

STUDY OF BASIC DESIGN OF A PRECAST SEGMENTAL BOX GIRDER BRIDGE

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ABSTRACT

Box girder bridges are being made into use at many places. Various studies have been performed so as to develop a more stable structure design by varying the shape of the bridge structure. This study is also aims at understanding the effect of changing the basic shape on the stability of the bridge. By varying the length of the over-hanging beam section and increasing the thickness of the joints, the variation in the stability has been studied. SAP 2000 software has been used to apply moving load and to study the deflections and stress contours .

KEYWORDS: Bridge, Box Girder Bridge, Design of Box Structure, Precast Bridge, SAP 2000

INTRODUCTION

Box girder bridges are very commonly used. It is a bridge which has its main beams comprising of girders in the shape of hollow boxes. The box girder normally comprises of pre-stressed concrete, structural steel or steel reinforced concrete. As shown in Figure 1, a box-girder cross section may take the form of single cell (one box), multiple spine (separate boxes), or multi-cell with a common bottom flange (continuous cells) [1]. The box girder bridge achieves its stability mainly because of two key features: shape and pre-stressed tendons [1].

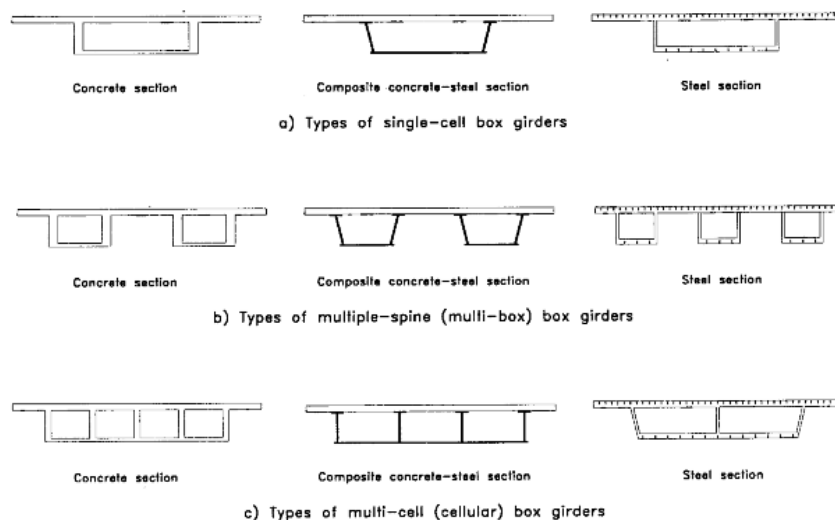


Figure 1: Box Girder Cross Sections

Several research has been done till now on Box Girder Bridges [2]. The development of the curved beam theory by Saint-Venant (1843) [3] and later the thin-walled beam theory by Vlasov (1965) [4] marked the birth of all research efforts published to date on the analysis and design of straight and curved box-girder bridges. Since then, numerous technical papers, reports, and books have been published in the literature concerning various applications of, and even modifications to, the two theories. A comprehensive review of analytical and experimental studies on box-girder bridges

was undertaken by Maisel (1970-85) [5-8] in England. This comprehensive review was extended by Swann (1972) [9], Maisel et al. (1973), and Maisel (1985).

Over the developments in the past few years, several new modifications have been introduced so as to make the box girder bridge more stable and increase its strength. These include, use of pre-stressed tendons [1], thickening of joints in the box structure [10], modifying the over-hanging beams [11-12], use of prestressed concrete [13] and multiple box type girder bridges [13]. This study basically covers the study of analyzing the bridge structure with thickened joints and elongated over-hanging beams together. Figure 2 shows the variation in the shape studied.

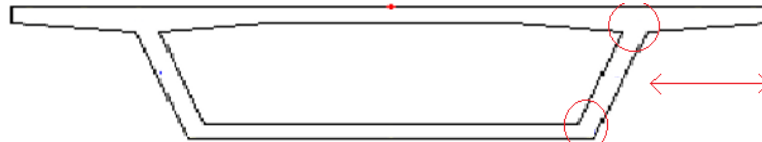


Figure 2: Positions of Prestressed Tendons

BRIDGE DESCRIPTION

The complete analysis of the bridge section and for the addition of prestressed tendons and loadings, SAP 2000 software has been used. The pre-defined Concrete Bridge AASHTO-PCI-ASBI has been considered for the study. Figure 3 gives the basic structure and dimensions of the AASHTO-PCI-ASBI type bridge section as taken in SAP 2000 software. [1]

Item	Value
General Data	
Bridge Section Name	BSEC2
Material Property	4000Psi
Total Width	330.7087
Total Depth	70.8661
Exterior Girder Bottom Offset (L3)	22.8346
Keep Girders Vertical When Superelevate? (Area & Solid Models)	No
Slab and Girder Thickness	
Top Slab Thickness (t1)	8.8583
Bottom Slab Thickness (t2)	7.874
Exterior Girder Thickness (t3)	10.5906
Fillet Horizontal Dimension Data	
f1 Horizontal Dimension	53.937
f2 Horizontal Dimension	47.2441
f3 Horizontal Dimension	0
Fillet Vertical Dimension Data	
f1 Vertical Dimension	4.9213
f2 Vertical Dimension	4.9213

Figure 3: Basic Structure and Dimensions of AASHTO-PCI-ASBI Type Bridge Section

The bridge structure was restricted to a two span and two lane section. Both the ends had fixed end supports.

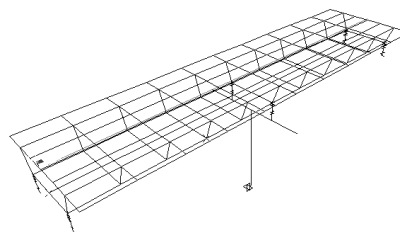


Figure 4: Two Span and Two Lane Bridge Section

Variation in Shape Analyzed

The variation in shape as shown in Figure 2 have been studied. The marked areas show the points where the joints are thickened and the line marked in the image shows the elongated over-hanging beam. 7 different cases were studied by varying the loads on the bridge structure for both, the basic shape as well as the modified shape of the box. Figure 5 shows the difference of the two shapes.

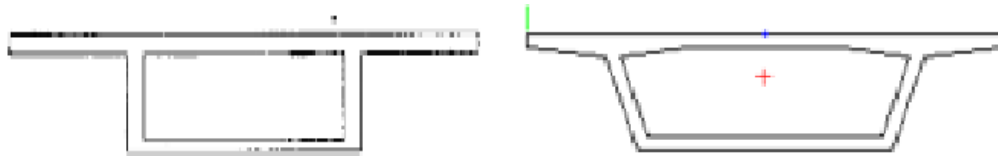


Figure 5: Difference in Shape of the Basic and the Modified Bridge Section

BRIDGE DECK LOADING

The loading taken for the analysis of these bridge sections was a combination of three moving vehicle loads, moving in the two lanes of the bridge deck. SAP 2000 has several pre-defined vehicle loads, and most basic type of truck and lane loadings include: H20-44 Truck Load, HS20-44 Truck Load, H20-44L lane Load. A combination of these three vehicle type loads have been imposed in every case so as to maintain uniform loading. Figure 6 shows the three types of vehicle loading used for the analysis.

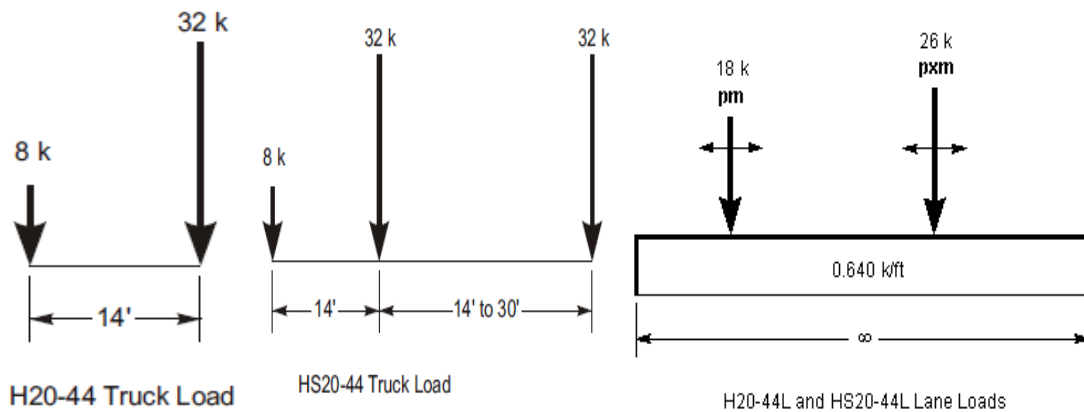


Figure 6: Vehicle Loads Used for Analysis

ANALYSIS

The SAP 2000 software gives the final results in the form of deflection curves, bending moment diagrams and even stress contours. But for the comparative study between the several cases, stress contours have been taken as the basis of comparison. The following cases show the position of the tendons added in the bridge structure and the corresponding stress contour obtained after the bridge analysis.

Case I: The basic structure of the box is analyzed. The bridge section is loaded with the combination of the three above mentioned loads.

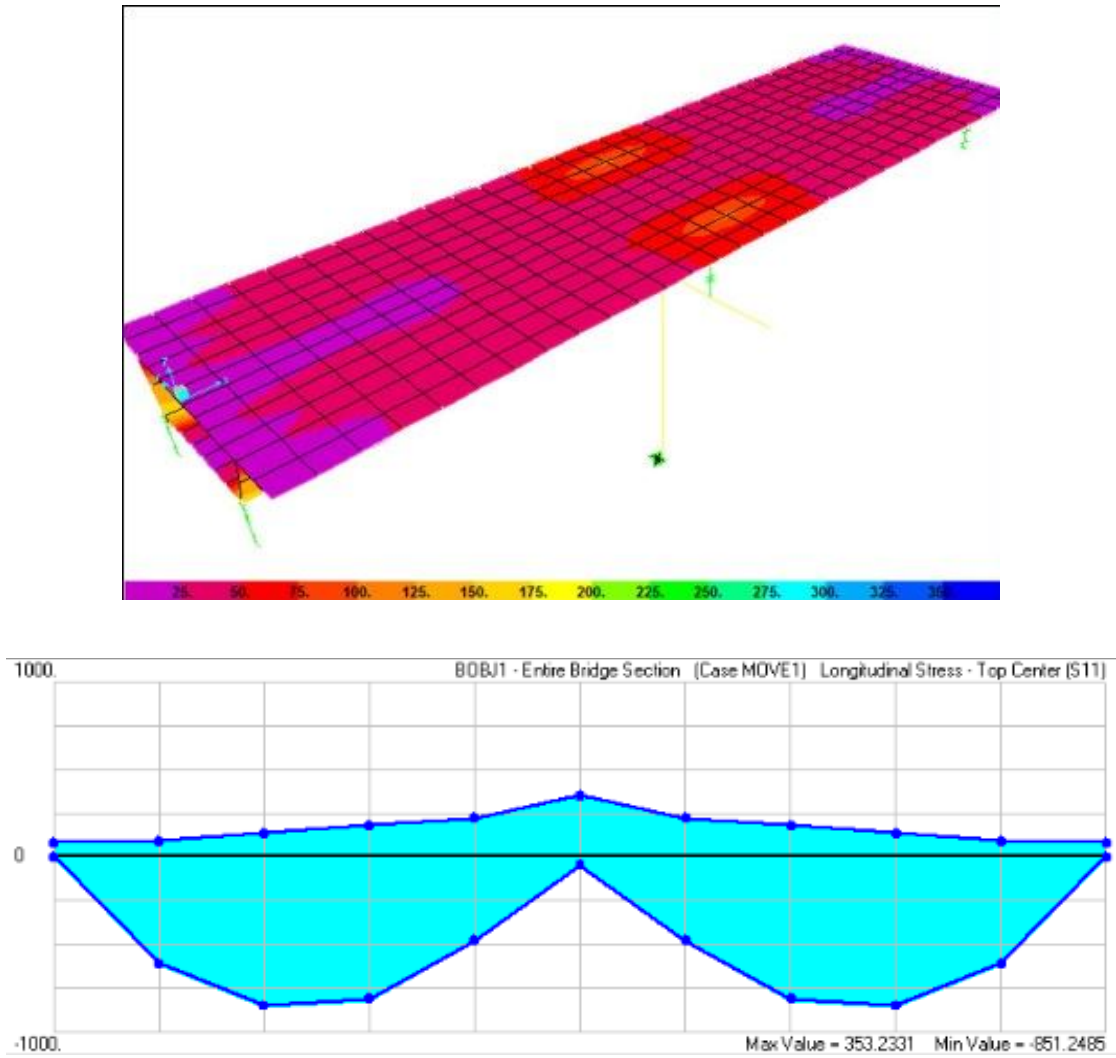
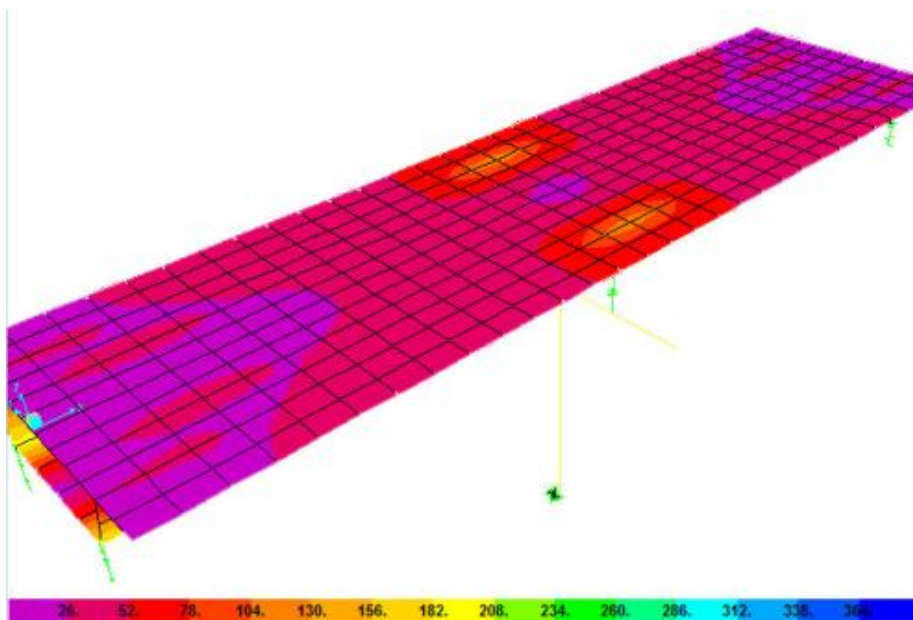


Figure 7: Stress Contours and Longitudinal Stress for Case I

Case II: The same loading as in Case I for the modified shape.



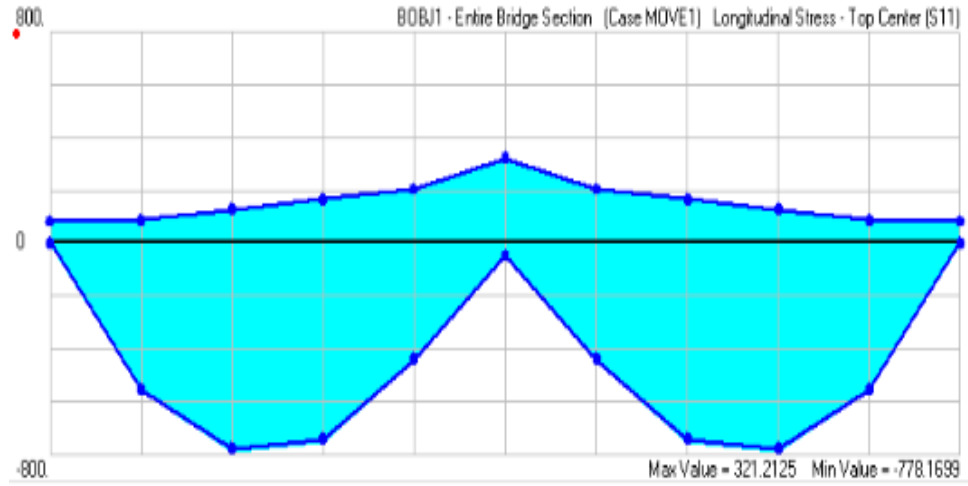


Figure 8: Stress Contours and Longitudinal Stress for Case - II

Case III: Double the load in basic structure analysis case.

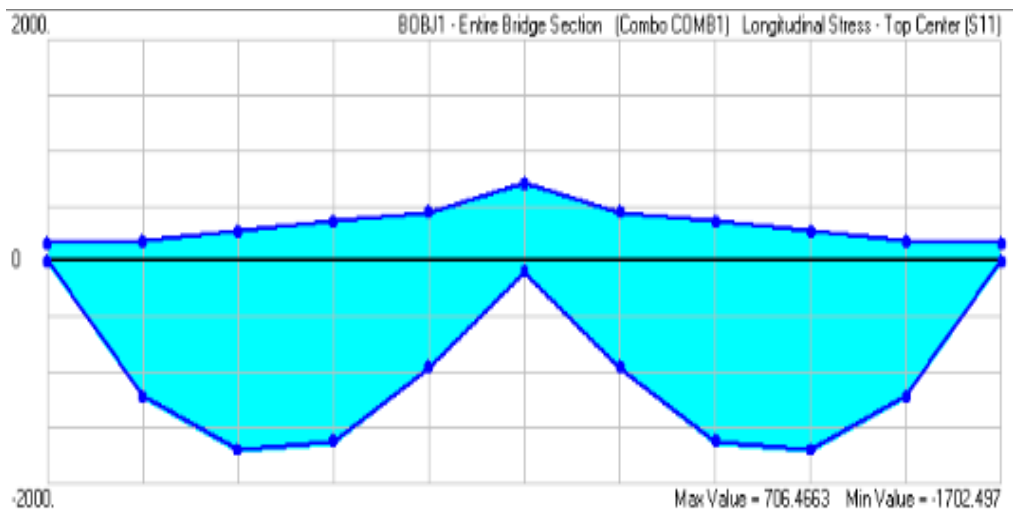
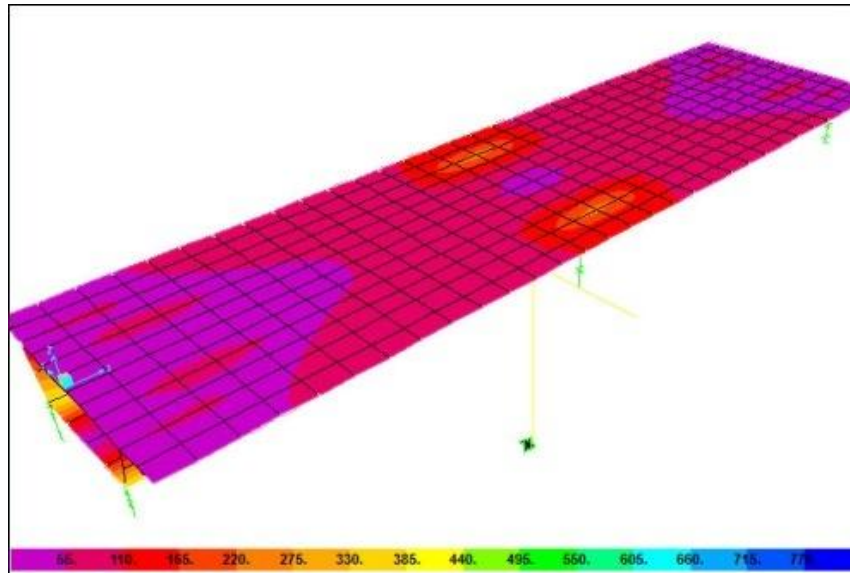


Figure 9: Stress Contours and Longitudinal Stress for Case III

Case IV: Same loading as in Case – III on the modified structure

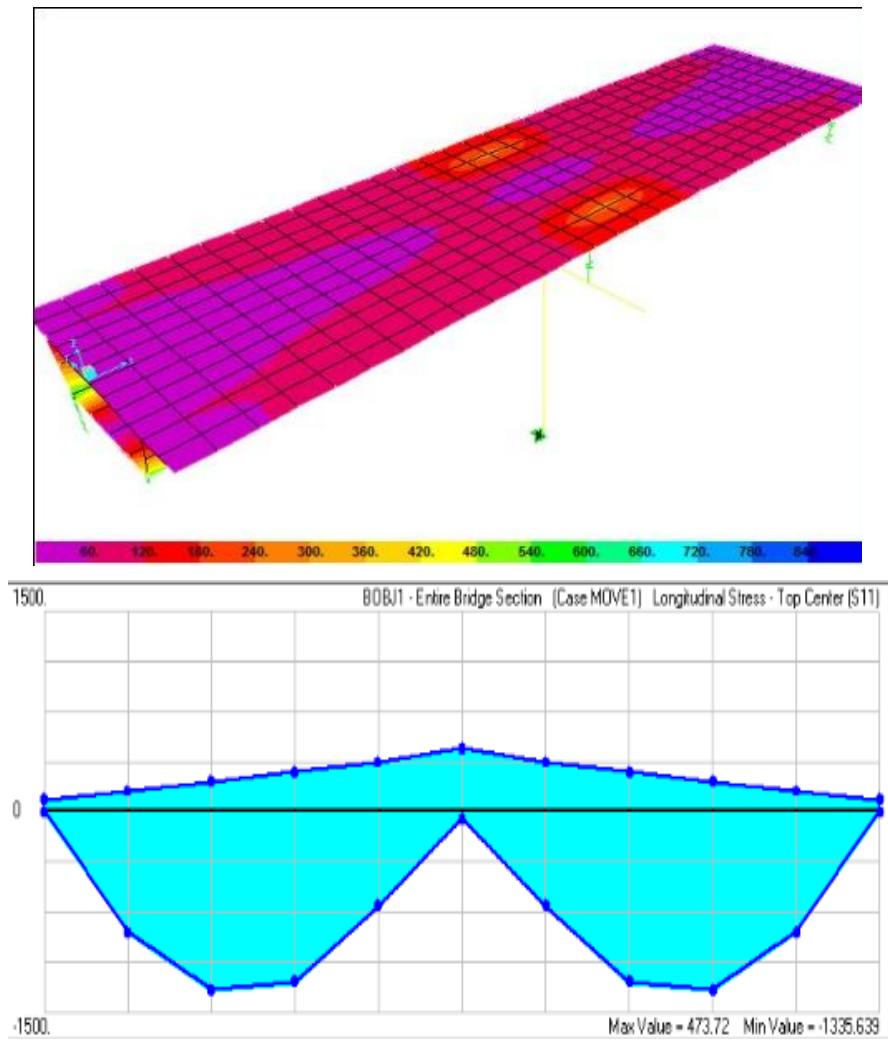
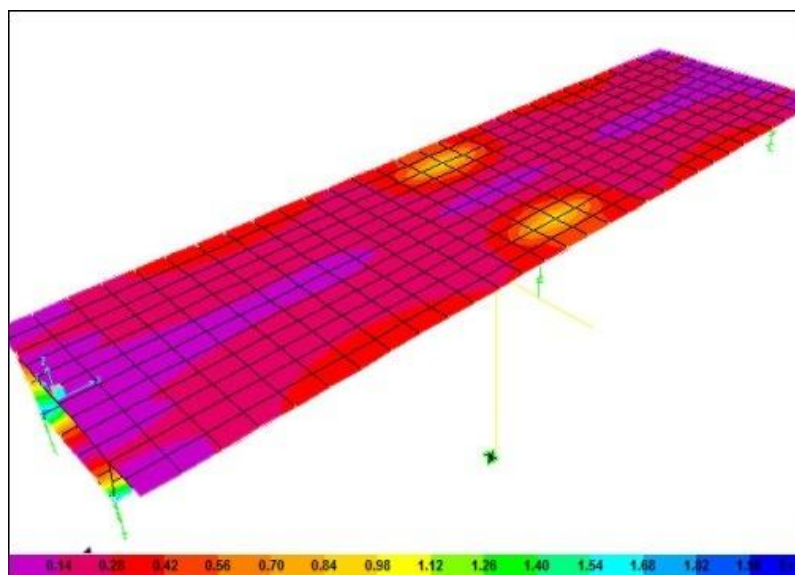


Figure 10: Stress Contours and Longitudinal Stress for Case IV

Case V: Triple loading for basic structure analysis case.



Impact Factor (JCC): 2.6676

Index Copernicus Value (ICV): 3.0

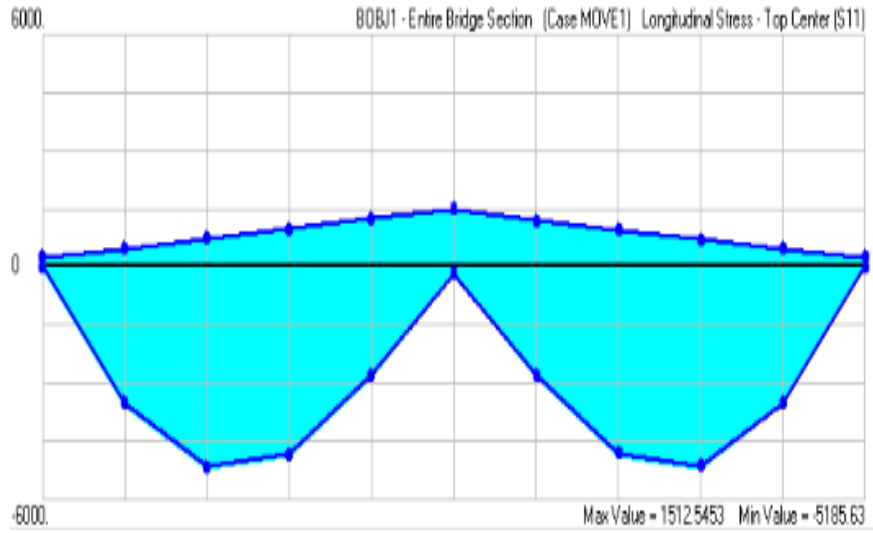


Figure 11: Stress Contours and Longitudinal Stress for Case V

Case VI: Same loading as in Case – V for the modified shape.

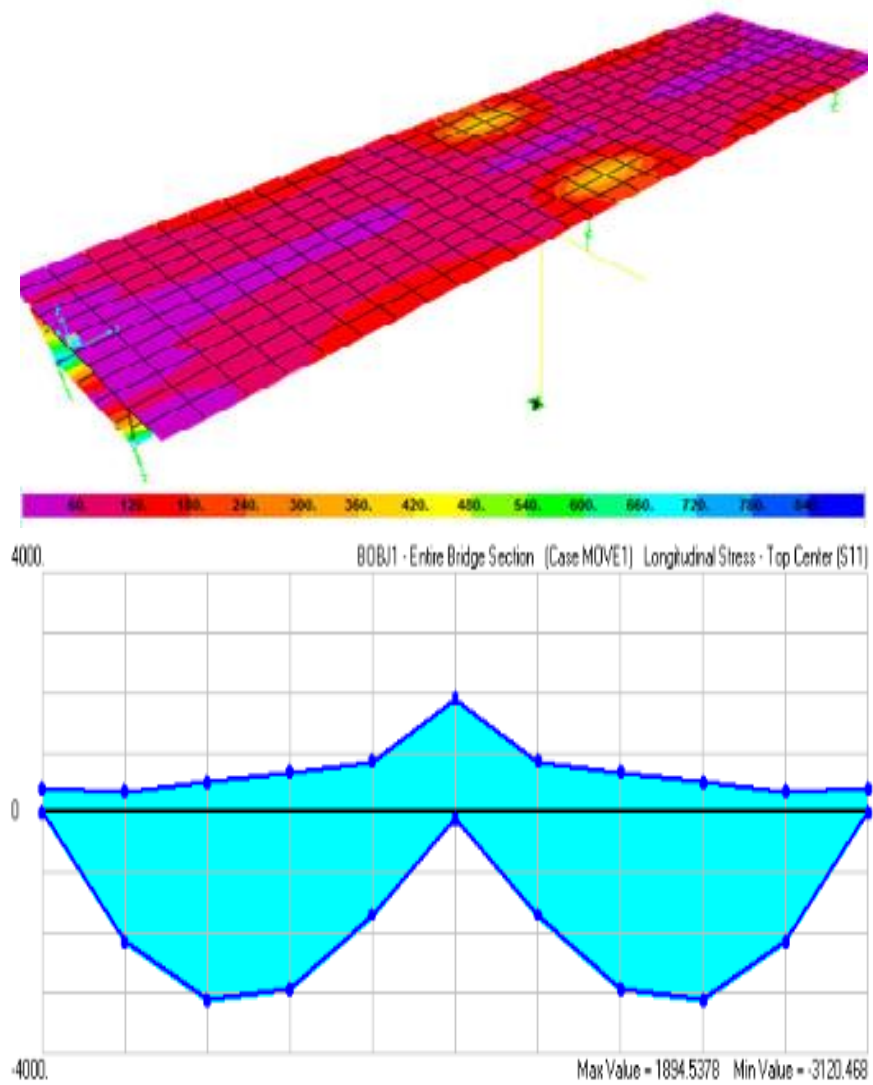


Figure 12: Stress Contours and Longitudinal Stress for Case VI

RESULTS AND DISCUSSIONS

The conclusion of entire analysis was obtained by comparing the stress contours of the different cases. After the complete analysis of the basic structure of the box girder bridge by using different loadings and making some modifications in the shape of the box, it was concluded that the more stable structure of the two cases for this box shape is the modified one with elongated over-hanging beams and thickened joints.

This shape of the box of a modified box girder bridge has some peculiar features like: the increased thickness at the fixed end of the cantilever beam, increased thickness at the bottom most portion of the box structure and sloping edges. Longer the cantilever beam more is the thickness of the entire section from the free end to the fixed end. This provides us more thickness at the fixed portions and also helps us to reduce the stress acting on the entire span of the beam. The benefit of this is that the bending moment acting at the fixed end is reduced and the beam becomes more stable.

The second peculiarity of this type of structure is the thickness at the bottom of the box. This thickness proves to be useful because the stress transferred through the sloping edges from the bridge deck to the bottom of the box is easily distributed. The joint at the base between the horizontal edge and sloping edge is weak and hence making it thick increases the efficiency.

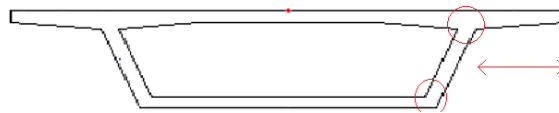


Figure 13: Modified Positions in the Basic Shape of the Bridge Section

REFERENCES

1. Garg, Chirag and Siva Kumar, M V N (2014). "Prestressed Tendons System in a Box Girder Bridge", International Journal of Civil Engineering (IJCE) Vol. 3-3, IASET.
2. Khaled M. Sennah, M.ASCE, and John B. Kennedy, F.ASCE (2002), "Literature Review in Analysis of Box-Girder Bridges", Journal Of Bridge Engineering, ASCE
3. Saint-Venant, B. (1843). "Memoire sur le calcul de la resistance et de la flexion des peicessolides a simple ou a double courbure, en pregnant simultanement en consideration les divers efforts auxquelsellespeuvent entre soumisesdans tous les sens." Compts-Rendus, 27,l'Academic des sciences de Paris, Paris, 1020–1031 (in French).
4. Vlasov, V. Z. (1965). "Thin-walled elastic beams." OTS61-11400, National Science Foundation, Washington, D. C.
5. Maisel, B. I. (1970). "Review of literature related to the analysis and design of thin-walled beams." Tech. Rep. No. 42440, Cement and Concrete Association, London.
6. Maisel, B. I. (1985). "Analysis of concrete box beams using small computer capacity." Can. J. Civ. Eng., 12(2), 265–278.
7. Maisel, B. I., and Roll, F. (1974). Methods of analysis and design of concrete box beam with side cantilevers, Cement and Concrete Association, London.

8. Maisel, B. I., Rowe, R. E., and Swann, R. A. (1973). "Concrete box girder bridges." *Struct. Eng.*, 51(10), 363–376.
9. Swann, R. A. (1972). "A feature survey of concrete box spine-beam bridges." Technical Rep. 42.469, Cement and Concrete Association, London.
10. Bakht, B., Jaeger, L. G., and Cheung, M. S. (1981). "State-of-the-art in analysis of cellular and voided slab bridges." *Can. J. Civ. Eng.*, 8(3), 376–391.
11. Dezi, L. (1985). "Aspects of the deformation of the cross-section in curved single-cell box beams." *Industria Italiana Del Cemento*, 55(7–8), 500–808.
12. Jeon, S. M., Cho, M. H., and Lee, I. (1995). "Static and dynamic analysis of composite box beams using large deflection theory." *Comput. Struct.*, 57(4), 635–642.
13. Lounis, Z., and Cohn, M. Z. (1995). "Computer-aided design of prestressed concrete cellular bridge decks." *J. Microcomput. Civ. Eng.*, 10(1), 1–11.
14. Cao Guo-Hui and Fang Zhi (2007). "Experimental Study on Behaviour of Concrete Box Girder Bridges Prestressed with external tendons" *Journal of Highway and Transportation Research and Development*, Vol.2 No.1 (34).
15. AASHTO (1980). *Guide specifications for horizontally curved highway bridges*, Washington, D.C.
16. AASHTO (1994). *AASHTO LRFD Bridge Design Specifications*, Washington, D.C.
17. AASHTO (1996). *Standard specifications for highway bridges*, Washington, D.C.
18. AASHTO (1993) *Guide specifications for horizontally curved highway bridges*, Washington, D.C.
19. AASHTO (1994). *AASHTO LRFD Bridge Design Specifications*, Washington, D.C.
20. AASHTO (1996). *Standard specifications for highway bridges*, Washington, D.C.
21. IS 1944: Part 5: 1981 Code of practice for lighting of public thoroughfare: Part 5 Lighting for grade separated junctions, bridges and elevated roads (Group D).
22. IRC-78, *Code of Practice for Road Bridges*, Indian Road Congress, India.
23. IRC-SP13, *Guidelines for the Design of Small Bridges and Culverts*, Indian Road Congress, India.
24. *Bridge Design Manual*, Texas Department Of Transportation (August 2001).

