Original Article
International Journal of Scientific Research in Civil Engineering
Available online at : www.ijsrce.com
© 2023 | IJSRCE | Volume 7 | Issue 4 | ISSN : 2456-6667

Analysis of a Tendon Bridge Considering Vehicular Loading Using CSI Bridge Software

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ARTICLEINFO

Article History:

Accepted: 05 July 2023
Published: 22 July 2023

Publication Issue
Volume 7, Issue 4
July-August-2023

Page Number
61-72

ABSTRACT

Precast bridges with segmental structure are commonly used for long span bridges. Time dependent elements such as creep, shrinkage, and relaxation, among others, create consi derable variation in stresses throughout the life of long span bridges, and seismic evaluation becomes crucial and imperative in such a condition. Time-dependent variables like creep, shrinkage, and relaxation, among others, have been highlighted in past analysis. In the analysis of balanced cantilever bridge, however, the present codes and authorities in this field suggest the lump sum provisions, leading to inadequate estimation of residual strength/service stress which may lead to critical conditions. If such bridges are subjected to earthquake forces/actions, the criticality could be higher and lead to unacceptable conditions. As a result, the analysis should be revised to account for the combined effects of time-dependent characteristics and seismicity. Because such studies are scarce or unknown, the Csi bridge has been used to investigate the seismic behavior of a precast segmental bridge while taking into consideration time-dependent elements.
The outcome of this study is reported such as, impact of time dependent factors and seismicity on analysis of balanced cantilever bridge and its comparison with conventional methods of analysis. The combined impact of seismicity and time dependent properties of the design moment of precast segmental bridge is compared with steel tendons and without steel tendons.

Keywords : Bridge, Analysis, stability, deflection, forces, Moment variation, steel tendons.

I. INTRODUCTION

The technology is advantageous over cable stay construction in terms of complexity and time. It is particularly suitable for bridge sites where base shuttering is not practicable and foundation is costly. Because of the various benefits afforded by the construction process and structural structure, concrete cantilever bridges built using the balanced cantilever method have become quite popular. Segmental, cast-in-place concrete cantilever bridges are now routinely used to build long span bridges. Because bridges are subjected to strong internal forces and stresses, prestressing is an essential component. Segmental construction is one of the most used techniques for prestressed concrete bridges. By using the cantilever construction approach, this strategy avoids false work and temporary supports, resulting in no obstruction to traffic or the waterway beneath the bridge. Construction time for multi-span bridges is longer since the structure's statical system, as well as support, loading, and environmental conditions, are constantly changing. Because of these conditions, the deformations and internal forces within a constructed part of the bridge changes. Due to this reason, The method and chronology of building have a significant impact on the end result. Creep and shrinkage, which are time-dependent features of concrete and prestressed steel, have the biggest impact on bridge behaviour during and after construction, among the several parameters that affect the long-term behaviour of bridge structures. Creep and shrinkage of concrete, as well as prestressed steel relaxing, have a significant impact on changes in deflection and stresses.

The balanced cantilever method of construction is a complicated way of bridge construction in which spans are built cantilever-style and then joined together after completion. As a result of established continuity and other factors, the moments developed in the span and at support during construction, after completion, and during the course of the service life did not remain constant. Two important influencing elements on the study and design of a balanced cantilever bridge are time dependent material characteristics and seismicity. Thus, the combined influence of time-dependent material property fluctuation and seismicity on the analysis of balanced cantilever bridges must be examined yet again. Or, to put it another perspective, it is critical to investigate the behaviour or response of a balanced cantilever bridge when earthquakes strike at various periods of the bridge's life span. This life span can include periods standard selection the completion of construction, at any point during the bridge's service life, and after a long time at the conclusion of the bridge's life span.

Precast Bridge

Precast buildings are substantially built before they are deployed. A precast construction is made of pre-stressed concrete, and the final form of the structure is placed where it will be used. Precast concrete is made out of fine stone gravels, cement, water, and admixtures. In the factory's batch plant, the concrete mix design provided by the civil is employed to prepare the mixture. A dispensing mechanism with an overhead crane transports the permitted batch of concrete to the moulds. When it comes to bridge construction, there are two methods. All bridges made of CFST or concrete materials are built in one of two ways. The "Single Span Construction Method" is one, while the "Segmental Construction Method" is the other. In a single span bridge, the entire span is built at the same time. The bridge's entire span is consolidated, and no component of the bridge span is isolated from the other. Piers and abutments are not included in the bridge's span. The bridge span is made up of three parts: beams, deck, and parapets. The span of the bridge does not include the abutments, piers, foundations, or arch. As previously stated, a CFST or concrete bridge can be constructed in either a single span or a segmented configuration. There are many spans of the bridge that are put on the piers in a segmented span bridge. Segmented spans are used to connect the piers to each other. To put it another way, the bridge's span has been divided into multiple segments or pieces. It is done because lifting the beams and slabs in sections is more convenient. Lifting a consolidated beam is extremely difficult, even for large machinery. As a result, the beam is pre-cast in parts on the ground before being elevated above the piers' tops.

Fig 1 Precast Segmental Bridge

II. REVIEW OF LITERATURE

Li Jia et al (2021) research paper presented an experimental evaluation of the flexural behaviour of ultra-high performance concrete (UHPC) beams prestressed with external carbon fiber-reinforced polymer (CFRP) tendons. The effects of the effective prestressing stress, partial prestressing ratio, deviated angle, and loading condition on the flexural behaviour were explored utilising a total of eight T-shaped beam specimens.

According to the experimental data, the shear capacity of completely prestressed beams was primarily determined by the effective prestressing stress in CFRP tendons and the ultimate tensile strength of UHPC, whereas partially prestressed beams failed in a ductile way. Internal steel reinforcement could significantly improve flexural capacity and deformation ability. Internal reinforcements in UHPC beams with CFRP tendons should not be ignored. Increased cracking load and flexural capacity were achieved with a higher effective prestressing stress. The deviating angle increased the efficiency with which high-strength CFRP tendons were utilised. The specimens' flexural behaviour was slightly influenced by the loading condition. Furthermore, a method for predicting the flexural capacity of UHPC beams prestressed with external CFRP tendons was presented and tested, taking into account the effect of steel fibres.

Vishal v Patil and MD. Ismail (2019) A comparative examination of two separate post tensioned slabs, one flat slab with drop and the other flat plate slab, was reported in this research work. Initially, the analysis was carried out using British code in manual slab design, and later, modelling was done using FEM software. All of the material and section parameters are defined first in the model, and then the frame with slab model is created using the grid. During modelling main tendons are laid with zero width spacing and auto resisting the selfweight of slab and in parabolic pattern.

Mehrdad Aghagholizadeh and Necati Catbas (2019) research paper presented comparative analysis of two bridges constructed with the most commonly used girder types in Florida. The analysis used the AASHTO Type III (American Association of State Highway and Transportation Officials) and Florida I-Beam girder types of bridges. Under baseline state and distinct prestress loss cases, two bridges with identical specifications but different girder types were examined. Bridges were modelled using finite element software, and the FE models were put through two types of virtual load testing, employing C5 and SU4 Florida legal loads.

The AASHTO interior bridge girder's failure probability is nearly 6 times that of the FIB bridge girder, according to the findings. It's also worth noting that the AASHTO bridges' system-level reliability should be higher as a result of the parallel placement of additional girders.

Objectives of the research

- Determining the reaction of precast segmental bridges under lateral loads.
- Determining the reaction of precast segmental bridges with steel tendons tendons under lateral loads.
- Find the deformability index of the beams that will determine the deformation capacity of the beam before failure and compare this index with similar steel reinforced beams
- Examine the behavior of prestressed steel tendons when used as an alternative to the conventional steel tendons and study the differences in the design procedure.

III. METHODS AND MATERIAL

Step 1: Defining bridge section data using analytical application CSi bridge.

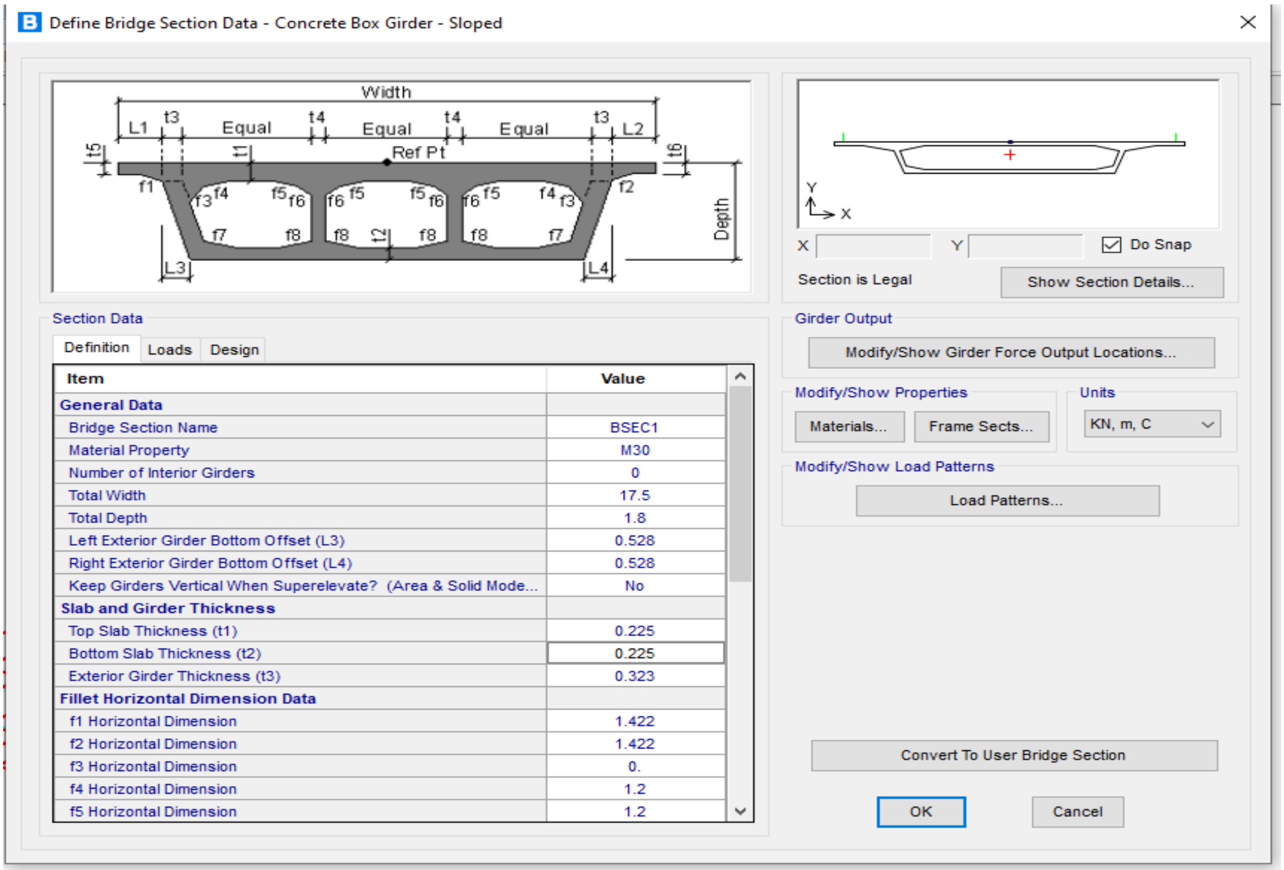


Fig 2 Defining Bridge section

Step 2 Defining material properties

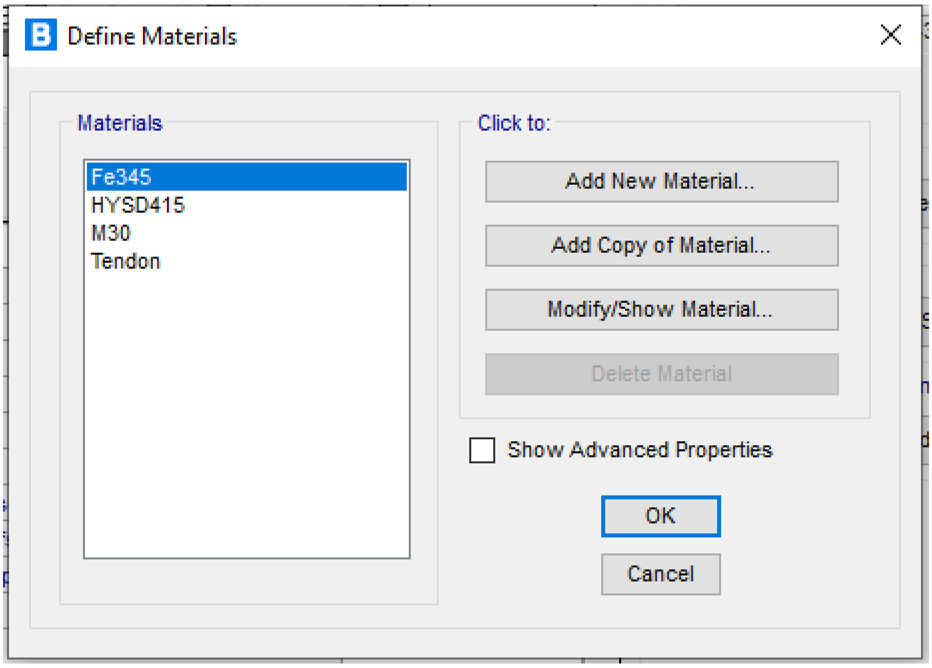


Fig 3 Defining material

Step 3 Defining Material property data for tendons

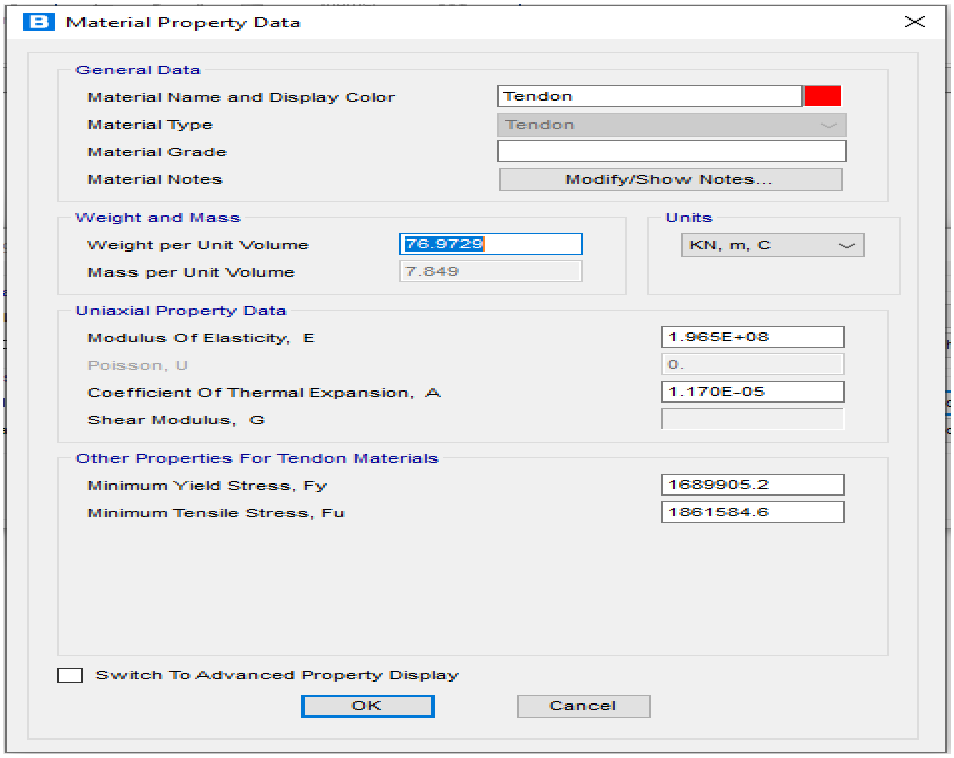


Fig 4 Defining material property data for tendons

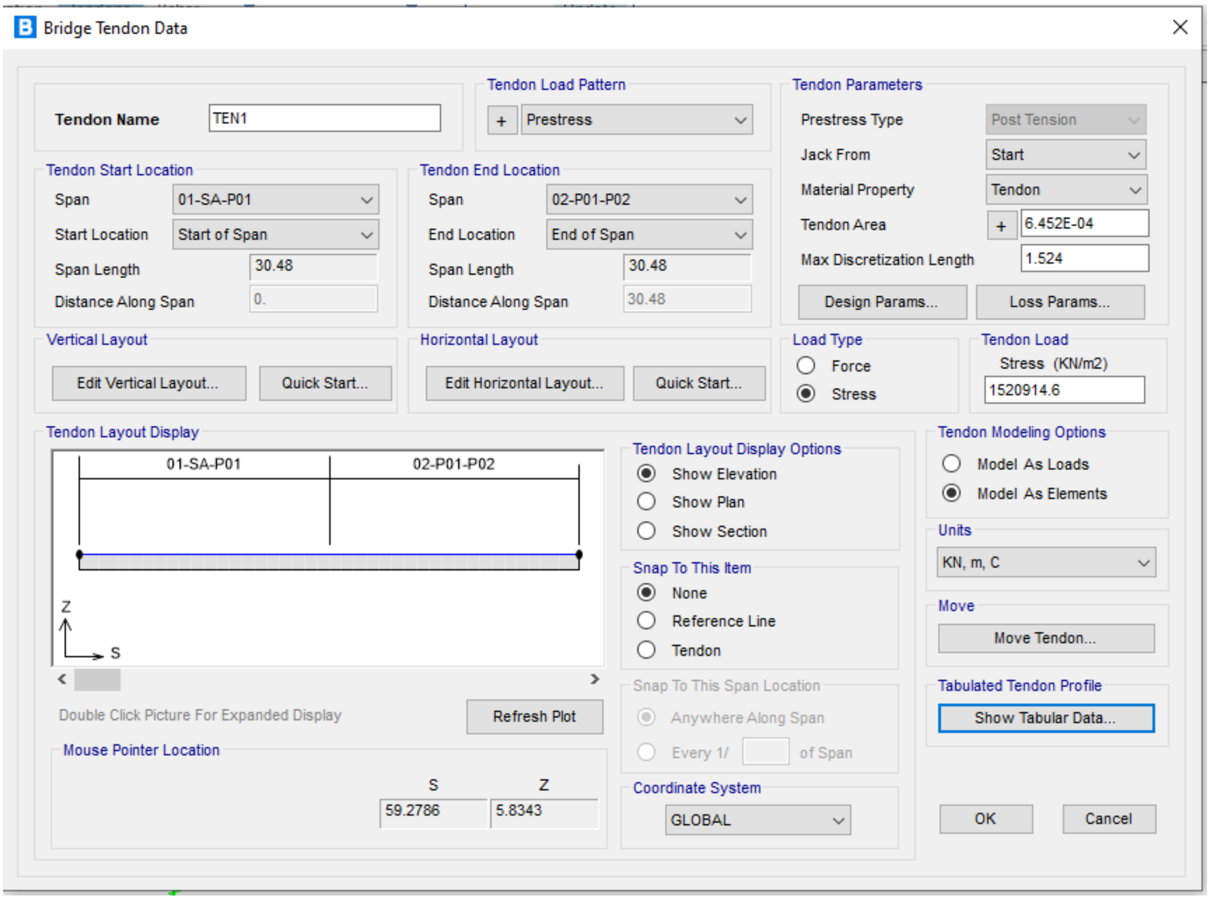


Fig 5 Bridge Tendon Data

Step 4 Assessment of Bridge Object Abutments and section points

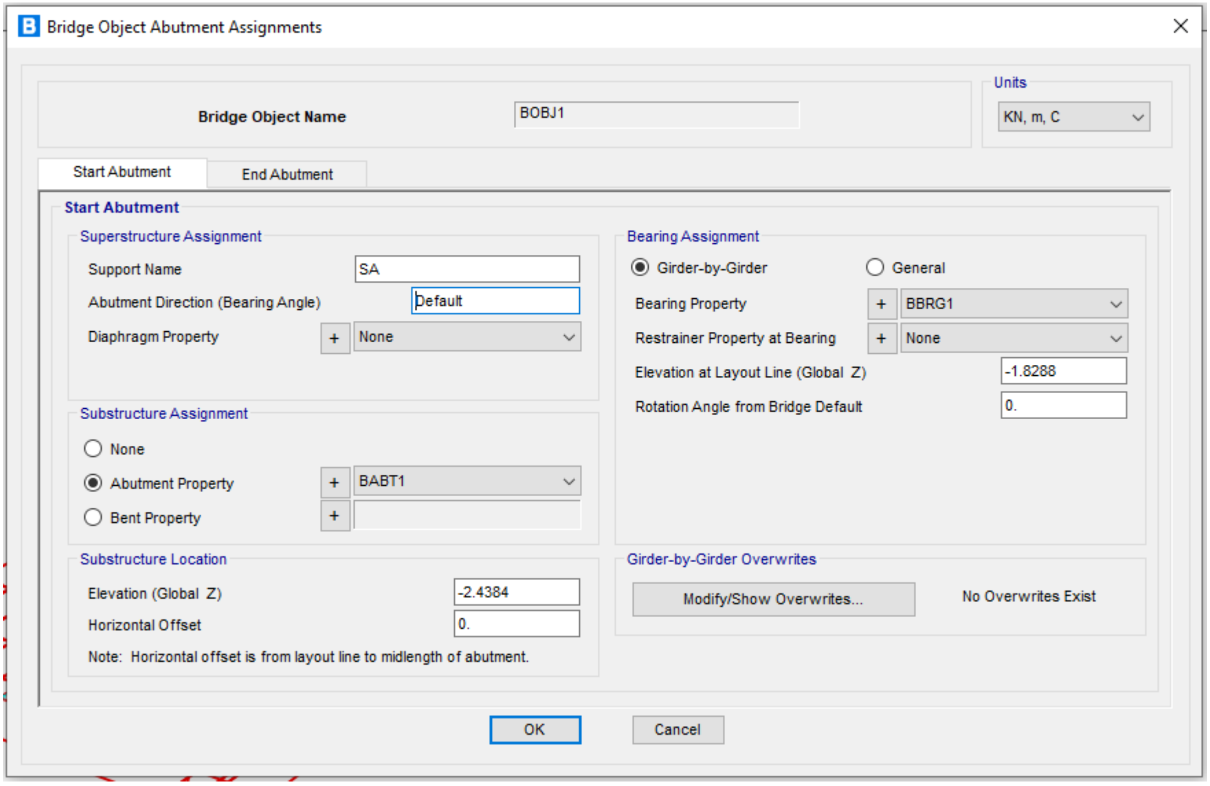


Fig 6 Bridge Object Abutment

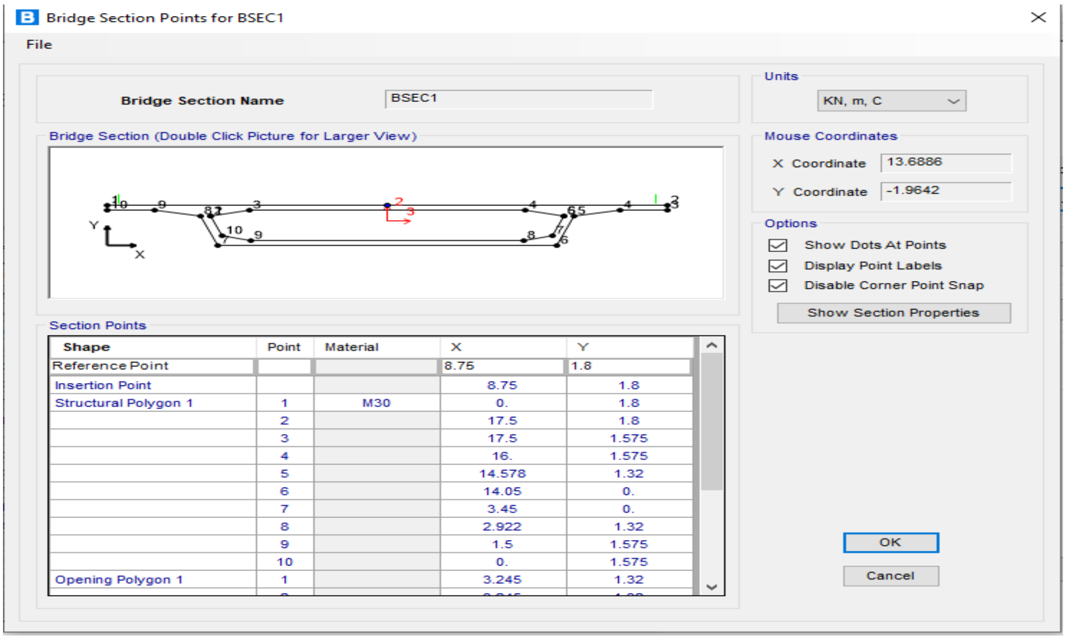


Fig 7 Section Point

Step 5 Defining Segmental Bridge Span Assembly

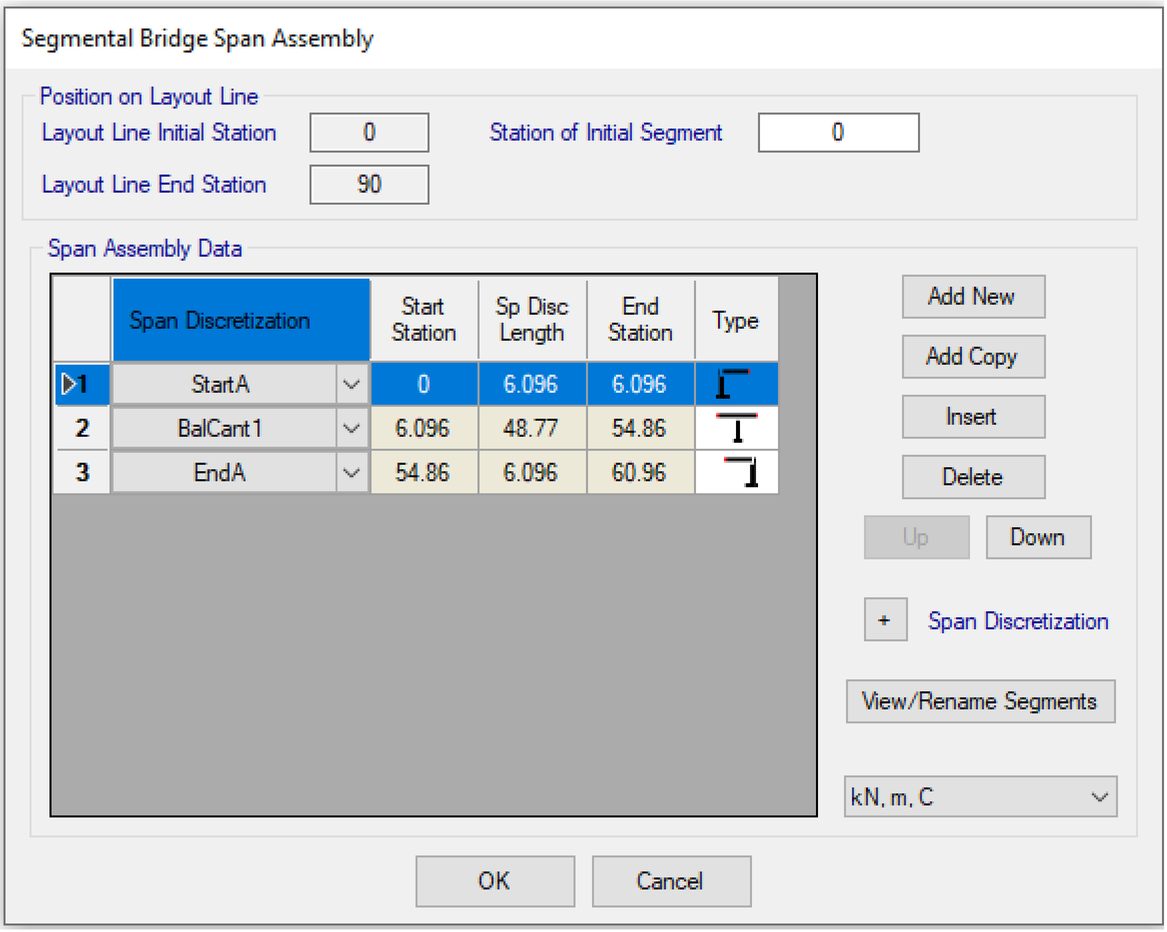


Fig 8 Segmental Bridge Span Assembly

Step 6 Defining loading pattern for the structure

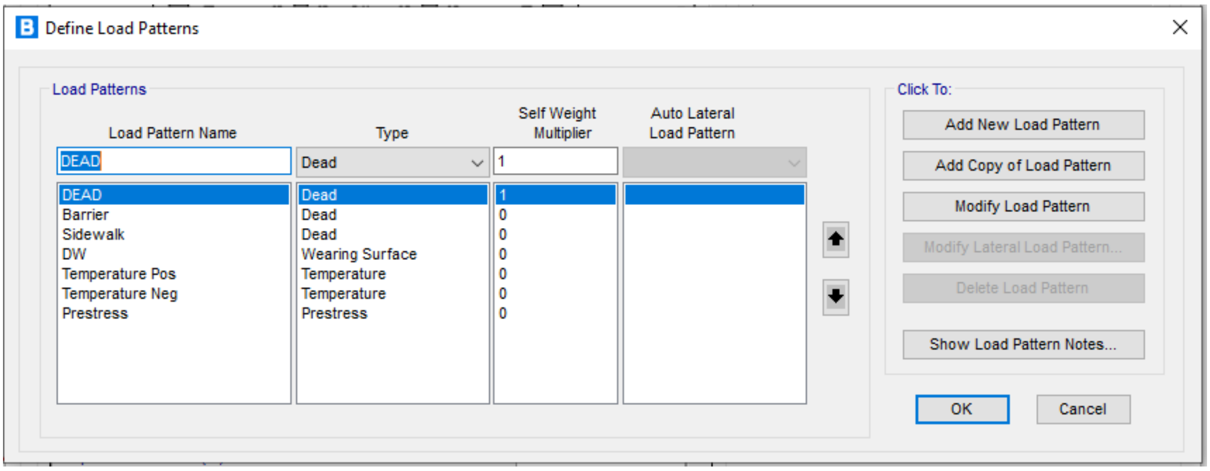


Fig 9 Defining Loading pattern for precast segmental bridge

Step 7 Analyzing the results of the structure for moment and deflection

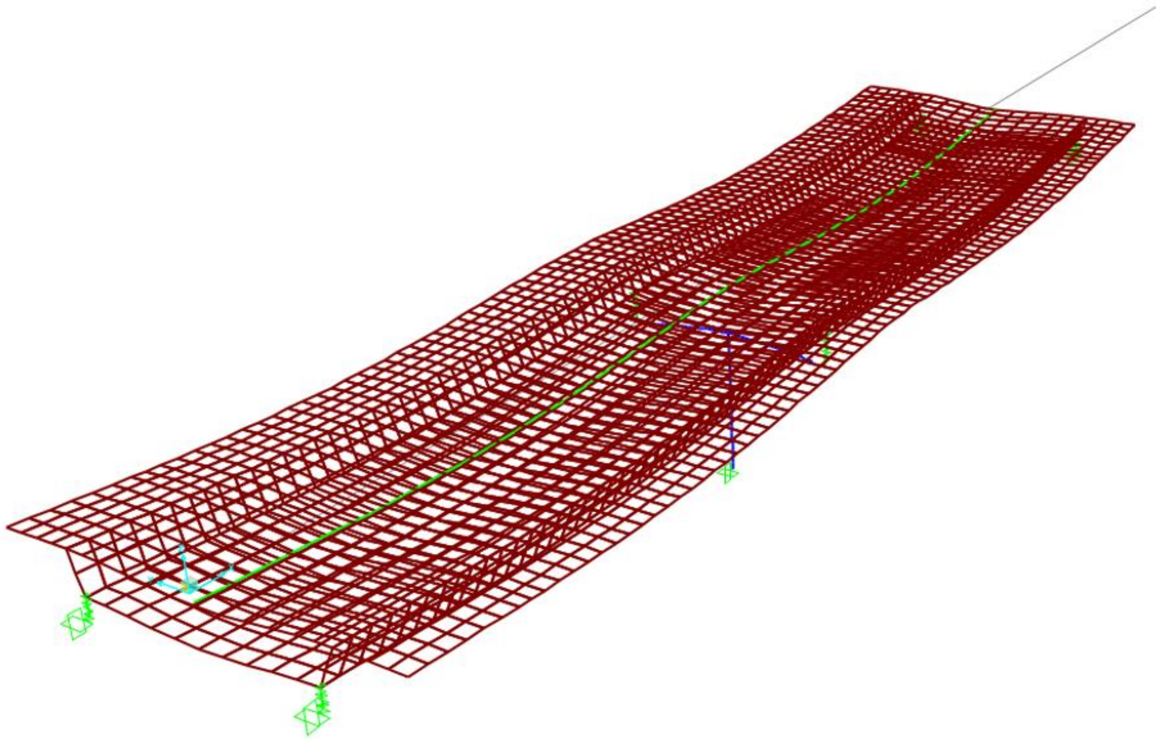


Fig 10 Deformed Shape for dead load

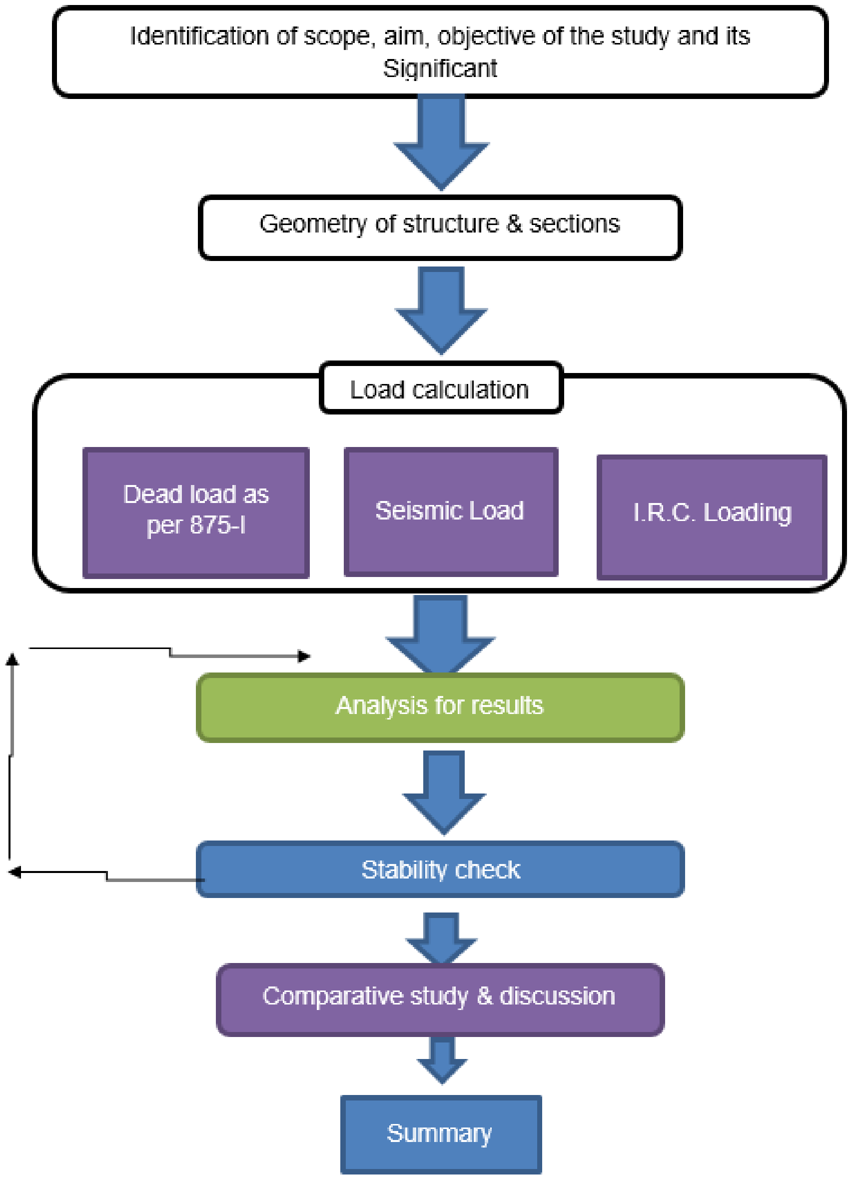
Step 8 Presenting the comparative analysis of the results with steel tendons and without steel tendons.

Table 1 Structural Data

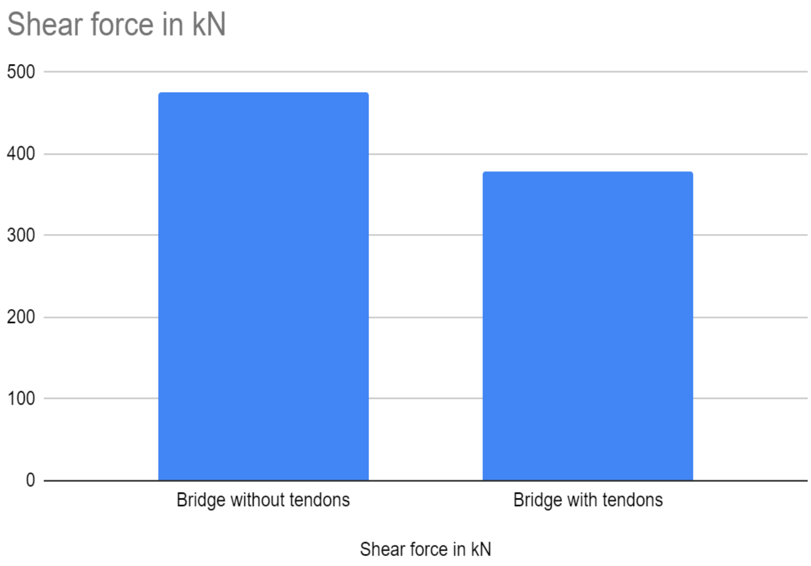
Dimension of the model	
Length	17500 mm
Height	3400 mm

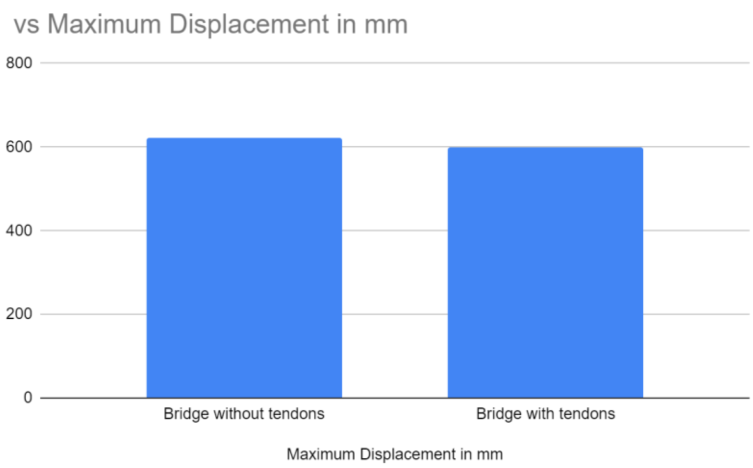
Web thickness	300 mm
Construction joint for crash barrier portion	3000 mm
Opening	800 x 900 mm
Haunch	100 x 100 mm

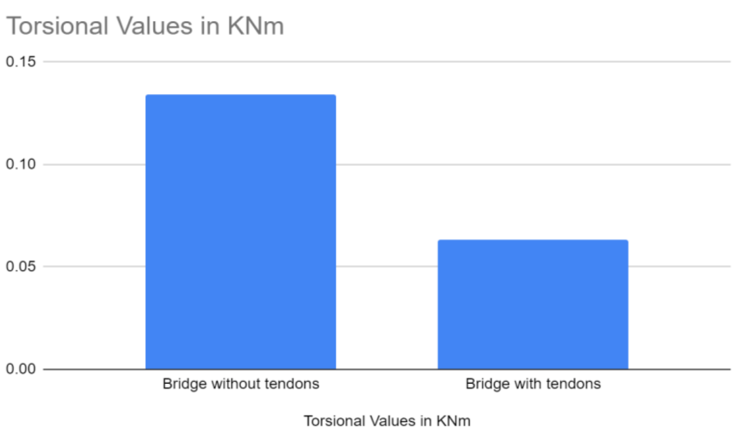
Flow Chart:

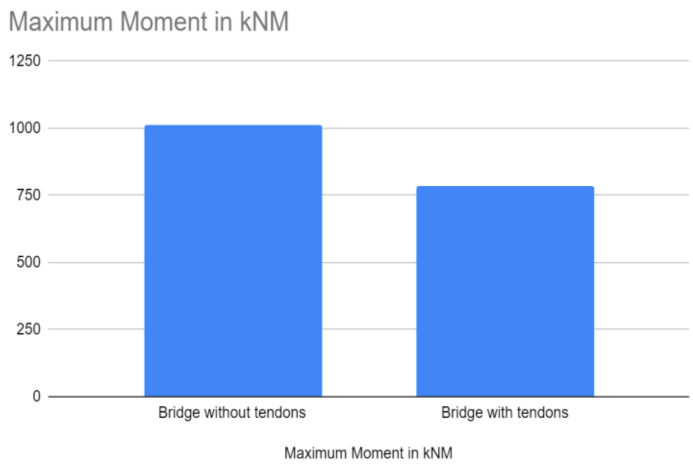


IV. ANALYSIS RESULT









V. CONCLUSION

This study is focused towards analyzing a precast segmental bridge considering the drawing as per DPR of Bundekhand Expressway presenting the comparison for bridge with steel tendons and without steel tendons. The comparison was made on parameters namely shear force, torsional values, maximum moment, maximum displacement and support reaction. The modeling and analysis of the case was using analytical application Csi Bridge.

Shear Force in kN

Shear force was least found in bridges with steel tendons as shear force for bridges with steel tendons was 379.207 kN whereas shear force for bridges without steel tendons was 476.098 kN.

Maximum Displacement

The structure was fragmental in segments to evaluate maximum displacement as a minor gap was seen in both the cases of 9% difference.

Torsional Values

The state of strain in a material that has been twisted by an applied torque is known as torsion. When a structural element is subjected to a twisting force, something happens. Torsion is the state of strain that has deformed the rectangles, and it is made up entirely of pure shear. The torsion values for bridge without tendons was 0.134 kn-m and bridge with tendons was 0.063 kn-m.

Support Reaction

A support reaction is a force that is applied to a support or a resultant restraining end moment that occurs as a result of the inability to move. Support responses in structural systems are in balance with external forces operating on the structure. Here the support reaction was maximum with a bridge with tendons in comparison to a bridge without tendons.

Maximum Moment

The maximum bending moment in a girder occurs when the shear force at that section is zero or changes sign because the bending moment is zero at the point of contra flexure. A sagging bending moment, also known as a positive bending moment, is one such bending moment. Here the bending moment was 785.007 kN-m for bridge with tendons whereas 1011.88 kN-m for bridge without tendons.

VI. FUTURE SCOPE

- Comparative analysis of bonded and unbonded tendons in different types of bridges should be analyzed in future.
- Analysis should be conducted using different analytical applications.
- The segmental precast bridge model, described in this report, should be was constructed and tested on the dual shake tables of SEESL

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Cite this article as :

Pradumn Raja Bundela, Prof. Rakesh Patel, Prof. Pushpendra Palash, "Analysis of a Tendon Bridge Considering Vehicular Loading Using CSI Bridge Software", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 7, Issue 4, pp.61-72, July-August.2023

URL : https://ijsrce.com/IJSRCE23747