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A Study on Effectiveness of Hendry Jaegar Method in Anaysis of T-Beam Bridges

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***Abstract*—** The development of the nation is mainly from Agricultural and industrial activities, so, it is required to facilitate the proper transportation by providing the Flyovers and Bridges. For constructing the flyovers or the bridges we find many types of section among which T-beam and box type are very popular. In order to find out the most suitable section, this project looks on the work of analysis, design and cost comparison of T-Beam and Box girders for different spans. The purpose of this study is to identify the suitable section for bridges of different spans and also identifying the suitable method of analysis.

Key words: T-Beam, IRC Loading, FEM, STAAD Pro 8vi, Hendry- Jaegar method etc.

INTRODUCTION

1.1 Background

A bridge is a structure built to span physical obstacles without closing the way underneath such as a road, valley or body of water etc. A bridge is an important elements in a transportation systems. The various type of bridges is used in all over word. The first reinforced concrete bridge was built by Adair in 1871 as a 15 m span bridge across the Waveney at Homersfield, England. The use of reinforced concrete for road bridges has becomes popular in India. T-beam bridges have been used widely in the span range of 10 m to 25 m.

Standard specification

Bridge design is a complex problem, calling for creativity and practicability, while satisfying the basic requirements of safety and economy. Specification and code of practice have been involved by the concerned government agencies and professionals institutions, based on years of observation, research and development. All highway bridges in India have to be built in accordance with the India Roads Congress (IRC) Code, specification prescribed by the Ministry of Road Transport and Highway, Government of India. The design of Railway bridge should conform to Indian Railway Standard (IRS) Code, specification prescribed by the Research, Design and Standard Organization (RDSO) of the Indian railway.

T-beam bridge

The T- beam bridges consist of the main longitudinal girders are designed as T-beam integral with part of the deck slab which is cast monolithically with the girders. The T-beam superstructure consists of the fallowing components :

I. Deck slab
II. Cantilever portion
III. Longitudinal girder (with T section)
IV. Cross-beam or diaphragms
V. Wearing course
VI. Footpath, if provided, Kerb and Handrail

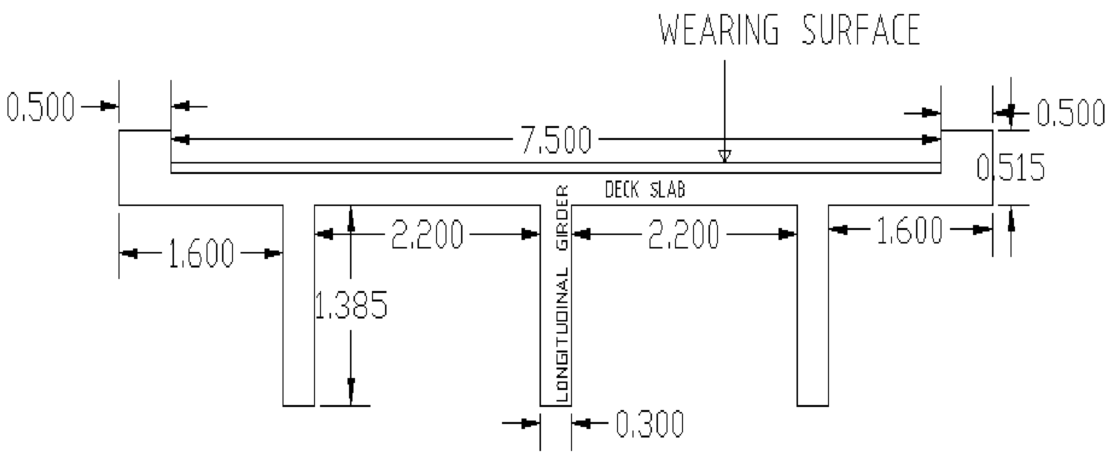

Figure 1: Cross section of RC T beam bridge (m)

IRC Class AA Loading: This Loading consists of either a tracked vehicle of 700 KN or a wheeled vehicle of 400 KN with dimensions as shown in figure 2.1. The tracked vehicle simulates a combat tank used by the army and ground contact length of the track is 3.6 m.

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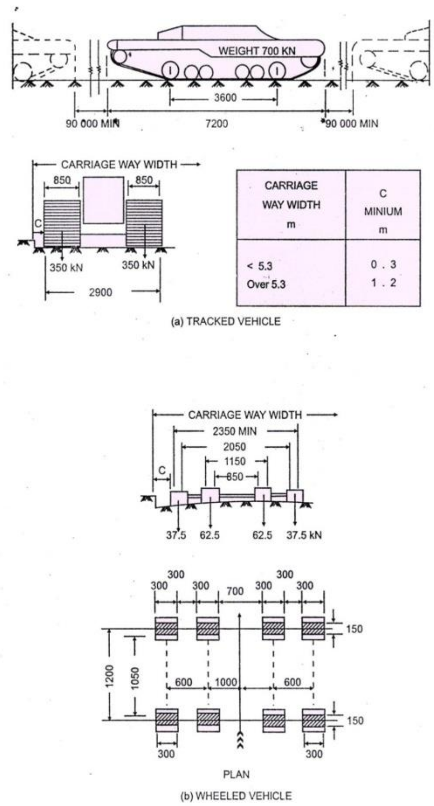

Figure 2: IRC Class AA Loadings

FINITE ELEMENT ANALYSIS

Finite elements, referred to as finite elements, connected together at a number of nodes. The finite elements method was first applied to problems of plane stress, using triangular and rectangular element. The method has since been extended and we can now use triangular and rectangular elements in plate bending, tetrahedron and hexahedron in three-dimensional stress analysis, and curved elements in singly or doubly curved shell problems. Thus the finite element method may be seen to be very general in application and it is sometimes the only valid analysis for the technique for solution of complicated structural engineering problems. It most accurately predicted the bridge behavior under the truck axle loading.

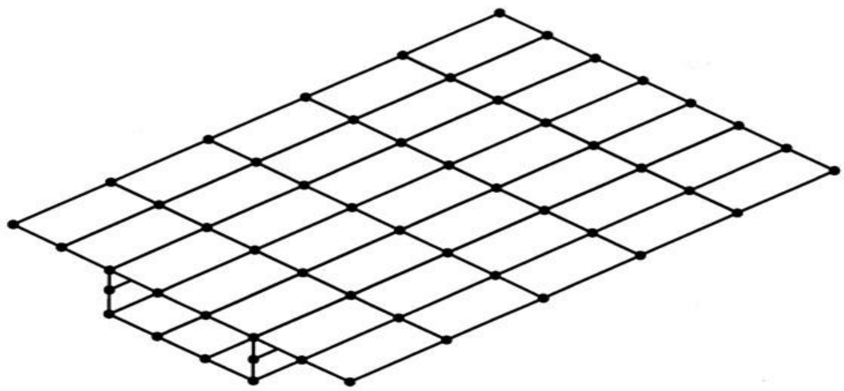

Figure 3: Three- Dimensional Structures Composed of Finite Plate Elements

Analysis of T beam bridge by Hendry Jaegar method:

Hendry-Jaegar method

The cross beam can be replaced by a uniform continuous transverse medium of equivalent stiffness. According to this method, the load distribution in an interconnected bridge deck system depends upon three dimensionless parameters given by,

$A = (12/\pi^4) \times (L/h)^3 \times (nEI_r/EI)$

$F = (\pi^2/2n) \times (h/L) \times (CJ/EI_r)$

$C = (EI_1/EI_2)$

$m_F = m_0 + (m_\infty - m_0) \sqrt{[(F\sqrt{A})/(3 + F\sqrt{A})]}$

L = span of the bridge

h = spacing of longitudinal girders

n = number of cross beam

EI, CJ = flexural and torsional rigidity of one longitudinal girder

EI_r = flexural rigidity of cross beam

The first parameter A represent a function of the ratio of span to the spacing of longitudinal girders and the ratio of the transverse to longitudinal flexural rigidity.

The second parameter F is measure to the ratio of torsional to flexural rigidity of longitudinal and cross girders respectively. The torsional rigidity of the transverse system is neglected in this analysis.

Hendry-Jaegar have presented graphs given the value of the distribution coefficient (m) for different numbers of longitudinal girders (Two to Six) and for two extreme value of F=0, F=∞ and the coefficient of intermediate values of F may be obtained by interpolation from the equation.

$$m_F = m_0+(m_\infty-m_0)\ \sqrt{[(F\sqrt{A})/(3+ F\sqrt{A})]}$$

PROBLEM

Design a RCC T- beam girder bridge to suit the fallowing data,

Clear roadway = 7.5 m

Effective span of T-beam = 16 m

Thickness of wearing coat D = 75 mm

Three T-beams spaced at 2.5 m intervals

Five Cross beam at 4 m intervals

Live Load = IRC tracked vehicles Loadings (for State Highway)

Concrete Mix M30 and Fe 415 grade HYSD bars

Clear cover = 40 mm

Using Hendry Jaegar method, calculate the design moments on deck slab, main girders and cross girders.

Deck Slab

The slab is supported on four sides by beams.

Thickness of slab H = 215 mm

Effective span in transverse direction = 2.5 – 0.3 = 2.2 m

Span in the longitudinal direction = 4 m

Effective span in the longitudinal direction = 4 – 0.25 = 3.750 m

Kerbs size = 500 mm x 300 mm. The cross-section of T-beam Deck slab are shown in figure5.1

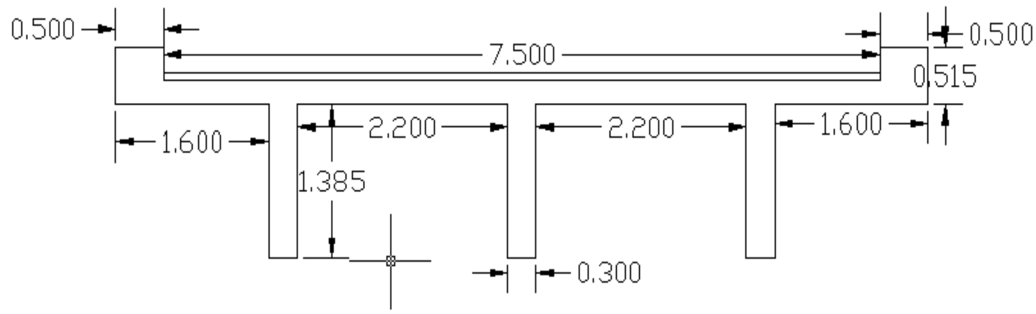

Figure 4: Preliminary Dimensions for Longitudinal T-beam Deck

Maximum B.M. due to dead load

Moment along short span = (0.085 + 0.15 x 0.024) 56.18 = 4.977 kN-m

Moment along long span = (0.024 + 0.15 x 0.085) 56.18 = 1.844 kN-m

B.M due to live load for IRC Class AA tracked vehicle

Moment along shorter span = 1.25 x 0.8 x 30.06 = 30.06 kN-m

Moment along longer span = 1.25 x 0.8 x 13.41 = 13.41 kN-m

Design of Longitudinal Girder

Effective span = 16 m

Slab thickness = 215 mm

Width of rib = 300 mm

Spacing of main beam = 2500 mm

Overall depth of the beam = 1600 mm

$$\text{Max. B.M. due to dead load} = \frac{33.25x16x16}{8} = 1064 \text{ kN-m}$$

B.M. due to Live Load

Design moment in exterior girder due to live load=(2485x1.1x0.81)=2214.13 kN-m.

Design moment in interior girder due to live load=(2485x1.1x 0..35) = 956.72 kNm

Design of Cross Girder

Weigth of the deck slab and wearing coarse per m^2 =(0.215x24 + 0.075x22)=6.8 kN/m^2

Self weight of the rib per meter = 1x0.25x1.085x24 = 11.1 kN/m

Dead load from slab = 2x0.5x2.5x1.25x6.8 = 21.25 kN

U.D.L on cross girder = 21.25/2.5 = 8.5 kN/m

Total load on cross girder = 11.1 + 8.5 = 19.6 kN/m

Assume cross girder is rigid so reaction on each girder = (19.6 x 5)/3 = 32.66 kN

B.M. due to dead load at 1.475 m from support

$$= (32.66 \times 1.475 – 19.6 \times 1.475^2/2) = 26.85 \text{ kN-m}$$

Load coming on cross girder = 350 (4 – 0.9)/4 = 271.25 kN

So reaction on each longitudinal girder = (2 x 271.25)/3 = 180.83 kN

Maximum B.M. due to live load in cross girder under the load

= (180.83 x 1.475) = 266.7 kN-m

Total design B.M. = 26.85 + 293.37 = 320.22 kN

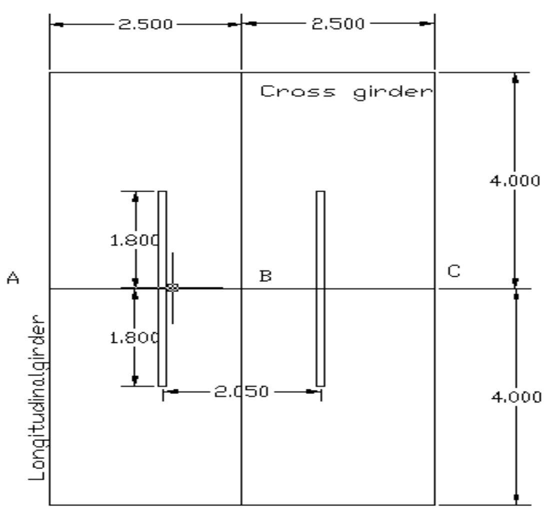

Figure 5: Position of Live Load for Max. B.M. in Cross Girder

STAAD MODEL OF T-BEAM BRIDGE

For the modeling of the bridge structure STAAD PRO-2006 is used. The bridge models are analyzed to conduct a comparative study of simply supported RC T-beam bridge with Hendry Jaegar method and finite element method.

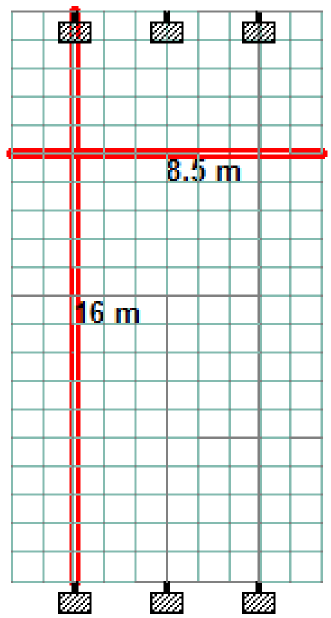

Figure 6: Plan of deck slab

RESULTS AND CONCLUSION

The results are presented in the form of tables.

Hendry-Jaegar Method Results

The values of maximum bending moments

Table No. 1: Hendry-Jaegar Method – IRC Class AA Tracked vehicle

Deck Slab	D.L. B.M. in shorter side M_X = 4.977 kN-m D.L. B.M. in longer side M_Y = 1.844 kN-m	

(Pigeaud's theory)	L.L. B.M. in shorter side M_X = 31.18 kN-m L.L. B.M. in longer side M_Y = 26.67 kN-m	M_X = 35.03 kN-m M_Y = 28.51 kN-m
OUTER GIRDER	D.L B.M. = 1064 kN-m L.L. B.M. = 2214.13 kN-m	B.M. = 3278.13 kN-m
INNER GIRDER	D.L. B.M. = 1064 kN-m L.L. B.M. = 956.72 kN-m	B.M.= 2020.72 kN-m
CROSS GIRDER	D.L. B.M. = 26.85 kN-m L.L. B.M. = 293.37 kN-m	B.M. = 320.22 kN-m

Table No. 2: STAAD PRO. Results – IRC Class AA Tracked vehicle

Deck Slab	D.L. B.M. in shorter side M_X = 9.81 kN-m D.L. B.M. in longer side M_Y = 0.62 kN-m	M_X = 34.58 kN-m M_Y = 15.02 kN-m
	L.L. B.M. in shorter side M_X = 24.77 kN-m L.L. B.M. in longer side M_Y = 14.4 kN-m	
OUTER GIRDER	D.L B.M. = 694 kN-m L.L. B.M. = 1717.26 kN-m	B.M. = 2411.26 kN-m
INNER GIRDER	D.L B.M. = 694 kN-m L.L. B.M. = 911.53 kN-m	B.M. = 1605.53 kN-m

CROSS GIRDER	D.L B.M. = 19.40 kN-m L.L. B.M. = 272.31 kN-m	B.M. =291.71 kN-m

CONCLUSION

The analysis and design of Deck slab and T-Beam of a Bridge has been carried out manually as per IRC guidelines and the following results have been noted.

1. This Thesis has been done the Analysis of T-Beam deck slab Bridge for IRC Loadings
2. Live Load due to Class AA Wheeled Vehicle produces the severest effect.
3. According to Hendry Jaegar method and Staad Pro, it has given highest importance to outer girder, then inner girder and cross girder.
4. Bending Moment in the Inner girder is lesser than the Outer girder hence lesser reinforcement in inner girder when compared to outer girder.
5. The design of the deck slab and T- beam has been manually done keeping in view the above results.

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