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Dynamic Analysis of Four-Lane Bridge Deck with Variation of Span Length and Girder Thickness under Different Loading Condition

ABSTRACT

A bridge is a construction built to span physical obstacles such as a body of water, valley, or road, for providing passage over the obstacle. In the present work, the analysisand results have been compared for a two-lane simply supported RC T-frame concreteplate girder bridge deck. This analysis according to IRC Chapter-3 is carried out and structural modeling, load and load combinations is applied according to the conditionsin the STAAD.Pro software with considering various vehicle databases i.e. Class AA and 70R loading. A dynamic analysis has been performed at different lengths of span to evaluate the effect of the structure length. Additionally, the effect of girder thicknesshas also been studied. The effective height of the bridge cross-section is kept 2 meters for all cases. In this work, maximum deformation, von-mises stress, shear stress, in- plane shear stress, membrane stress, bending and twisting moment is achieved and compared with each other.

INTRODUCTION

The T-beam used as part of the construction is a load-bearing structure made of reinforced concrete, wood, or metal, with a cross-sectional area in the shape of a T. Thehighest point of the molded T-cross segment is filled as a flange or a. Pressure piece inopposite compression stress. The web (vertical area) of the beam under the compressionflange serves to resist shear stress and give paired bending forces a more noticeable pause.

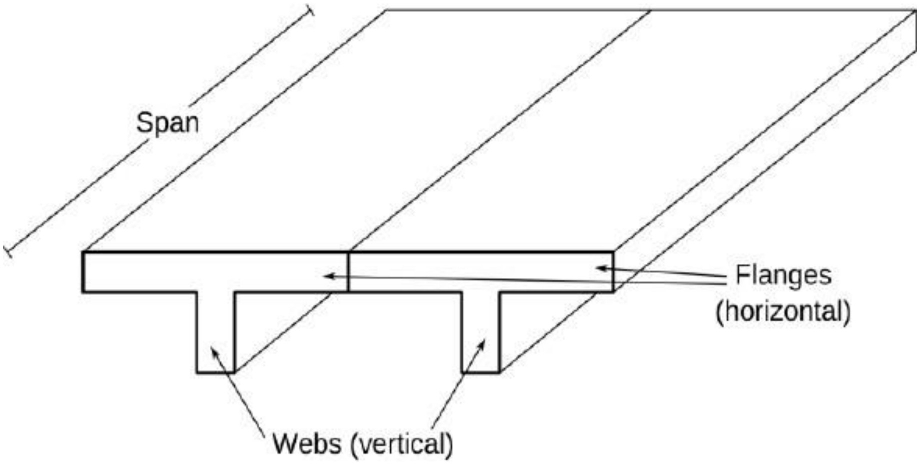
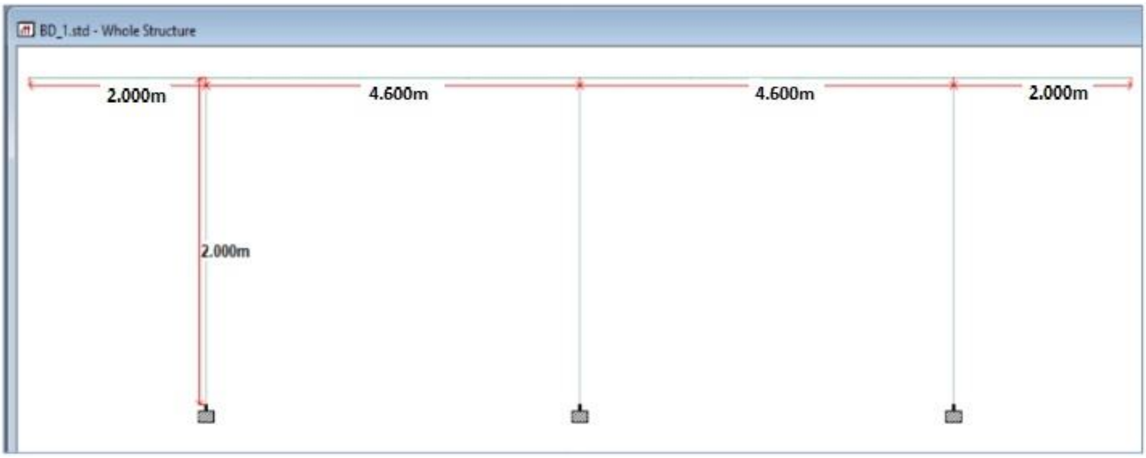


Figure 1. T-Beam

Girder is a term used in construction to refer to horizontal support beams that can be made from a variety of building materials such as stainless steel, concrete, or a combination of these materials. A girder bridge is a basic and common type of bridge in which the bridge deck is built on top of the supporting girders, which in turn are placed on the piers and abutments that support the span of the bridge. The types of girders used for girder bridges are usually I-beams, so they are named because their shape is reminiscent of a Capitol Roman letter I, or box-girder girders made of steel orconcrete and are shaped like a box. open. Girder bridges are often used for straight bridges that are 10 to 200 meters (33 to 650 ft) long, such as light rail bridges, pedestrianbridges, or highway overflows. The longest girder bridge in the world is 700 meters (2,300 ft) long and is located in Brazil.

2. Methodology

In present work, single span four lane RCC slab T-frame bridge deck has beenconsidered. To obtained the effect of aspect ratio (span/width) and vehicle database, thetwo different span length and vehicle data (as shown in Figure 4.1) has been consideredin T-frame bridge deck and it has been modelled using the STAAD.Pro Software, and The bridge deck is analysed using same for Dead load as well as two different class oflive load i.e. IRC Class AA and 70R tracked loading loads.



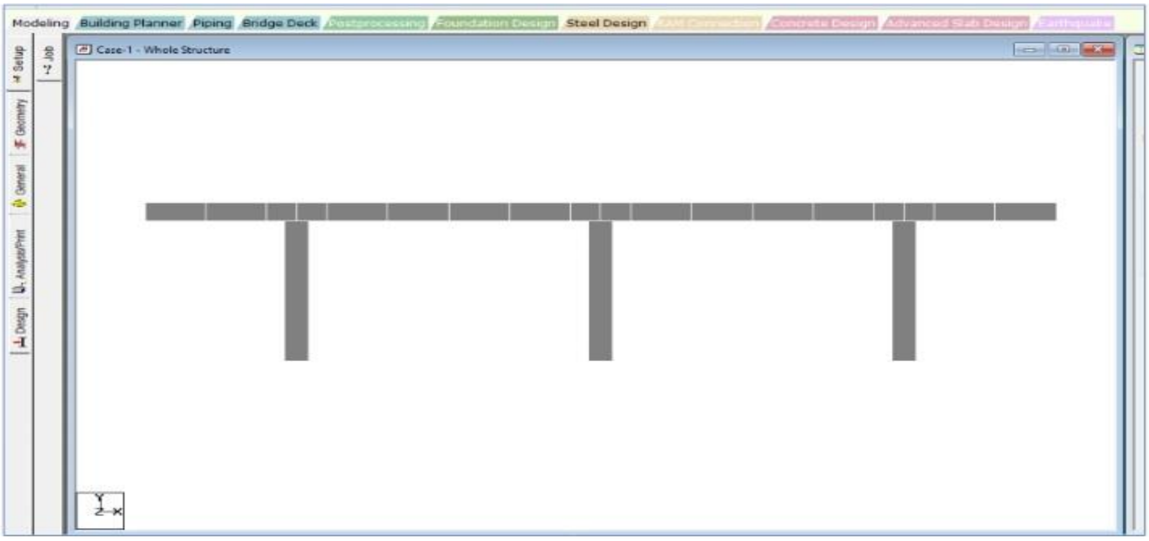


Figure 2. Modeling of T- frame girder bridge deck in STAAD.Pro software

Table 1. Description of proposed bridge deck

Bridge Type	T-Frame Slab Bridge Deck
Effective Span Length	20m, 30m, 40m and 50m
Height of T-Girder	2m
Lane of Bridge	Four lanes
Slab thickness	0.3m
Carriageway Width	10.75m
Total Width of Bridge Deck	13.20m
No. of longitudinal Girder	3
No. Cross girder	5, 7, 9 and 11
Distance Between Longitudinal Girder	4.6m c/c
Distance Between Cross Girder	5m c/c
Thickness of Girder	0.22m, 0.24m, 0.26m and 0.28m
Grade of Concrete	M30
Live load	Class AA Loading Class 70R Loading

3. Result and Discussion

In the present work, the live load of the vehicle has been applied according to IRC Chapter-3 loading i.e. AA and 70R loadings have been applied in different span lengthsto achieve the effect of the proposed bridge deck. Also, the thickness of the girder is 0.28 m for all span lengths. The results obtained by the software have been obtained byconsidering the combined load (DL + LL).

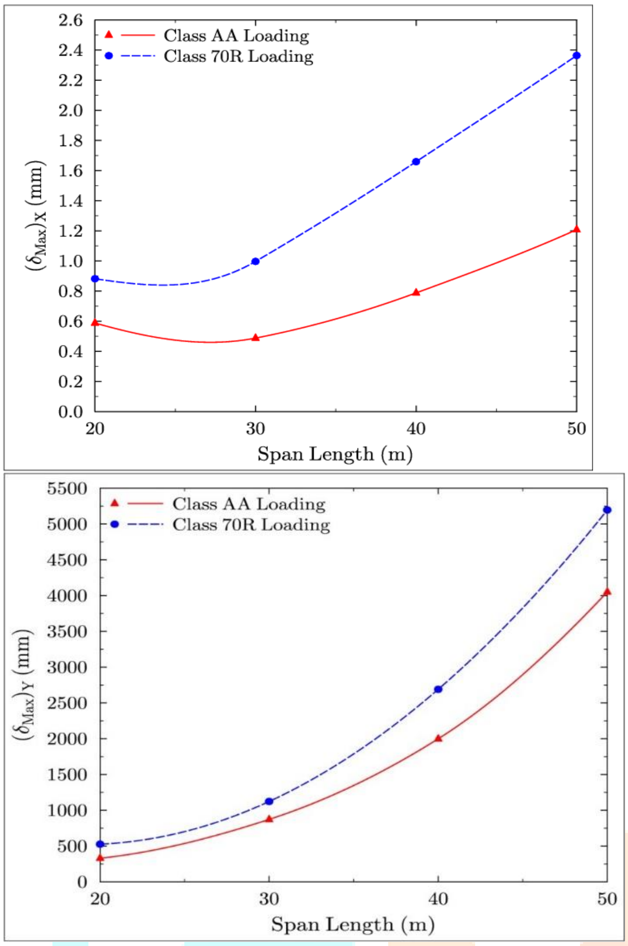


Figure 3. Graphical representation of maximum deformation in X and Y-direction due to class AA and 70R loading in variation of span length of bridge deck

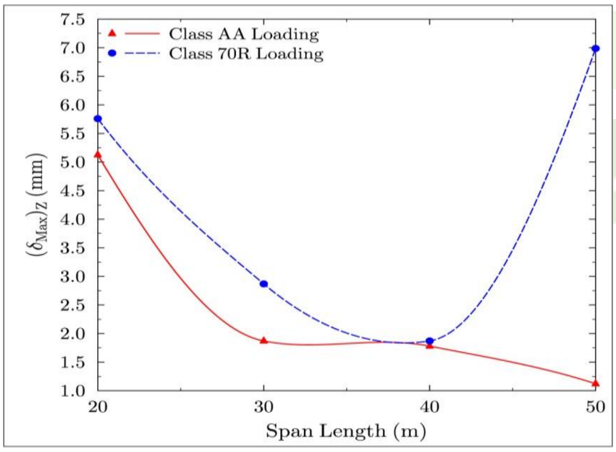


Figure 4. Graphical representation of maximum deformation in Z-direction dueto class AA and 70R loading in variation of span length of bridge deck

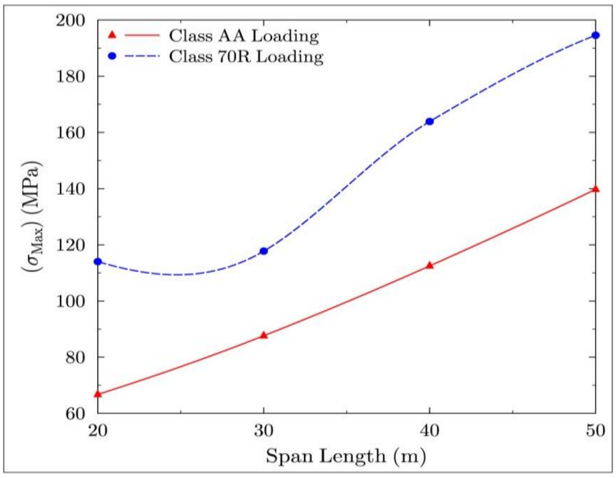


Figure 5. Graphical representation of maximum von misses stress due to classAA and 70R loading in variation of span length of bridge deck

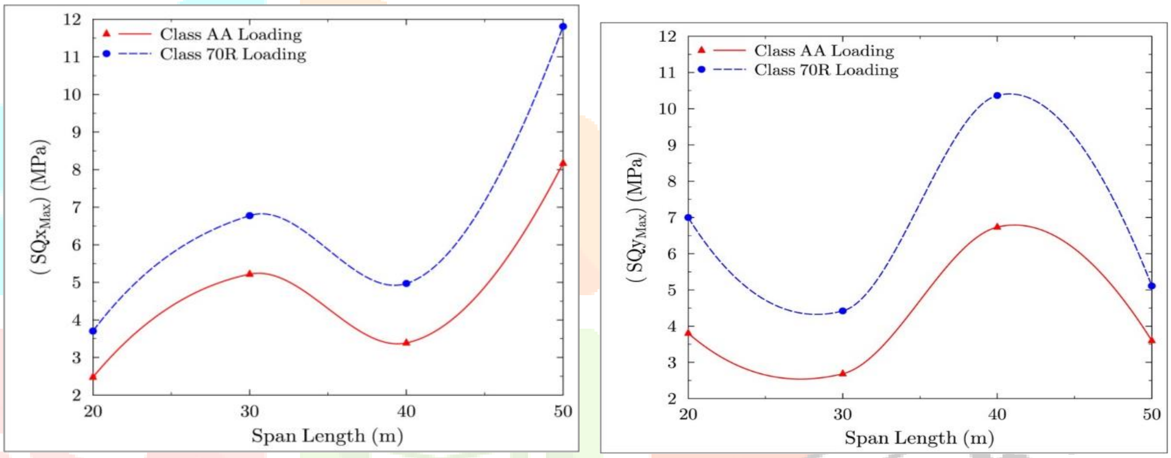


Figure 6. Graphical representation of maximum shear stress in X and Y-direction dueto class AA and 70R loading in variation of span length of bridge deck

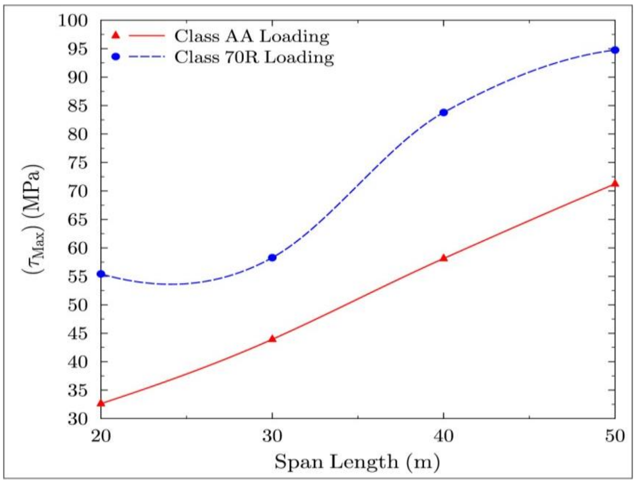


Figure 7. Graphical representation of maximum in-plane shear stress due toclass AA and 70R loading in variation of span length of bridge deck

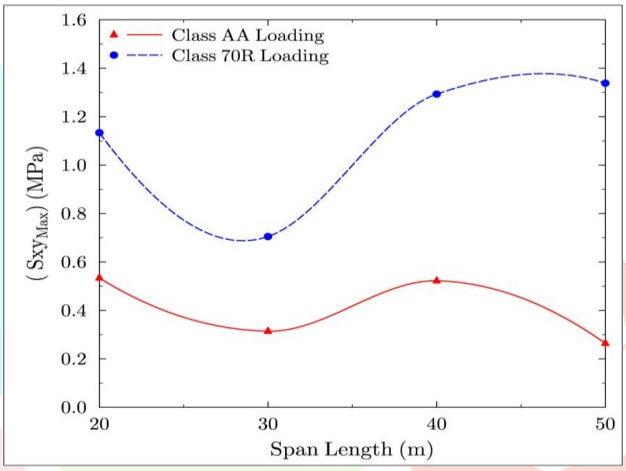


Figure 8. Graphical representation of maximum membrane stress due to classAA and 70R loading in variation of span length of bridge deck

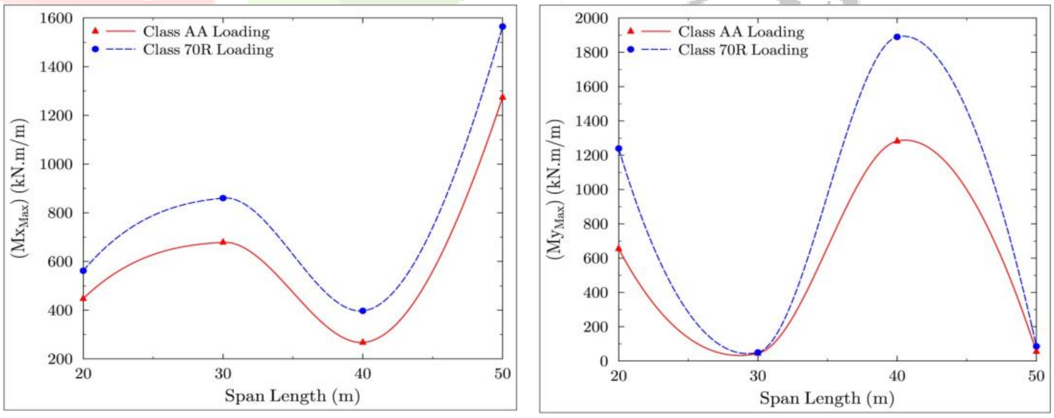


Figure 9. Graphical representation of maximum bending moment in X and Y- direction due to class AA and 70R loading in variation of span length of bridge

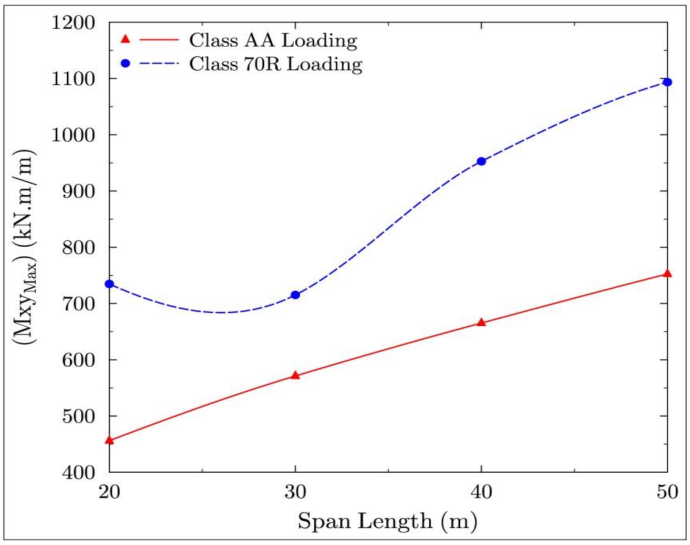


Figure 10. Graphical representation of maximum twisting moment due to classAA and 70R loading in variation of span length of bridge deck

Now, the effect of girder thickness of the bridge deck has been obtained. The girder thickness has been varied in the range of 0.22 to 0.28m and the length of span has beenconsidered as fixed at 20m. Again, live vehicle load has been applied as per IRC Chapter-3 loading condition, therefore the class AA and 70R loading is applied in proposed bridge decks.

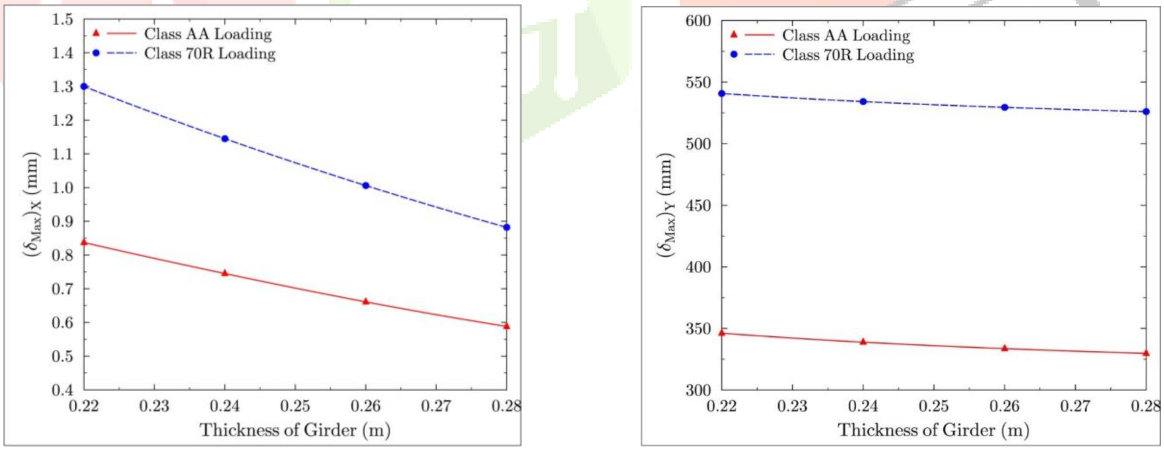


Figure 11. Graphical representation of maximum deformation in Y-directiondue to class AA and 70R loading in variation of thickness of girder of bridge deck

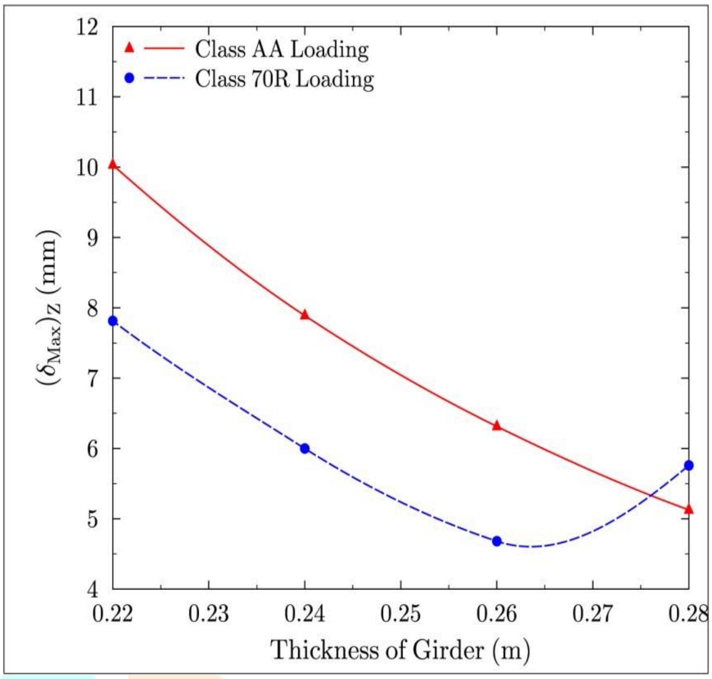


Figure 12. Graphical representation of maximum deformation in Z-direction due to class AA and 70R loading in variation of thickness of girder of bridge deck

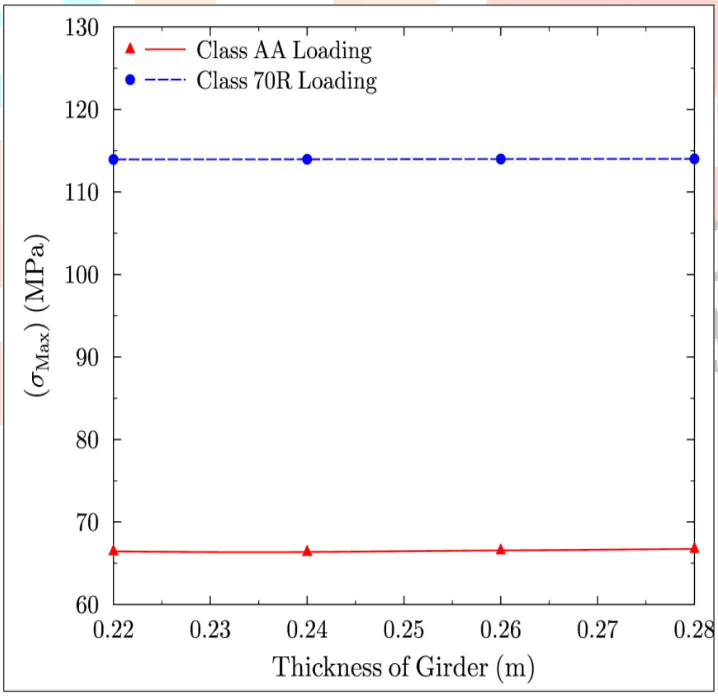


Figure 13. Graphical representation of maximum von misses stress due to class AA and 70R loading in variation of thickness of girder of bridge deck

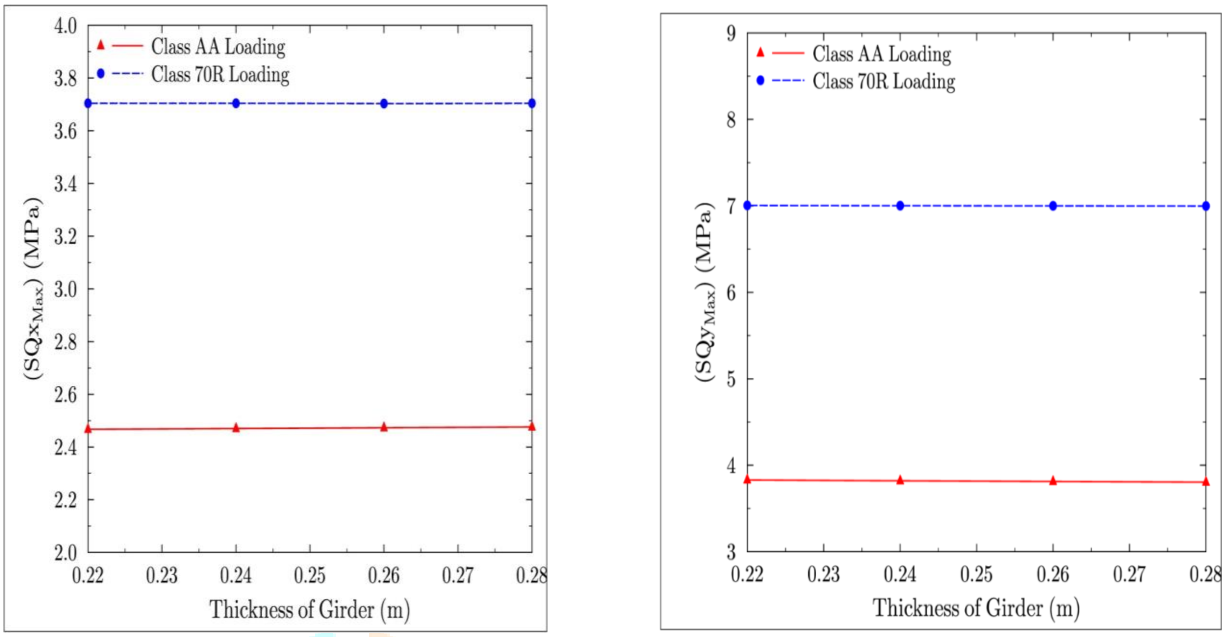


Figure 14. Graphical representation of maximum shear stress in X-directiondue to class AA and 70R loading in variation of thickness of girder of bridge deck

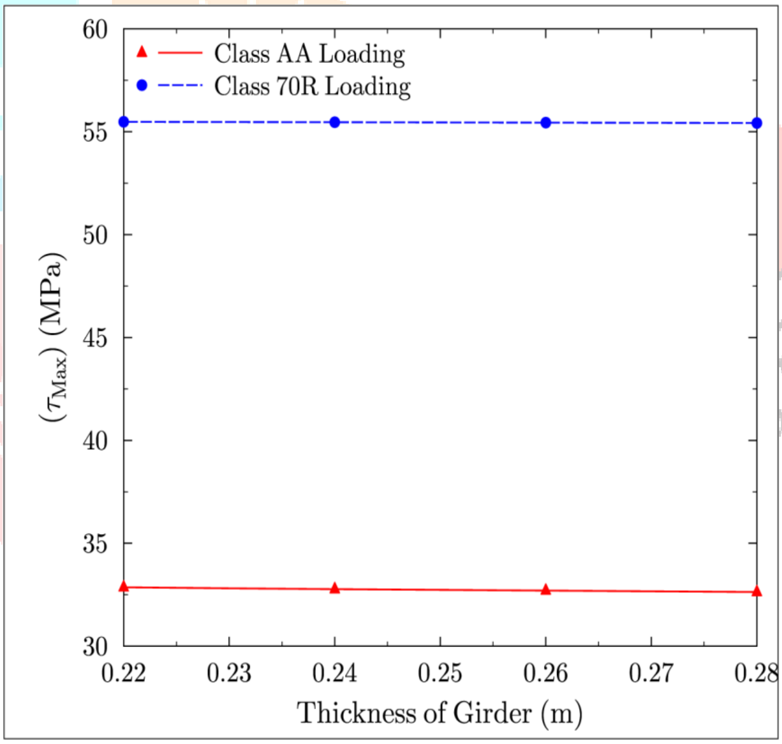


Figure 15. Graphical representation of maximum in-plane shear stress due to class AA and 70R loading in variation of thickness of girder of bridge deck

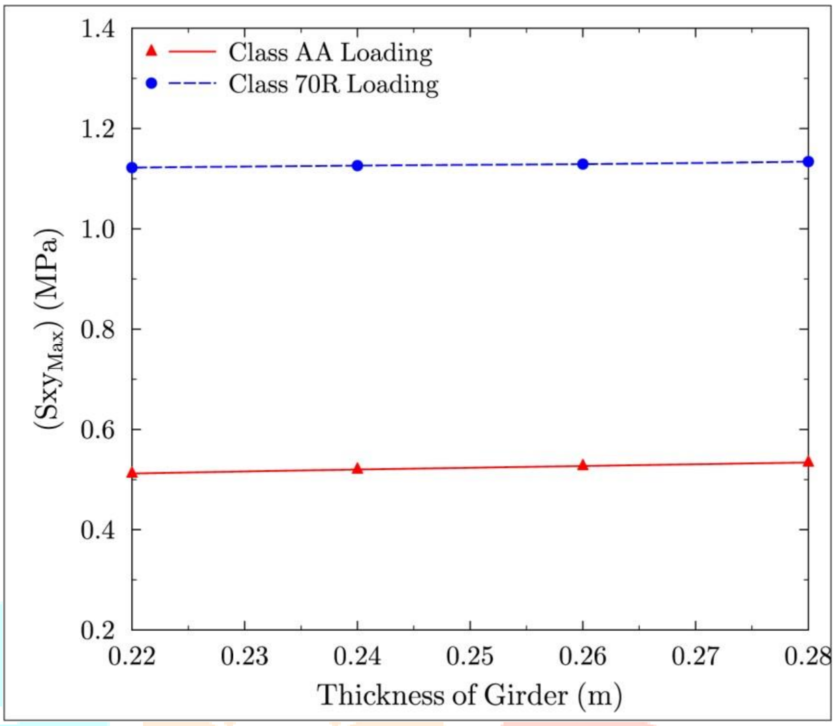


Figure 16. Graphical representation of maximum membrane stress due to classAA and 70R loading in variation of thickness of girder of bridge deck

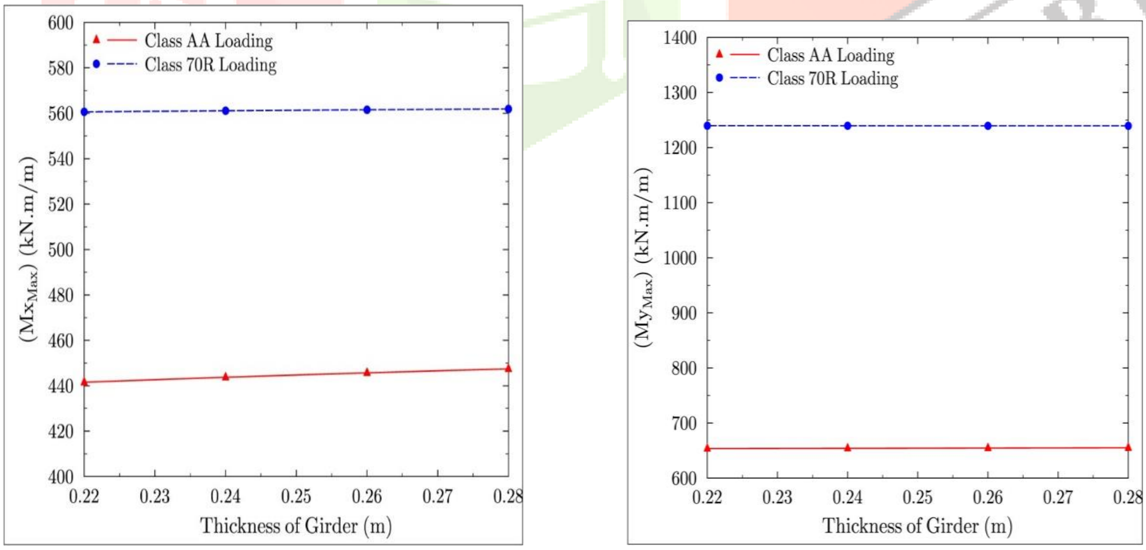


Figure 17. Graphical representation of maximum bending moment in X and Y- direction due to class AA and 70R loading in variation of thickness of girder ofbridge deck

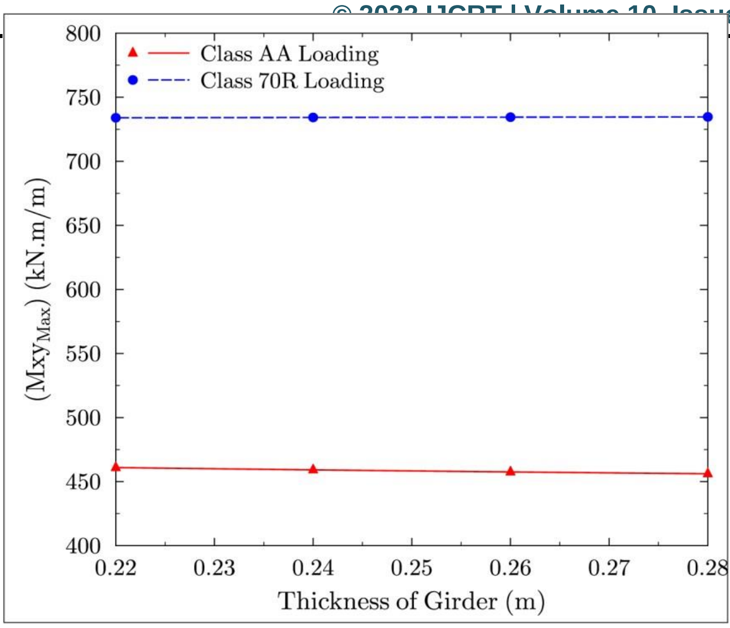


Figure 18. Graphical representation of maximum twisting moment due to classAA and 70R loading in variation of thickness of girder of bridge deck

4. Conclusion and Future Scope

From analysis the major conclusion has been concluded:

- Present work, the four-lane, and span highway bridge have been considered to study the effect of simply supported RC T-beam bridge deck under standard IRC chapter- 3 load classes AA and 70R types.
- Work consisting of the two continuous spans or lane in the longitudinal direction with a span length of 20m, 30m, 40m, and 50m.
- It has been concluded that the maximum deformation in X-Y-Z–direction, von mises stress, in-plane shear stress, and twisting moment due to class AA and 70R live vehicle loading condition respectively. In these figures it has been observed that the value of maximum deformation in X-Y-Z-direction, von mises stress, shear stress in X-direction, in-plane shear stress, bending moment in X-direction and twisting moment increase as the span length is increased when the thickness of the girder is fixed for these cases.
- And it has been also observed that the shear stress in Y-direction, membrane stress and bending moment in Y-direction increasing followed by decreases with increasing the length of the span respectively due to both loading conditions.
- Additionally, the effect of girder thickness of the bridge deck has been obtained.The girder thickness has been varied in the range of 0.22 to 0.28m and the lengthof span has been considered as fixed at 20m. Again, live vehicle load has been applied as per IRC Chapter-3 loading condition, therefore the class AA and 70Rloading is applied in proposed bridge decks.
- The maximum deformation in X & Z–direction due to class AA and 70R live vehicle loading condition respectively. In these figures it has been observed thatthe value of maximum deformation in X and Z–direction decrease as the thickness of the girder is increased.
- And, the maximum deformation in Y-direction, von-misses stress, shear stress inX & Y-direction, in-plane shear stress, membrane stress, bending moment in X& Y-direction and twisting moment is nearly

same or nearer while increasing thickness of the girder respectively due to both loading conditions.

Future Scope

- A further research for development of new technologies in composite construction such as slim-floor slabs with semi continuous connections to the columns, new steel sheets or systems to minimize the time of erection and assembly is desirable.
- The use of precast concrete and even the pre-stressed concrete component in certain composite structure applications may prove fruitful as it has potential due to the economy that can be achieved by these components in terms of time,labour and money.
- The use of fiber reinforced concrete, high strength concrete, self-compacting concrete etc. instead of the conventional concrete may be explored in steel- concrete composite construction.
- In the present study the total cost of RCC slab and steel truss were included in the objective function. However, the cost of the structure can be calculated precisely by including labour cost, connection cost, stud connection cost and cost of reinforcement in the objective function which will through light on the effect of each in cost minimization.

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