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Analysis of RCC-T Frame Girder Bridge under IRC Loading i.e Class AA and 70R

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ABSTRACT

Bridge is the structure which is used for carrying the traffic over the valley or river by connecting highways or railways.This study focuses on the Analysis of RCC-T Frame Girder Bridge under standard IRC loading , and the comparing analysis with different cases or modeling by present for various spans in STAAD.Pro software. To perform the bridge deck slab interaction with the two different loading considered as IRC Codes i.e. Class AA and 70R.To evaluate the suitability of the bridges for short as well as long spans, the four different length of span has been considered i.e. 20m, 30m, 40m and 50m respectively. To evaluate the effect of girder thickness for 20m span or short span length, the four different girder thickness has been considered viz. 0.22m, 0.24m, 0.26m and 0.28m respectively.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.

Keywords: RCC-T Frame Girder Bridge, STAAD.Pro software, IRC Codes i.e. Class AA and 70R

INTRODUCTION

In recent decades, it has been established that a significant part of the world's bridges is not functioning as they should. In some cases, bridges have a significantly higher traffic load than originally intended. . Now there is a significant change from bridges that make it easier to design bridges that will require less maintenance.the modern trend is towards bridges that are very uncertain and have few joints or supports. With the introduction of the new generation design code, Eurocodes, the Swedish Transport Administration calls for a new approach to the analysis of bridge structures where general structural behavior will be taken into account. In addition, for bridges with slab superstructures, the Swedish Transport Administration recommends analysis based on plate or shell theory. According to the Swedish Transport Administration, equivalent frame analysis is no longer an acceptable method for slab bridge analysis. Comparative studies should focus on analysis of specific bridge structures with finite element method (FEM) and shell theory and equivalent 2D frame analysis. A bridge is a construction built to cross physical barriers such as a body of water, valley, or highway, so as to provide a passage over the barrier. The design of the bridge varies depending on the function of the bridge, the nature of the land on which the bridge is constructed, the materials used for construction and the money available to build it. A bridge has three main elements. First, the substructure (foundation) transfers the load weight of the bridge to the ground; It is made up of components such as columns (also called columns) and columns. A stirrup is a connection between the end of the bridge and the path leading to the ground; Provides support for the last sections of the bridge. Second, the bridge superstructure is the horizontal platform that spans the space between the columns. Finally, the bridge deck. Guidelines for non-linear analysis of bridge structure present a collection of general recommendations for modeling and analysis of bridges and highway overpasses that are subject to seismic earthquakes, and which design or evaluate the capacity or flexibility of critical bridge components and systems essential.

LITERATURE REVIEW

(Li, 2024)[1], To explore the vulnerability of a reinforced concrete girder bridge and reinforced concrete building during an earthquake, and to compare the difference in the seismic capacity of the two types of engineering structures, the nonlinear vulnerability numerical and probabilistic model analysis methods were combined. Overall, 1069 reinforced concrete girder bridges and 949 reinforced concrete buildings damaged in the Wenchuan earthquake of May 12, 2008 were selected for vulnerability analysis. The vulnerability grades of damaged samples were evaluated according to the Chinese seismic intensity scale (CSIS-08),and the vulnerability matrix of reinforced concrete girder bridges and reinforced concrete buildings in multiple intensity regions was established. The results obtained were in good agreement with the actual earthquake damage investigation results, which verifies the accuracy of the comparison model (GFRM, EQRM, vulnerability matrix, function, and curve model based on SN, FR, and EP, MDI parameter matrix model) to a certain extent, and can be extended to the vulnerability rating and prediction of reinforced concrete girder bridges and reinforced concrete buildings in the future.

(Nettis et al., 2024)[2], This study proposes a framework for efcient risk assessment of multi-span girder bridges considering knowledge-based uncertainties. The framework is intended to be applied to risk-informed prioritisation of bridge portfolios. It is based on subsequent modules that involve the input of knowledge data, the simulation of knowledge-based uncertainties, simplifed seismic analysis, fragility and loss assessment. This study proposes a framework for efcient risk assessment of multi-span girder bridges considering knowledge-based uncertainties. The framework is intended to be applied to risk-informed prioritisation of bridge portfolios. It is based on subsequent modules that involve the input of knowledge data, the simulation of knowledge-based uncertainties, simplified seismic analysis, fragility and loss assessment.

(Network et al., 2023)[3], This study focuses on the design of I-bridge girders, specifically longitudinal and cross girders. The bridge in question has a span of 22m, and the girders are constructed accordingly. The longitudinal girders have dimensions of 1800 * 1000 mm, while the cross girders measure 1800x1000 mm. The bridge consists of four longitudinal girders spaced at 3000 mm c/c, and four cross girders. The design of these girders is carried out using the CSI Bridge software. Two identical models are created in CSI Bridge for the purpose of this study, with loadings adjusted to comply with IRC codes and AASHTO-LRFD specifications, respectively. By applying these different loadings, the shear force, bending moment, and average rotation in both the longitudinal and cross girders are determined. In terms of loading and design methods, IRC codes demonstrate a superior combination when compared to AASTHO specifications. The utilization of IRC codes for the design of bridge girders results in minimal deflection and bending moment, making IRC class AA and 70R loading the most cost-effective and optimal choice for bridge girder design in India.

(Farhan & Tasleem, 2021)[4], The model has to be prepared by studying the dimensions and grade of concrete used. The young's modulus and moment of inertia is calculated and keeping the flexural rigidity same across cross sections an equivalent model has to be prepared by using a different suitable material. The equivalent model is then scaled to a ratio suitable to the shake table dimensions and properties. The shake table test results are then compared with the software analytical results The presented practice of dynamic similitude may be used in shake table testing of scaled structure models to supplement data for the process of design decision-making. The presented examples show that using scale models to predict or verify the prototype structure's behavior is feasible, subject to the constraints of imperfect similitude scaling. The present approach may be used to help meet design practice needs.

(Sirse et al., 2020)[5], the purpose of this paper is to compare the results of analysis and design of different papers performed using these codes for both the types of bridges i.e. T-beam and box girder bridge. Various researchers studies are available on the design and analysis of Tbeam bridge and box girder bridge using IRC:112-2011 and IRC:21-2000. The purpose of this study is to determine the most economical and preferable design code for both T-beam bridges and box girder bridges. It has been found from the literatures that deflection in case of limit state method i.e. IRC:112-2011 is less or within limits than that of IRC:21-2000.

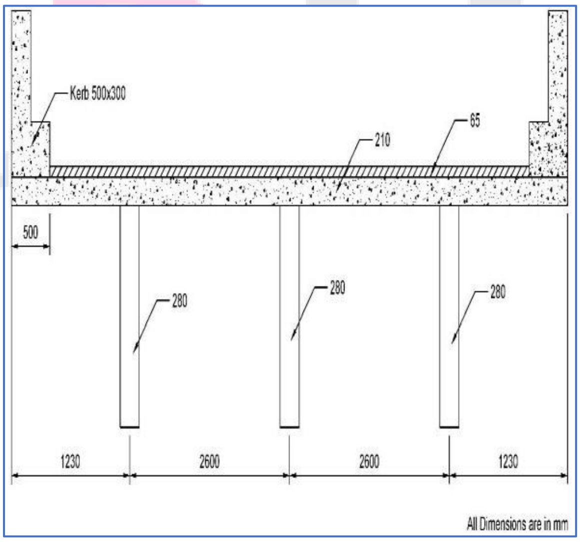
OBJECTIVE

- To performed the of simply supported RCC T-frame girder bridge under standard IRC loading, and the comparing analysis with different cases or modeling by present for various spans in STAAD.Pro software.
- To perform the bridge deck slab interaction with the two different loading considered as IRC Codes i.e. Class AA and 70R.
- To evaluate the suitability of the bridges for short as well as long spans, the four different length of span has been considered i.e. 20m, 30m, 40m and 50m respectively.
- To evaluate the effect of girder thickness for 20m span or short span length, the four different girder thickness has been considered viz. 0.22m, 0.24m, 0.26m and 0.28m respectively.

METHODOLOGY

A plate girder bridge is a bridge built on RC girders by placing or type T-Frame concrete girder. Therefore, the plate girder bridge is usually a precast type that can save construction time and transportation by transporting and placing tasks. Precast beams on top of pre- built bridge columns on site. The analysis is carried out with the help of IRC loading conditions in STAAD.Pro. The results are finally analysed and compared to produce the better results for dynamic conditions.

In present work, single span two lane RCC slab T-frame bridge deck has been considered. To obtained the effect of aspect ratio (span/width) and vehicle database, the two different span length and vehicle data (as shown in Figure 4.1) has been

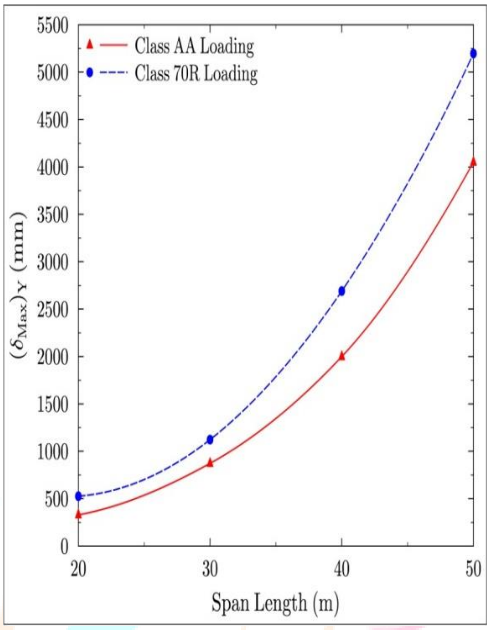


considered in T-frame bridge deck and it has been modelled using the STAAD.Pro Software, and The bridge deck is analysed using same for Dead load as well as two different class of live load i.e. IRC Class AA and 70R tracked loading loads. The dimension of the deck is followed in the design as shown in Table 4.1. The structural details of the slab are given and it meshed. The applied loading for the static and dynamic (transient) analysis consists of the IRC Class AA and 70R loadings. For static analysis the loadings are applied throughout the structure and for the dynamic analysis loads are applied on the centre of the deck. For dynamic analysis, the loads are varying place to place because its time dependent

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	Two lanes
Slab thickness	0.3m
Carriageway Width	5.2m
Total Width of Bridge Deck	7.66m
No. of longitudinal Girder	3
No. Cross girder	5, 7, 9 and 11
Distance Between Longitudinal Girder	2.6m 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

Figure 1 Cross section of proposed bridge deck



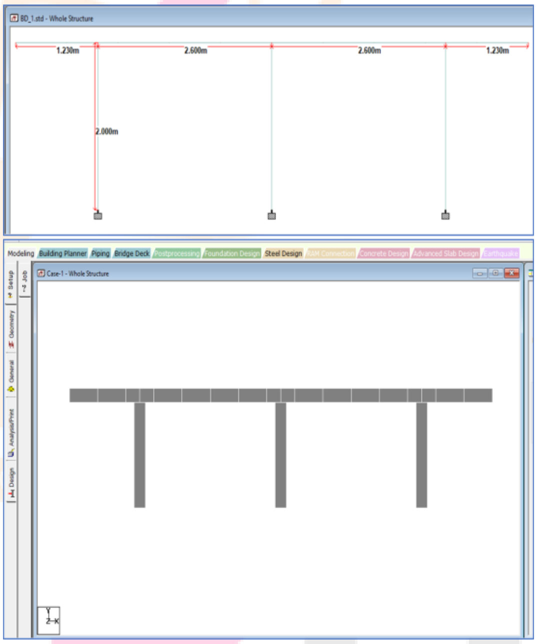


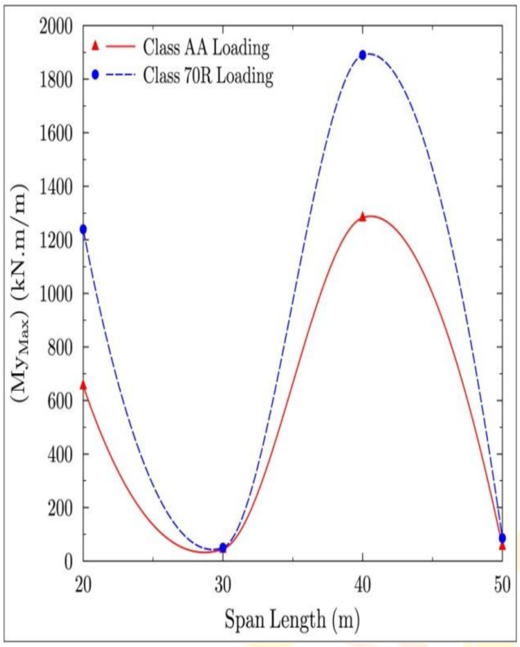
Figure 2 Modeling of T- frame girder bridge deck in STAAD.Pro software

RESULT

Effect of Span Length in Bridge Deck under Class AA and 70R Loading

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 is 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.

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

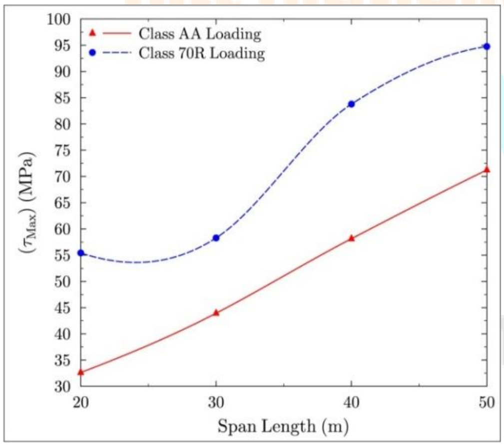


Figure 4 Graphical representation of maximum von mises sterss due to class AA and 70R loading in variation of span length of bridge deck

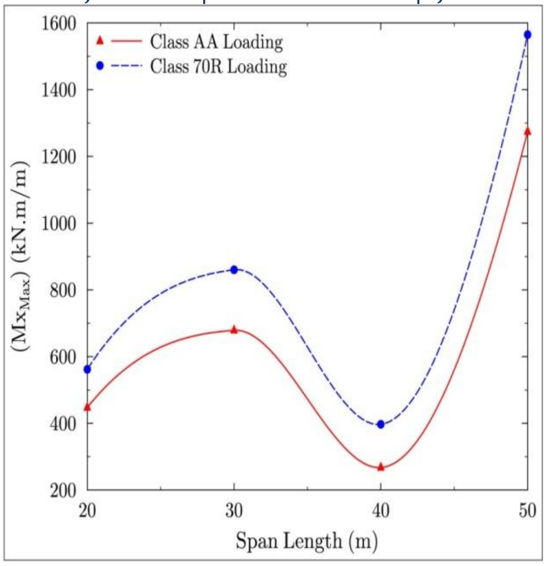


Figure 5 Graphical representation of maximum bending moment in X-direction due to class AA and 70R loading in variation of span length of bridge deck

Figure 6 Graphical representation of maximum bending moment in Y-direction due to class AA and 70R loading in variation of span length of bridge deck

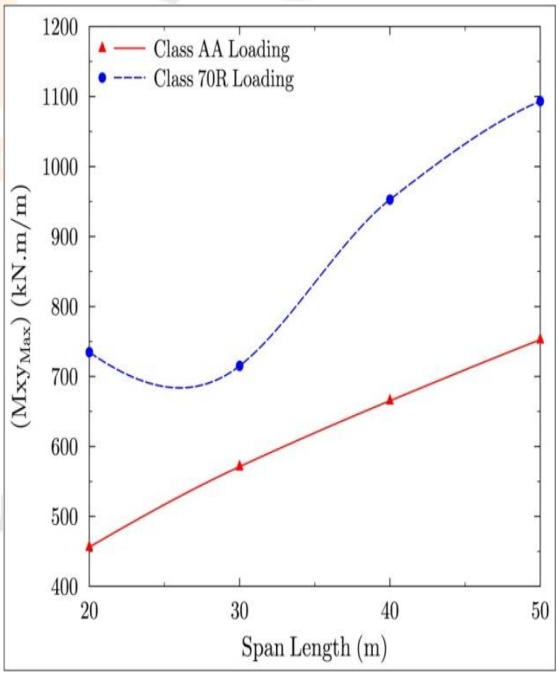


Figure 7 Graphical representation of maximum twisting moment due to class AA and 70R loading in variation of span length of bridge deck

Effect of Girder Thickness in Bridge Deck under Class AA and 70R Loading

It has been observed that the value of maximum deformation in X and Z– direction decrease as the thickness of the girder is increased.

And, it is observed that the maximum deformation in Y-direction, von-mises stress, shear stress in X & 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

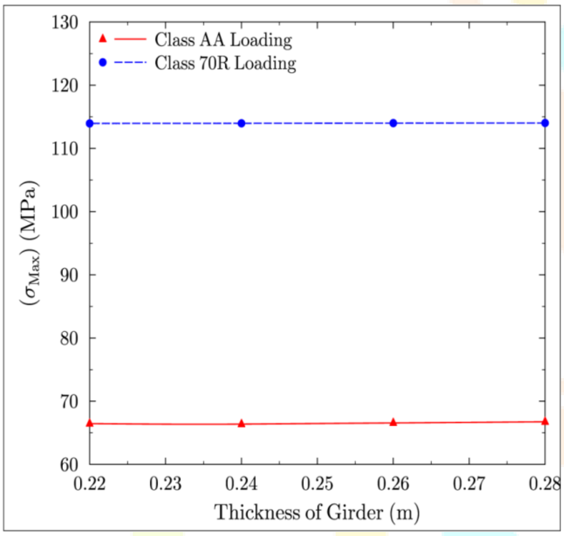


Figure 8 Graphical representation of maximum von mises stress due to class AA and 70R loading in variation of thickness of girder of bridge deck

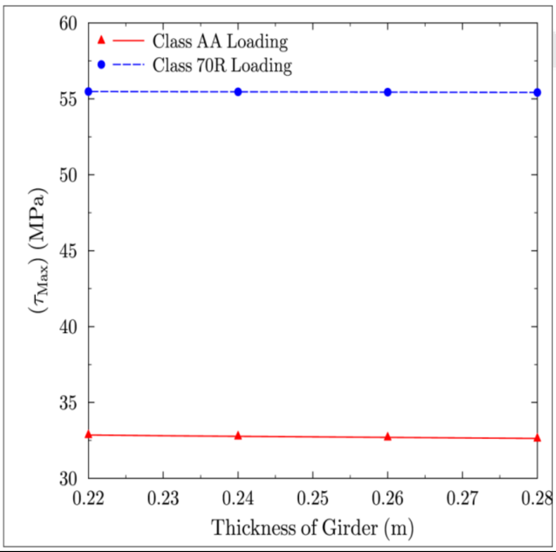


Figure 9 Graphical representation of maximum in-plane shear stress due to class AA and 70R loading in variation of thickness of girder of bridge deck

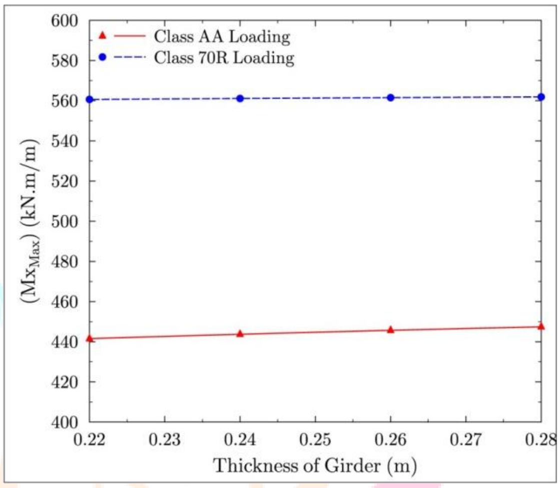


Figure 10 Graphical representation of maximum bending moment in X-direction due to class AA and 70R loading in variation of thickness of girder of bridge deck

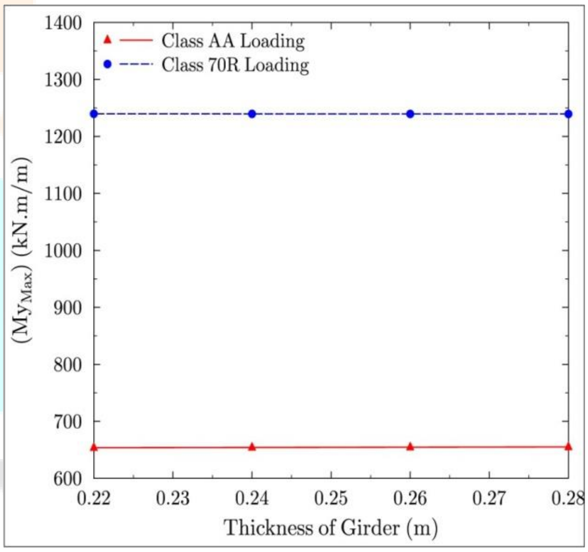


Figure 11 Graphical representation of maximum bending moment in Y-direction due to class AA and 70R loading in variation of thickness of girder of bridge deck

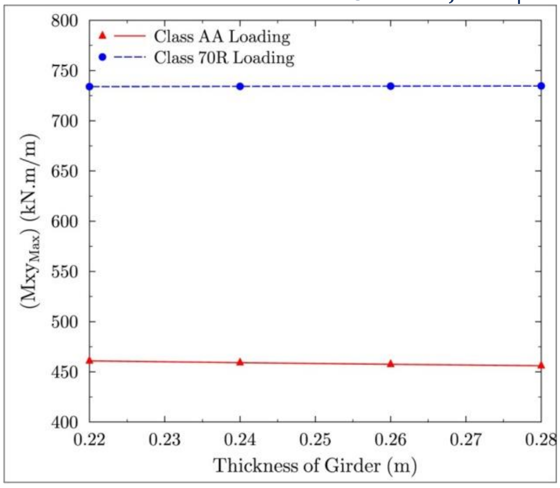


Figure 12 Graphical representation of maximum twisting moment due to class AA and 70R loading in variation of thickness of girder of bridge deck

CONCLUSION

- Present work, the two-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 length of 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 70R loading 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 that the 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-mises stress, shear stress in X & 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.

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