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T-BEAM DECK SLAB BRIDGE ANALYSIS

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Abstract: Before Design of Any Structure we should know what the structural components in the structure, should know the specifications of the components, what are the loads to be considered in the design of structure and should know the analytical concepts. So This thesis gives the brief idea about the meaning of bridge and its classification, loads to be considered and the different methods to be adopted for the analysis of T-Beam deck slab bridge(only deck Slab with girders). This project Analyze the simple T-Beam Deck Slab. In T-Beam Deck Slab consists Slab with Longitudinal and Cross Girders. Girders have analyzed with three different Rational Methods (Courbon theory, Guyon-Massonet, Hendry Jaegar) for four IRC Loadings (Class-AA, Class-A, Class-B, Class-70R) and three Different country Loadings which are AASHTO Loading, British Standard Loading, Saudi Arabia Loading. Also this project Compare the All the Loadings and All the Methods which are mentioned above and the same bridge is analyzed as a three- dimensional structure using software STAAD ProV8i. Analysis of girders in the Bridge means Calculation of Moments and Shear forces induced in the longitudinal and cross girders at different positions for above mentioned loadings. Also analyzed the Moments induced in the Slab due to IRC Loadings Only. A simple example problem could be taken from the Text book (Design of Bridges by N. Krishna Raju) for this Project and also taken some of the curves and Graphs.

Keywords: Courbon theory- Hendry Jaegar- Guyon Massonet-Class-AA,Class-A-Class-70R-Class-B- AASHTO-Saudi Arabia- British Standard-STAAD Pro

I. METHOD OF ANALYSIS OF DECK SLABS

1.1. Analysis of Slab Decks:

- The analysis of deck slabs can be done in two ways depending upon the importance and classification of bridge
- They are Solid slabs spanning in one directionSlabs spanning in Two directions
- According to our project we are using slabs spanning in two directions.
- The moments develop due to wheel loads on the slab both in the longitudinal and transverse directions.
- These moments are computed by using the design curves developed by "westergard" or "Pigeaud's
- method".
- Pigeaud's method is applicable to rectangular slabs supported freely on all the four sides.
- The bending moments Can be calculated using the following Formula's

$M1=(m1+\mu m2)W$
$M2=(m2+\mu m1)W$
μ=poission's ratio for concrete from IRC-21:2000 = 0.15
m1,m2=coefficients for moments along short span and long span (from pigeaud's curves)
W= wheel load under consideration
K=Ratio of short to long span direction= (B/L)
u and v =Dimensions of the load spread after allowing for dispersion through the wearing coat and structural slab.
L=Long span length
B=short span length

1.2. Analysis of Girders:

A typical Tee beam deck slab generally comprises the longitudinal girder, continuous deck slab between the Tee beams and cross girders to provide lateral rigidity to the bridge deck. The longitudinal girders are spaced at intervals of 2 to 2.5 m and cross girders are provided at 4 to 5 m Intervals. The distribution of live loads among the longitudinal girders can be estimate by any of the following rational methods.

- Courbon method
- GuyonMassonet method
- Hendry Jaegar method

1.2.1.Courbon's method:

Among these methods, courbon 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 method is popular due to the simplicity of computations as detailed below:
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 is increased or decreased depending upon the position of the girders. This is calculated by courbon theory by a reaction factor given by,
$R_i=[\ P \times I_i / \sum I_i] \times [1+(\sum I_i / \sum I_i\, d_i^2\ ) \times e \times d_i\ ]$
P= total live load (kN)
I_i=moment of inertial of longitudinal girder (i)
e=eccentricity of the live load (m)
d_i= distance of girder (i) from the axis of the bridge.

1.2.2.Guyon-Massonet:

This method has the advantage of using a single set of distribution co-efficient for the two extreme cases of no torsion grillage and a full torsion slab thus enabling the determination of the load distribution behavior of any type of bridge.

M_{mean}= (M/n)

Design bending Moment=(1.10 x K x M_{mean} x I.F.)

K=distribution co-efficient (which is depends on flexural parameter and torsional parameters) they are:

$\theta = b/2a\ [i/j]^{0.25}$

$\alpha = G(i_o+j_o)/(2E\sqrt{ij})$

2a= span of the bridge

2b=effective width of the bridge

i=second moment of area per unit transverse width

j=second moment of area per unit longitudinal width

We should find the K_α value as interpolation formula

$K_\alpha = K_0+K_1-K_0\sqrt{\alpha}$

K_0, K_1 values from morice and little tables for five reference stations (0,b/4,b/2,3b/4 and b)

The equation of transverse moment for a concentrated load ‘W’ at a distance ‘u’ from the left support is given by

$My=Wb/a\ [\mu_\theta \sin(\prod u/2a) - \mu_{3\theta} \sin(3\prod u/2a) + \mu_{5\theta} \sin(5\prod u/2a)$+----------]

If there is uniformly distributed load ‘p’ acting over a distance ‘2C’ then

$My=4pb/\prod\ [\mu_\theta \sin(\prod C/2a) + (1/3)\ \mu_{3\theta} \sin(3\prod C/2a) + (1/5)\ \mu_{5\theta} \sin(5\prod C/2a)$+----------]

1.2.3. Hendry-jaegar Method:

Hendry and Jaegar assume that the cross beams can be replaced in the analysis by a uniform continuous transverse medium of equivalent stiffness. According to this method, the distribution of loading in an interconnected bridge deck system depends on the following three dimensionless parameters.

$A= (12/\prod^4) \times (L/h)^3 \times (nEI_T/EI)$

$F=(\prod^2/2n) \times (h/L) \times (CJ/EI_T)$

$C=2E\ (1+\mu) = 0.4E$----------------- (where μ=0.15)

Where L= the span of the bridge

h=spacing of longitudinal girders

n=number of cross beams

EI, CJ=flexural and torsional rigidities, respectively, of one longitudinal girder

EI_T=flexural rigidity of one cross beam

The parameter A is the most important of the above three parameters. It is a function of the ratio of the span to the spacing of longitudinal and the ratio of transverse to longitudinal flexural rigidity.

Graphs giving the values of the distribution co-efficient(m) for different conditions of number of longitudinal (two to six) and two extreme values of F, i.e., zero and infinity, are available in ----------. Co-efficient for intermediate values of F may be obtained by interpolation from

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

Where m_F is the required distribution co-efficient and m_0, m_∞ are respectively the co-efficient for F=0 and F=∞.

II. T-BEAM ANALYSIS USING RATIONAL METHODS

Clear width of road way=7.5m

Span (center to center bearings)=16m

Thickness of wearing coat=80mm

CROSS SECTION OF DECK:

Assume thickness of slab initially=200mm

Assume Three main girders are spaced 2.5m center to center

Kerbs=600mm wide and 300 mm deep

Cross girders are provided 4m interval center to center

Depth of Main girder=1600 mm

Width of Main girder=300 mm

Depth and width of cross girders same as main girders

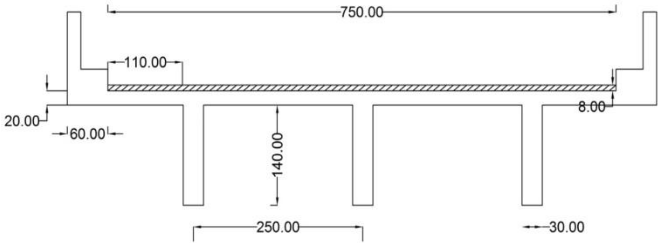

Fig1. Cross Section View Of Deck Slab

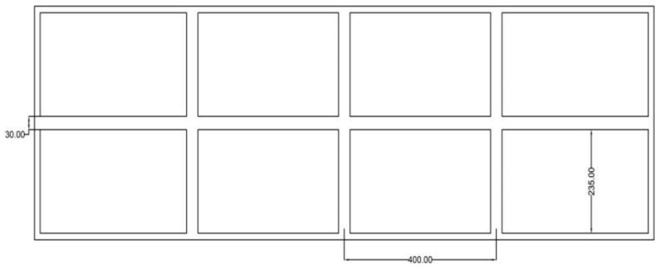

Fig.2. Top View Of The Deck Slab

OUTER GIRDER	D.L. B.M. = 1218	2679.5 kN. m
	L.L. B.M. = 1461.5	
	D.L. S.F.= 292	563.93 kN
	L.L. S.F. = 271.93	
INNER GIRDER	D.L. B.M. = 1218	2097.95 kN.m
	L.L. B.M.= 879.95	
	D.L. S.F.= 292	680.09 kN
	L.L. S.F. = 388.09	
CROSS GIRDER	D.L. B.M. = 25.10	294.1 kN.m
	L.L. B.M.= 269	
	D.L. S.F.= 30.47	213.77 kN
	L.L. S.F. = 183.3	

Table 1: Courbon's B.M. And S.F. For Class-AA

OUTER GIRDER	D.L. B.M. = 1218	2679.5 kN. m
	L.L. B.M. = 1461.5	
	D.L. S.F.= 292	563.93 kN
	L.L. S.F. = 271.93	
INNER GIRDER	D.L. B.M. = 1218	2097.95 kN.m
	L.L. B.M.= 879.95	
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	L.L. B.M.= 269	
	D.L. S.F.= 30.47	213.77 kN
	L.L. S.F. = 183.3	

Table2: Courbon's B.M. & S.F. For Class-70R

OUTER GIRDER	D.L. B.M. = 1218	2439 kN. m
	L.L. B.M. = 1221.5	
	D.L. S.F.= 292	496.98 kN
	L.L. S.F. = 204.98	
INNER GIRDER	D.L. B.M. = 1218	2078.16 kN.m
	L.L. B.M.= 860.16	
	D.L. S.F.= 292	548 kN
	L.L. S.F. = 256.99	
CROSS GIRDER	D.L. B.M. = 25.10	129.98 kN.m
	L.L. B.M.= 104.88	
	D.L. S.F.= 30.47	121.67 kN
	D.L. B.M. = 1218	

Table3: Courbon's B.M.& S.F. For Class-A

OUTER GIRDER	D.L. B.M. = 1218	2007.5 kN. m
	L.L. B.M. = 789.53	
	D.L. S.F.= 292	424.70 kN
	L.L. S.F. = 132.70	
INNER GIRDER	D.L. B.M. = 1218	1731.39 kN.m
	L.L. B.M.= 513.39	
	D.L. S.F.= 292	445.69 kN
	L.L. S.F. = 153.39	
CROSS GIRDER	D.L. B.M. = 25.10	87.65 kN.m
	L.L. B.M.= 62.55	
	D.L. S.F.= 30.47	84.86 kN
	L.L. S.F. = 54.39	

Table 4: Courbon's B.M. And S.F. For Class-B

OUTER GIRDER	B.M.	2283.71kN.m
	S.F.	897.28 kN
INNER GIRDER	B.M.	1935.87 kN.m
	S.F.	737.73 kN
CROSS GIRDER	B.M.	585.62 kN.m
	S.F.	370.17 kN

Table 5: Guyon-Massonet B.M. And S.F. For Class-AA

OUTER GIRDER	B.M.	2281.69 kN.m
	S.F.	910.76 kN
INNER GIRDER	B.M.	1885.78 kN.m
	S.F.	722.48 kN
CROSS GIRDER	B.M.	547.63 kN.m
	S.F.	362.36 kN

Table 6: Guyon-Massonet B.M.& S.F. For Class- 70R

OUTER GIRDER	B.M.	1792.90 kN.m
	S.F.	441.18 kN
INNER GIRDER	B.M.	1612.6 kN.m
	S.F.	515.32 kN
CROSS GIRDER	B.M.	102.62 kN.m
	S.F.	81.97 kN

Table 7: Guyon- Massonet B.M. & S.F. For Class-A

OUTER GIRDER	B.M.	1443.71 kN.m
	S.F.	406.789 kN
INNER GIRDER	B.M.	1328.21 kN.m
	S.F.	430.59 kN
CROSS GIRDER	B.M.	73.40 kN.m
	S.F.	62.47 kN

Table 8: Guyon-Massonet B.M. And S.F. For Class-B

OUTER GIRDER	B.M.	2732.36 kN.m
	S.F.	572.10 kN
INNER GIRDER	B.M.	2141.92 kN.m
	S.F.	694.60 kN
CROSS GIRDER	B.M.	318.47 kN.m
	S.F.	229.39 kN

Table 9: Hendry-Jaegar B.M. And S.F. For Class- AA

OUTER GIRDER	B.M.	2746.02 kN.m
	S.F.	568.93 kN
INNER GIRDER	B.M.	2141.92 kN.m
	S.F.	680.09 kN
CROSS GIRDER	B.M.	294.10 kN.m
	S.F.	213.77 kN

Table 10: Hendry-Jaegar B.M. And S.F. For Class- 70R

OUTER GIRDER	B.M.	1942.45kN.m
	S.F.	413.77kN
INNER GIRDER	B.M.	1735.24kN.m
	S.F.	378.94kN
CROSS GIRDER	B.M.	87.65kN.m
	S.F.	84.86kN

Table 11: Hendry-Jaegar B.M. And S.F. For Class- B

OUTER GIRDER	B.M.	2431.79 kN.m
	S.F.	496.02 kN
INNER GIRDER	B.M.	2084.62 kN.m
	S.F.	550.91 kN
CROSS GIRDER	B.M.	129.98 kN.m
	S.F.	121.67 kN

Table 12: Hendry-Jaegar B.M. And S.F. For Class- A

LOADING SYSTEM	MX (KN.M)	MY (KN.M)
CLASS-AA	33.68	14.02
CLASS-70 R	34.89	15.35
CLASS-A	21.91	14.81
CLASS-B	14.09	11.31

Table 13: Slab Moments Using Piegaud's Theory

OUTER GIRDER	B.M.	2078 kN.m
	S.F.	473.37 kN
INNER GIRDER	B.M.	2009 kN.m
	S.F.	587.67 kN
CROSS GIRDER	B.M.	136.61 kN.m
	S.F.	156.12 kN

Table 14: Courbon B.M. And S.F. For Hs 20-44 Loading

OUTER GIRDER	B.M.	2584.6 kN.m
	S.F.	622.5 kN
INNER GIRDER	B.M.	2474.3 kN.m
	S.F.	831.03 kN
CROSS GIRDER	B.M.	165.9 kN.m
	S.F.	255.79 kN

Table 15: Courbon B.M. And S.F. For Saudi Loading

OUTER GIRDER	B.M.	3450 kN.m
	S.F.	1291 kN
INNER GIRDER	B.M.	2429.9 kN.m
	S.F.	834.38 kN
CROSS GIRDER	B.M.	212.6 kN.m
	S.F.	180.47 kN

Table 16: Courbon B.M. And S.F. For British Loading

III. ANALYSIS USING STAAD PRO V8i

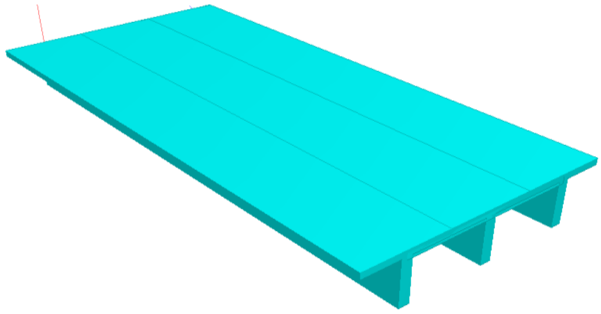


Fig.4. 3d-Model Of The T-Beam Deck Slab In STAAD

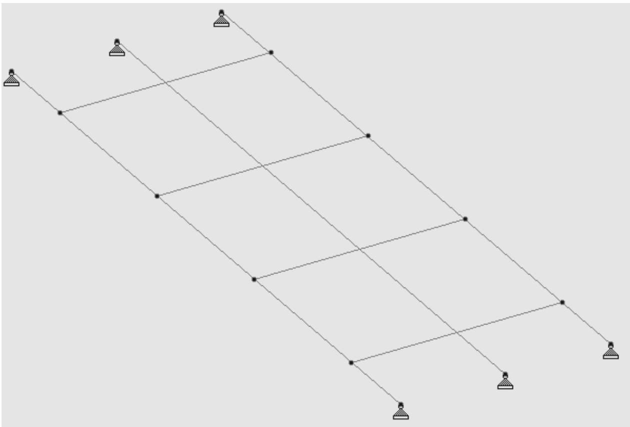


Fig.4. Model Of The T-Beam Deck Slab In STAAD

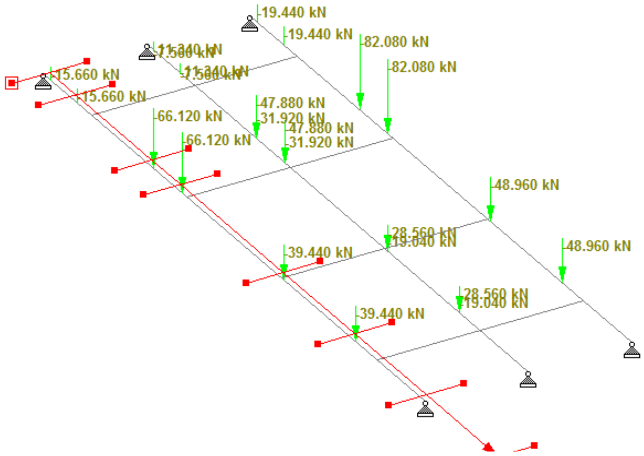


Fig.5. IRC Class-A Loading InSTAAD PRO V8I

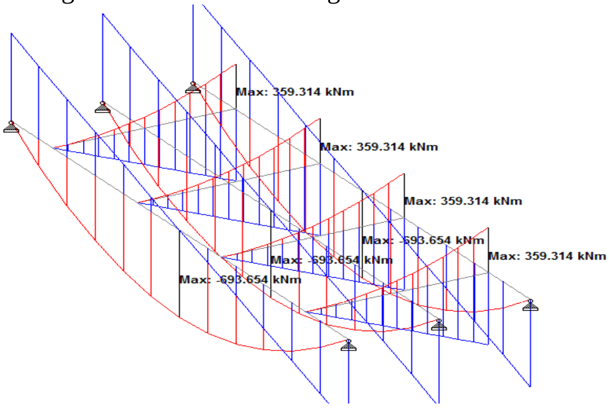


Fig.6. B.M. And S.F. For Class-A Loading

INNER GIRDER	Bending Moment	1449.94 kN.m
	Shear Force	353.12 kN
OUTER GIRDER	Bending Moment	1471.96 kN.m
	Shear Force	357.40 KN
CROSS GIRDER	Bending Moment	359.31 kN.m
	Shear Force	171.73 KN

Table 17: STAAD Analysis For Class-A

INNER GIRDER	Bending Moment	2484.65 kN.m
	Shear Force	879.73 kN
OUTER GIRDER	Bending Moment	1647.80 kN.m
	Shear Force	444.84 KN
CROSS GIRDER	Bending Moment	312.31 kN.m
	Shear Force	255 KN

Table 18: STAAD Analysis For Class-AA

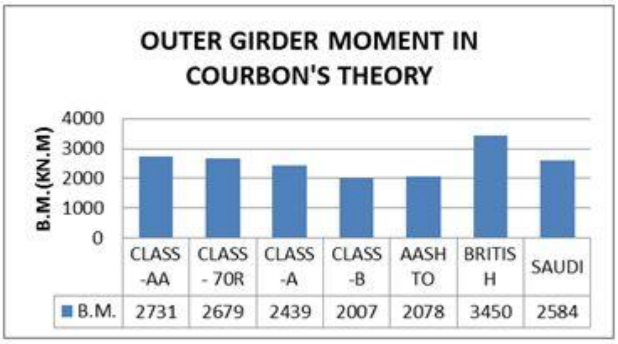
INNER GIRDER	Bending Moment	3048.6kN.m
	Shear Force	858.95kN
OUTER GIRDER	Bending Moment	1594 kN.m
	Shear Force	433.73 KN
CROSS GIRDER	Bending Moment	359.31kN.m
	Shear Force	143.73 KN

Table 19: STAAD Analysis For Class-70R

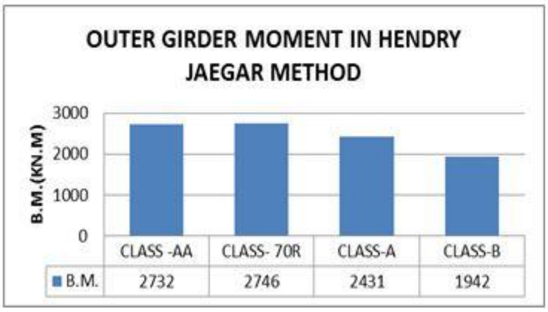
INNER GIRDER	Bending Moment	1144.9 kN.m
	Shear Force	278.87 kN
OUTER GIRDER	Bending Moment	1067.4 kN.m
	Shear Force	262.15 KN
CROSS GIRDER	Bending Moment	74.40 kN.m
	Shear Force	132.0 KN

Table 20: Staad Analysis For Class-B

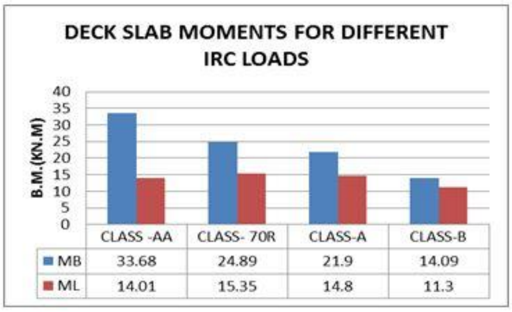
IV. COMPARISION OF LOADINGS WITH GRAPHS



Graph No.1: Outer Girder Moment in Courbon theory

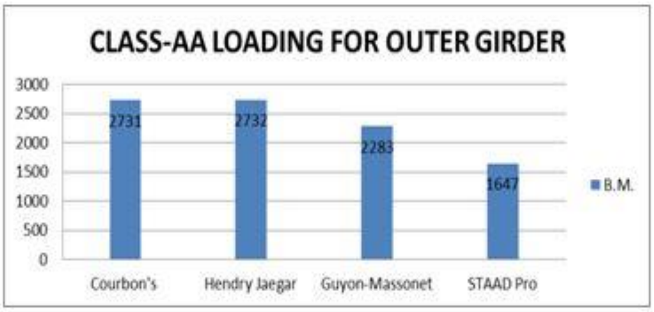


Graph No.2: Outer Girder Moment in Hendry-Jaegar Method

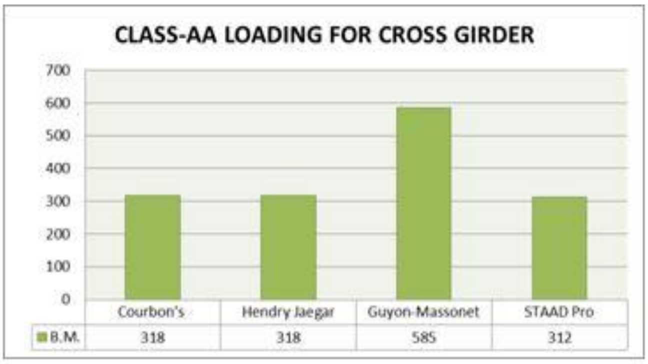


Graph No.3: Deck Slab Moments for Different IRC Loads

Graph No.4: CLASS-AA loading for Inner Girder



Graph No.5: CLASS-AA loading for Outer Girder



Graph No.6: CLASS-AA loading for Cross-Girder

V. CONCLUSION

- This Thesis has been done the Analysis of T-Beam deck slab Bridge for four IRC Loadings and other three countries (AASHTO, Saudi Arabia, British) Loading.
- For Each IRC loading has done in the three different rational methods and STAAD Pro software also.
- In this Analysis British Standard Loading has given the highest B.M. and S.F. values as compared to all the Loadings.
- As per this Analysis the highest B.M. and S.F. values Decrement order is British Standard, Class-AA,Class-70R, Saudi Arabia, Class-A, AASHTO, Class-B.
- In the overall Analysis as per our Indian Standard Class-AA and Class-70R are gives the highest B.M. and S.F. values compared to all the IRC Loadings.
- According to the three rational Methods, each method has given the highest importance to the Outer Girder and Second for Inner Girder and then Cross Girder.
- From the STAAD Pro Analysis, it has given more importance to Inner Girder and Next for Outer Girder.
- Out of all the Methods of Analysis of this Deck Slab Bridge, STAAD Pro has given highest Bending Moment, Shear Force for Inner Girder and Hendry JaegarMethod for Outer Girder and Guyon-Massonet for Cross Girder.
- The STAAD pro result nearly reaches the values obtained by Guyon-Massonet method for class AA tracked vehicle. For class AA Tracked vehicle the STAAD pro result is reduced by (13%) as compared to Guyon-Massonet method and increase in result compared to Courbon's method by (14%) for Bending Moment for Inner Girder. For class AA Tracked vehicle the STAAD pro result is Increased by (39.71%) as compared to Hendry-Jaegar method and increase in result compared to courbon's method by (0.036%) for Outer Girder.

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