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COMPARATIVE ANALYSIS OF T-BEAM BRIDGE BY RATIONAL METHOD AND STAAD PRO

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ABSTRACT

The 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. T-beam bridge decks are one of the principal types of cast-in place concrete decks. T-beam bridge decks consist of a concrete slab integral with girders. The finite element method is a general method of structural analysis in which the solution of a problem in continuum mechanics is approximated by the analysis of an assemblage of finite elements which are interconnected at a finite number of nodal points and represent the solution domain of the problem. A simple span T-beam bridge was analyzed by using I.R.C. loadings as a one dimensional structure using rational methods. The same T-beam bridge is analysed as a three-dimensional structure using finite element plate for the deck slab and beam elements for the main beam using software STAAD ProV8i, three different span of 16m, 20m and 24m was analysed. Both FEM and 1D models where subjected to I.R.C. Loadings to produce maximum bending moment, Shear force and similarly deflection in structure was analysed. The results obtained from the finite element model are lesser than the results obtained from one dimensional analysis, which means that the results obtained from manual calculations subjected to IRC loadings are conservative.

KEYWORDS: T-beam, I.R.C. Loadings, FEM, STAAD ProV8i

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 obstacle to be crossed may be a river, a road, railway or a valley.Bridges range in length from a few metre to several kilometre. They are among the largest structures built by man. 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. Most bridges have a concrete, steel, or wood framework and an asphalt or concrete road way on which people and vehicles travel.

The T-beam Bridge is by far the Most commonly adopted type in the span range of 10 to 25 M. The 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. Simply supported T-beam span of over 30 m are rare as the dead load then becomes too heavy.

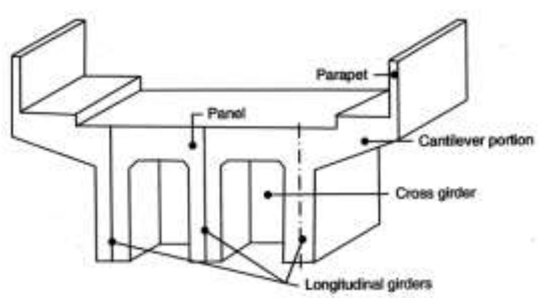

Fig 1 Components of T-Beam Bridge

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OBJECTIVES & METHODOLOGY OF THE STUDY

Objectives

In this project a comparative study on the behavior of simply supported RC T-beam Bridge with respect to span moments under standard IRC loading. The study is based on the analytical modeling of RC T-beam Bridges by Rational method and Finite Element Method for different spans and calculate the maximum loads on bridge.

Methodology

- Analysis of T-BEAM Bridge is carried out by Rational method for different spans i.e is 16m, 20m and 24m.
- Analysis Of Rational method and FEM will be done by using IRC Codes.
- Analysis is done for IRC Class AA tracked vehicle loading.
- FEM Analysis of T-BEAM Bridge is carried out by using StaadPro V8i Software for different spans.
- Comparision of rational method and FEM results from Staad Pro will be done.

LOADS ACTING ON BRIDGE

A. 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. It is simply calculated as the product of volume and material density. Superimposed dead load is the gravity load of non-structural parts of the bridge. Such items are long term but might be changed during the lifetime of the structure. Thus, such superimposed dead loading is particularly prone to increases during the bridge lifetime. For this reason, a particularly high load factor is applied to road pavement. Bridges are unusual among structures in that a high proportion of the total loading is attributable to dead and superimposed dead load. This is particularly true of long-span bridges.

B. 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) 1. Highway bridges: In India, highway bridges are designed in accordance with IRC bridge code. IRC: 6 - 1966 – Section II gives the specifications for the various loads and stresses to be considered in bridge design. 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

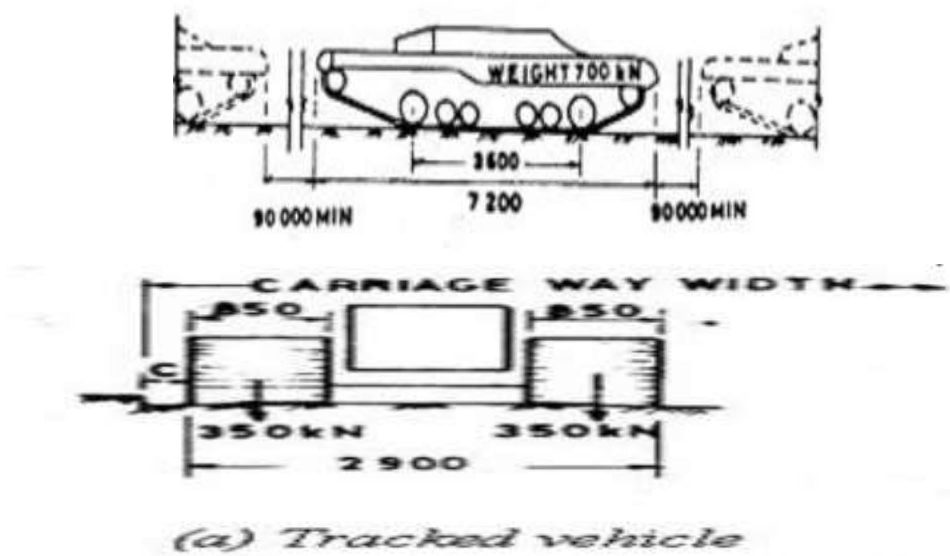

Fig 2.1 IRC Tracked vehicular loading

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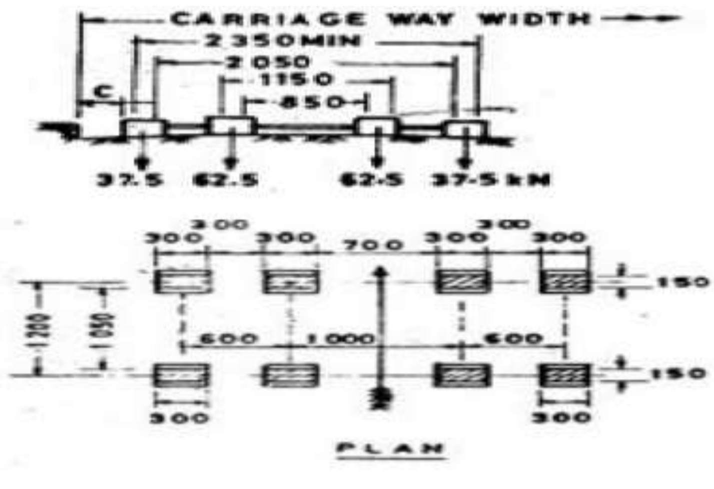

(a) Wheeled vehicle

Fig 2.2 IRC Wheeled loading

IRC class AA loading consists of either a tracked vehicle of 70 tonnes or a wheeled vehicle of 40 tonnes with dimensions as shown in Fig.2. The units in the figure are mm for length and tonnes for load. 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. Class 70R loading is not discussed further. Class A loading consists of a wheel load train composed of a driving vehicle and two trailers of specified axle spacing‟s (FIG 3). This loading is normally adopted on all roads on which permanent bridges are constructed. Class B loading is adopted for temporary structures and for bridges in specified areas. For class A and class B loadings, reader is referred to IRC: 6 -2000 – Section II.

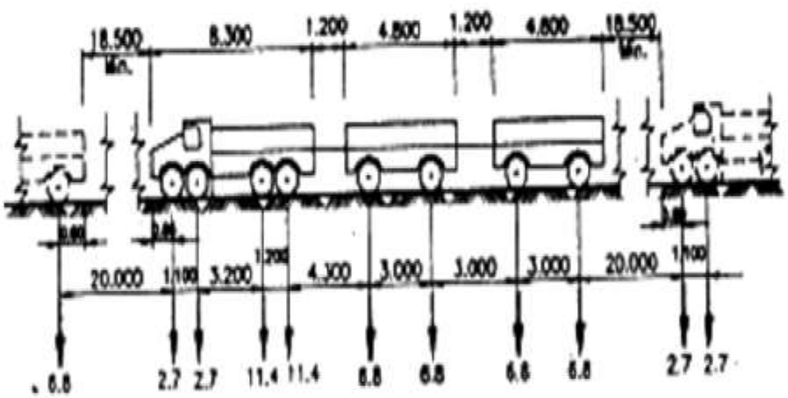

Fig 2.3 IRC Class A loading

C. Impact load

The impact factors to be considered for different classes of I.R.C. loading as follows: a) For I.R.C. class A loading The impact allowance is expressed as a fraction of the applied live load and is computed by the expression, I=A/(B+L) Where, I=impact factor fraction A=constant having a value of 4.5 for a reinforced concrete bridges and 9.0 for steel bridges. B=constant having a value of 6.0 for a reinforced concrete bridges and 13.5 for steel bridges. L=span in meters. For span less than 3 meters, the impact factor is 0.5 for a reinforced concrete bridges and 0.545 for steel bridges. When the span exceeds 45 meters, the impact factor is 0.088 for a reinforced concrete bridges and 0.154 for steel bridges.

b) For I.R.C. Class AA or 70R loading

(i) For span less than 9 meters

For tracked vehicle- 25% for a span up to 5m linearly reduced to a 10% for a span of 9m. For wheeled vehicles-25%

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(ii) For span of 9 m or more
For tracked vehicle- for R.C. bridges, 10% up to a span of 40m. For steel bridges, 10% for all spans.
For wheeled vehicles- for R.C. bridges, 25% up to a span of 12m. For steel bridges, 25% for span up to 23 meters.

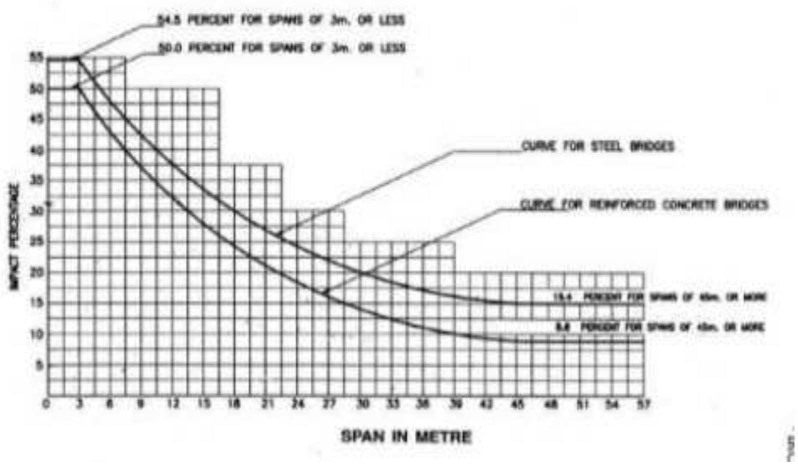

Fig 2.4 Impact percentage curve for highway bridges for IRC class A and IRC Class B loading

RATIONAL METHODS OF ANALYSIS OF BRIDGE

Courbon's Method

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

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

Courbon's method is popular due to the simplicity of computations as detailed below:
When the live loads are positioned nearer to the kerb the centre of gravity of live load acts eccentrically with the centre of gravity of the girder system. Due to this eccentricity, the loads shared by each girder is increased or decreased depending upon the position of the girders. This is calculated by Courbon's theory by a reaction factor given by,

$$R_x = \left(\frac{\sum W}{n}\right)\left[1 + \left(\frac{\sum I}{\sum {d_x}^2}.I\right)d_x.e\right]$$

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.

Guyon-Massonet Method

Guyon-Massonet Method is based on the application of orthotropic plate theory to the bridge deck system. Morice and Little have successfully applied this theory to the analysis of bridge deck systems. The method has the advantage of using a single set of distribution coefficients for the two extreme cases of no torsion grillage and full torsion slab thus enabling the determination of the load distribution behaviour of any type of bridge deck.

The longitudinal bending moments at various points along the cross-section are obtained by multiplying the mean longitudinal bending moments by the appropriate distribution coefficients for these points. The mean longitudinal bending moment is the bending moment developed by considering the total load on the span as, uniformly spread over the whole width of the bridge. Hence the mean bending moment per girder can be expressed as

$$M_{mean} = (M/n)$$

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Where, M = Total mean longitudinal bending moment
n = Number of girders
The design bending moment is then computed as Design B.M.= $(1.10 \times K \times M_{mean} \times I.F.)$
Where, K = Distribution coefficient
I.F = Impact factor
The factor 1.10 is used to compensate for the error involved in using only the first term of the Fourier series in finding the distribution coefficients, as suggested by Rowe based on experiments.

The distribution coefficient 'K' depends on the flexural and torsional parameters expressed as,
Flexural parameter

$$\theta = \left(\frac{b}{2a}\right)\left(\frac{i}{j}\right)^{0.25} \qquad (1)$$

Torsional parameter

$$\alpha = [G(i_0 + j_0)/(2E\sqrt{ij})] \qquad (2)$$

Where, 2a = Span of the bridge
2b = Effective width of bridge
i = Second moment of area per unit transverse width
j = Second moment of area per unit longitudinal width
G. j_0 = Torsional stiffness per unit width.
G. j_0 = Torsional stiffness per unit length.
The values of distribution coefficient Kα is calculated from the interpolation formula.

$$K_\alpha = K_0 + (K_1 - K_0\sqrt{\alpha}) \qquad (3)$$

Where K_0 and K_1 refers to the distribution coefficients corresponding to α = 0 and α = 1. Rowe has presented the values of K_0 and K_1 for five reference stations (0, b/4, b/2, 3b/4 and b) and for various load positions and for values of θ from 0 to 3.0 in a graphical form. The values of K_0 and K_1 for range of θ between 0.2 to 0.8 have been presented in a tabular from for ready use in design office by sarkar.

The maximum transverse moment occurs when an internal line of wheels coincides with the longitudinal centre line of the bridge, the maximum moments being at the centre of the bridge at the reference station O. The equation of transverse moment for a concentrated load 'W' at a distance 'u' from the left support is given by,

$$M_y = \left(\frac{Wb}{a}\right)\left[\mu_\theta \sin(\pi u/2a) - \mu_{3\theta} \sin\left(\frac{3\mu u}{2a}\right) + \mu_{5\theta} sin\left(\frac{5\pi u}{2a}\right) + \cdots\right] \qquad 4(a)$$

If there is a uniformly distributed load 'p' acting over a distance '2c' then,

$$M_y = \left(\frac{4pb}{\pi}\right)\left[\mu_\theta \sin(\pi c/2a) + (1/3)\mu_{3\theta} \sin\left(\frac{3\pi c}{2a}\right) + (1/5)\mu_{5\theta} sin\left(\frac{5\pi c}{2a}\right) + \cdots\right] \qquad 4(b)$$

Where- μ_θ, $\mu_{3\theta}$, $\mu_{5\theta}$, are the distribution coefficients corresponding to the flexural parameters θ, 3θ and 5θ respectively. Coefficient 'μ' is analogous to the distribution coefficient 'K' for longitudinal moments, 'μ_0' represents the coefficient for α = 0 and μ_1 for α =1.0. The value of μ corresponding to any other intermediate value of α can be evaluated using the interpolation relationship.

$$\mu_\alpha = \mu_0 + (\mu_1 - \mu_0)\sqrt{\alpha}$$

The coefficients μ_0 and μ_1 are determined for values of θ, 3θ, and 5θ, from the charts for the reference station 0, where the maximum transverse moment will occur for position of loads. Graphs of these functions are plotted and values of 'μ' for actual load positions are determined. Then M_{yo} and M_{y1} are calculated for μ_0 and μ_1 respectively using the equations 4(a) or 4(b). The transverse moment M_y at the centre of the bridge is given by,

$$M_y = M_{y1} + (M_{y1} - M_{y0})\sqrt{\alpha}$$

FINITE ELEMENT METHOD OF ANALYSIS

The finite element method is a well-known tool for the solution of complicated structural engineering problems, as it is capable of accommodating many complexities in the solution. In this method, the actual continuum is replaced by an equivalent idealized structure composed of discrete elements, referred to as finite elements, connected together at a number of nodes. The finite element 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 form of analysis for difficult deck problems. The finite element method is a numerical method with powerful technique for solution of complicated structural engineering problems. It is mostly accurately predicted the bridge behavior under the truck axle loading. The finite element method involves subdividing the actual structure into a suitable number of sub-regions that are called finite elements. These elements can be in the form of line elements, two dimensional elements and three- dimensional elements to represent the structure. The intersection between the elements is called nodal points in one dimensional problem where in two and three-dimensional problems are called nodal lines and nodal planes respectively. At the nodes, degrees of freedom (which are usually in the form of the nodal displacement and or their derivatives, stresses, or combinations of these) are assigned. Models which use displacements are called displacement models and models based on stresses are called force or equilibrium models, while those based on combinations of both displacements and stresses are called mixed models or hybrid models. Displacements are the most commonly used nodal variables, with most general purpose programs limiting their nodal degree of freedom to just displacements. A number of displacement functions such as polynomials and trigonometric series can be assumed, especially polynomials because of the ease and simplification they provide in the finite element formulation. To develop the element matrix, it is much easier to apply a work or energy method. The principle of virtual work, the principle of minimum potential energy and castigliano's theorem are methods frequently used for the purpose of derivation of element equation. The finite element method has a number of advantages; they include the ability to:

- Model irregularly shaped bodies and composed of several different materials.
- Handle general load condition and unlimited numbers and kinds of boundary conditions.
- Include dynamic effects.
- Handle nonlinear behavior existing with large deformation and non- linear materials.

ANALYSIS OF T-BEAM BRIDGE BY RATIONAL METHODS

COURBON METHOD

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

Deck Slab

The Slab is supported on four sides by beams

Thickness of Slab, H = 200mm

Thickness of Wearing Coat, D = 80mm

Span in the transverse direction = 2.5m

Maximum Bending Moment due to Dead Load

a) Weight of Deck Slab = 0.200 X 24 = 4.80 KN/M^2
b) Weight of Wearing Course = 0.08 X 22 = 1.76 KN/M^2
c) Total Weight = 6.56 KN/M^2

LONGITUDINAL GIRDER AND CROSS GIRDER DESIGN

a) Reaction Factor Bending Moment in Longitudinal Girders by Courbons's Method for Class AA Tracked Vehicle

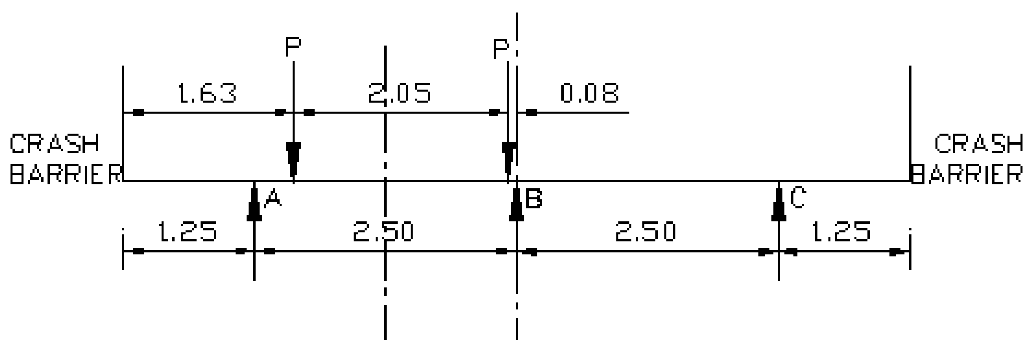

Fig 3.1: Position of Class AA Tracked Vehicle for obtaining reaction factors

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Minimum Clearance Distance: 1.2 + 0.85/2 = 1.625m

$e = 1.1m, \quad P = \frac{W}{2}$

$\sum x^2 = (2.5)^2 + (0)^2 + (2.5)^2 = 2(2.5)^2 = 12.5m$

For outer girder, x = 2.6m, for inner girder x = 0

Therefore,

$$R_A = \frac{\sum P}{n}\left[1 + \frac{nex}{\sum x^2}\right]$$

$$R_A = \frac{4P}{3}\left[1 + \frac{3 \times 1.1 \times 2.5}{2(2.5)^2}\right]$$

$R_A = 0.5536W$ and $R_B = 0.3333W$

b)Dead load from slab for girder

Dead load of deck Slab is Calculated as follows

weigth of

1.Parapet Railing…………………...…..0.700KNm

2. Wearing Coat= (0.08 x1.1x22)……….1.936KNm

3. Deck slab = (0.2x1.1x24)………..…5.280KNm

4.kerb=(0.5x0.6x1x24)….………7.200KNm

Total……………………………...=15.116 KNm

Total Dead load of Deck=(2x15.116)+(6.56x5.3)=65KNm

It is assumed that dead load is shared equally by all girders Therefore, DL/girder=21.66KNm

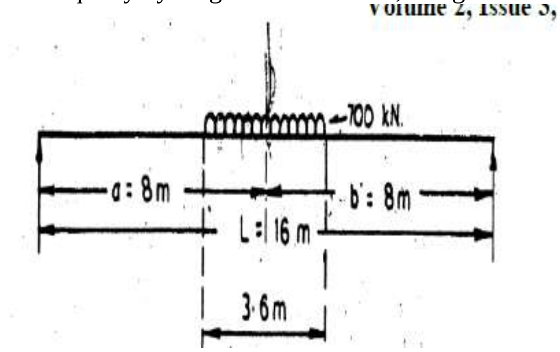

Fig 3.2 The Live Load Is Placed Centrally On The Span.

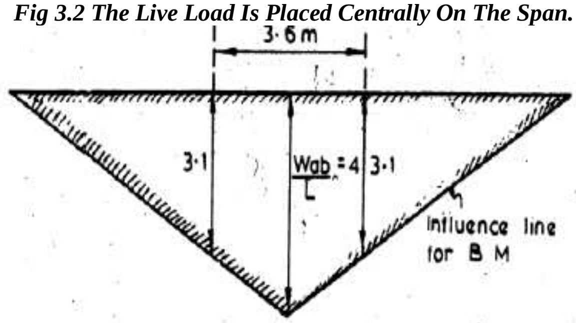

Fig 3.3 Influence Line for Bending Moment in Girder

Reaction Of W2 On Girder B	=	63KN
Reaction Of W2 On Girder A	=	287KN

c)Live load BM in girder

Span of girder= 16m

Impact factor (For class AA Loads)=10%

LLBM=0.5(4+3.1)= 2485 KNm

Bending Moment including Impact and reaction factor for outergirder is=(2485x1.1x0.5536)=1513 KNm

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Bending Moment including impact and reaction factor for inner girder =(2485x1.1x0.3333)=912 KNm

d).Live load shear
for estimating the maximum Live load shear in the girders, The IRC Clas AA Load are placed
Total load on Girder B =(350+63)=413 KN
Maximum reaction in girder B=(413x14.2)/16=366KN
Maximum reaction in girder A=(413x14.2)/16=255KN
Maximum liveload shears with impact factor in

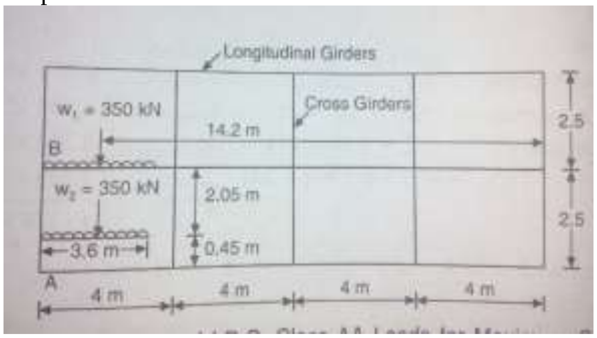

Fig 3.4 Position of IRC CLASS AA TRACKED Load for Maximum Shear

inner girder=(366x1.1)=402.6 KN
outer girder = (255x1.1)=280.5 KN
e). Dead load BM and SF in main girder. The depthof the girder is assumed as 1600mm
Depth of rib=1.4m
Width=0.3m
Weight of rib/m=(1x0.3x1.4x24)=10.08kNm
Reaction on Main girder=(10.08x2.5)=25.2kN
Reaction from deck slab on each girder=21.66kNm
total deadload/m on Girder=(21.66+10.08)=31.74kNm
M_{max}=(31.74X16^2)/8+(25.2X16)/4+(25.2X16)/4=1218kNm
Deadload Shear at Support
(31.74X16)/2+(25.2)+(25.2/2)=292kN

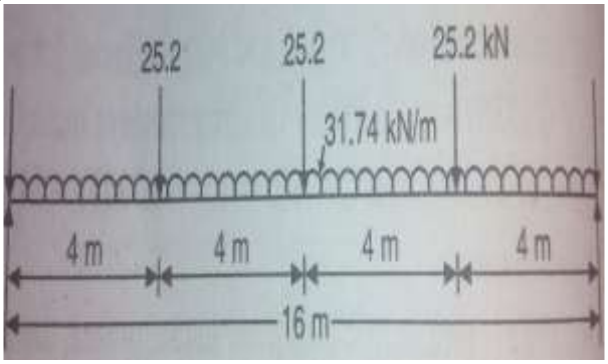

Fig 3.5 Dead load main girders

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f) Design BM and SF are shown in tables

Table 1.1 BM and SF

SHEAR FORCE	DLBM	LLBM	TOTAL SF
OG	292	280	572.1
IG	292	402.6	694.6

BENDING MOMENT	DLBM	LLBM	TOTAL BM
OG	1217.493	1512.992	2730.486
IG	1217.493	911.6223	2129.116

GUYON MASSONET METHOD

Preliminary Details

Clear Roadway = 7.5m   Concrete Grade = M25

Three T-beams at 2.5m intervals   Steel Fe 415

Deck Slab

The Slab is supported on four sides by beams

Thickness of Slab, H = 200mm

Thickness of Wearing Coat, D = 80mm

Span in the transverse direction = 2.5m

Maximum Dead Load

a) Weight of Deck Slab = 0.200 X 24 = 4.80 KN/M^2
b) Weight of Wearing Course = 0.08 X 22 = 1.76 KN/M^2
c) Total Weight = 6.56 KN/M^2

Cross-Sectional Properties Of Girders

The cross section of the deck togrther with the cross-section of the main and cross girders dimension are as shown in figure.

The cross sectional properties are as follows

Main Girder

$I=21.62 \times 10^{10} mm^4$

$i=(I/B)=(21.62 \times 10^{10})/2500= 0.864 \times 10^8 mm^4/mm$

$Z_t=(I/Y_t)= (21.62 \times 10^{10})/465= 4.64 \times 10^8 mm^3$

$Z_t=(I/Y_b)= (21.62 \times 10^{10})/1135= 1.90 \times 10^8 mm^3$

Cross Girder

$J=24.74 \times 10^{10} mm^4$

$j=(J/B)=(24.74 \times 10^{10})/4000= 0.618 \times 10^8 mm^4/mm$

$Z_t=(I/Y_t)= (24.74 \times 10^{10})/375= 6.59 \times 10^8 mm^3$

$Z_t=(I/Y_b)= (24.74 \times 10^{10})/1225= 2.01 \times 10^8 mm^3$

Torsional inertia of Girders

I_0 Or $J_0= R.a^3.b$

Main Girder

$(b/a)=(2500/200)=12.5$ therefore, R=0.333

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$(b/a)=(1400/300)=4.66$ therefore, $R=0.287$
$I_0=(0.33 \times 200^3 \times 2500)+(0.287 \times 300^3 \times 1400)$
$= 1.75 \times 10^{10}\ mm^4$
$i=(I_0/B)=(1.75 X 10^{10})/2500 = 0.07 X 10^8\ mm^4/mm$

Cross Girder
$(b/a)=(4000/200)=20$ therefore, $R=0.333$
$(b/a)=(1400/300)=4.66$ therefore, $R=0.287$
$I_0=(0.33 \times 200^3 \times 4000)+(0.287 \times 300^3 \times 1400)$
$= 1.15 \times 10^{10}\ mm^4$
$j=(J_0/B)=(1.15 X 10^{10})/4000 = 0.028 X 10^8\ mm^4/mm$

Distribution Coefficients
$\Theta=(b/2a)(i/j)^{0.25}$
where 2b= Effective width of bridge=8.7m
2a=span of bridge=16m
$\Theta=(4.35/1.6)[(0.864 \times 10^8)/(0.618 \times 10^8)]^{0.25}=0.3$
$\alpha=[0.2(0.07x10^8) + (0.028 \times 10^8)/\sqrt{(0.864 \times 10^8)/(0.618 \times 10^8)}]$
$=0.026$
$\sqrt{\alpha}= 0.161$

Maximum moments in longitudinal Girders
a) Dead Load
a) Weight of Deck Slab $= 0.200 X 24 = 4.80\ KN/M^2$
b) Weight of Wearing Course $= 0.08 X 22 = 1.76\ KN/M^2$
c) Total Weight $= 6.56\ KN/M^2$

Self wt of girder =(0.3x1.4x24) =10.08kN/m
weight of cross girder =(0.3x1.4x24) =10.08kN/m

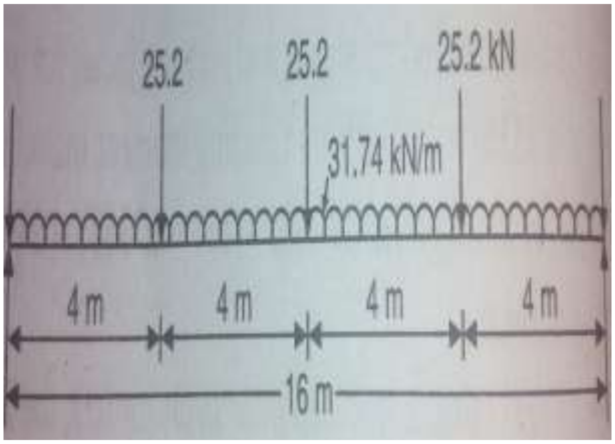

fig 7.7 Dead Weight

Reaction on main girder:
Due to wt of cross girders
=(10.08 x 2.5)=25.2KN
Reaction from deck slab on each girder
=(6.56 x 2.5)=16.4KN/m
Maximum BM at centre due to dead loads
$=[(16.4 \times 16^2)/8+(25.2 \times 16)/4 +(25.2 \times 16)/4]=726.4\ kNm$

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BM Considering Load distribution Effect
Liveload of footpath=[P'-(40L-300)/9] Kg/m^2
=[400-(40 x 16-300)/9]=363 Kg/m^2 =3.63 KN/m^2
Mean moment due to footpath deadloads
M_{mean}=[(6x2x16^2)/8]=384KNm
M_{fdl}=[(1.1 X D_{kf} x M_{mean})/3]
=[(1.1 X 0.996 x 384)/3]=140.23KNm
M_{fll}=[(1.1 X D_{kf} x M_{mean})/3]
=[(1.1 X 0.996 x 384)/3]=51.213KNm
M_{Mean} =((350x8)-(350x0.9))=2485 KNm
M_{LL}=2485 x 1.38 x1.1=1237.36 KNm
M_{max}=2155.6 KNm
Vmax=554.6 KN

Design BM and SF of GM Method are shown in tables

Table 1.2 BM and SF

LOADS	Units
BM	2155.6 KNm
SF	554.6KN

Similarly for 20m,24m the analysis where done as above Procedure for Two methods by using EXCEL Spread sheets and there results are given below:

Table 1.3 BM and SF of CM method and GM method

Methods	Span(M)	Bending Moment(KNm)	Shear Force (KN)
Courbon Method	20	3929.14	808.28
	24	5540.35	929.71
Guyon Massonet	20	2611.2	755.6
	24	3611.97	866.51

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 rational method and finite element method. The modeling involves the construction of t-beam bridge model with single span. The bridge models are simply supported at the two ends. PROCEDURE FOR THE ANALYSIS

1) Create the structural model including member properties and support conditions.
2) Go to the command menu and the vehicle loading.
3) Define the position of the vehicle in load window.
4) Then go for the analysis.
5) Proceed with the same procedure to get the maximum support and span moments by changing the transverse and longitudinal position of vehicle.
6) Proceed with analysis and post-processing in the normal way.

Staad Pro model has been created and illustrated in the following diagram.
Analysis of Staad Model for 20m is shown in as follows

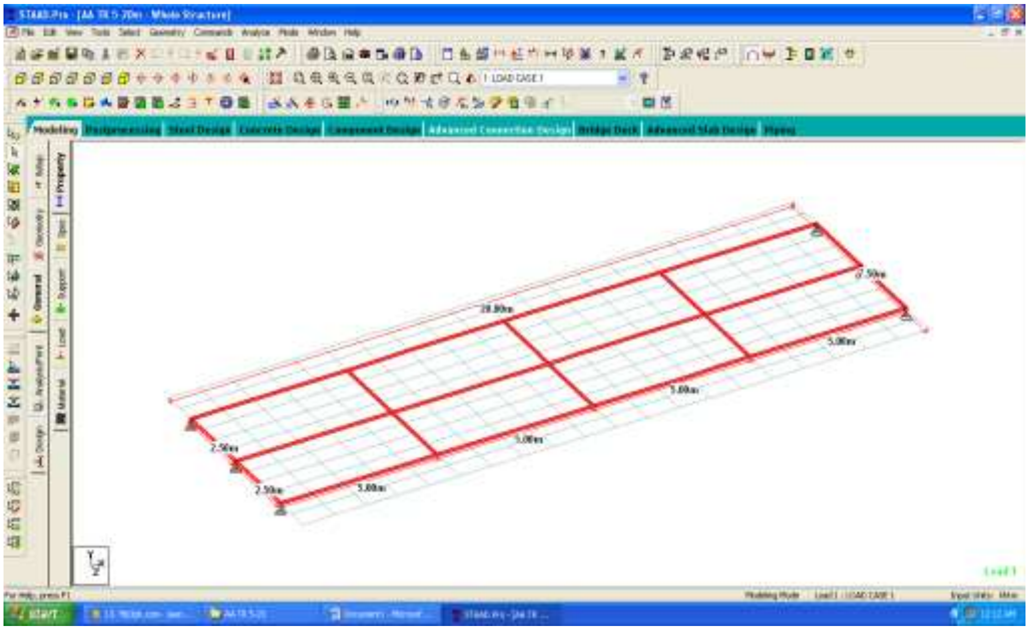

Fig (7.1) The beam element

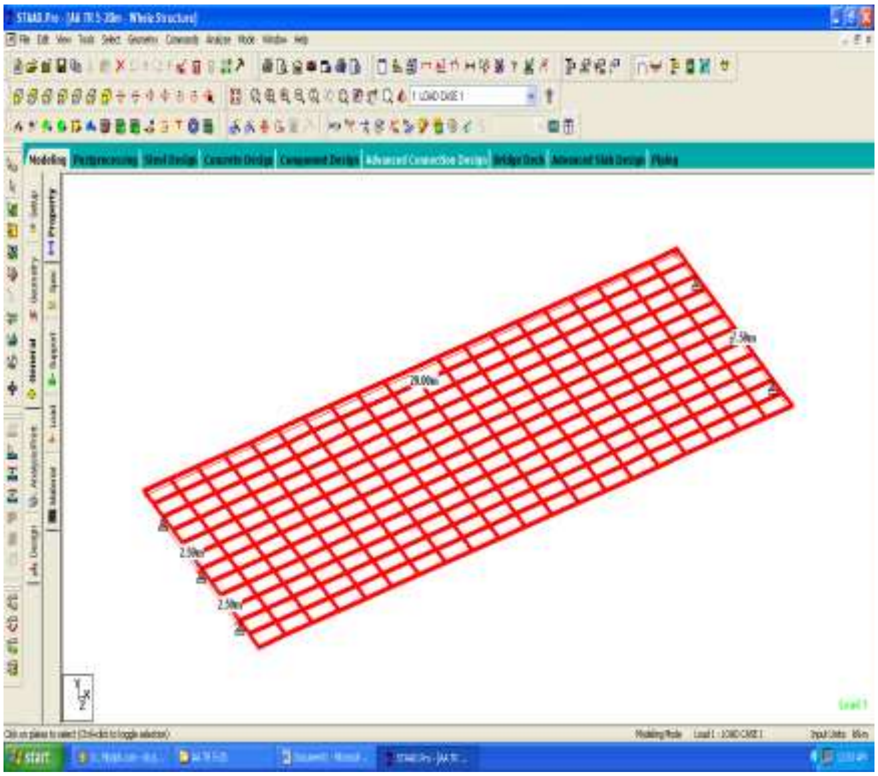

Fig (7.2) The deck slab

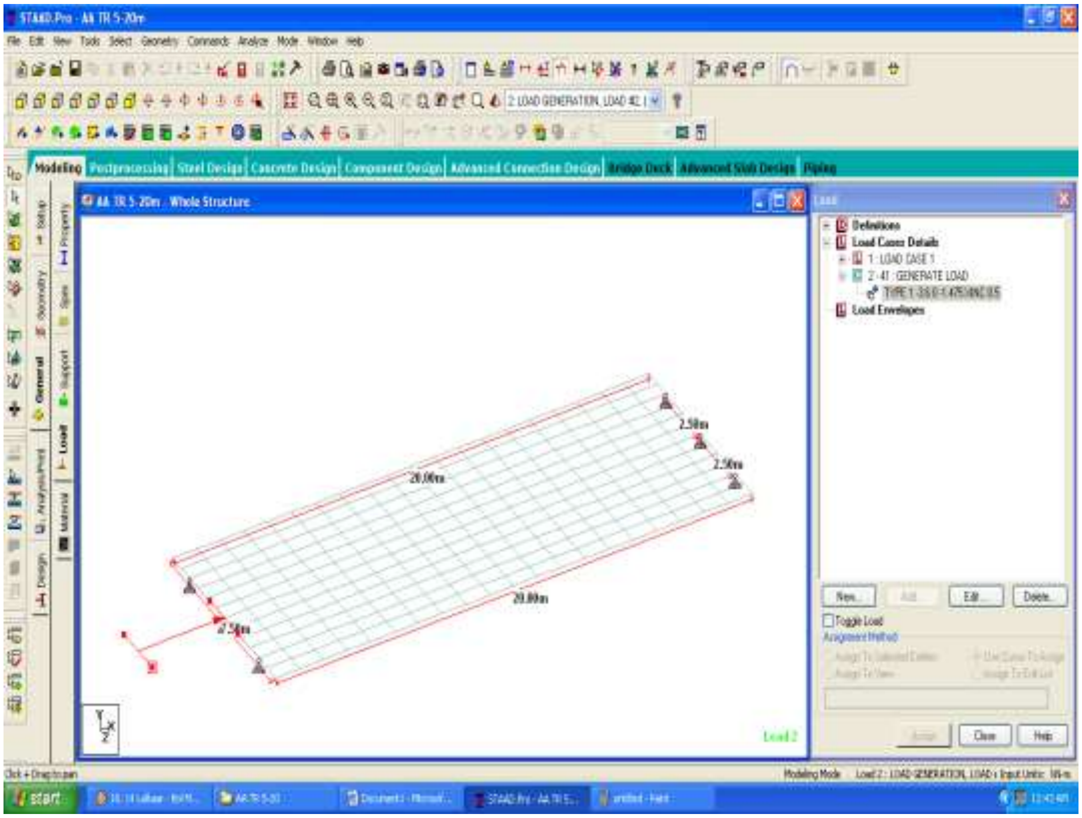

Fig (7.4) Details of the vehicle initial position

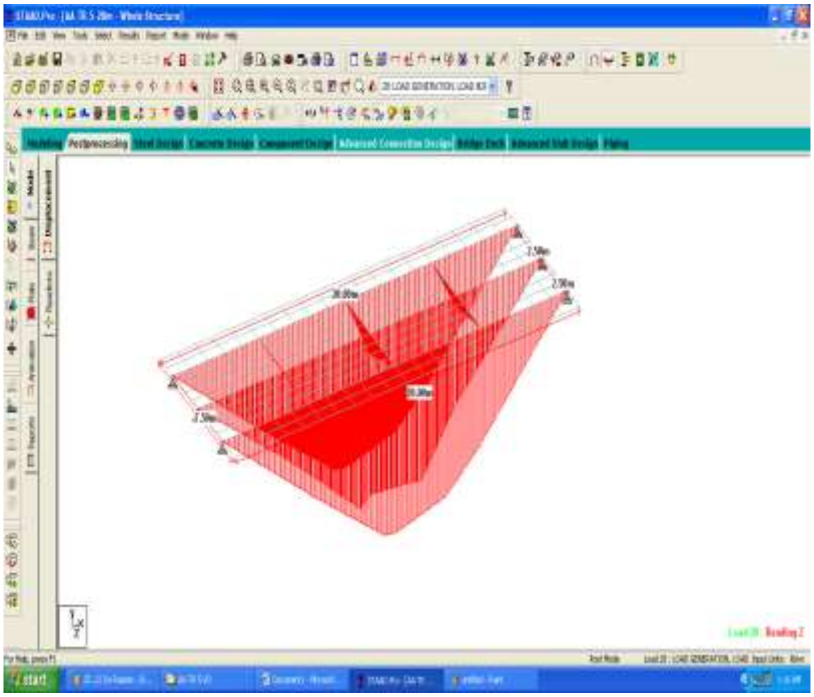

Fig (7.6) Bending Moment diagram

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(ISRA), Journal Impact Factor: 2.114

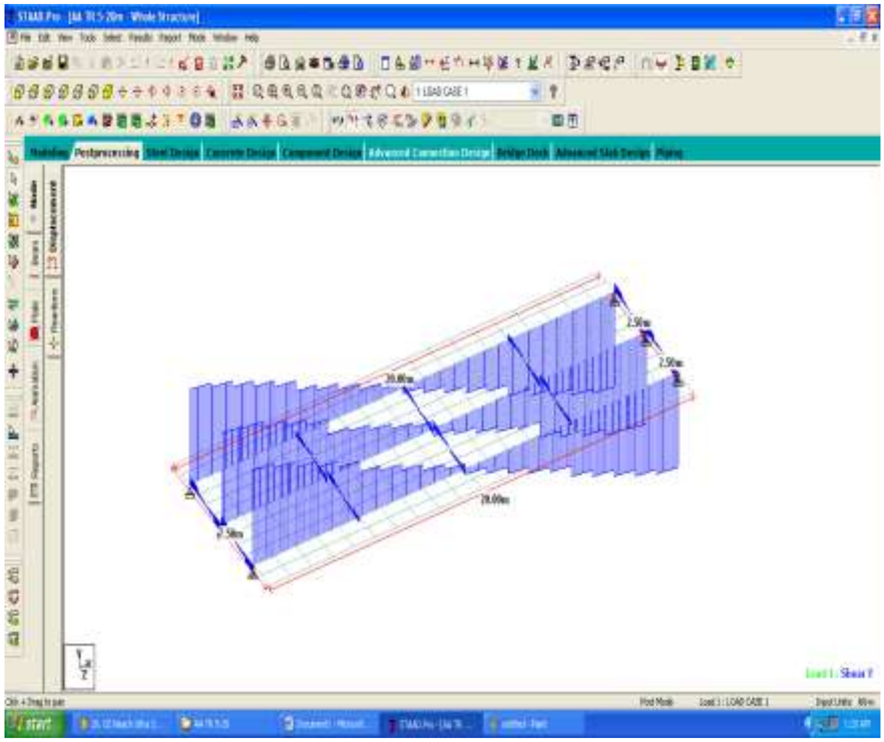

Fig (7.7) Shear Force diagram

RESULTS AND DISCUSSION

The results are presented in the form of tables and graphs.

Rational Methods Result

The values maximum Bending moments and Shear forces

Table No. (2.1) Courbon's Method – AA Tracked vehicle

No. of cross girders		5
16m span	Bending Moment (kN-m)	2730.03
	Shear Force (kN)	694.96
20m span	Bending Moment (kN-m)	3929.14
	Shear Force (kN)	808.28
24m span	Bending Moment (kN-m)	5540.35
	Shear Force (kN)	929.71

Table No. (2.2) Guyon Massonet Method – AA Tracked vehicle

No. of cross girders		5
16m span	Bending Momen (kN-m)	2154.80
	Shear Force (kN)	652.83
20m span	Bending Moment (kN-m)	2611.16
	Shear Force (kN)	755.61
24m span	Bending Moment (kN-m)	3311.97
	Shear Force (kN)	866.51

Staad Results

Table No. (8.3) AA TRACKED – BM, SF and Deflection for longitudinal girder of span 20m

Interval	DEAD LOAD			LIVE LOAD			TOTAL		
	Load Case - 1			Load genaration - 19 (max)					
	SF	BM	DEFLECTION	SF	BM	DEFLECTION	SF (kN)	BM (kNm)	DEFLECTION (mm)
0	289.028	-15.314	0	277.593	-11.168	0	566.621	-26.482	0
1	278.948	-299.302	-6.474	277.593	-288.761	-7.593	556.541	-588.063	-14.067
2	247.012	-591.962	-12.766	286.742	-599.038	-15.016	533.754	-1191	-27.782
3	236.932	-833.935	-18.711	286.742	-885.78	-22.093	523.674	-1719.715	-40.804
4	190.243	-1064.457	-24.163	278.902	-1194.342	-28.65	469.145	-2258.799	-52.813
5	180.163	-1249.66	-28.991	278.902	-1473.244	-34.512	459.065	-2722.904	-63.503
6	112.961	-1396.024	-33.077	453.754	-1915.187	-39.533	566.715	-3311.211	-72.61
7	102.881	-1503.944	-36.347	-21.197	-2107.718	-43.385	81.684	-3611.662	-79.732
8	57.995	-1590.465	-38.734	9.44	-2114.971	-45.962	67.435	-3705.436	-84.696
9	47.915	-1643.42	-40.189	9.44	-2124.412	-47.308	57.355	-3767.832	-87.497
10	-23.668	-1673.055	-40.682	260.807	-2141.054	-47.416	237.139	-3814.109	-88.098
11	-33.748	-1644.347	-40.189	-214.143	-1949.017	-46.234	-247.891	-3593.364	-86.423
12	-75.399	-1587.945	-38.734	-214.857	-1716.079	-43.916	-290.256	-3304.024	-82.65
13	-85.479	-1507.506	-36.347	-214.857	-1501.222	-40.596	-300.336	-3008.728	-76.943
14	-122.639	-1390.01	-33.077	-206.529	-1270.514	-36.403	-329.168	-2660.524	-69.48
15	-132.719	-1262.331	-28.991	-206.529	-1063.985	-31.467	-339.248	-2326.316	-60.458
16	-209.029	-1056.62	-24.163	-203.828	-844.001	-25.916	-412.857	-1900.621	-50.079
17	-219.109	-842.551	-18.711	-203.828	-640.174	-19.87	-422.937	-1482.725	-38.581
18	-264.774	-582.273	-12.766	-204.278	-420.517	-13.452	-469.052	-1002.79	-26.218
19	-274.854	-312.459	-6.474	-204.278	-216.239	-6.787	-479.132	-528.698	-13.261
20	-289.026	-15.315	0	-197.866	-9.499	0	-486.892	-24.814	0

Table No. (8.4) AA TRACKED - SF, BM and Deflection for longitudinal girder of different spans

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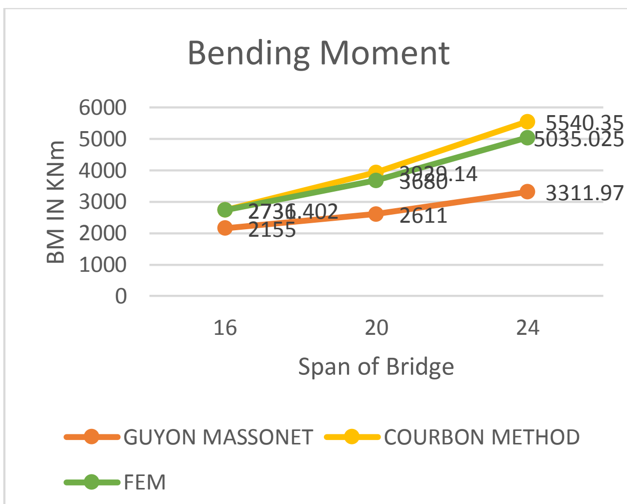
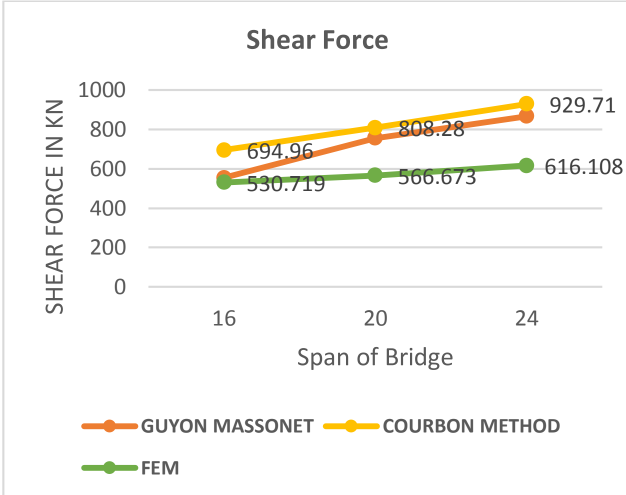
	DEAD LOAD			LIVE LOAD			TOTAL LOAD		
SPAN	SF	BM	DEFLECTION	SF	BM	DEFELECTION	SF	BM	DEFLECTION
	KN	KNm	mm	KN	KNm	mm	KN	KNm	mm
16m	233.689	-1097.018	-171.411	297.023	-1639.381	-233.829	530.712	-2736.399	-405.24
20m	289.028	-1673.055	-40.682	277.593	-2141.054	-47.416	566.621	-3814.109	-88.098
24m	344.689	-2370.665	-82.813	271.418	-2664.36	-83.63	616.107	-5035.025	-166.443

Comparision of results Obtained from FEM analysis by Staad Pro, Courbon's Method and Guyon Massonet Method.



Graph 8.1(a) Comparision of results of FEM, CM and GM for Bending Moment



Graph 8.1(b) Comparision of results of FEM, CM and GM for Shear Force.

DISCUSSIONS

Parametric study is carried out on two-lane bridge and Bending moment and Shear force values where arrived at by two approximate methods i.e. Courboun's method, Guyon massonet method for class AA Tracked vehicle. These values are also compared with STAAD-PRO results.

The results obtained are presented in the form of tables and graphs.

1) Maximum BM occurs for class AA Tracked vehicle. Hence class AA Tracked vehicle case is the most critical case for maximum BM in longitudinal girder.
2) Maximum SF occurs for class AA Tracked vehicle. Hence class AA Tracked vehicle case is the most critical case for maximum Shear force in longitudinal girder.
3) Guyon-massonet method underestimates the BM values as compared to Courbon's method for class AA Tracked vehicle by about (2%) for 12m and by (41%) for 24m.
4) Guyon-massonet method underestimates the SF values as compared to Courbon's method for class AA Tracked vehicle by about (10%) for 12m and by (21%) for 24m.
5) Guyon-massonet method has the advantage of using single set of distribution coefficients for the two extreme cases namely, no torsion grillage and a full torsion slab.
6) BM and SF values are validated by comparing STAAD-PRO results with the values obtained by approximate methods for various spans of longitudinal girder and it is observed that the Courbon's method BM values well matches with STAAD-PRO values.

CONCLUSION

The comparative study was conducted based on the analytical modeling of simply supported RC T-beam bridge by rational method and Finite element method using Staad Pro. Based on this study Courbon's method gives the average result with respect BM values in the longitudinal girder as compared to Guyon Massonet method. whereas Guyon-massonet method underestimates the BM values when compared with Courbon's method.The Staad pro result almost matches with the values obtained by Courbon's method for class AA tracked vehicle. For class AA Tracked vehicle the Staad pro result is reduced by (0.01%) as compared to Courbon's method and increase in result compared to Guyon-massonet method by (34.22%) for Bending Moment.For class AA Tracked vehicle the Staad pro result is reduced by (33.73%) as compared to Courbon's method and increase in result compared to Guyon-massonet method by (26.93%) for Shear Force.

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