International Journal of Civil
Engineering (IJCE)
ISSN(P): 2278-9987; ISSN(E): 2278-9995
Vol. 3, Issue 3, May 2014, 1-8

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

PRESTRESSED TENDONS SYSTEM IN A BOX GIRDER BRIDGE

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ABSTRACT

This research study analyzes the several positions in a box girder bridge where the pre-stressed tendons can be added. By keeping a constant loading and varying the positions the of the tendons, a comparative study has been done so as to understand the most effective positions of these pre-stressed tendons. For the analysis, SAP 2000 software has been used and the study has been done on the basic AASHTO type section of the box girder bridge. Two equal spans of the bridge with a two lane deck have been studied and the loading has been considered of moving type vehicles. The stress contours and deflections of the bridge deck have been observed so as to compare the results.

KEYWORDS: Bridge, Box Girder Bridge, Prestressed Tendons, Prestressed Tendons System, Tendons

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].

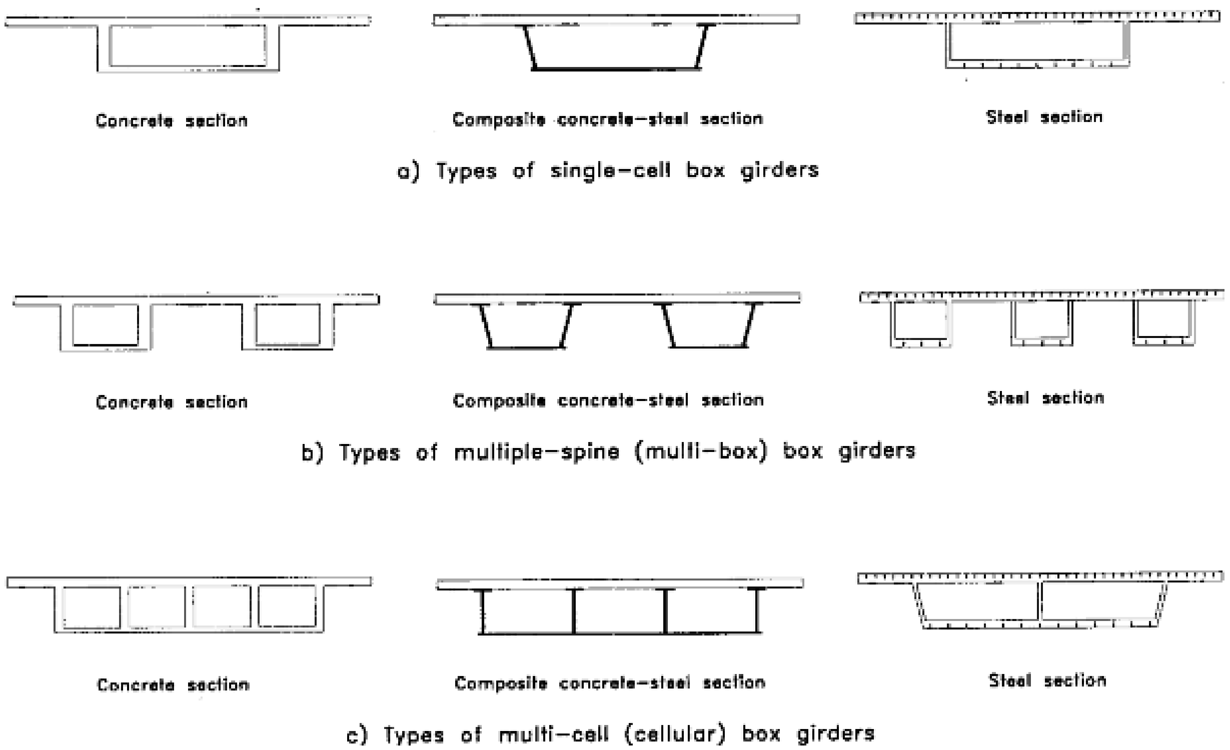

Figure 1: Box Girder Cross Sections

Several research has been done till now on Box Girder Bridges [1]. The development of the curved beam theory by Saint-Venant (1843) [2] and later the thin-walled beam theory by Vlasov (1965) [3] 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) [4-7] in England. This comprehensive review was extended by Swann (1972) [8], 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, thickening of joints in the box structure [9], modifying the over-hanging beams [10-11], use of prestressed concrete [12] and multiple box type girder bridges [12]. One of these modifications also includes the use of prestressed tendons in the box section [13]. Various positions for the prestressed tendons to be added in the box section have been found [13]. The primary positions can be seen in Figure 2.

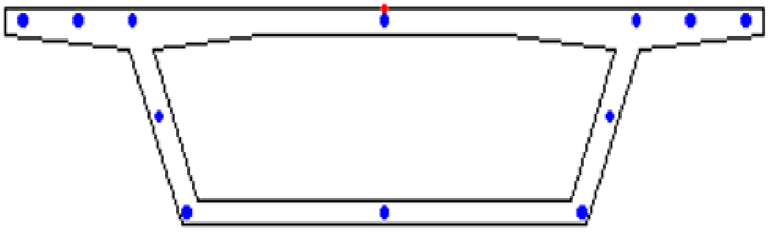

Figure 2: Positions of Prestressed Tendons

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.

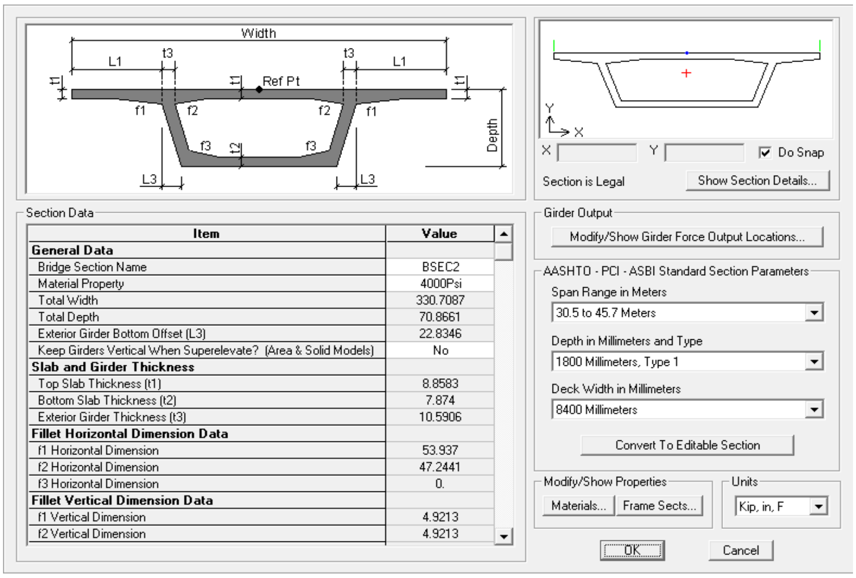

Figure 3: Basic Structure and Dimensions of AASHTO-PCI-ASBI Type Bridge Section

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

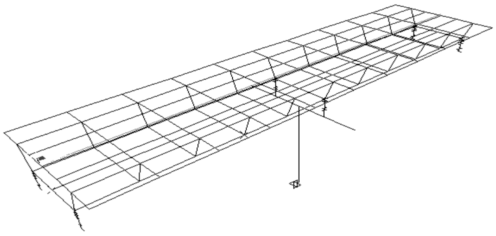

Figure 4: Two Span and Two Lane Bridge Section

PRESTRESSED TENDONS

The predefined stress tendons were added to the bridge section at various positions in different combinations as shown in Figure 2. Various combination of these positions have been analyzed in different cases so as to find out the most effective combination. The tendons have been added in two parts, each being over one complete span of the deck section from end to end. Curved tendons have been used at each position. Figure 5 shows the shape and orientation of a tendon in the bridge section.

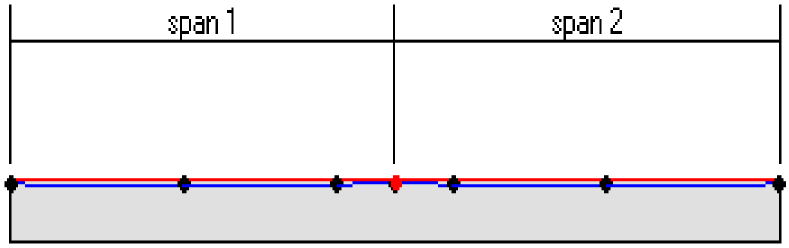

Figure 5: Shape of the Prestressed Tendons Added to the Bridge Section

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.

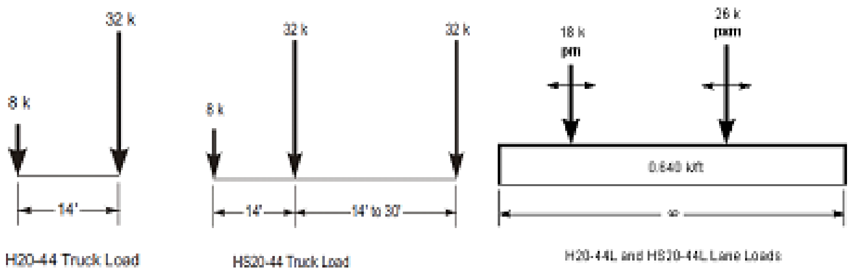

Figure 6: Vehicle Loads Used for Analysis

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**

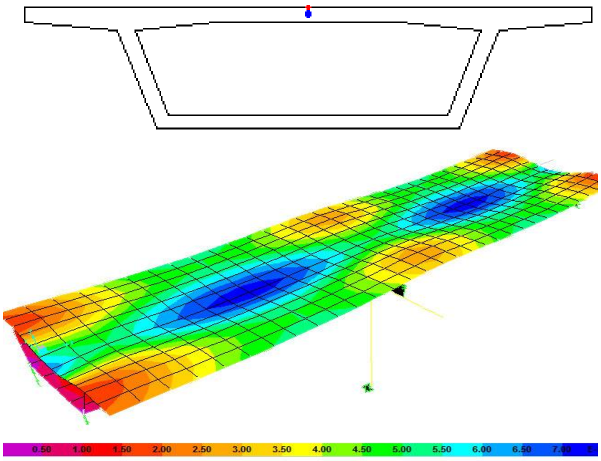

Figure 7: Position of Tendon and Corresponding Stress Contour for Case I

- **Case II**

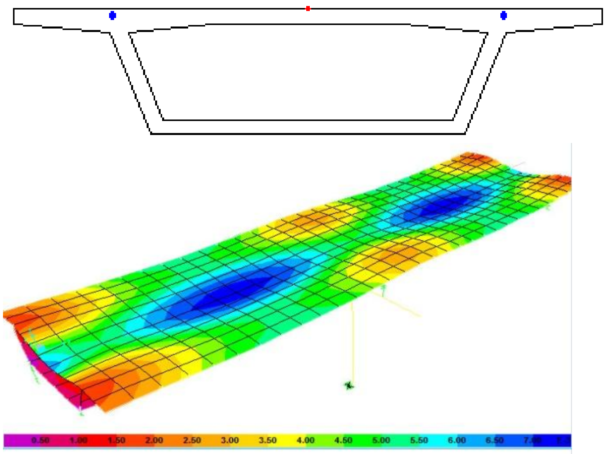

Figure 8: Position of Tendon and Corresponding Stress Contour for Case II

- **Case III**

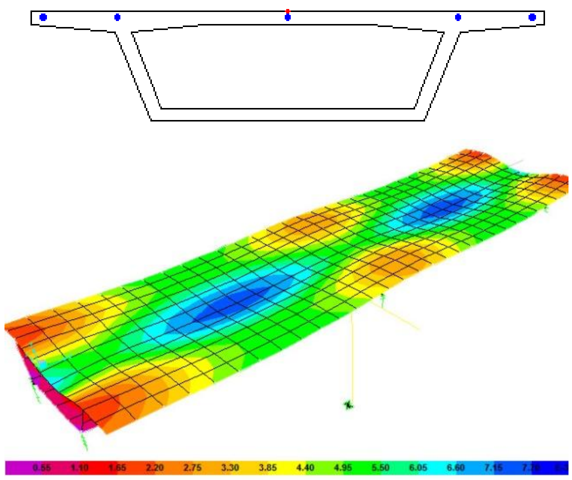

Figure 9: Position of Tendon and Corresponding Stress Contour for Case III

- **Case IV**

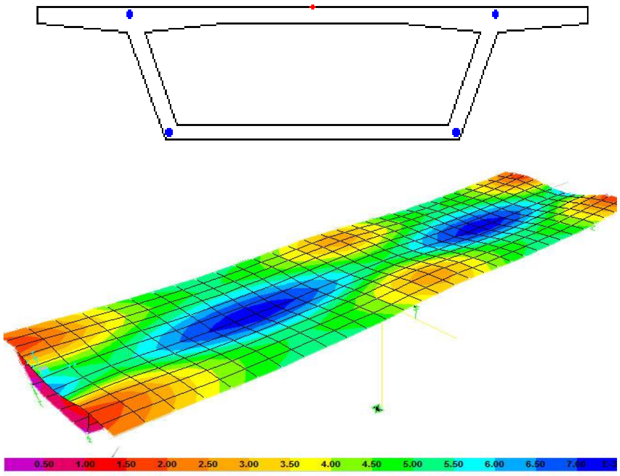

Figure 10: Position of Tendon and Corresponding Stress Contour for Case IV

- **Case V**

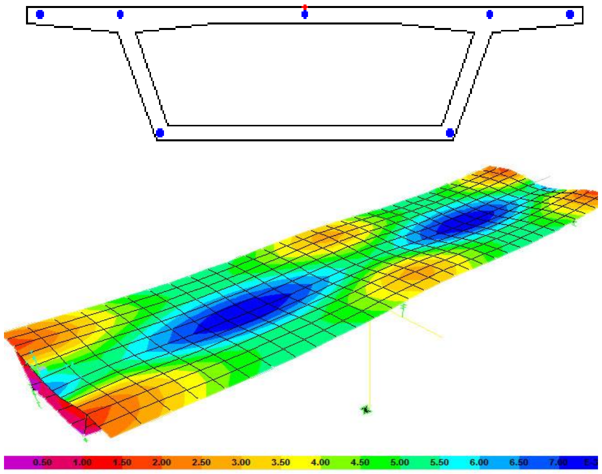

Figure 11: Position of Tendon and Corresponding Stress Contour for Case V

- **Case VI**

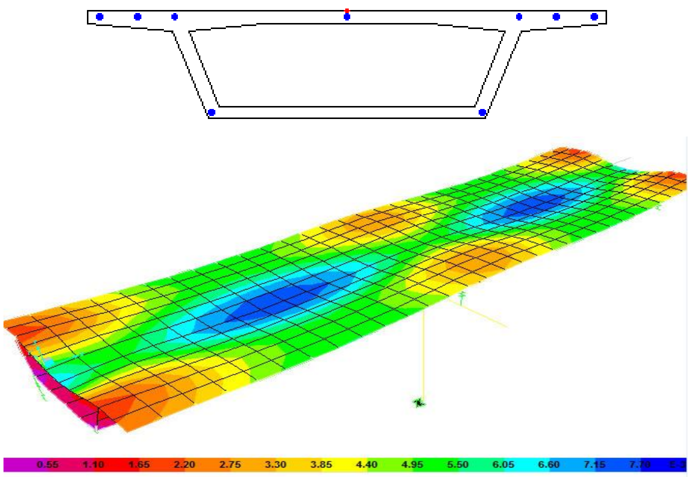

Figure 12: Position of Tendon and Corresponding Stress Contour for Case VI

- **Case VII**

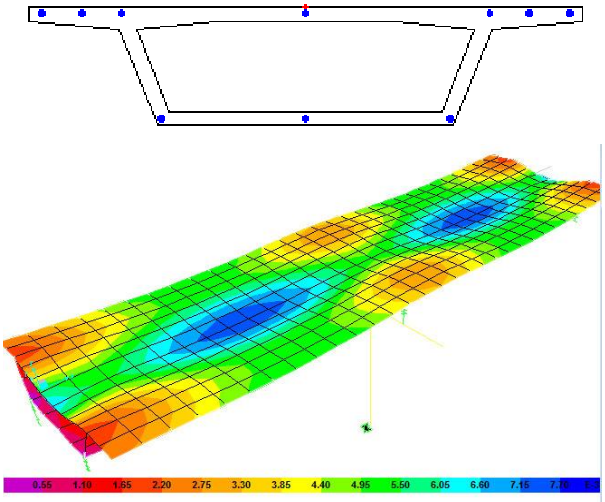

Figure 13: Position of Tendon and Corresponding Stress Contour for Case VII

- **Case VIII**

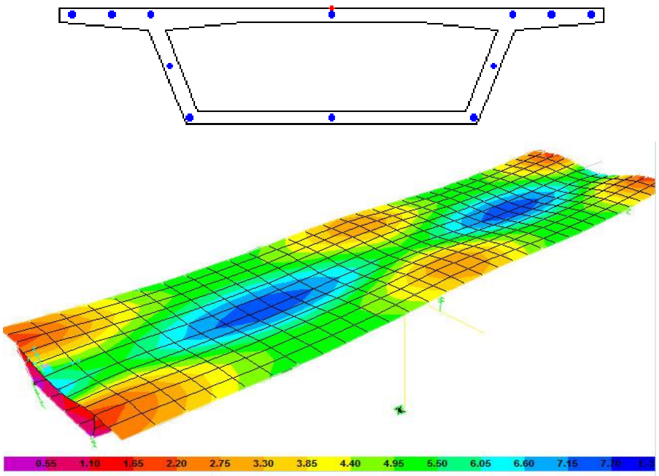

Figure 14: Position of Tendon and Corresponding Stress Contour for Case VIII

RESULTS AND DISCUSSIONS

The conclusion of entire analysis was obtained by comparing the stress contours of the different cases. As we increased the number of tendons at different positions, and keeping the same loading for all cases, the stability of the bridge increased at every step. Adding some tendons showed drastic changes in the displacement contours whereas some tendons showed minor or negligible changes.

When the analysis was done from Case I to Case III, tendons were added over the entire span of the over-hanging beams and deck section only. The results showed that the displacement in the over-hanging beams reduced considerably. Case IV was added with tendons at the bottom of the structure. These tendons were combined along with tendons at the bottom center and over the entire top span till Case VII.

Case VII results showed that the bridge structure had become more and more stable as compared to the previous cases. Case VIII included two extra tendons, which were added to the slant edges of the structure. Addition of these two beams did not show any considerable changes in the stability of the bridge. These beams only added weight to the bridge and their presence showed negligible difference.

As a result of the entire study, Figure 14 shows the major positions of tendons which prove to be effective in adding stability to the bridge. Tendons can be added to the other positions as well but these eight positions have the most significant effect in reducing the stress acting over the entire bridge section.

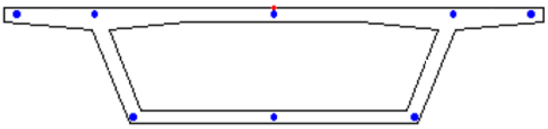

Figure 15: Most Effective Positions of Tendons in a Bridge Section

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