Efficacy of Cross Girders in RCC T-Beam Bridges

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Abstract- *T-Beam structure is so named because the main longitudinal girders are designed as T-beams integral with part of the deck slab, which is cast monolithically with the girders. The present study is aimed to understand the different structural aspects related to this system the analysis of a single span RCC T -Beam Bridge girders was performed to know the live load distribution along the longitudinal girder. Firstly, analysis of T-Beam Longitudinal girder with variable length has been studied. Secondly the study of effect of cross girder on RCC T-Beam Longitudinal girder has been studied and in last part the study of effect on RCC T-Beam Longitudinal girder with variable spacing of cross girder has been studied.*

Keywords- Longitudinal girder, Courbon's theory, T-beam bridge, Staad-pro, Indian Road Congress, IRC Live Loads.

I. INTRODUCTION

A Bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The demands on design and on materials are very high. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature.

The T-beam Bridge is by far the Most commonly adopted type in the span range of 10 to 25 M. Simply supported T-beam span of over 30 m are rare as the dead load then becomes too heavy. In T-Beam Bridge, the main longitudinal girders are designed as T-beams integral with part of the deck slab, which is cast monolithically with the girders.

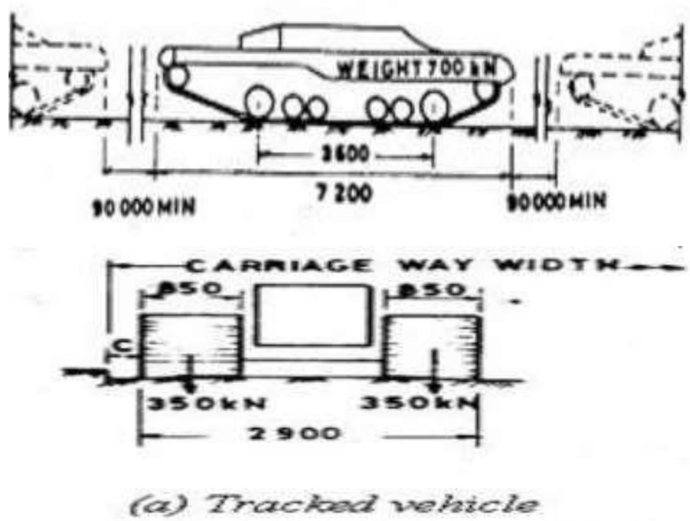
LOADS ACTING ON BRIDGE

Dead and Superimposed Dead Load

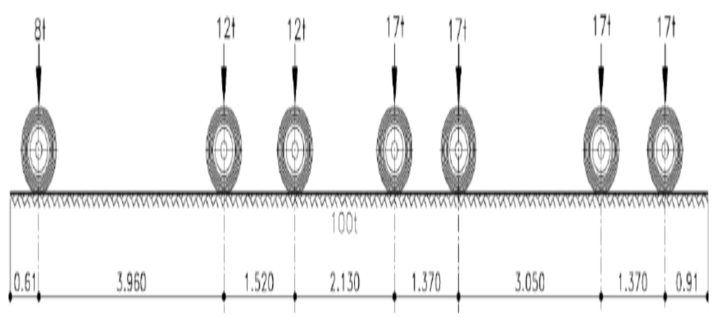
For general building structures, dead or permanent loading is the gravity loading due to the structure and other items permanently attached to it.

Live Loads

Road bridge decks have to be designed to withstand the live loads specified by Indian Roads Congress (I.R.C: 6-2000 sec2). There are three types of standard loadings for which the bridges are designed namely, IRC class AA loading, IRC class a loading and IRC class B loading.



IRC Class AA Wheeled Live loading



IRC Class 70R Wheeled Live loading

Normally, bridges on national highways and state highways are designed for these loadings. Bridges designed for class AA should be checked for IRC class A loading also, since under certain conditions, larger stresses may be obtained under class A loading. Sometimes class 70 R loading given in the Appendix - I of IRC: 6 - 1966 - Section II can be used for IRC class AA loading.

II. OBJECTIVES OF PRESENT STUDY

1. Analysis of 15-24m span T-BEAM Bridge for IRC class AA loading and 70R loading by Rational Method.
2. Analysis of 15-24m span T-BEAM Bridge will be performed by using Professional Software.
3. The effect of Cross girder on longitudinal girder will be evaluated.

III. METHODOLOGY

1. Study of previous work related to T- Beam RCC Bridge.
2. FEM Analysis of T-BEAM RCC Bridge is carried out by using STAADPro Software for different spans.
3. Analysis is done for IRC class AA loading and 70R loading.
4. Study of analysis results in terms of maximum shear force, maximum bending moment, maximum deflection to understand the response of T-Beam RCC Bridge.
5. Comparison of rational method and FEM results from STAAD Pro software will be done.

IV. THEORETICAL FORMULATION

A. METHODS OF ANALYSIS

The distribution of live load among the longitudinal girders can be estimated by any of the following rational methods.

1. Courbon's method
2. Guyon Massonet method
3. Hendry Jaegar method

A.1 Courbon's Method

Among the above mentioned methods, Courbon's method is the simplest and is applicable when the following conditions are satisfied:

- The ratio of span to width of the deck is greater than 2 but less than 4.
- The longitudinal girders are interconnected by at least five symmetrically spaced cross girders.
- The cross girder extends to a depth of at least 0.75times the depth of the longitudinal girders.

The center of gravity of live load acts eccentrically with the center of gravity of the girder system. Due to this eccentricity, the loads shared by each girder are increased or decreased depending upon the position of the girders.

This is calculated by Courbon's theory by a reaction factor given by

$$R_x = (\Sigma W/n)\ [\Sigma I/\Sigma d_x^2.I)\ d_x.e]$$

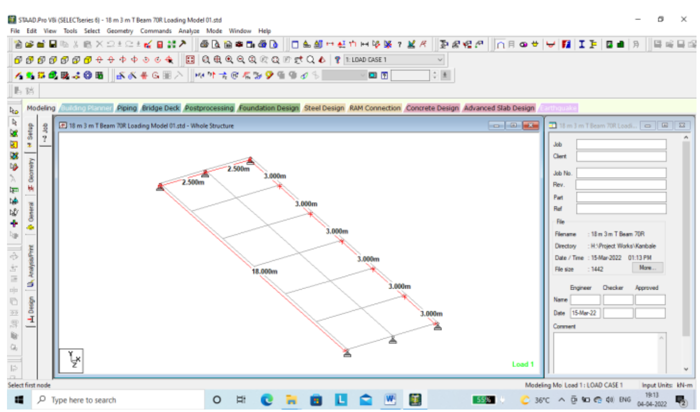
Where,
R_x=Reaction factor for the girder under consideration,
I = Moment of inertia of each longitudinal girder,
d_x= Distance of the girder under consideration from the central axis of the bridge,
W = Total concentrated live load,
n = Number of longitudinal girders,
e = Eccentricity of live load with respect to the axis of the bridge.

B. SOFTWARE VALIDATION

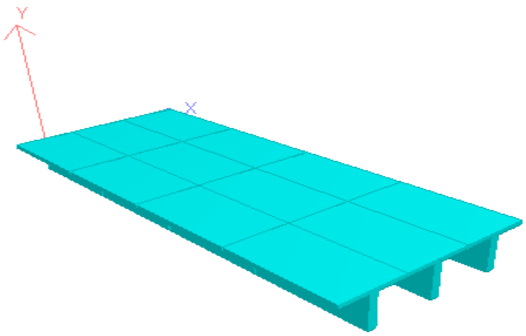
For the purpose of software validation the theoretical problem was taken from the book "Design of Bridges" by author "N. Krishna Raju". The model was validated in STAAD Pro software and the results were compared with the data and values of the parameter mentioned in the book.

B.1 IRC Class AA Tracked Loading

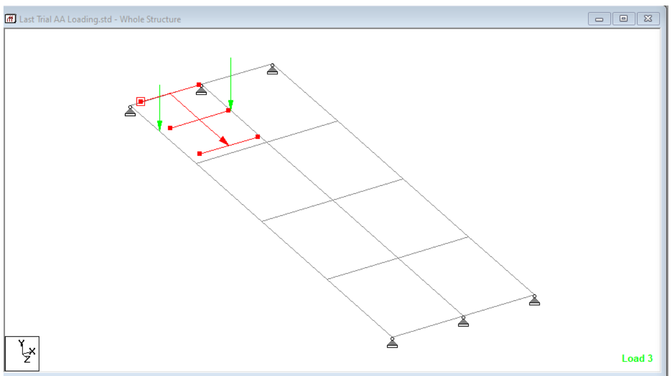
A R.C.C. T-Beam bridge having a deck slab 200 mm thick, wearing coat 100 mm thick, 3 longitudinal girder and 5 cross girders provided. Design long girder for the using following data Analysis of Superstructure by IRC CLASS AA TRACKED LOADING for 16m
Preliminary Details Clear Roadway = 7.5m Concrete Grade = M25
Three T-beams at 2.5m intervals Steel Fe 415



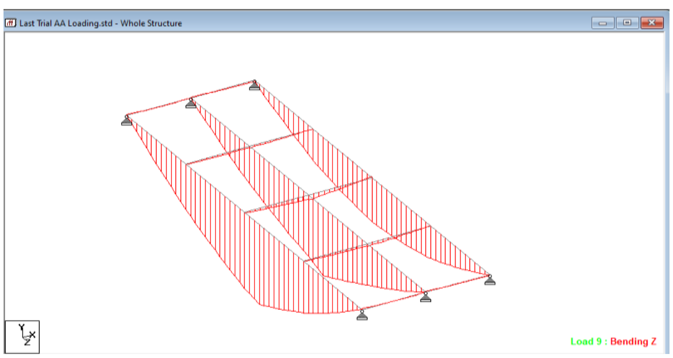
Plan of T-Beam Bridge



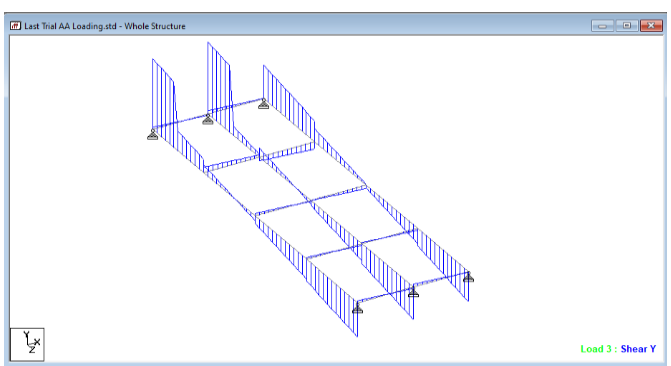
3D of T-Beam Bridge



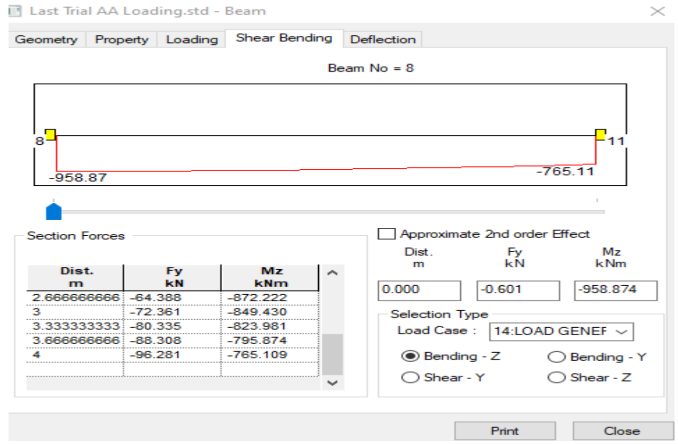
Class AA Load on T-Beam Bridge



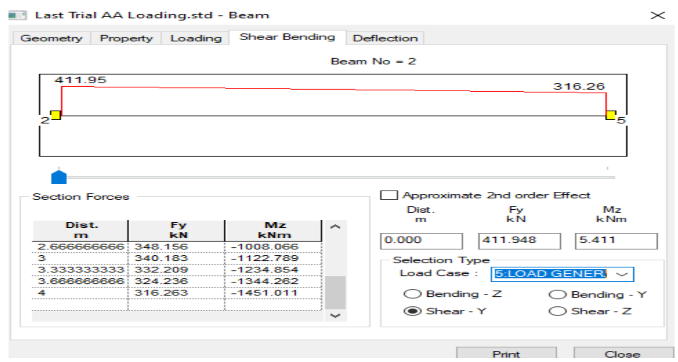
Class AA Load BMD



Class AA Load SFD



Class AA Load BMD result



Class AA Load SFD result

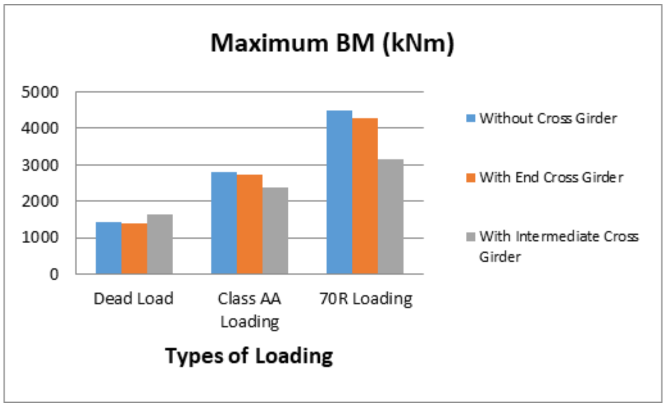
Sr. No.	Result	Load	Manual Calculation Results	STAADPro Results	Difference	% Difference
1	BM	DL	1218 kNm	1174.65 kNm	43.35 kNm	3.55 %
2	BM	Class AA	912 kNm	958.87 kNm	46.87 kNm	4.88 %
3	SF	DL	292 kN	286.02 kN	5.98 kN	2.04 %
4	SF	Class AA	402.6 kN	411.95 kN	28.34 kN	2.26 %

Middle girder Results for IRC Class AA Loading

At the end, the result of validation study is fairly matched with the bending moment and shear force results of the present study.

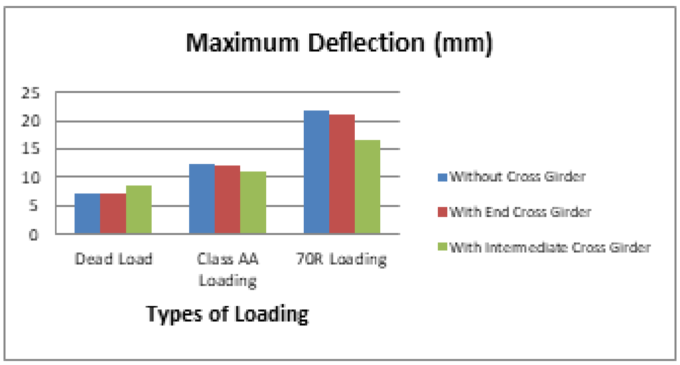
V. PARAMETRIC INVESTIGATION

V.1 Comparative Analysis of RCC T-Beam Longitudinal girder with effect of cross girder.



Span m	Type of Loading	Without Cross Girder	With End Cross Girder	With Intermediate Cross Girder
18m	Dead Load	1410.06	1399.75	1621.56
	Class AA Loading	2792.30	2719.08	2368.15
	70R Loading	4468.69	4285.52	3158.17

Maximum Shear Force of span 18m for effect of cross girder



Span m	Type of Loading	Without Cross Girder	With End Cross Girder	With Intermediate Cross Girder
18m	Dead Load	7.245	7.182	8.693
	Class AA Loading	12.439	11.988	11.101
	70R Loading	21.782	21.144	16.481

Maximum Deflection of span 18m for effect of cross girder

VI. CONCLUSION

From the analysis of various types RCC T-Beam bridge following prominent conclusions are drawn.

- The IRC Class 70R loading gives more results compared to the IRC Class AA loading in Maximum bending moment as well as maximum shear force case and in all other parameters.
- Bending moment and Shear force and Deflection due to the both the live loads reduces when cross girders are provided. Provision of cross girders brings integrity in the structure and it helps to distribute the live load to all the three longitudinal girders to a large extent.
- Dead load results of the longitudinal girder increases with the provision of cross girder due to additional dead load of cross girders.
- It observed that for IRC Class 70R loading the BM results decreased by 4.09 % with provision of end cross girder and decreases by 29.32 % with provision of intermediate cross girder as compared to without cross girder case.
- For IRC Class AA loading the BM results decreases by 2.69 % with provision of end cross girder and 15 % with provision of intermediate cross girder as compared to without cross girder case.
- It observed that for IRC Class 70R loading the SF results decreased by 7.88 % with provision of end cross girder and 25.90 % with provision of intermediate cross girder as compared to without cross girder case.
- It observed that for Dead load the Deflection of longitudinal girder decreases with provision of end cross girder and increases with provision of intermediate cross girder due to increase in dead load.
- It observed that for IRC Class AA loading and IRC Class 70R the Deflection of longitudinal girder decreases with provision of end cross girder and intermediate cross girder as cross girder distribute the live load to all the three longitudinal girders to a large extent.

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