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An Investigation on the Parametric Effects of Curvature & Skew Responses of an Evaluated Curved Box Girder Bridge

Jyoti Yadav[1], Dr. G. Shravan Kumar[2]

[1]*PhD Scholar, Department of Civil Engineering, Sarvepalli Radhakrishnan University, Bhopal, M.P, India*

[2]*Professor, Department of Civil Engineering, Sarvepalli Radhakrishnan University, Bhopal, M.P, India*

ABSTRACT

For the purpose of the parametric study, six box girder bridge models with varying curvature and constant span length were constructed. In addition, five models with changeable skew angle and thirty models with combined effect were produced. A box Girder Bridge example is selected from the available literature in order to conduct a validation study on it. This is done to verify the methodology of finite element modelling. After modelling and analyzing the example box girder in SAP 2000, it was revealed that the responses matched the relevant literature results rather well. In order to conduct the parametric research, SAP2000 models of all 42 box girder bridges were developed. The span length, the cross-section, and the quality of the material have not changed. Only the skew angle and radius of curvature are modifiable characteristics. The superstructure of the box girder bridge consists of the single-cell box, as shown in the bridge's cross section. The bridges' curvature varies only horizontally over their whole length. Each model is evaluated for both its own weight and the moving load it will encounter. In addition to a modal analysis, a static analysis taking into account both dead load and moving load is conducted. In addition to the longitudinal stress at the top and bottom of the cross sections, the bending moment, torsion, and deflection are also recorded. In comparison to the answers of a straight bridge, the responses of a curved box girder bridge are evaluated.

Keywords- Radius of curved bridge, skew angle, bending moment, longitudinal stress, deflection, torsion.

1. INTRODUCTION

Bridges are used to span any man-made or natural ground feature, such as a stream, road, railway, or valley, in order to link roads. A bridge is a structure that transports commodities over an impediment such as a stream, road, railway, or valley while preserving rail and vehicle traffic connection. The Over Bridge allows a road, train, or pipeline to go over a barrier. A road, a train, or a pipeline may pass under an impediment beneath a bridge. In order to divert traffic across highways, a flyover is constructed over a bridge. There is a growing need for skewed bridges as the requirement for complex intersections and space limits in metropolitan areas increase. Slanted bridges are useful in areas where environmental impact is a concern and when modifying the road's alignment is neither feasible nor cost-effective due to the topography. If a road alignment crosses a river or other obstruction at an angle different than 90 degrees, a skew crossing may be necessary. A slanted bridge takes much more research and planning than a straight bridge. Horizontally curved bridges are more problematic than straight bridges in situations such as complex interchanges or river crossings, where geometric restrictions and the constraints of a limited site area make the adoption of a typical straight superstructure hard. Analyzing curved and skewed bridges is facilitated by finite element analysis, which is, nevertheless, a more challenging method. The designer should thus devise a more basic solution to the problem.

2. PROBLEMDESCRIPTION

Currently, it is believed that a straight bridge has a trapezoidal cross section with a constant span length of 50 meters. When assessing class 70 R tracked vehicles, just consider the bridge's own weight in addition to super dead load and moving load. Concrete is used for bridge construction. Sectional and material qualities are shown in the table. The Span length, Load, Material Property, and Cross Section of all bridge types are identical. The results of the analytical model include bending moment, torsion, time period, and longitudinal stress at the top of the center.

3. ANALYSIS & METHODOLOGY

Super dead load calculation is given below:

Railing weight   Wearing coat weight

Height of railing = 1m.   Weight of wearing coat = 22 KN/m3.

Width of railing = 0.25m. Thickness of wearing coat = 0.075m.

Length of railing = 1.47m. Total area load = 22*0.75 = 1.65 KN/m2.

Total load = 25*0.25*1.47*1 = 9.2 KN.

Material property		Sectional property	
Weight per unit volume =	25 KN/m3	Length of span =	50m
Young's modulus (E) =	32500 X 10^3 KN/m2	Width of top flange =	8.4m
Poisson's ratio (μ) =	0.15	Depth of box girder =	2.31m
Shear modulus (G) =	1.413 X 10^7 KN/m2	Thickness of top flange =	0.38m
Coefficient of thermal expansion (A) =	1.17 X 10^-5/°C	Width of web =	0.38m
Specific compressive strength of concrete (Fc') =	45 X 103 KN/m2	Width of bottom flange =	3.68m
		Thickness of bottom flange =	0.38m

Table 1: Materials and Section Properties of Bridge

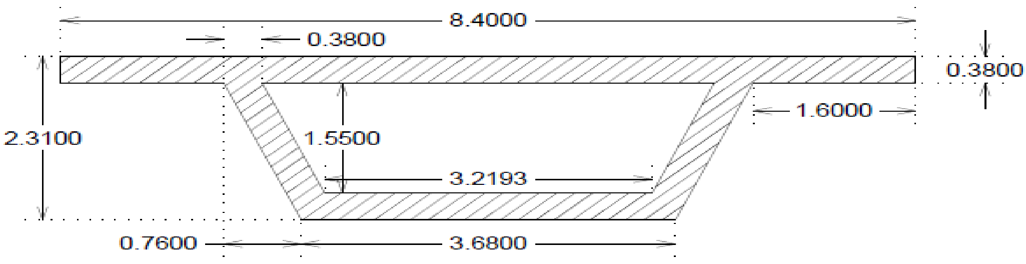

Fig. 1: cross section of bridge deck

4. EFFECT OF RADIUS ON CURVEDBRIDGE

Using the SAP2000 bridge module with shell components, the straight and curved box girder models are created. Thus, the horizontal alignment of Bridge Wizard is bent. Modeled is a single, straight bridge with a 50-meter span. Six models of curved bridges with radiuses of 200 m, 225 m, 250 m, 275 m, 300 m, and 350 m have been developed. The box girder's cross section is trapezoidal. The analytical model for a 200-meter radius is 50C200S90. Both curved and straight model outcomes should be evaluated. A graphical comparison of the results of the straight bridge model and the bridge with all curves.

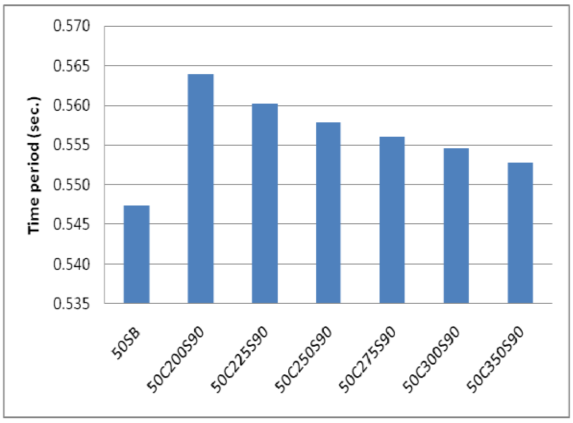

Fig 2: comparison oftimeperiod

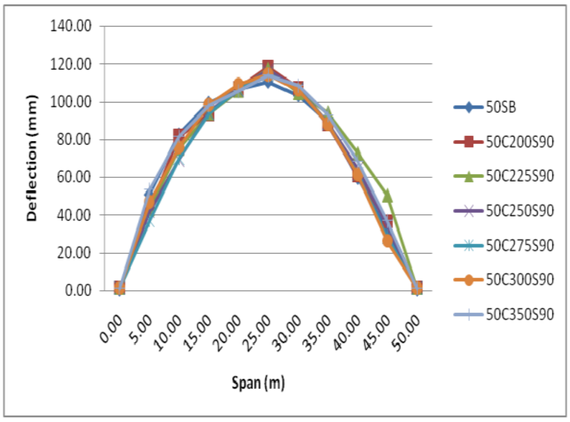

Fig. 3: comparison of deflection due toD.L. +S.D.L.

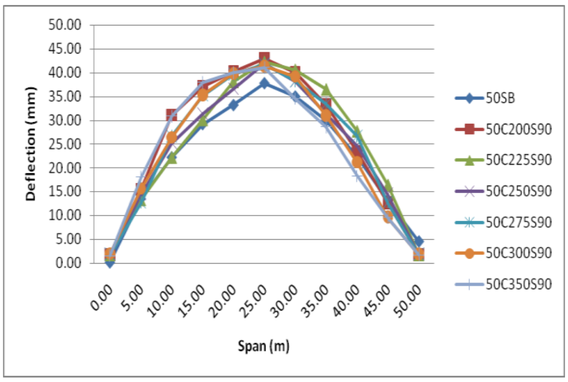

Fig. 4: comparison of deflection due tomovingload

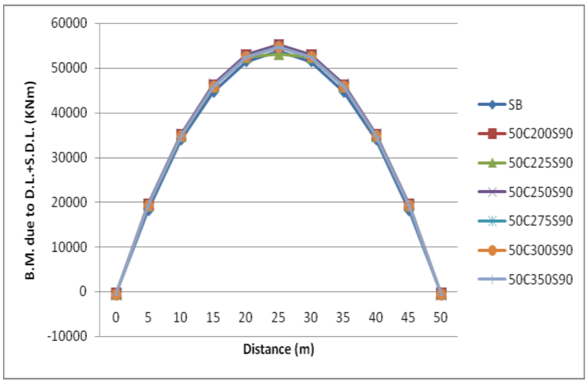

Fig. 5: Comparison of B.M. due toD.L. +S.D.L.

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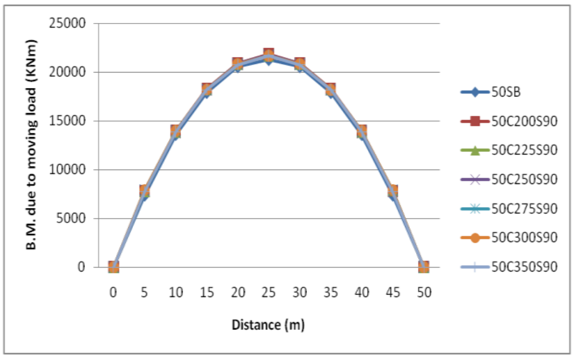


Fig. 6: Comparison of B.M. due tomovingload

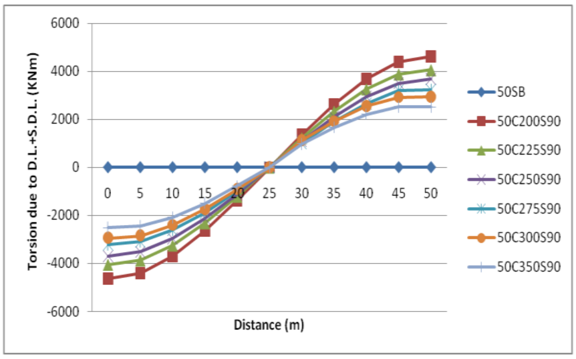


Fig. 7: Comparison of torsion due toD.L. +S.D.L.

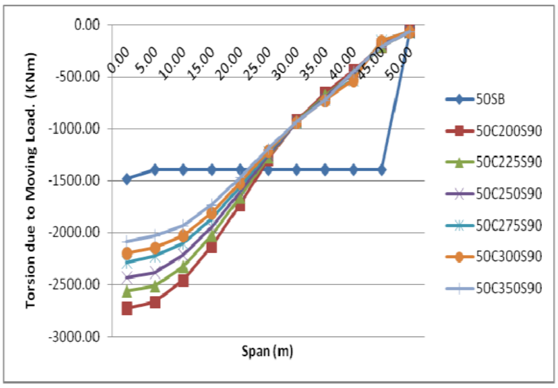


Fig. 8: Comparison of torsion due tomovingload

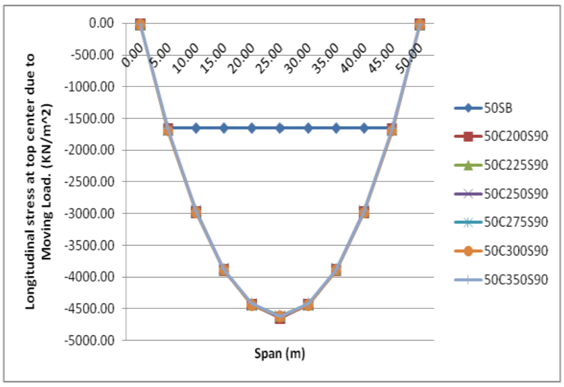
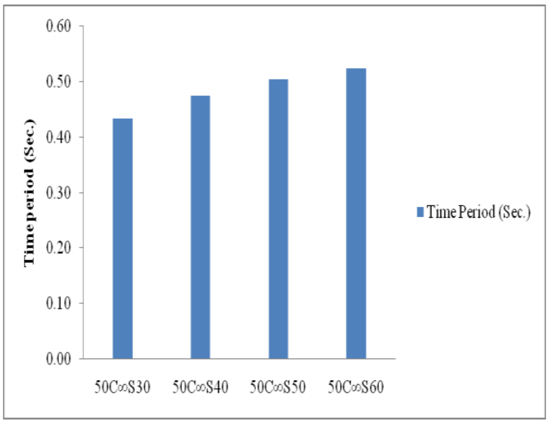


Fig. 9: Comparison of long. Stress at topcenter

5. EFFECT OF ANGLE ON SKEW BRIDGE

Five skew bridges are modelled having radius infinite and angle 30°, 40°, 50°, 60° and 70°. The box girder has trapezoid cross section. Skew angle taken with respect to horizontal axis. Notation of analytical model is given like 50C∞S30 for 30° skew angle. Comparison of result for all skew bridge model for straight span in graphical form.



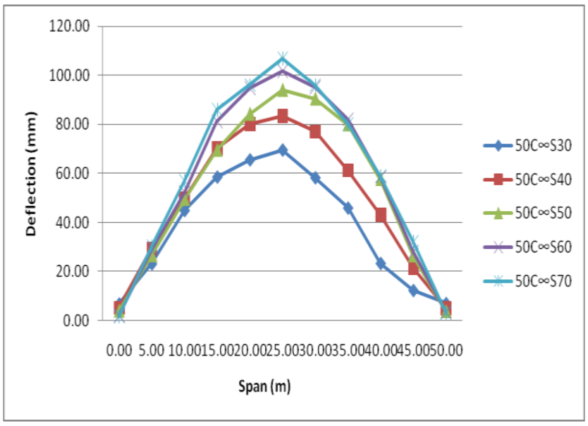


Fig. 10: comparison oftimeperiod

Fig. 11: comparison of deflection due toD.L.+S.D.L.

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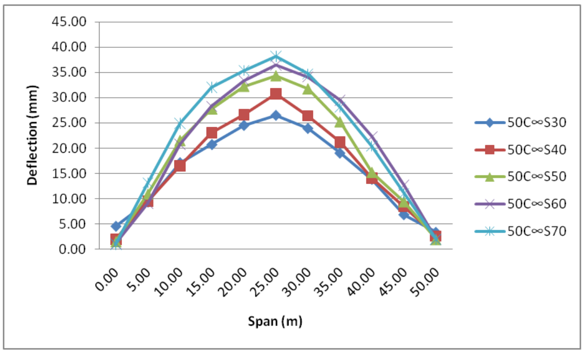


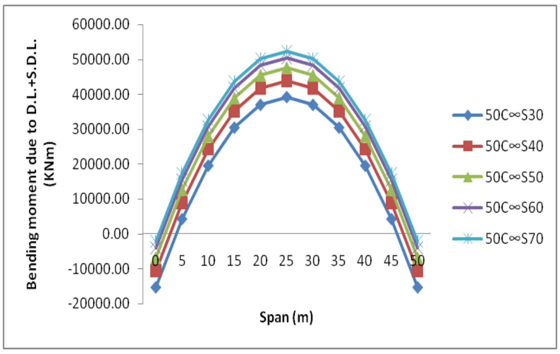
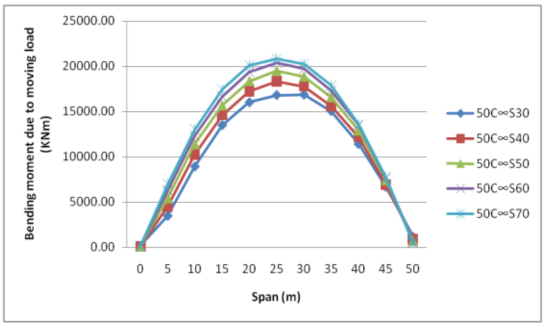


Fig. 12: comparison of deflection due tomovingload

Fig. 13: Comparison of B.M. due toD.L.+S.D.L.



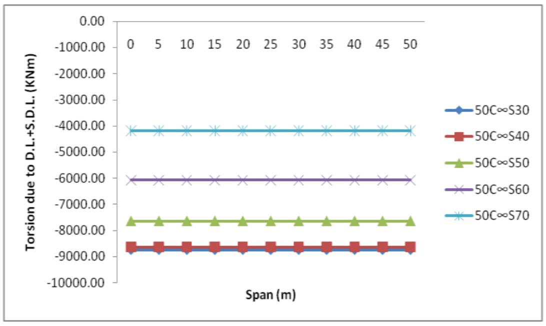
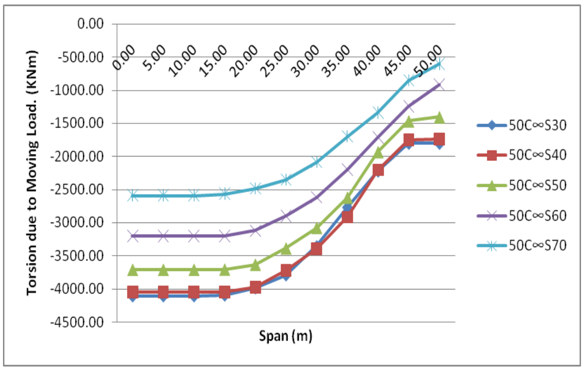


Fig. 14: Comparison of B.M. due tomovingload

Fig. 15: Comparison of torsion due toD.L. +S.D.L.



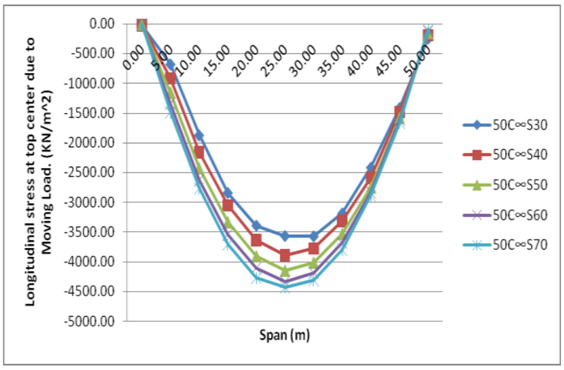


Fig. 16: Comparison of torsion due tomovingload

Fig. 17: Comparison of long. Stress at topcenter

6. CONCLUSION

1. Time is reduced by increasing the radius of curvature for a given skew angle. As a result, that time period's worth is greater than a straight bridge.
2. When the radius of curvature is increased for a given skew angle, the deflection value decreases. Deflection occurs greater on curved bridges as a result.
3. In the cases of dead load plus super dead load and moving load, the value of the bending moment decreases as the radius of curvature increases.

4. Torsion's effects are not present in a straight bridge under static loads. For a curved bridge, the torsion value is larger near the support than at the center. Torsion value decreases as radius increases.
5. When a moving load is present, the torsion value of a straight bridge remains constant across the bridge's span.
6. In a straight bridge, the longitudinal stress value is constant.
7. A curved bridge has a larger longitudinal stress value at the top and bottom of the cross section than a straight bridge.
8. For all radii and straight bridges, the value of time period increases as the skew angle increases.
9. For all radii and all load cases taken into consideration in the research, the value of deflection increases with increasing skew angle.
10. For all radii and all load cases taken into consideration in the research, the value of the bending moment increases with increasing skew angle.
11. For all radii and all load cases taken into consideration in the research, the value of torsion decreases as the skew angle increases.
12. Increased skew angle for shifting load at top and bottom faces results in an increase in longitudinal stress value at the midpoint of the bridge.

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