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Research Article

"Design Optimization of Box Girder Bridges for Improved Structural Performance"

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ABSTRACT

Bridge construction today has achieved a worldwide level of importance. Bridges are the key elements in any road network Use of box girder is gaining popularity in bridge engineering fraternity because of its better stability, serviceability, economy, aesthetic appearance and structural efficiency. In a prestressed concrete box girder bridge, the need to contain and deviate the longitudinal tendons of the internal prestressing increases the web thickness and the self-weight of the deck. As the span increases, the reduction of dead load is a primary need. Reductions to dead load permit savings in equipment costs while creating a reserve for service loads. External prestressing allows the combination of conventional materials to create innovative prestressed composite structures. Compared with conventional prestressed concrete box girders, these structural schemes are lighter and more efficient, and may extend the field of application of several conventional construction techniques. In present study a shapes of Box Girder Bridges in that Box girder bridge and Trapezoidal girder bridge made up of prestressed concrete which is analysis for moving loads as per Indian Road Congress (IRC:6) recommendations, Prestressed Code (IS: 1343) and also as per IRC: 18 specifications. The results show that the analytical calculation results agree well with the numerical calculation results using ANSYS, thus proving the accuracy of the analytical calculation method in this paper.

Keywords: ANSYS classical method, Concrete Box Girder Bridge, Deformation, Flexure strength, Prestress Force, Shear strength.

INTRODUCTION

In a period of 20 years, the highway bridge industry has been enjoying an unparalleled boom along with the economic development. However, to build new highway bridges could be limited or troubled by the existing geographical highway or railway layouts if using commonly-used bridges with a high construction depth. [21] Especially in densely populated areas this high construction depth would significantly extend the bridge approaches or ramps and simultaneously increase the mounts of landfills as demolition work. The construction and use of bridges creates as the beginning of human civilization, which provides space over the barrier. The bridge is an important part of the infrastructure program.

There will be a strong focus on the height of the built bridges. And at the same time the bridge should ensure safety and should be economical. [8] A girder box is a bridge where large beams carry girders in the shape of an empty box. Now a day girder box bridges are commonly used for highway operations and modern simple railway buildings because of their great rigidity and strength and comparability to an equal member of the open cross section. It has gained wide acceptance in highway and bridge systems due to its efficient construction, better stability, usability and constructioneconomy. [22]

Maintenance of the girder box can be easy, as the internal space can be made directly available. There are two sections of the most commonly used girder box, rectangular and trapezoidal sections. Instead of a rectangular

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section when it comes to the trapezoidal phase, the geometry is simple and has no complexity in construction. The purpose of this study was to focus on the benefits of the trapezoidal phase in relation to the efficiency of the structure over the rectangular section of the girder box. [7]

The functionality and safety of the bridge that must meet all the design codes is important and other construction materials must be properly considered. Typically, the construction of a bridge is designed to determine the size of the members and the geometry of the structure to achieve the lowest cost. [1] Bridges may be needed when crossing a railway, a road, a footpath and even a conveyance. The location of the bridge should be chosen in such a way that it offers significant commercial and social benefits, efficiency and effectiveness.

They shorten distances, speed up transportation, and facilitate trade. [6] Different types of girder bridges are adopted over time. For a distance of 20 m to 50 m box girder and T beam bridge girders are used. Boxers, however, have gained widespread acceptance of the highway and bridges due to their efficient operation, better stability, usability, construction economy and aesthetic appeal. The analysis and design of the box-girder bridges is very complex due to its three behaviors which include bracing, twisting and bending of long and unbroken directions.

The girder box comes in a variety of cross sections and cell cells.

OBJECTIVES AND SCOPE OF PROJECT

- To study the effect of shape of girder on behavior of bridges under the same loading and moving loading to check support reactions, bending stresses, shear stresses and deflection by using Finite element analysis.
- To study the effect on total deformation and total equivalent stresses of girders by using tendon.
- Develop three-dimensional finite element models of box girders using the commercially available finite element computer program "ANSYS".

METHODOLOGY PROBLEM STATEMENT

As studied, the shape optimization of box girder bridge considering same loading for two and four lanes for span 20 to 80 m.

Two types of girders use in this modeling of girders are

- **Box girder bridge**:
  a) Single box girder bridge b) Multi-box girder bridge

- **Trapezoidal girder bridge:**

a) Single trapezoidal girder bridge b) Multi- Trapezoidal girder bridge

LOADING CALCULATION (Reference: Code-IRC-6-2016)

The following are the various loads to be considered for the purpose of analysis.
a) Self-Weight b) Dead load c) Live load d) Wind load e) Impact load

RESULTS AND DISCUSSION

Comparative Analysis of Bridge Deck Subjected To IRC Class AA Load

After time history analysis of model IRC Class AA 10000 KN load is applied at the time step interval of 0.2 sec shows in following model, for comparison purpose total deformation, principal stress, equivalent stress, shear stress, normal stress, force reaction and moment reaction are compared.

Trapezoidal girder Bridge:

a) Multi-Trapezoidal girder bridge:

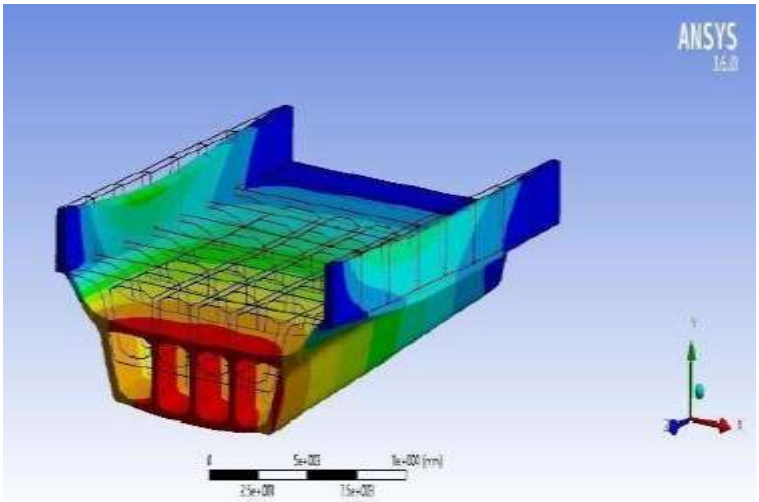
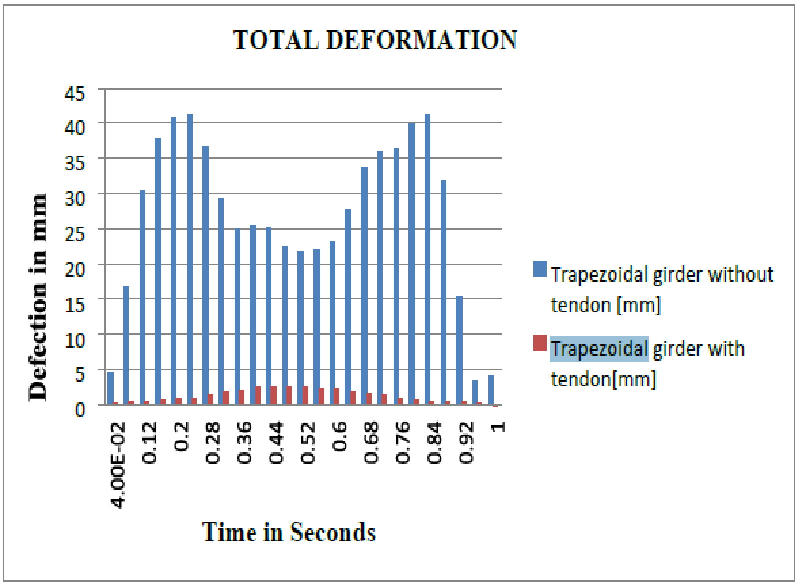


Fig.- Multi-Trapezoidal girder with tendon- Deformation



Graph -Multi-Trapezoidal girder Deformation

From above graph it is seen that time in X direction and deformation (mm) in Y direction. This graph shows reduced total deformation using tendon.

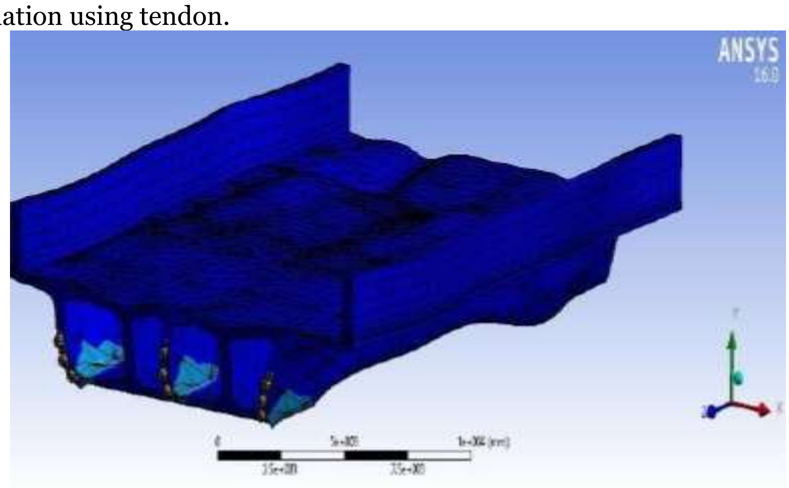


Fig.- Multi Trapezoidal girder with tendon Equivalent Stress

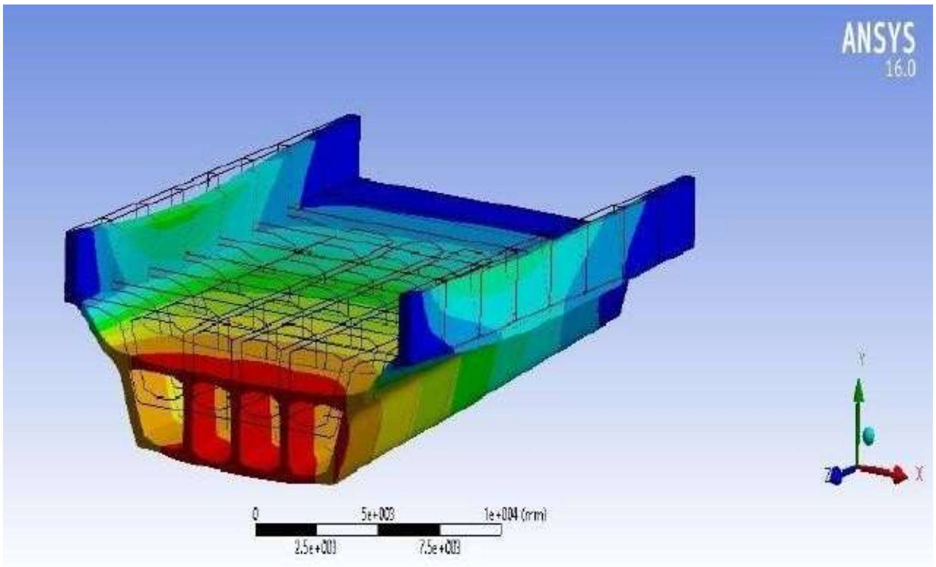
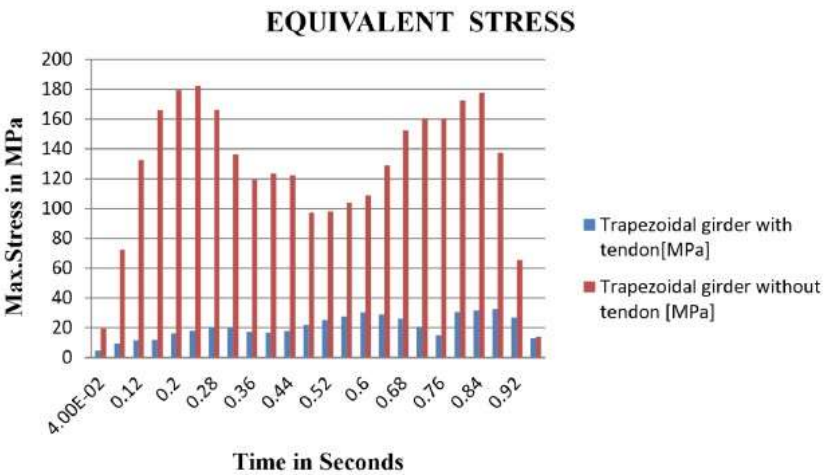


Fig.- Multi Trapezoidal girder without tendon Equivalent Stress



Graph- Multi Trapezoidal girder Equivalent Stress

From above graph it is seen that time in X direction and maximum stress in Y direction. This graph shows reduced equivalent stress using tendon.

b) Single-Trapezoidal girder bridge:

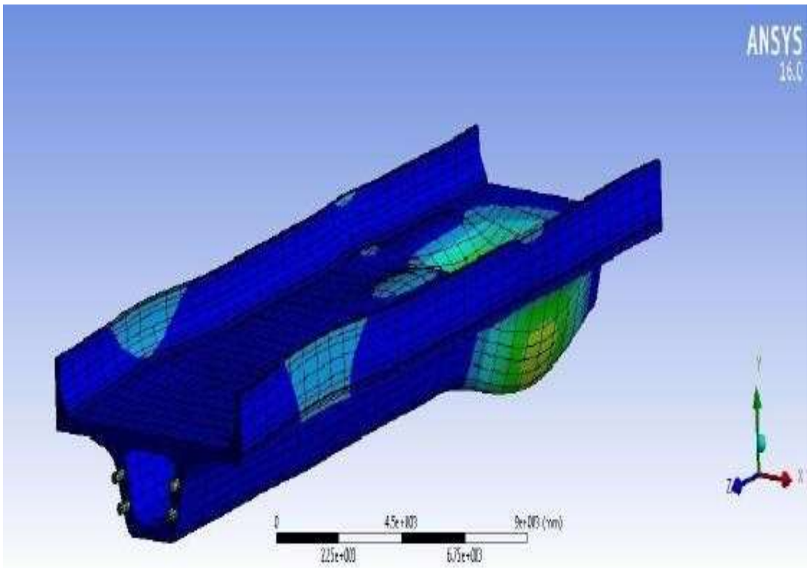


Fig.-Single Trapezoidal girder with tendon- Deformation

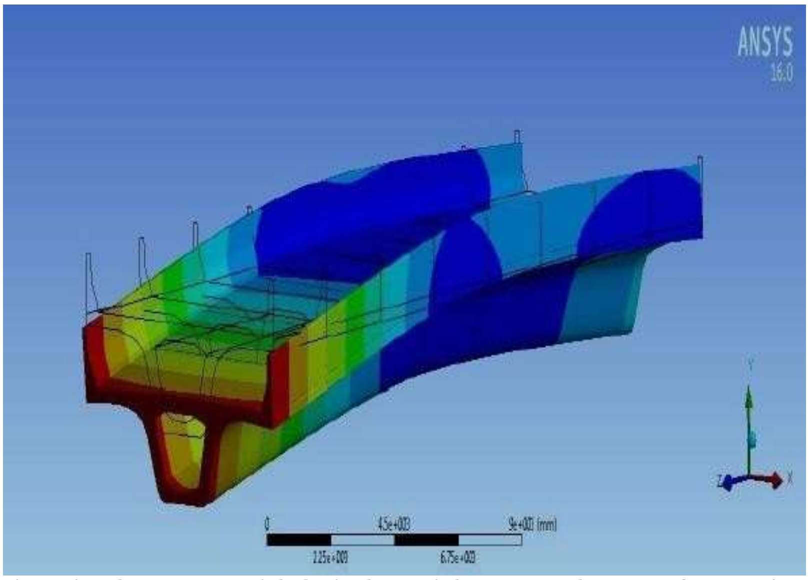
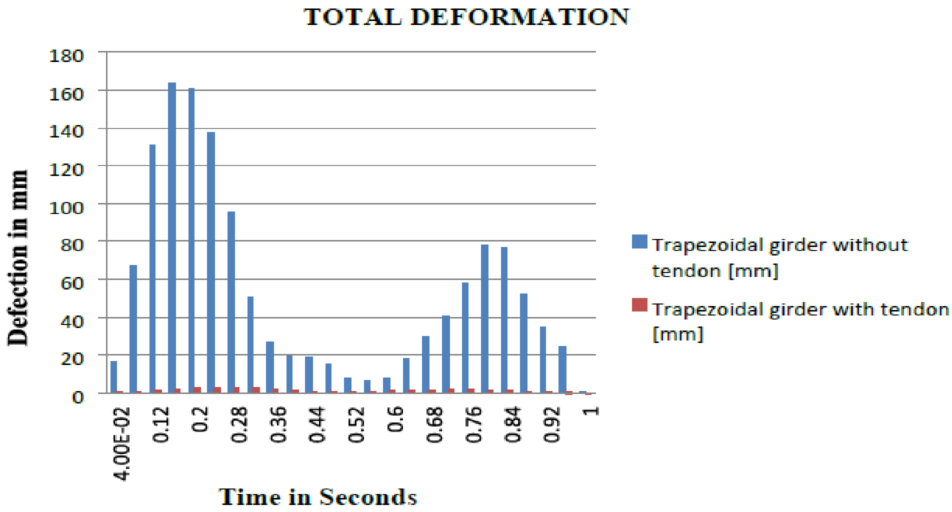


Fig -Single Trapezoidal girder without tendon- Deformation



Graph -Single Trapezoidal girder- Deformation

From above graph it is seen that time in X direction and deformation (mm) in Y direction. This graph shows reduced total deformation using tendon.

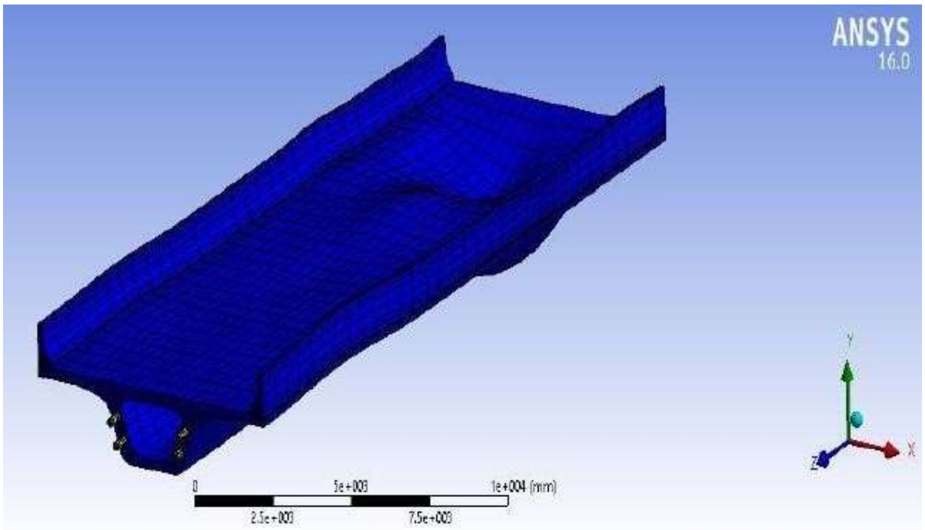


Fig.- Single Trapezoidal girder with tendon-Equivalent Stress

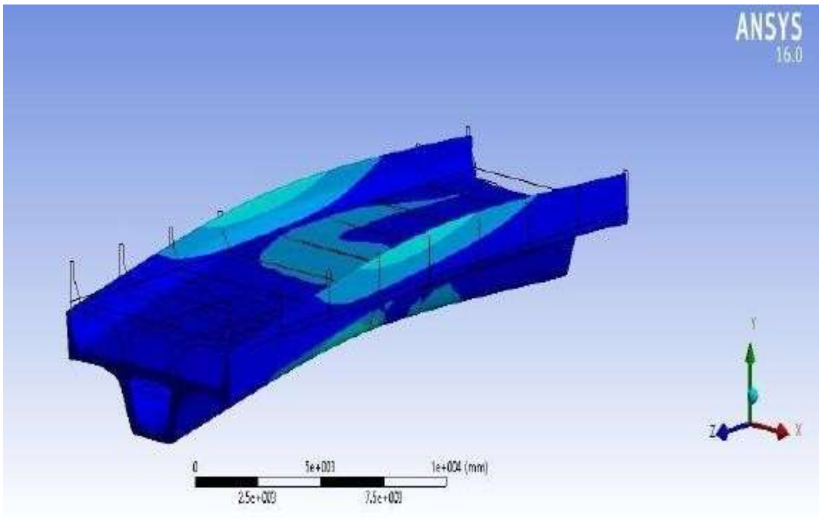
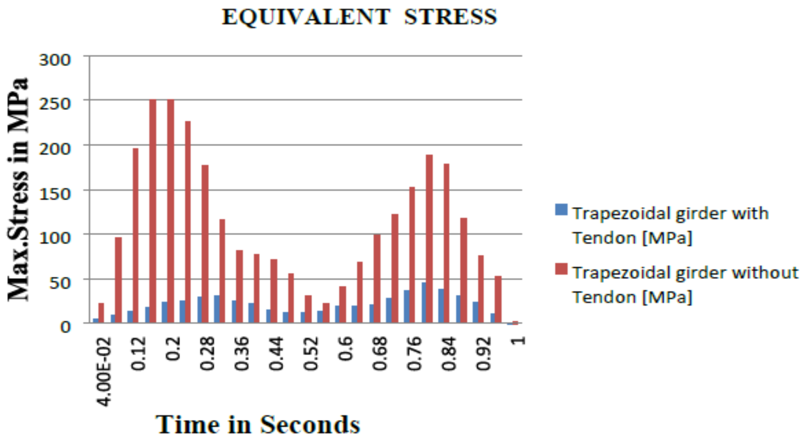


Fig.- Single Trapezoidal girder without tendon- Equivalent Stress



Graph- Single Trapezoidal girder Equivalent Stress

From above graph it is seen that time in X direction and maximum stress in Y direction. This graph shows reduced equivalent stress using tendon.

Box girder Bridge

a) Multi-Box girder bridge

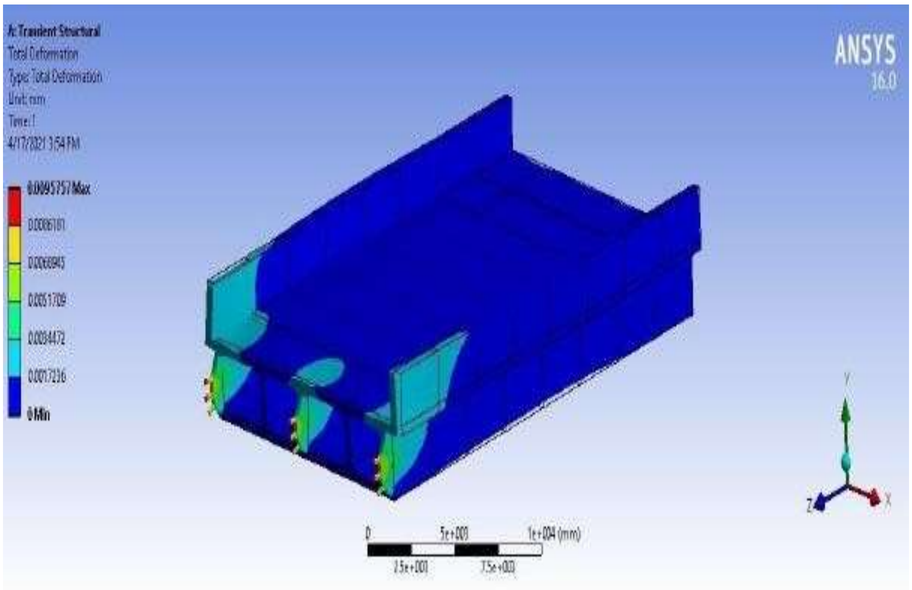


Fig.- Multi-Box girder with tendon- Deformation

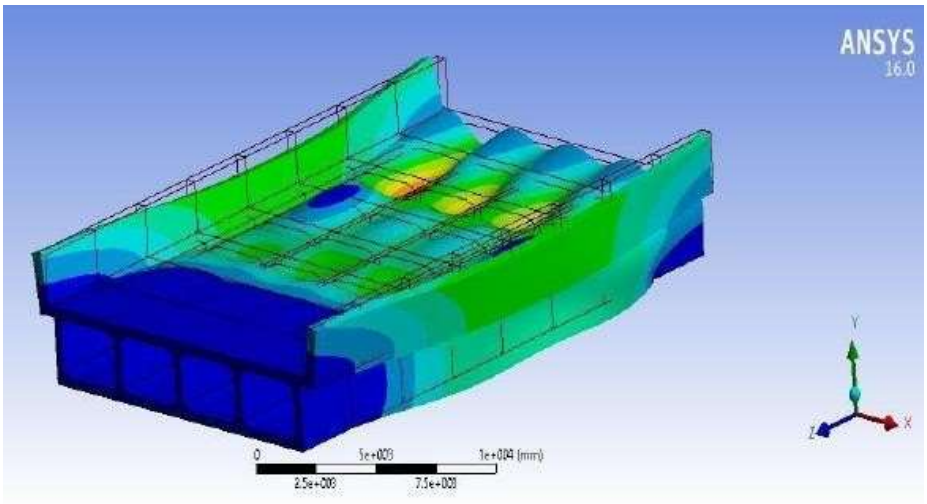
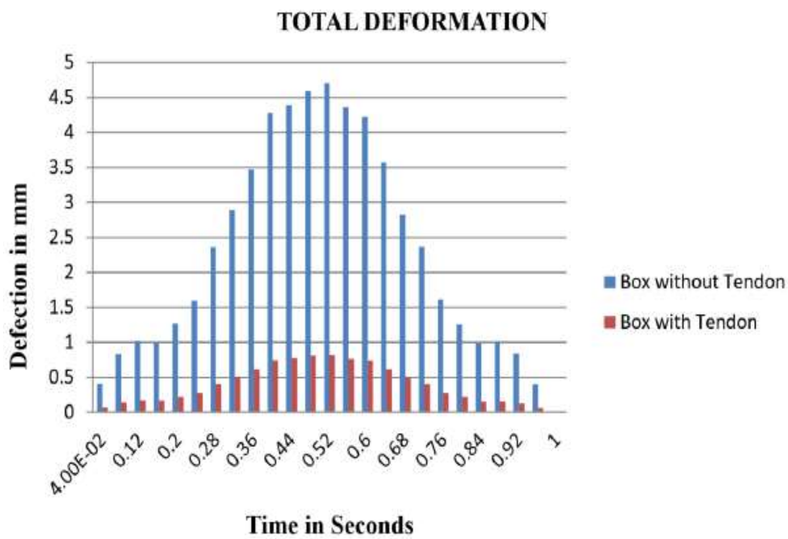


Fig.- Multi-Box girder without tendon- Deformation



Graph - Multi-Box girder Deformation

From above graph 6.5 it is seen that time in X direction and deformation (mm) in Y direction. This graph shows reduced total deformation using tendon.

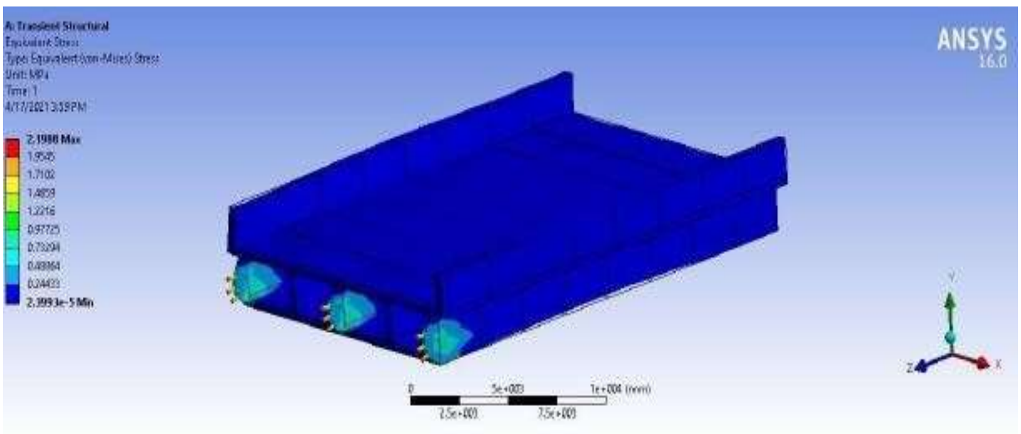


Fig. - Multi-Box girder with tendon-Equivalent Stress

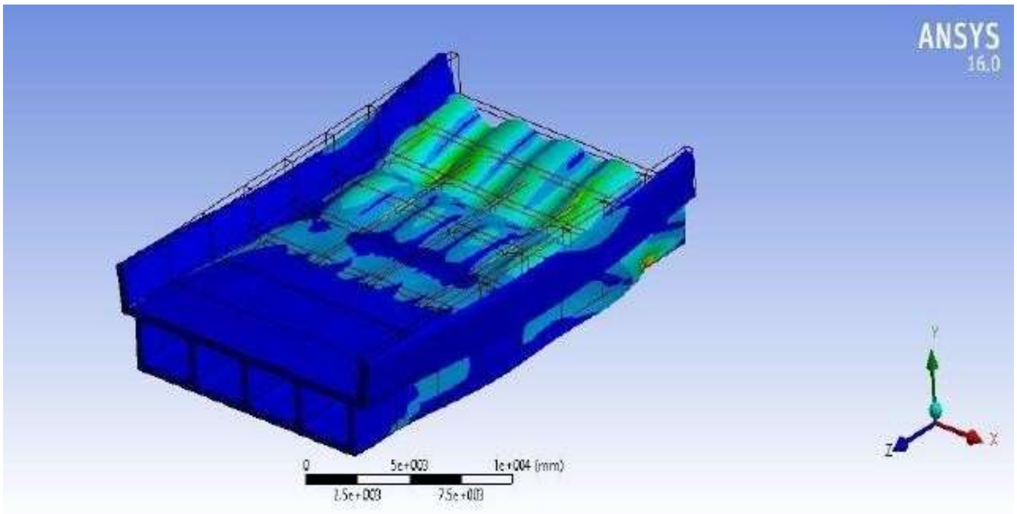
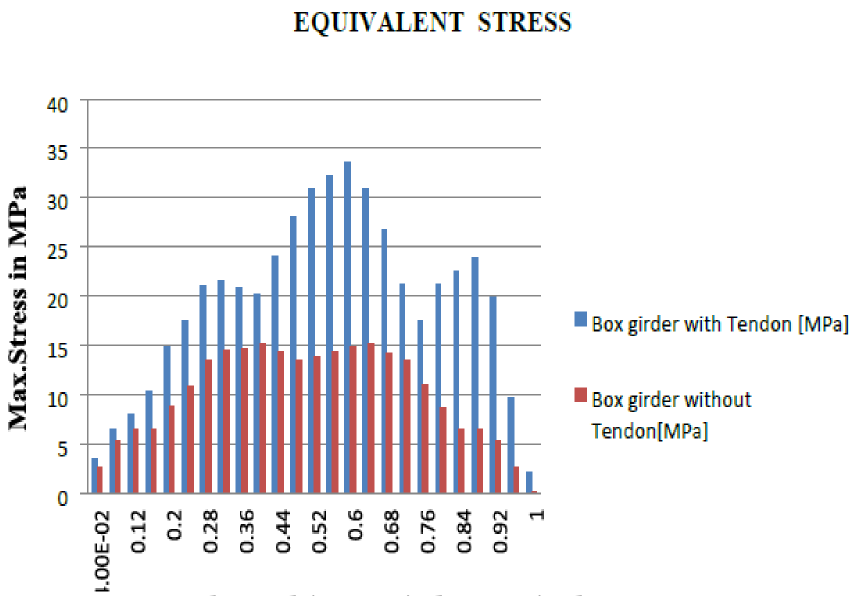


Fig.- Multi-Box girder without tendon- Equivalent Stress



Graph- Multi-Box girder Equivalent Stress

From above graph it is seen that time in X direction and maximum stress in Y direction. This graph shows reduced equivalent stress using tendon.

b) Single-Box girder bridge

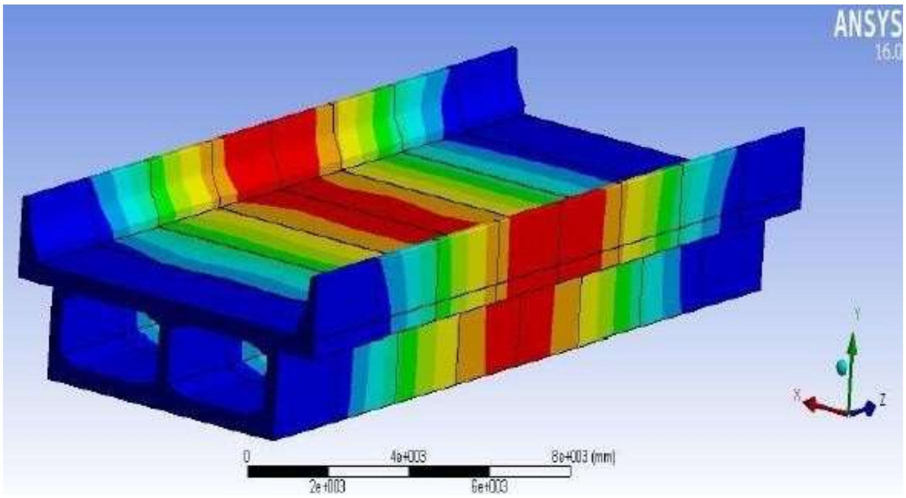


Fig.- Single-Box girder with tendon-Deformation

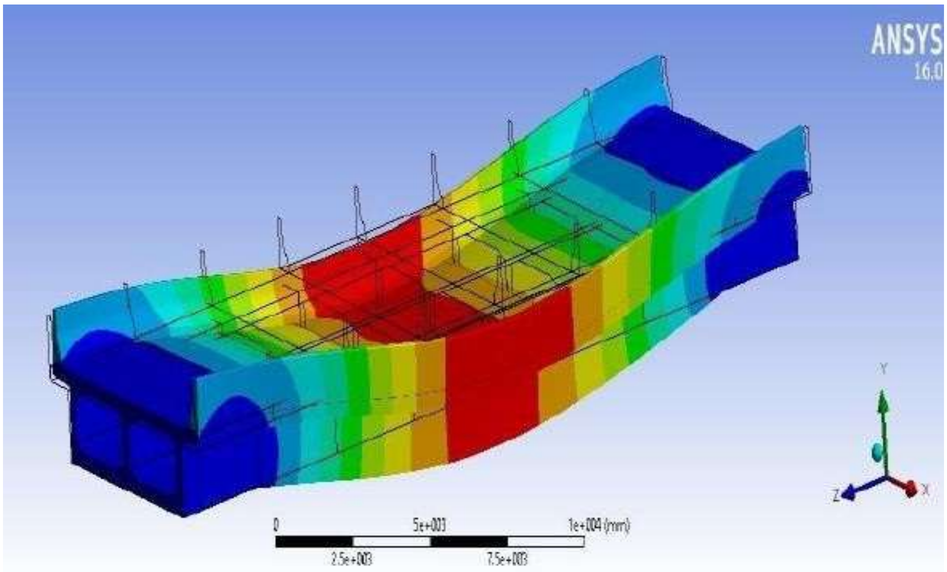
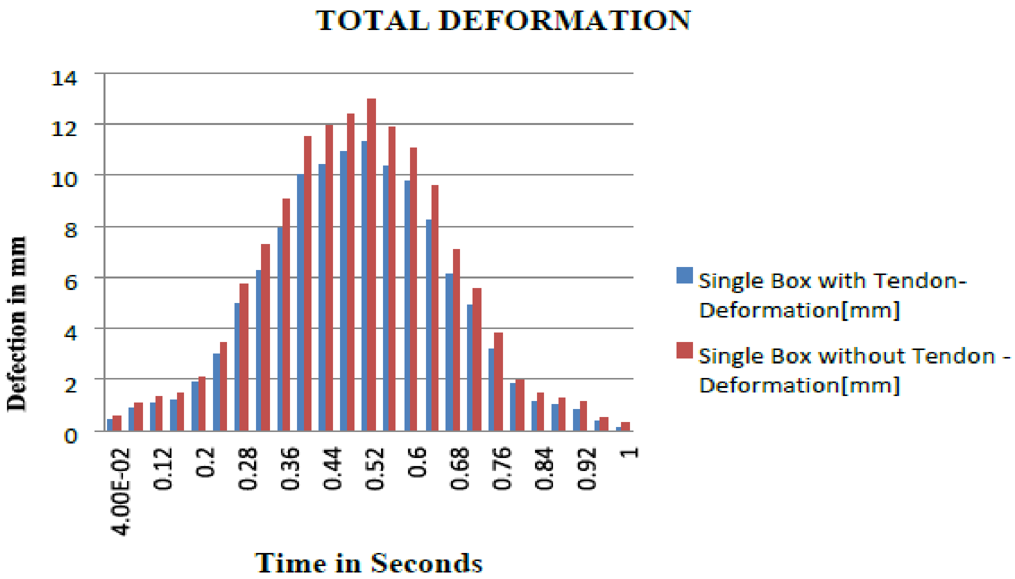


Fig.- Single-Box girder without tendon- Deformation



Graph- Single-Box girder Deformation

From above graph it is seen that time in X direction and deformation (mm) in Y direction. This graph shows reduced total deformation using tendon.

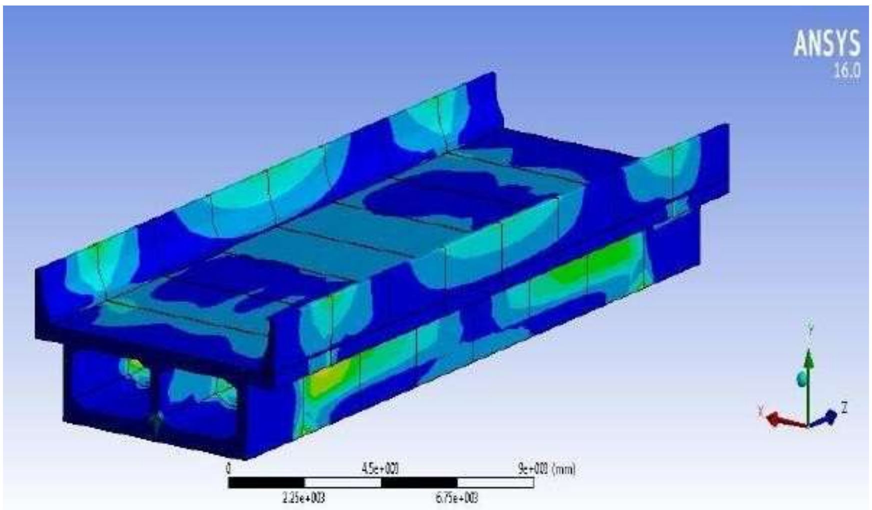


Fig - Single-Box girder with tendon-Equivalent Stress

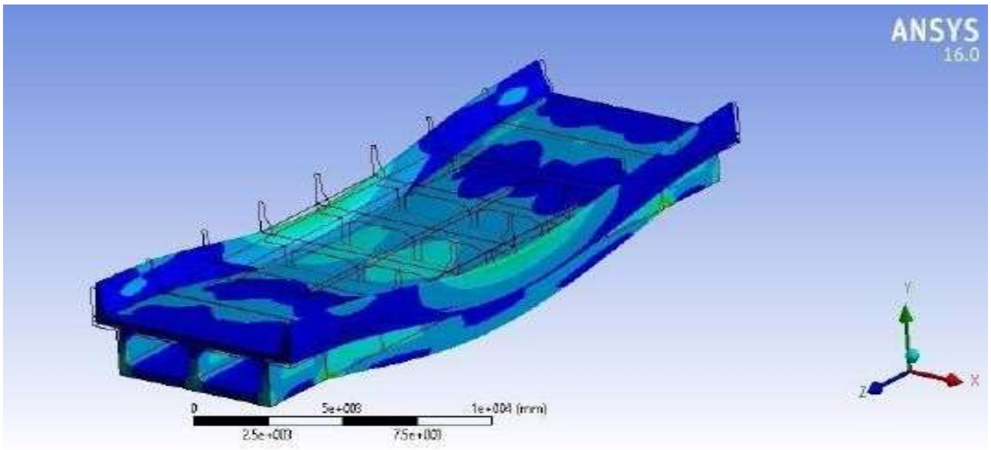
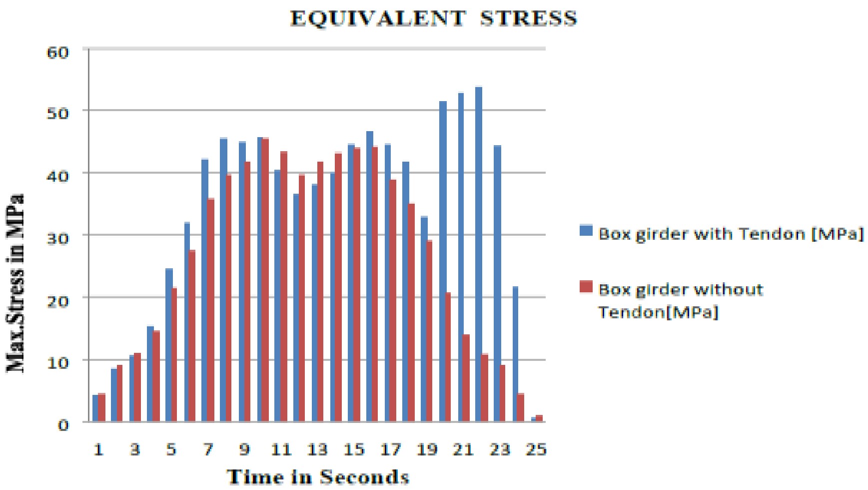


Fig.- Single-Box girder without tendon- Equivalent Stress



Graph - Single-Box girder Equivalent Stress

From above graph it is seen that time in X direction and maximum stress in Y direction. This graph shows reduced equivalent stress using tendon.

CONCLUSION

The various trail of L/d ratios are carried out for Box Girder Bridges, deflection and stress criteria satisfied the well within permissible limits. As the depth increases, the prestressing force decreases, and the no. of cables decrease. Because of prestressing the more strength of concrete is utilized and well governs serviceability.

- The various trail of L/d ratios are carried out for Box Girder Bridges, deflection and stress criteria satisfied the well within permissible limits. As the depth increases, the prestressing force decreases, and the no. of cables decrease. Because of prestressing the more strength of concrete is utilized and well governs serviceability.
- For Multi trapezoidal box girder, the average total deflection of bridge is decreased by 21.03% after using tendons in girder bridges.
- Also for Multi trapezoidal box girder, the equivalent stress of bridge is decreased by 37.03% after using tendons in girder bridges.
- For Single trapezoidal box girder, the average total deflection of bridge is decreased by 38.05% after using tendons in girder bridges.
- For Single trapezoidal box girder, the equivalent stress of bridge is decreased by 16.04% after using tendons in girder bridges.
- For Multi box girder, the average total deflection of bridge is decreased by 34.07% after using tendons in girder bridges.
- For Multi box girder, the average equivalent stress of bridge is decreased by 23.06% after using tendons in

girder bridges.

- For Single box girder, the average total deflection of bridge is decreased by 14.02% after using tendons in girder bridges.
- For Single box girder, the average total deflection of bridge is decreased by 11.09% after using tendons in girder bridges.

The accuracy of the model was validated, and the limitations of matching finite element models to analytical tests held under conditions that are less than ideal was illustrated. The development of a finite element model of an entire bridge illustrates not only the capability of ANSYS to represent the behavior of a realistic structure but also the specific capability of the model to predict deflections, strains, and stresses.

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