# Parametric Study on Effect of Curvature and Skew on Box Type Bridge

**[1]Mr. Bhalani Raj, [2]Prof. Dipak Jivani**

[1]Research Scholar, [2]Assistant Professor
Structural Engineering Department
Darshan Institute of Engineering and Technology – Rajkot

***Abstract* – For the purpose of the parametric study, six box girder bridge models with constant span length and varying curvature and five models with varying skew angle and thirty model for combined effect. In order to validate the finite element modelling method, an example of box Girder Bridge is selected from literature to conduct a validation study. The example box girder is modelled and analysed in SAP 2000 and the responses are found to be fairly matching with the results reported in literature. For the purpose of the parametric study, the forty two box girder bridges are modelled in SAP2000. The span length, cross-section and material property remains unchanged. The only parameter that changes is the radius of curvature and skew angle. The cross section of the superstructure of the box girder bridge consists of single cell box. The curvature of the bridges varies only in horizontal direction. All the models are subjected to self weight and moving load of vehicle. A static analysis for dead load and moving load and a modal analysis are performed. The longitudinal stress at top and bottom of cross sections, bending moment, torsion and deflection are recorded. The responses of a box girder bridge curved in plan are compared with that of a straight bridge.**

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

## I. INTRODUCTION

Bridges are the links in roads, which close the discontinuity across any natural or manmade feature on the ground like channel, road, railway or valley. Bridge is a structure which maintains the communication such as the road and railway traffic and other moving loads over an obstacle like, a channel, a road, a railway or a valley. Over Bridge carries road, railway or pipeline pass over obstacle. Under bridge carries road, railway or pipeline pass under obstacle. Flyover is construct over bridge to divert traffic over the roadways.

There is a growing demand for skewed bridges as the needs for complex intersections and the problems with space constraint in urban areas arise. Skewed bridges are useful when roadway alignment changes are not feasible or economical due to the topography of the site and also at particular areas where environmental impact is an issue. If a road alignment crosses a river or other obstruction at an inclination different from 90°, a skew crossing may be necessary. The analysis and design of a skew bridge are much more complicated than those for a right bridge.

Horizontally curved bridge are more demanding than straight bridge in situations like at complicated interchanges or river crossing where geometric restrictions and constraints of limited site space make extremely difficult for adoption of standard straight superstructure. Finite element method is very usefull for analysis for curved and skew bridge, but it is more complicated method. So that designer should find some simplified solution to solve the problem.

## II. PROBLEM DESCRIPTION

In present work, Straight bridge consider having constant span length 50m and trapezoidal cross section. For analysis purpose only consider self weight of bridge plus super dead load and moving load as class 70_R tracked vehicle. Concrete used as bridge material. Sectional and material property described in table. Span length, loading, material property and cross section remain same for all bridge model. Result obtained from analytical model is bending moment, torsion, time period and longitudinal stress at top of center.

Super dead load calculation is given below:

Railing weight
Height of railing = 1m.
Width of railing = 0.25m.
Length of railing = 1.47m.
Total load = 25*0.25*1.47*1 = 9.2 KN.

Wearing coat weight
Weight of wearing coat = 22 KN/m3.
Thickness of wearing coat = 0.075m.
Total area load = 22*0.75 = 1.65 KN/m2.

| Material property | |
|---|---|
| Weight per unit volume = | 25 KN/m3 |
| Young's modulus (E) = | 32500 X 10^3 KN/m2 |
| Poisson's ratio (μ) = | 0.15 |
| Shear modulus (G) = | 1.413 X 10^7 KN/m2 |
| Coefficient of thermal expansion (A) = | 1.17 X 10^-5/°C |
| Specific compressive strength of concrete (Fc') = | 45 X 103 KN/m2 |

| Sectional property | |
|---|---|
| Length of span = | 50m |
| Width of top flange = | 8.4m |
| Depth of box girder = | 2.31m |
| Thickness of top flange = | 0.38m |
| Width of web = | 0.38m |
| Width of bottom flange = | 3.68m |
| Thickness of bottom flange = | 0.38m |

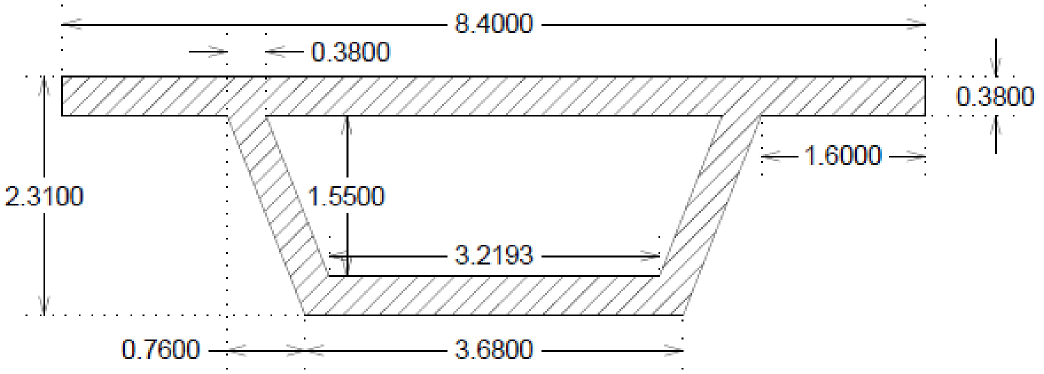
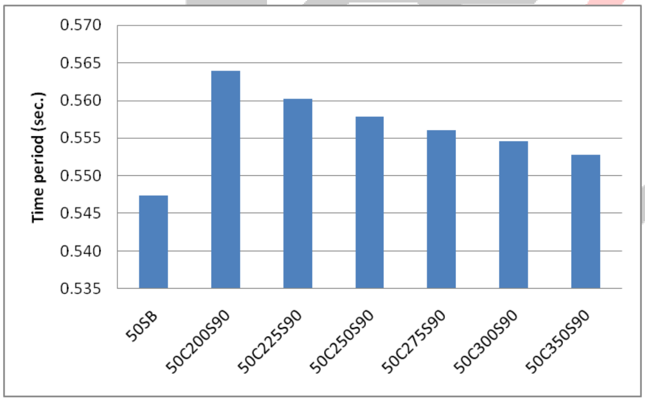



Fig. 1 : cross section of bridge deck

## III. EFFECT OF RADIUS ON CURVED BRIDGE

The straight and curved box girder model are made using bridge module with shell elements of SAP2000. The horizontal alignment from bridge wizard is made curved by horizontally. One straight bridge is modelled having span 50m. Six curved bridges are modelled having radius of curvatures 200m, 225m, 250m, 275m, 300m and 350m. The box girder has trapezoid cross section. Notation of analytical model is given like 50C200S90 for 200m radius. Result should be taken for all curved and straight model. Comparison of result for all curvature bridge model with straight bridge model in graphical form



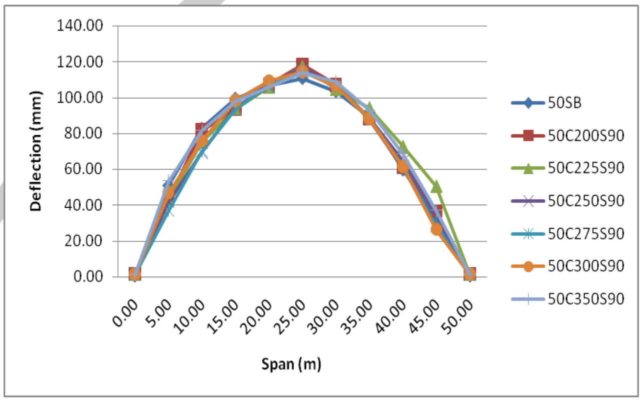




Fig 2 : comparison of time period

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

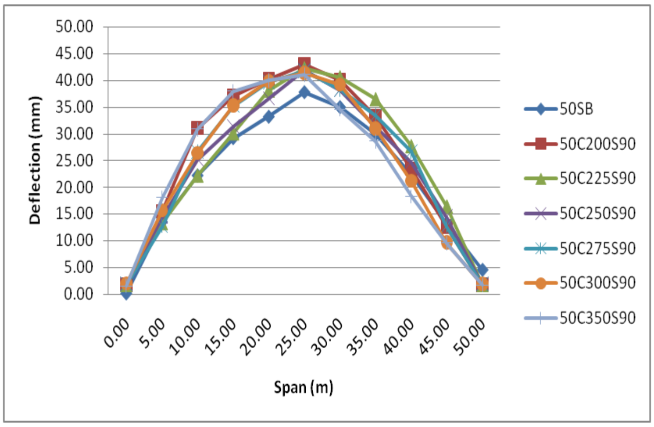



Fig. 4 : comparison of deflection due to moving load

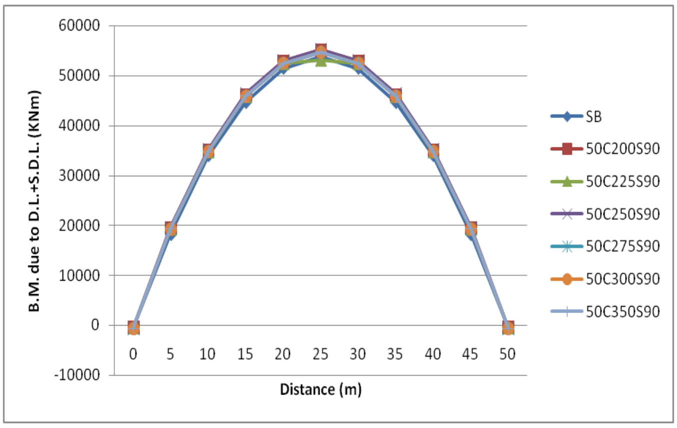



Fig. 5: Comparison of B.M. due to D.L.+S.D.L.

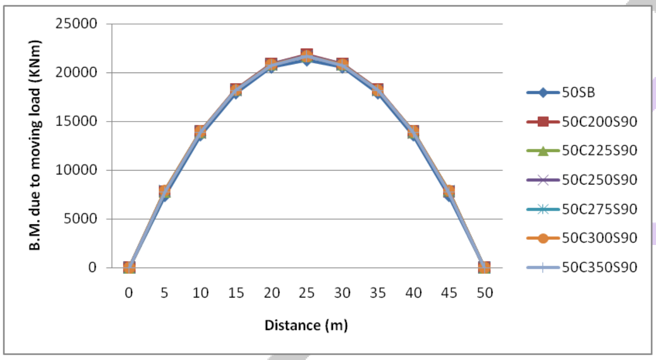



Fig. 6: Comparison of B.M. due to moving load

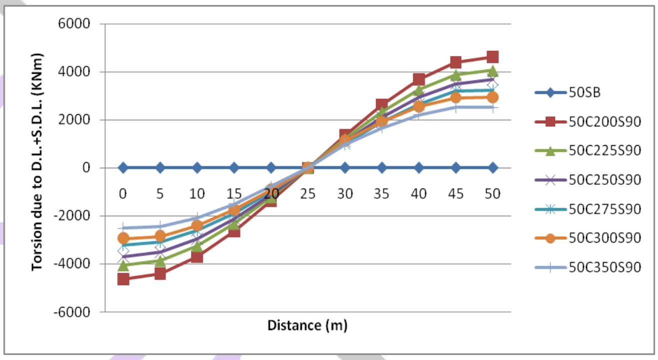



Fig. 7: Comparison of torsion due to D.L.+S.D.L.

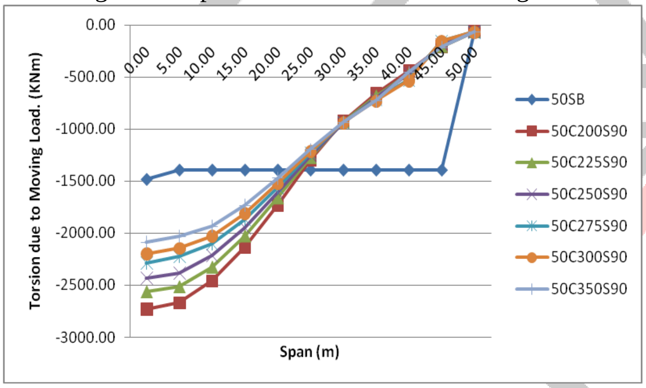



Fig. 8: Comparison of torsion due to moving load

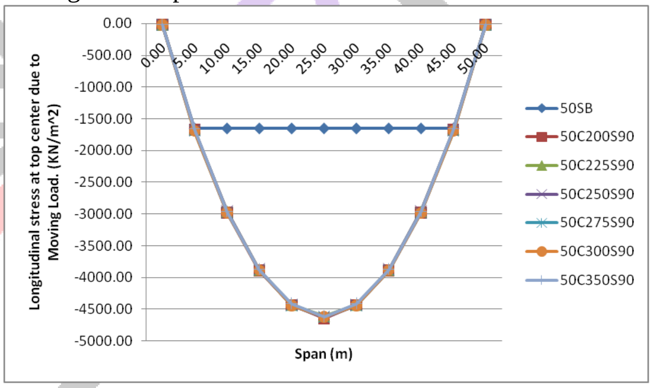



Fig. 9: Comparison of long. Stress at top center

## IV. 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.

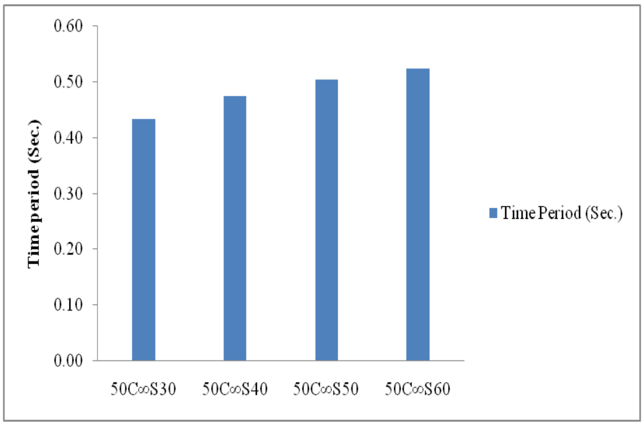



Fig. 10: comparison of time period

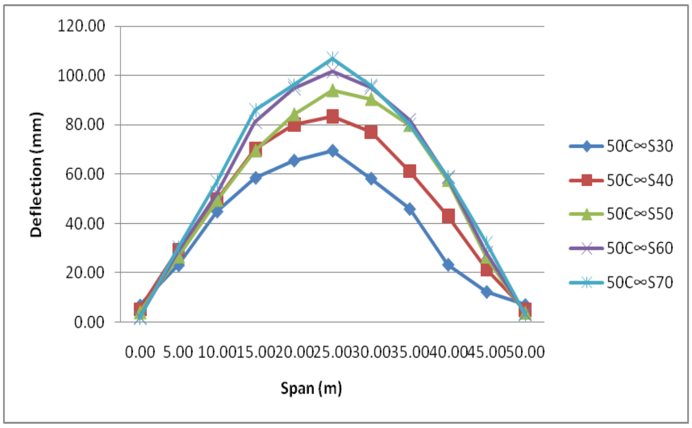



Fig. 11: comparison of deflection due to D.L.+S.D.L.

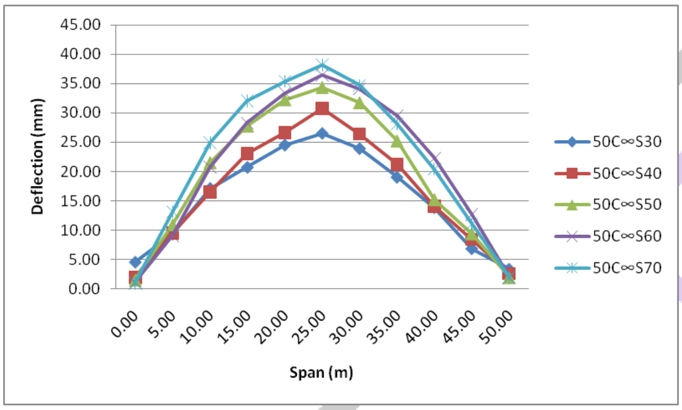



Fig. 12: comparison of deflection due to moving load

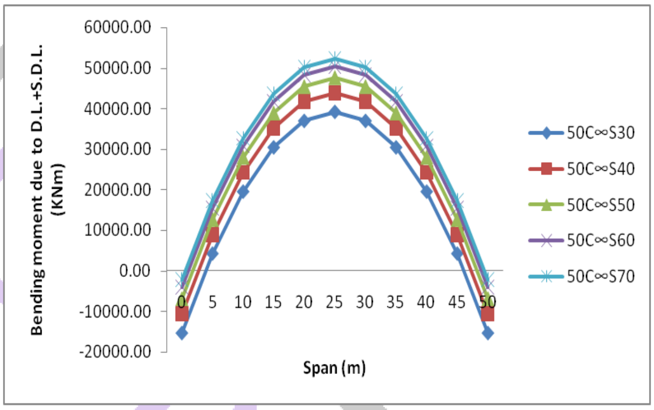



Fig. 13: Comparison of B.M. due to D.L.+S.D.L.

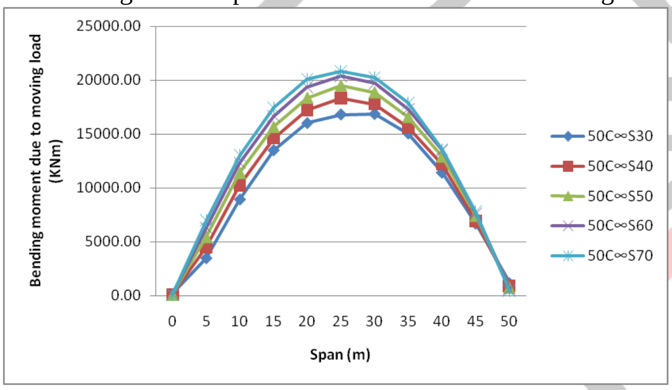



Fig. 14: Comparison of B.M. due to moving load

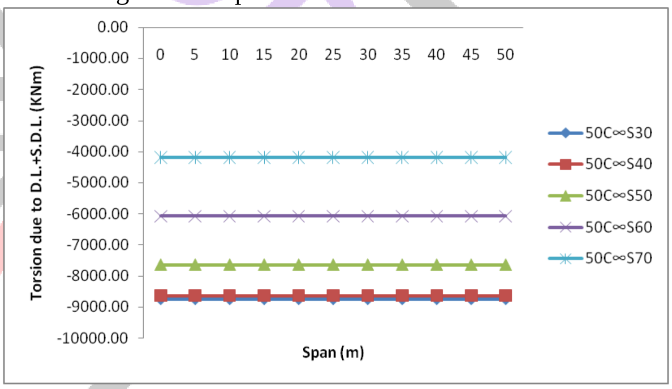



Fig. 15: Comparison of torsion due to D.L.+S.D.L.

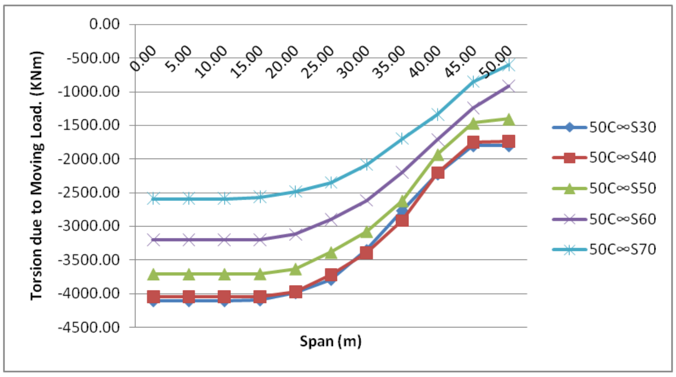



Fig. 16: Comparison of torsion due to moving load

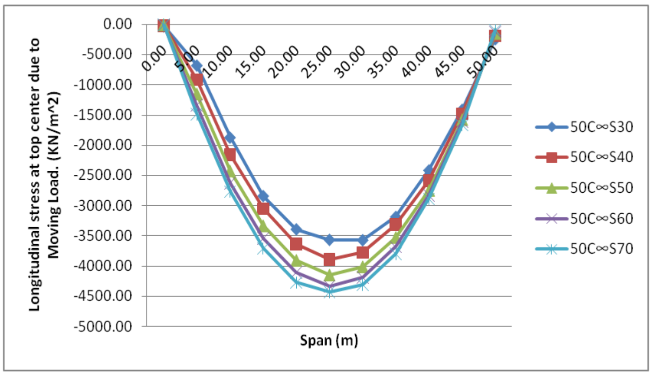



Fig. 17: Comparison of long. Stress at top center

## V. CONCLUSION

1. By increasing radius of curvature for same skew angle, time period is decrease. So that time period value is more compare to straight bridge.
2. By increasing radius of curvature for same skew angle, value of deflection is decrease. So that deflection is more in curved bridge.
3. As increasing value of radius of curvature, value of bending moment is also decrease in dead load plus super dead load and moving load case.
4. Effect of torsion is not induce in straight bridge for static load case. Value of torsion is higher at support as compared to center for curved bridge. Value of torsion decrease by increasing radius.
5. In straight bridge value of torsion is constant in span of the bridge for moving load case.
6. Longitudinal stress value constant in straight bridge.
7. Longitudinal stress value at top and bottom of cross section of curved bridge is higher than straight bridge.
8. Value of time period increase with increasing skew angle for all radius and straight bridge.
9. Value of deflection increase with increasing skew angle for all radius and all load case which consider in study.
10. Value of bending moment increase with increasing skew angle for all radius and all load case which consider in study.
11. Value of torsion decrease with increasing skew angle for all radius and all load case which consider in study.
12. Longitudinal stress value increase at mid span of bridge with increase skew angle for moving load at top and bottom face.

## REFERENCES

[1] Wilson T, Mahmoud H, Chen, Seismic Performance of skew and curved reinforced concrete bridge in mountainous states,ELSEVIER, Engineering Structures 70 (2014) 158-167.
[2] Khaled M. Sennah,John B. Kennedy, literature review in analysis of box-girder bridges,ASCE 1084-0702(2002)7:2(134).
[3] P.K. Gupta, K. K. Singh, A. Mishra, Parametric Study on Behaviour of box-girder Bridges Using Finite Element Method, Asian journal of civil engineering 11:1(2010)135-148.
[4] Ansuman k, Vikash k, P. Maiti & P. Singh, Study on Effect of Skew Angle in Skew Bridges, International Journal of Engineering Research and Development,2:12(2012)13-18.
[5] Luo m, Jing-hong G., Sensitivity analysis of continuous curved bridge under different curvature radius, Applied mechanics and materail,587-589(2014)1650-1654.
[6] Yaping Wu, Shizhong Liu, Yuanlin Zhu and Yuanming Lai, Matrix analysis of shear lag and shear deformation in thin-walled box beams,(ASCE)0733-9399(2003) 129:8(944).
[7] E.C. Hambly "Bridge deck behaviour second edition"
[8] IRC: 6-2000, Standard Specifications and Code of Practice for Road Bridges,Section II, Loads and Stresses, The Indian Roads Congress, 2000.
[9] Bridge Manual, SAP (2000). Linear and Nonlinear Static and Dynamic Analysis and Design of Three-Dimensional structures.