of all the considered extension braces utilizing Staad Pro.

Keywords: Stiffness, modal analysis, Linear Static analysis, loading system, Dynamic Characteristics.

INTRODUCTION:

1. GENERAL

Bridges are defined as structures which can be provided a passage over a gap without ultimate manner beneath. They can be wanted for a passage of railway, roadway, foot path or even for carriage of fluid, bridge web site needs to be so selected that it offers most industrial and social advantages, performance, effectiveness and equality. Bridges are state's lifelines and backbones in the event of war. Bridges represent ideals and aspirations of humanity. They span barriers that divide, carry people, groups and international locations into nearer proximity. Bridge production constitutes a significance element in communique and is an essential element in progress of civilization, bridges stands tributes to the paintings of civil engineers.

METHODOLOGY

Preliminary Design Approach:

a. Back span to main span ration while fixing the basic arrangement of cable stayed bridge should be such that it should be always less than 0.5 in order to highlight the main span of cable stayed bridge. When stiffness of bridge is taken into account the optimum length of back span should be 0.4 to 0.45 of main span.
b. The spacing of stay anchors of cable stayed bridge along the deck should be incompatible with the longitudinal girder and size of stay should be limited such that breaking load is less than 25-30 MN.
c. stay oscillations can occur due to various effects such as Vortex shading, wake induced vibrations, cable galloping, parametric instability, Rattling etc should be damped by incorporating internal and external damping mechanism.
d. pylon height of cable stayed bridge determines the overall stiffness of the structure, as the stay angle (α)increases, the required stay size will decreases & height of pylon will increase. However, weight of stay cable & deflection of deck become minimum when (α) is minimum. Therefore, the most effective stay is that one with angle $\alpha=45^\circ$.
e. for the design of deck, tuning of loads in stays, to reduce the moments in the deck, under the applied Dead Load to small moments between stays, however reducing the dead load moments in the deck to purely local effects will not provide the optimal solution.

f. For the Static analysis the common approach is to model either a half or the entire structure as a space frame. The pylon, deck and the stays will usually be represented within the space frame model by ‘bar’ elements. The stays can be represented with a small inertia and a modified modulus of elasticity that will mimic the sag behaviour of the stay.

g. Dynamic analysis is the determination of the frequencies and the modes of vibration of the structure. This information is utilized for the following aspects of the design such as the seismic analysis of the structure; response of the structure in turbulent steady flow wind, the physiological effect of vibrations.

Analysis using STAAD Pro

Introduction The following is the fundamental considerations for the effective use of STAAD-PRO (i.e. Structural Analysis & Design Program software) for the analysis of structures. It must be mentioned however that since STAAD is a computer program, blind faith should not be placed in STAAD or any other engineering program. It is therefore strongly recommended that until at least one years’ experience of continually using STAAD is obtained, and for important structures parallel hand calculations for the analysis and design of the structure be done as well.

1.1 BOX GIRDER BRIDGE DECK

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 either prestressed concrete, structural steel, or a composite of steel and reinforced concrete. It is typically rectangular or trapezoidal in cross section. Box girder bridges are commonly used for highway flyovers and for modern elevated structures of light rail transport. The box girder can also be part of portal frame bridges, arch bridges, cable-stayed and suspension bridges of all kinds. Box girder decks are cast in-place units that can be constructed to follow any desired alignment in plan, so that straight, skew and curved bridges of various shapes are common in the highway system. Because of high torsional resistance, a box girder structure is particularly suited to bridges with significant curvature.

Staad Pro can perform both linear static and multistep static analysis. Certain types of load patterns are multi- stepped, meaning that they actually represent many separate spatial loading patterns applied in sequence. These include the vehicle, live, and wave types of load patterns. Staad Pro. dynamic analysis capabilities include the calculation of vibration modes using Ritz or Eigen vectors, response-spectrum analysis, and time-history analysis for both linear and nonlinear behaviour.

Figure1.1 Box Girder Bridge

Figure. 1.2 Double Cell – Box Girder

2. GEOMETRICAL CONFIGURATION OF THE BRIDGE DECK

2.1 Rectangular Double cell Box Girder

Table2.1 Geometrical parameters of the Rectangular Double cell Box Girder (RDBG)

3.

Geometrical Parameter	Dimension
Span of the Bridge Deck	20m
Total Width of the Deck	8.7m
Width of the Deck	7.5m
Depth of deck	1.2m
Width of the beam	0.3m
Thickness of the Deck slab	0.25m
Thickness of the soffit slab	0.25m
Cross girder	0.3m
No. of cross girders	5

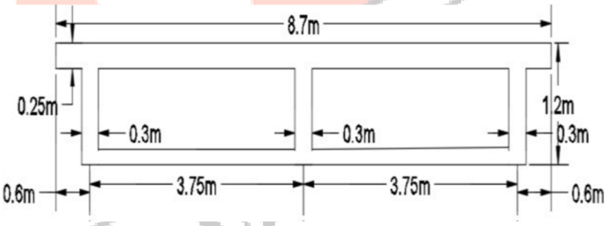


Figure2.1 Cross section of Rectangular Double cell Box Girder.

Considered different span of the girder is 20m, 30m, 40m and 50m with a total depth of 1.2m, 1.8m, 2.4m and 3.0m respectively.

2.2 Trapezoidal Double cell Box Girder

Table2.1 Geometrical parameters of the Trapezoidal Double cell Box Girder (TDBG)

Geometrical Parameter	Dimension
Span of the Bridge Deck	20m
Total Width of the Deck	8.7m
Width of the Deck	7.5m
Depth of deck	1.2m
Width of the beam	0.3m
Thickness of the Deck slab	0.25m
Thickness of the soffits lab	0.25m
Cross girder	0.3m
No. of cross girders	5

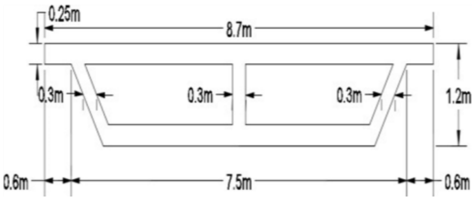


Figure2.2 Cross section of Trapezoidal Double cell Box Girder.

Considered different span of the girder is 20m, 30m, 40m and 50m with a total depth of 1.2m, 1.8m, 2.4m and 3.0m respectively.

2.3 MATERIAL PROPERTIES OF THE BRIDGE GIRDERS

Table 3.5, shows the material properties of the bridge girders

Table2.5 Properties of the bridge girders.

Concrete	Density	25 kN/m^3
	Poisson's Ratio	0.2
	Young's Modulus	33.5E+06kN/m^2
	Grade Of Concrete	M25
Steel	Density	78.5kN/m^3
	Poisson's Ratio	0.3
	Young's Modulus	200E+06kN/m^2
	Yield Stress, F_y	0.6GPa

2.4 LOADS CONSIDERED FOR THE STUDY

Dead load and moving loads are considered based on RC: 6-2010.

According to IRC: 6-2010, and other parameters we considered

- Dead Load(IRC875Part I)
- Moving Load(IRC6–2010)

IRC Class AA Tracked Vehicle is considered for this study.

3 RESULTS:

3.1 NATURAL TIME PERIOD AND FREQUENCIES

Modal analysis is performed on different types of girders namely T-Bridge girder, Box Girder single cell, Box girder multi cell, box girder slope single cell and box girder slope multi cell and the resulting mode shapes are noted down for different spans. In the present analysis, only 3 modes are considered. Table 4. Shows the values of time period and frequencies for different girders and for different spans. As time period is inversely proportional to frequency, the Bridge with higher frequency values showed lower time period values

$$f\alpha\frac{1}{T}$$

Table3.1 Natural Time Period and Frequencies for Different girders for 20m Span

GIRDERS	Time Period (sec)	Frequency (cyc/sec)
RDBG	0.17	5.73
TDBG	0.17	5.69

3.2 MODE SHAPES

Modal analysis is performed on different spans and different types of bridge girders and mode shapes are shown below.

3.2.1 For 20m Span

3.2.2 (a)Rectangular Double cell Box Girder

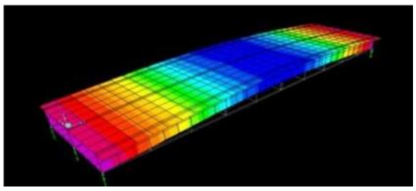


Figure3.1 First Mode Shape for Rectangular Double cell Box Girder 20m Span.

3.3.3 (b) Trapezoidal Double cell Box Girder

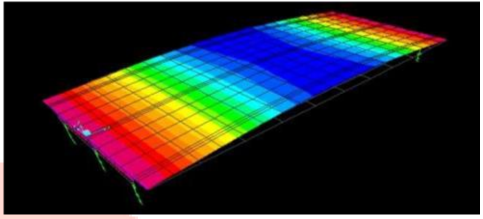


Figure3.2 First Mode Shape for Trapezoidal Double cell Box Girder 20m Span.

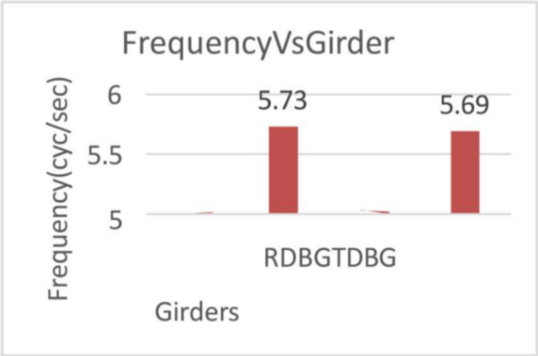


Figure3.3 Frequency (cyc/sec) Value for different girders shapes for 20m span

Table3.2 Natural Time Period and Frequencies for Different girders for 30m Span

GIRDERS	Time Period (sec)	Frequency (cyc/sec)
RDBG	0.22	4.51
TDBG	0.21	4.61

3.3.1 For 30m Span

3.3.2 (a) Rectangular Double cell Box Girder

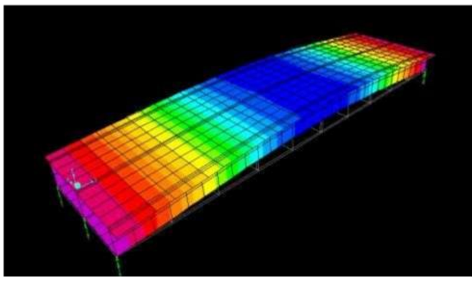


Figure 3.4 First Mode Shape for Rectangular Double cell Box Girder 30m Span.

3.3.2 (b)Trapezoidal Double cell Box Girder

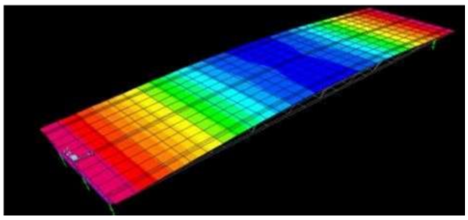


Figure3.5 First Mode Shape for Trapezoidal Double cell Box Girder 30m Span.

Figure3.7 Frequency (cyc/sec) Values For different girders shapes for 30m Span

Table3.3 Natural Time Period and Frequencies for Different girders for 40m Span

GIRDERS	Time Period (sec)	Frequency (cyc/sec)
RDBG	0.34	2.86
TDBG	0.35	2.83

3.4.1 For 40m Span

3.4.1 (a) Rectangular Double cell Box Girder

Figure 3.8 First Mode Shape for Rectangular Double cell Box Girder40m Span.

3.4.2 (b) Trapezoidal Double cell Box Girder

Figure3.9 First Mode Shape for Trapezoidal Double cell Box Girder 40m Span.

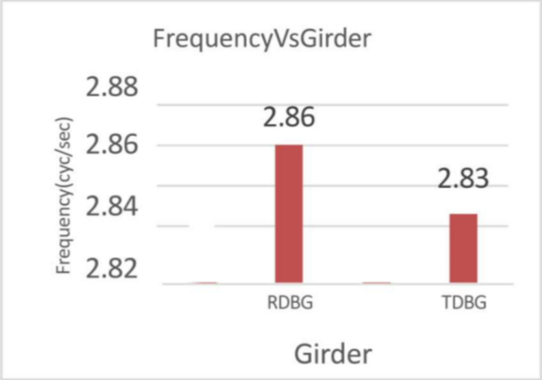


Figure3.10 Frequency (cyc/sec) Value for different girders shapes for 40m span

Table3.4. Natural Time Period and Frequencies for Different girders for 50m Span

GIRDERS	Time Period(sec)	Frequency (cyc/sec)
RDBG	0.17	5.73
TDBG	0.17	5.69

3.5.1 For 50m Span

3.5.1 (a) Rectangular Double cell Box Girder

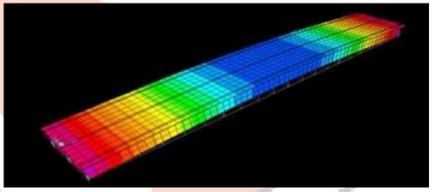


Figure3.11 First Mode Shape for Rectangular Double cell Box Girder 50m Span.

3.5.1 (b) Trapezoidal Double cell Box Girder

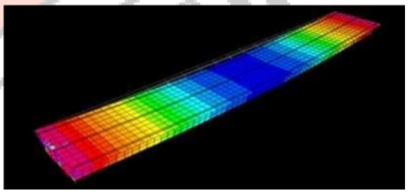
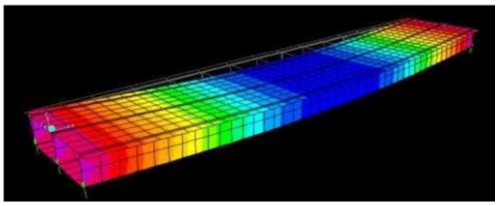


Figure3.12 First Mode Shape for Trapezoidal Double cell Box Girder 50m Span



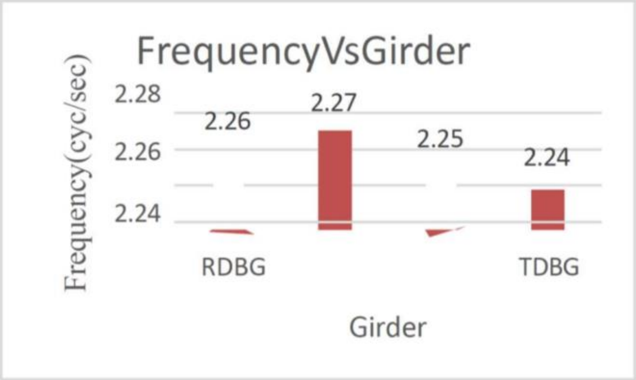


Figure3.7 Frequency (cyc/sec)Values For different girders shapes for 50m Span

3.6 STIFFNESS FOR DIFFERENT GIRDERS

Below results shows the stiffness values obtained for different types of girders with 4 different spans subjected to Class AA Tracked Vehicle.

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

f=natural frequency
(cycles/sec) m=mass (kg)
k=stiffness(N/m)

Table3.6 Frequencies (cyc/sec) and Stiffness (kN/m)for Different girders for 20m Span

GIRDERS	Frequency (cyc/sec)	Stiffness (kN/m)
RDBG	5.73	144.74
TDBG	5.69	137.49

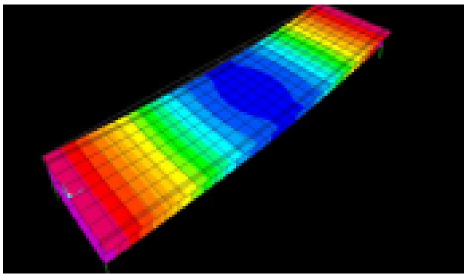


Figure 3.6 First Mode Shape for Rectangular Single cell Box Girder 20m Span

Table3.7 Frequencies (cyc/sec) and Stiffness (kN/m)for Different girders for 30m Span

GIRDERS	Frequency (cyc/sec)	Stiffness (kN/m)
RDBG	4.51	94.18
TDBG	4.61	95.07

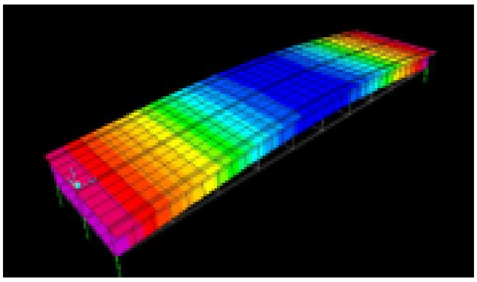


Table3.8 Frequencies (cyc/sec) and Stiffness (kN/m) for Different girders for 40m Span

GIRDERS	Frequency (cyc/sec)	Stiffness (kN/m)
RDBG	2.86	39.81
TDBG	2.83	37.81

Table3.9.Frequencies (cyc/sec) and Stiffness (kN/m) for Different girders for 50m Span

GIRDERS	Frequency (cyc/sec)	Stiffness (kN/m)
RDBG	2.23	25.58
TDBG	2.2	24.21

4. CONCLUSION

This paper gives basic principles for analysis of box girder by simple beam theory and beam on elastic foundation.

1. Percentage difference between results from simple beam theory and finite element method for longitudinal analysis is 2.95% for top slab and-6.85% for bottom slab.

2. Shear stresses obtained at the junction of webs and flanges are more compared with stresses in web portions.

3. Torsional shear stresses obtained is very less because, for box girder bridge dead load distributed uniformly which is much more than live load from vehicle. Box girder gives very high torsional rigidity.

4. St. Venant torsional shear stresses adopted is only for thin-walled members of closed sections.

5. Distortional warping stress is caused by variation in the transverse bending curvature along the length is 20 percent of longitudinal bending stress due to beam bending.

6. Inclined webs of box girder behaves structurally better based on force flow condition. Trapezoidal box girder offers more resistance to shear generated.

7. The effect of distortion of cross section can be restricted by providing diaphragms at regular interval, which improve bending stiffness of web and flange.

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