Parametric Study of Curved Skew Bridges for Varying Superstructure

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Abstract- *The present study deals with the combined effect of curvature and skew in bridges and behavior of I-girder, U-girder and Box-girder bridges under dead load and vehicle load. Here single span RCC bridge resting on abutments at both ends is considered for the analysis. Behavior of all the superstructures are compared under irregularities such as curvature in plan and skewness in abutments. The angles considered for curvature and skewness are 0°, 15°, 30°, 45°. All the models are subjected to dead load, superimposed load, and IRC vehicular live load (CLASS 70R). Parameters such as torsion and bending moments are compared for all models. Codes considered for analysis are IRC 6, IRC 112, IRC 5. Modelling and analysis are done using CSIBRIDGE software.*

Keywords- Box girder, I girder,U-girder IRC, Torsion, Bending moment, CSibridge, Curvature, Skew, RCC

I. INTRODUCTION

Bridge is a structure built to overcome barriers in the path and decreases the distance between two far locations. These barriers could be natural or manmade elements. Sometimes these congested situations results in the complexity in bridge geometries. Which eventually leads to the skewed abutment and curvature in plan.

1.1 Skew Bridge

Sometimes it is not possible to built a bridge that spans perpendicular to the obstacle that it crosses. So a bridge with abutments not perpendicular to layout line of bridge is called skew bridge. And a skew angle can be defined as the angle between pier/abutment alignment and a line perpendicular to the center line of bridge span.

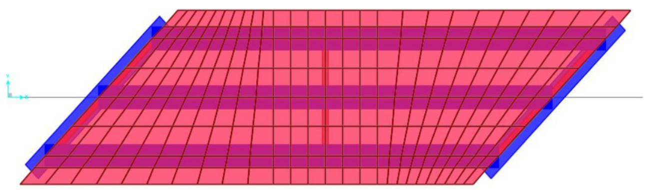

Fig -1: Skew bridge

1.2 Curved Bridge

Curved bridges are widely used as interchanges or useful in densely populated areas to avoid the traffic and it also increases the aesthetics. Although curvature in bridge makes bridge behavior more complicated.

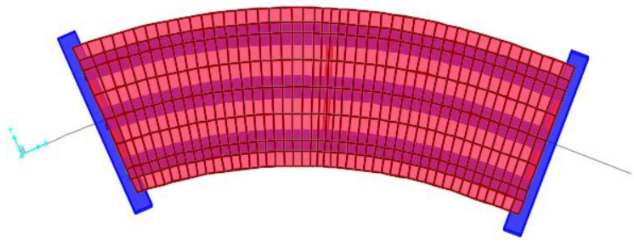

Fig -2: Horizontally curved bridge

1.3 Curved Skew Bridge

Sometimes curvature and skewness can't overcome the complex situations. In such conditions combined use of skew and curvature in bridge is necessary. Bridges having both skew and curvature in plan are known as curved skew bridges. Their behavior becomes more complex due to combined effect of skew and curvature.

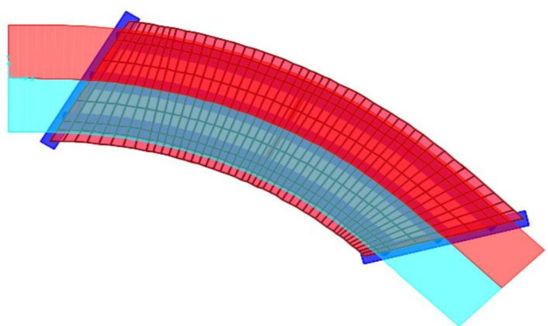

Fig -3: Curved and skew bridge in plan

II. RESEARCH SIGNIFICANCE

As bridges are important part of the transportation system it is necessary to understand the behavior of bridges under dead and vehicular loading. As the irregularities such as curvature and skewness in bridges increases, the load transfer becomes more complex. So, it is necessary to analyze the combined effect of curvature and skewness on the bridge.

In this paper three super structure conditions with I-girder, U-girder and Box-girder are compared for torsion and bending moment with varying curvature and skew angles. The objective of the study is to evaluate the combined effect of curvature and skewness in bridge and to compare the effectiveness of all the superstructures.

III. MODELLING AND ANALYSIS

3.1 Bridge Configuration

For Modelling, a 25meter long single span bridge has been selected. Girder bottom is connected to abutment through a bearing. A bearing is having 100000 kn/m of stiffness in longitudinal direction and fixed in two other translations. Abutment is 10.5m in length. M30 concrete and HYSD415 bars are used.

In present work three different superstructure conditions are taken, I girder, U girder and Box girder. super structure dimensions are so selected that their effective cross section area remains same.

3.1.1 I-Girder Cross Section

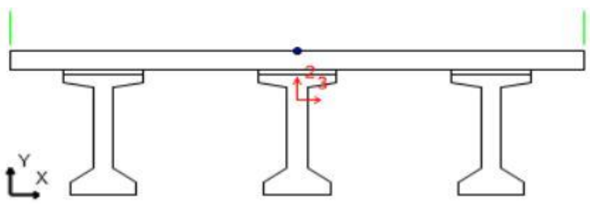

Fig -4: I girder bridge cross section

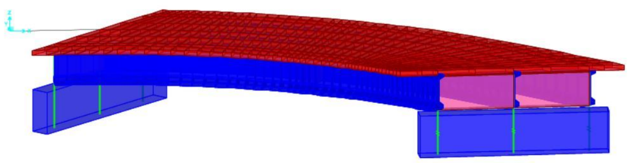

Fig -5: Modelling of I girder bridge

Thickness of slab= 0.3m
Total width=8.7m
Depth of I-girder=2m
Top flange width=1.2m
Top flange thickness=0.15m
Bottom flange width=1m
Bottom flange thickness=0.2m
Cross section area=5.86m^2

3.1.2 Box-Girder Cross Section

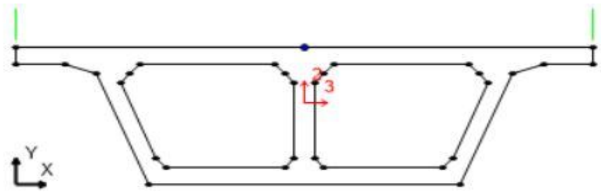

Fig -6: Box girder bridge cross section

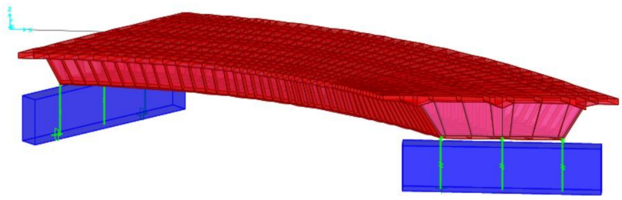

Fig -7: Modelling of box girder bridge

Thickness of top slab=0.3m
Thickness of bottom slab=0.3m
Total width=8.7m
Total depth=2.3m
No. of cells=2
Thickness of girder=0.3m
Cross section area=5.90m^2

3.1.3 U-Girder Cross Section

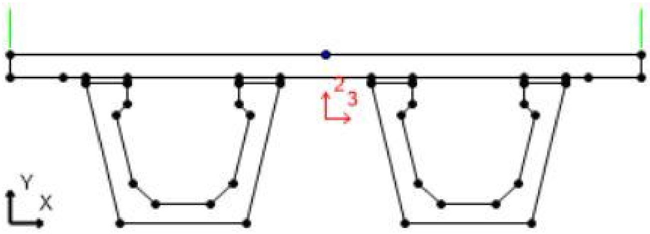

Fig -8: U girder bridge cross section

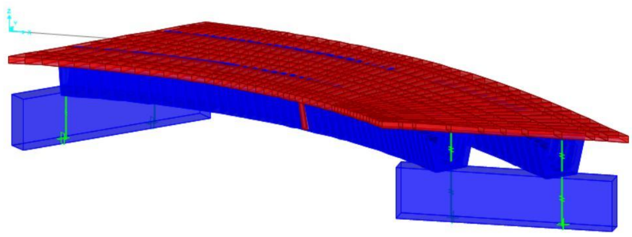

Fig -9: Modelling of U girder bridge

Thickness of slab= 0.3m
Total width=8.7m
Depth of U-girder=1.8m

Top width of girder=2.6m
Bottom width of girder=1.5m
Bottom thickness of girder=0.25m
Cross section area=5.87m^2

- Software CSI bridge has been used for modelling and performing analysis.

For curved bridges super elevation of 0.5% is taken.
Super elevation can be taken from

$$\mathbf{e + f = v^2 / g \cdot r}$$

Where, e = super elevation, r = radius, g = gravitational acceleration, f = friction co-efficient, v = velocity in m/s
For curvature centrifugal force also should be considered,

$$\mathbf{C = WV^2/127R}$$

Where, R= Radius of curvature, W= Equivalent distributed live load in kN/m, V=speed of vehicle

And breaking force of 25% of axle load should be considered.

In addition to different superstructures, bridges vary in geometry too. Abutment skew and curvature in superstructure are considered as two variables. Skew angle and curvature angle both vary as 0°, 15°, 30°and 45°. So total of 16 different conditions with varying angle of skew and curvature are considered. And with 3 different superstructures total of 48 models are generated.

IV. RESULT ANALYSIS

Results obtained from CSI bridge software in terms of Torsion and Bending moment are exported to excel and used to derive the charts.

4.1 Bending Moments

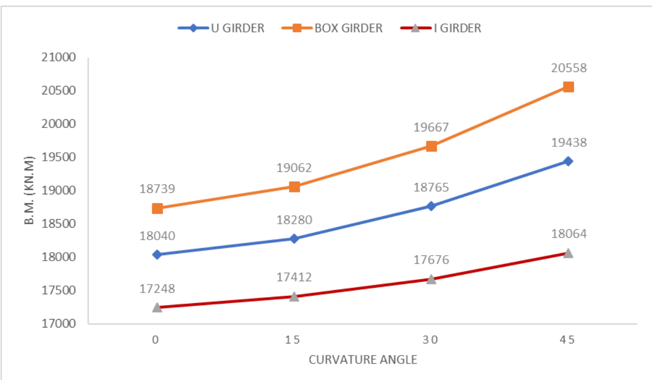

Chart -1: Bending moment for 0° Skew

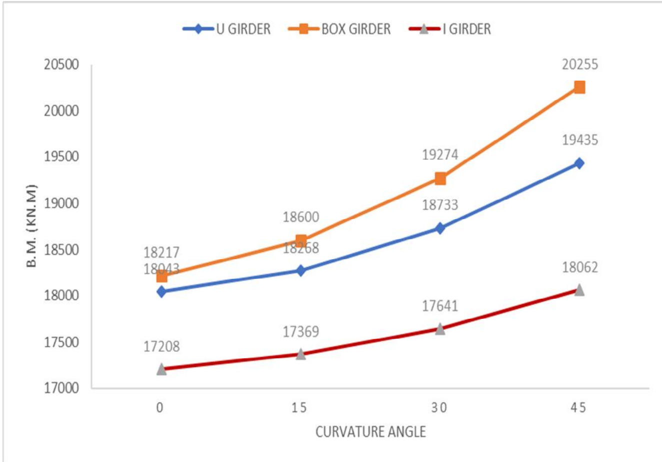

Chart -2: Bending moment for 15° Skew

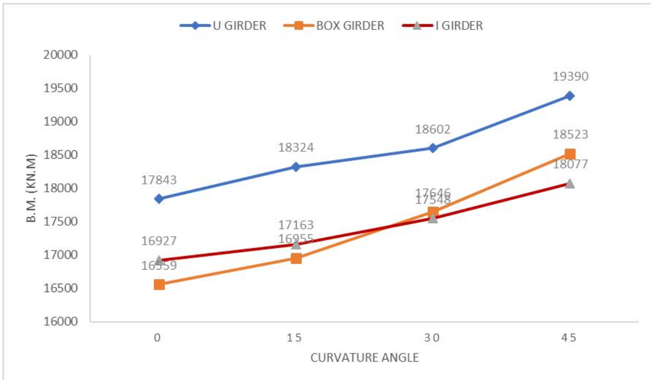

Chart -3: Bending moment for 30° Skew

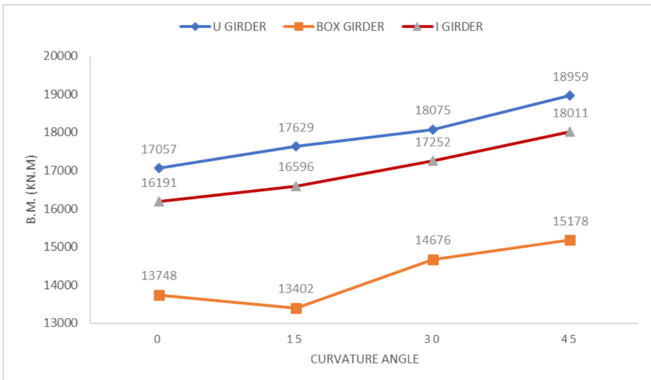

Chart -4: Bending moment for 45° Skew

4.2 Torsion

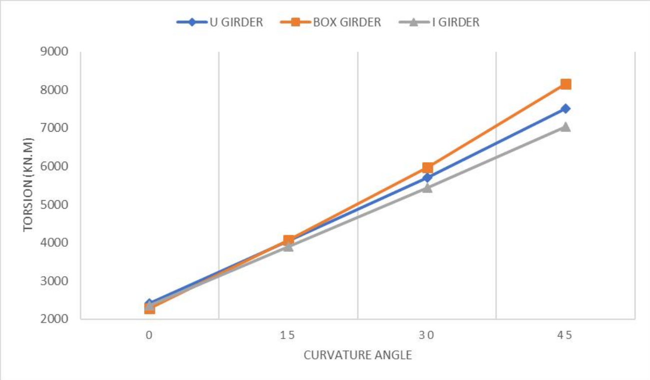

Chart -5: Torsion for 0° Skew

Chart -6: Torsion for 15° Skew

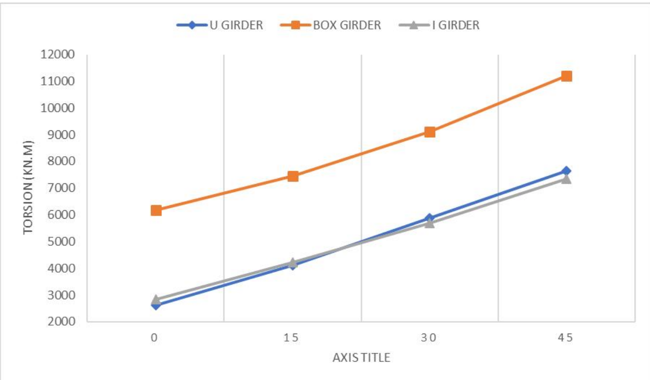

Chart -7: Torsion for 30° Skew

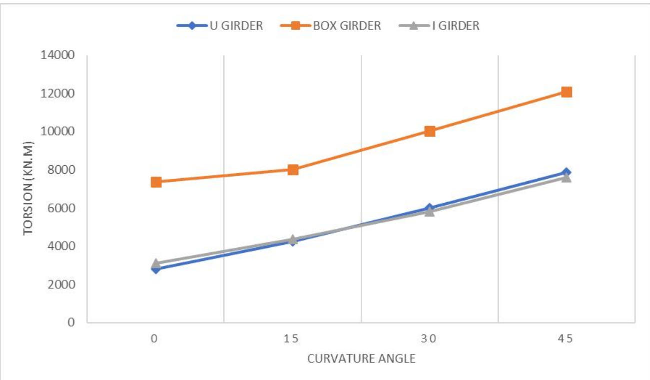

Chart -8: Torsion for 45° Skew

III. CONCLUSIONS

- The bending moment increases with the curvature angle on the other hand, the bending moment reduces with increase in skew angle. When the combined effect of curvature and skew is considered with reference to the increase in their angles, it can be seen that the bending moment increases, which proves that curvature has slightly greater influence on bridge as compared to skew.
- Torsion increases with the increase in skew and curvature angles.
- For the skew angle upto 15 accompanied by varying curvature, maximum bending moment is obtained for the box girder while minimum bending moment is found for I girder.
- In accordance to skew angles greater than 15 the bending moment of box girder gradually decreases as compared to U girder and I girder. At this phase, maximum bending moment is observed for U girder.
- For the skew and curvature angle of 0 a minor difference is observed in torsion for all the girders.
- With the increase in skew angle maximum torsion is observed for box girder as compared to U girder and I girder. The value of torsion for U girder and I girder remains nearly the same.

IV. ACKNOWLEDGEMENT

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