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A Comparative Analysis of T-Beam Bridge using Rational Method and IS Code Method with STAAD PRO

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Abstract: This Project gives the brief idea about the meaning of bridge, loads to be considered and the different methods to be adopted for the analysis of T-Beam Bridge. Present Study is mainly focus on design of T-Beam Bridge by Rational Method (mainly Hendry-Jaeger Method) as a One Dimensional Structure using different IS Codes and compare it with Three Dimensional Structure using software STAAD Pro V8i.Analysis of Bridge means Calculations of Bending Moments and Shear Forces induced in the Deck Slab, Longitudinal Girders and Cross Girders at different positions for IRC Class AA Tracked Loading.
Keywords: T- Beam Bridge, IRC Codes, Hendry-Jaeger Method, STAAD Pro V8i.

I. INTRODUCTION

T-Beam used in construction is a load bearing structure of reinforced concrete with a T shaped cross section used for carriage of persons, cattle, vehicles, water or other materials carried across in pipes or conveyors. The bridges crossing carrying a road or railway over another structure are called as Flyover. The top of the T-shaped cross serves as flange which is a compression member in resisting compressive stresses. The web of the beam serves to resist shear stress and bending.

II. METHODOLOGY

A typical T-beam deck slab generally comprises the longitudinal girder, continuous deck slab between the T-Beam and cross girder to provide lateral rigidity to the bridge deck. The distribution of live loads among the longitudinal girders can be estimated by any of the following rational methods.

1) Hendry-Jaeger Method
2) Courbon's Method
3) Guyon Massonet Method

A. Analysis of T-Beam bridge using Rational Method -

1) *Hendry –Jaeger Method:* In the analysis proposed by Hendry and Jaeger method, the cross beams can be replace 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,

$A = (12/\pi^4)\,(L/h)^3 (nEI_r/EI)$……………………………………………… (1)

$F = (\pi^2/2n)\,(h/L)\,(GJ/EI_r)$…………………………………………………… (2)

$C = (EL_1/EI_2)$

Where, L= the span of the bridge deck
h =spacing of longitudinal girders
n= Number of cross beams
EI= Flexural rigidity of one longitudinal girder
GJ= Torsional rigidity of one longitudinal girder
EI_1, EI_2 =Flexural rigidities of the outer and inner longitudinal girders
EI_r =Flexural rigidity of one cross beam

The first parameter '*A*' represents a function of the ratio of span to the spacing of longitudinal girders and the ratio of transverse to longitudinal flexural rigidity. The second parameter '*F*' is measure of ratio of the torsional to flexural rigidity of longitudinal and cross girders respectively.

Hendry and Jaeger have presented graphs giving the values of the distribution coefficients *(m)* for different number of longitudinal girders (two to six) and for the two extreme value of F=0, F=∞.Coefficients for intermediate values of F may be obtained by interpolation from the equation,

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

Where, m_F = required distribution coefficients

m_0= coefficients for F=0

m_∞= coefficients for F=∞ Typical graphs for distribution coefficients for a three girders system for F=0 and F=∞ are given in figures.

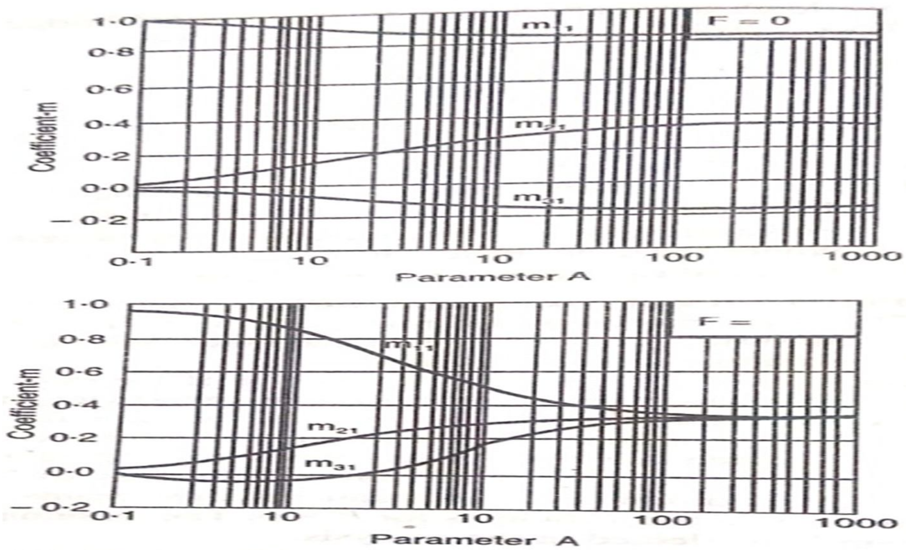


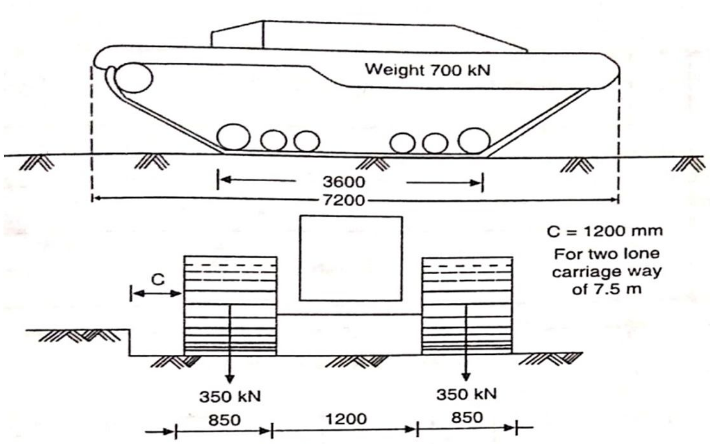
Fig.1: Distribution Coefficients for Three Girder Bridge with Load on Girder.

B. Analysis for IRC class AA Tracked Vehicle Loading

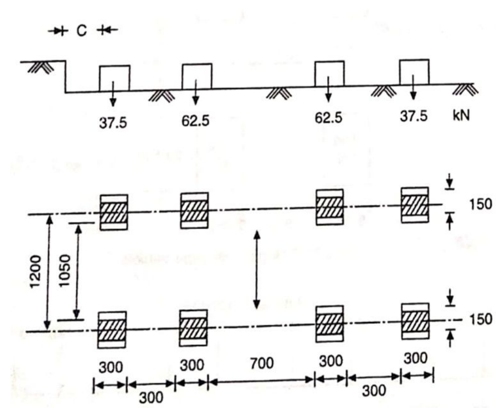
The standard IRC loads specified in IRC: 6-2000 are grouped under four categories as detailed below:

1) IRC class AA loading
2) IRC class 70 R Loading
3) IRC class A loading
4) IRC class B loading

a) *IRC Class AA Loading:* Two different types of vehicles are specified under this category grouped as tracked and wheeled vehicles. The IRC Class AA tracked vehicles (simulating an army tank) of 700 KN and a wheeled vehicle (heavy duty army truck) of 400 KN as -.



(a) Tracked Vehicle



(b) Wheeled Vehicle

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III. ANALYSIS OF T-BEAM BRIDGE USING RATIONAL METHOD

A. Preliminary Details

Clear width of roadway = 7.5 m
Span Length = 16 m center to center
Average Thickness of wearing coat = 60 mm
Concrete Mix = M20 Grade
Steel = Fe415 Grade HYSD Bars

B. Cross Section of Bridge Deck

Assumptions-
Thickness of Deck Slab = 200 mm
Three Longitudinal Girders provided at 3 m c/c.
Width of Longitudinal Girder = 300 mm
Cross Girders provided at every 4 m intervals.
Width of Cross Girder = 200 mm
Kerb = 500 mm wide and 250 mm deep
Depth of Longitudinal Girder is taken as @ 100 mm per m of span
= 16 x 100 = 1600 mm

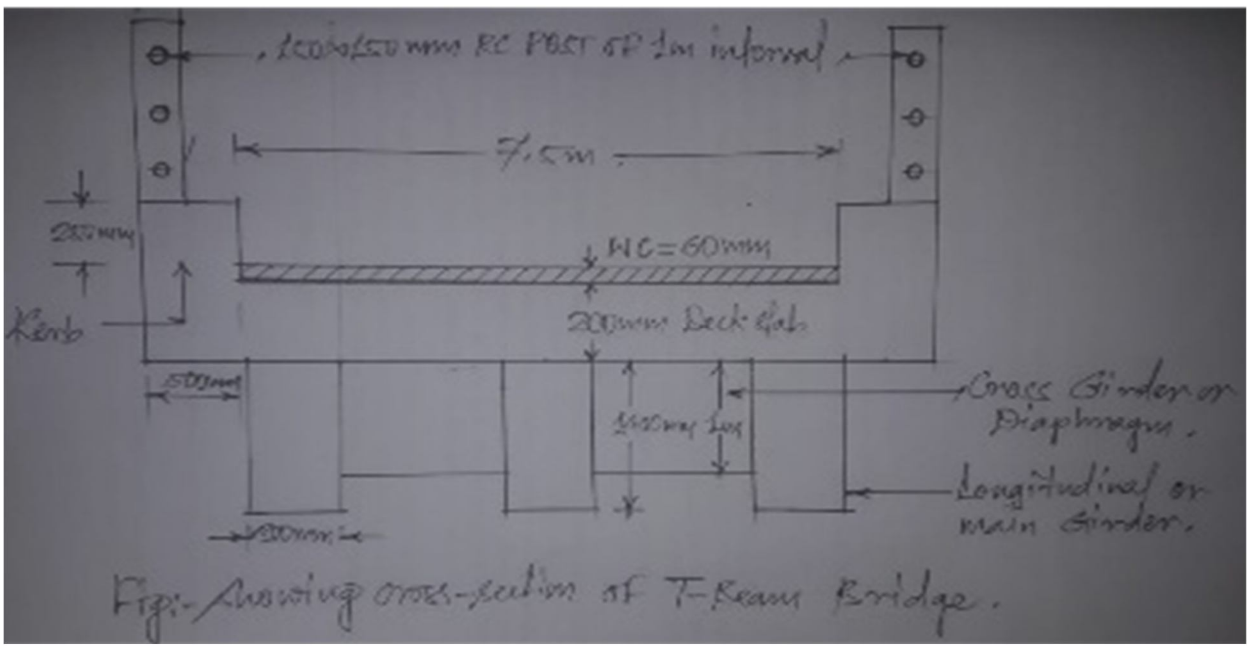

Fig.2: Cross Section of T-Beam Bridge

C. Design of Bridge Deck Slab Panel

Pigeaud's curves should be used to calculate bending moment in the design of Deck Slab Analysis given as-
As per IRC 6:2000 and IRC 21:2000, Impact Factor = 25% for IRC Class AA loading is Considered and Continuity Factor =0.8 should be taken as the slab is Continuous.
LLBM along short span = 35.77 KNm
LLBM along long span = 21.79 KNm
LLSF = 58.10 KN
DLBM along short span = 2.92 KNm
DLBM along long span = 1.87 KNm
DLSF = 8.262 KN
Total Design Bending Moment = 62.35 KNm
Total Design Shear Force = 66.36 KNm

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D. Design of Longitudinal Girders

1) Calculation of Distribution Factor by Hendry-Jaeger Method

From Steel Table, Use I-Section of follow. Properties for design of Bridge Longitudinal Girder as-

I = 2728.3 cm^4, Ir = 2783.0 cm^4, J = 28823.5 cm^4

Assume, G = 0.4 E …… {As G = 2 E (1+ 0.15)}

The main design parameters 'A' and 'F' are computed as

$A = (12/\pi^4)\,(L/h)^3 (nEI_r/EI)$ =95.32

$F = (\pi^2/2n)\,(h/L)\,(GJ/EI_r)$ =0.766

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

As 'F' is very nearly equal to zero i.e. F<<<<<<0 Then, $m_F = m_0$

For Outer Girder, $m_F = m_0 = 0.81$

For Inner Girder, $m_F = m_0 = 0.38$

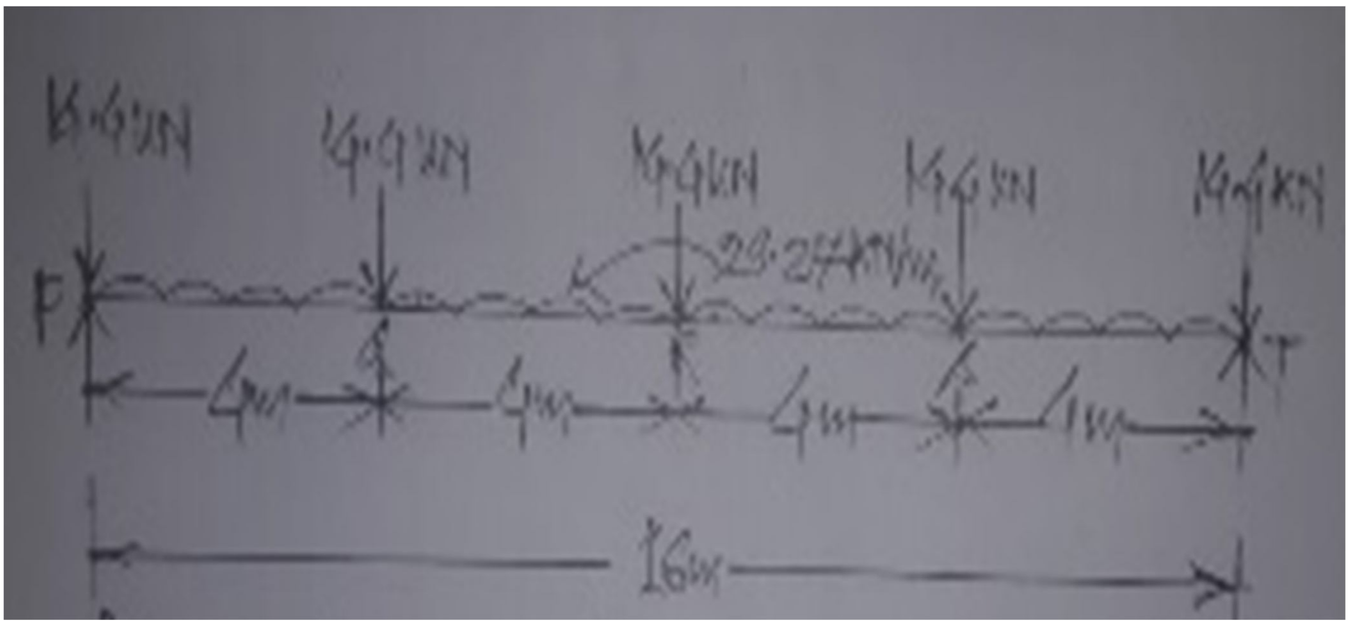

Fig.3: Maximum Bending Moment at the Centre of the Span

LLBM for Outer Girder = 22.14135 KNm
LLBM for Inner Girder = 1038.73 KNm
LLSF for Outer Girder = 233.486 KN
LLSF for Inner Girder = 450 KN
DLBM for Outer Girder = for Inner Girder= 1051.84 KNm
DLSF for Outer Girder = for Inner Girder= 255.76 KN
Total Design Bending Moment for Outer Girder = 3265.975 KNm
Total Design Bending Moment for Inner Girder = 2090.57 KNm
Total Design Shear Force for Outer Girder = 489.246 KNm
Total Design Shear Force for Inner Girder = 705.76 KNm

E. Design Of Cross Girders

LLBM for Cross Girder = 392.854 KNm
DLBM for Cross Girder = 18.75 KNm
LLSF for Cross Girder = 198.92 KN
DLSF for Cross Girder = 23.3 KN1
Total Design Bending Moment for Cross Girder = 411.604 KNm
Total Design Shear Force for Cross Girder = 222.22 KNm

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Deck Slab	Shear Force	66.362 KN
	Bending Moment	62.35 KNm
Outer Girder	Shear Force	489.246 KN
	Bending Moment	3265.975 KNm
Inner Girder	Shear Force	705.76 KN
	Bending Moment	2090.57 KNm
Cross Girder	Shear Force	222.22 KN
	Bending Moment	411.604 KNm

TABLE: 1. Hendry-Jaeger B.M. and S.F. for Class AA Loading

IV. ANALYSIS OF T-BEAM BRIDGE USING STAAD PRO V8i

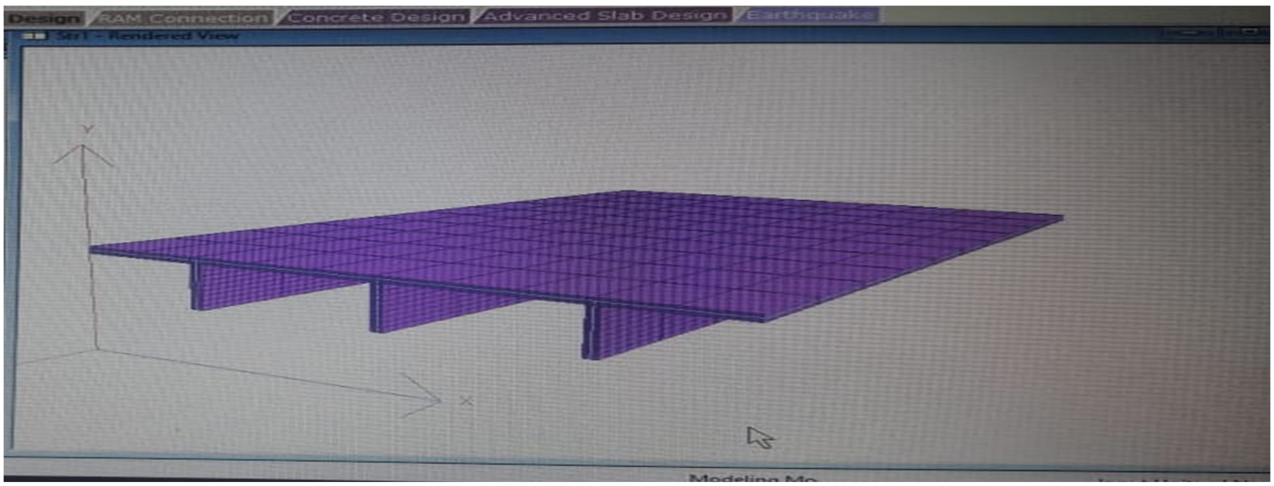

Fig.4: 3D Model of T-Beam Bridge in Staad Pro Software V8i

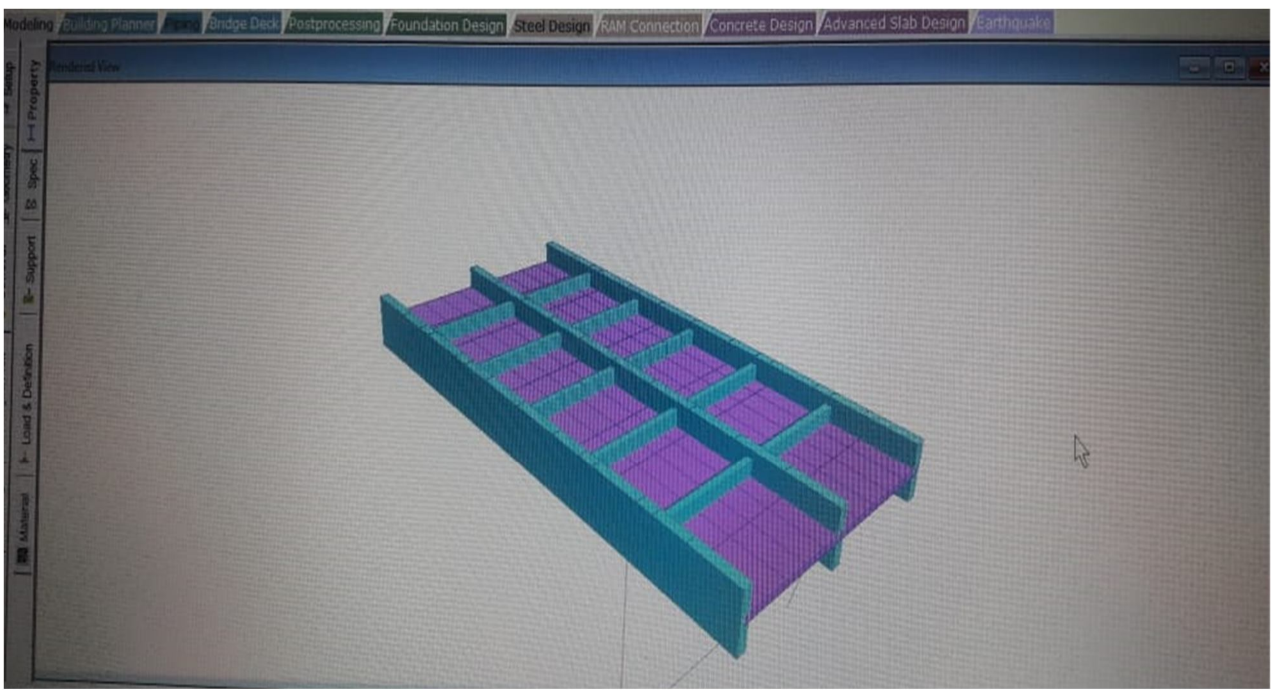

Fig.5: Model of T-Beam Deck Slab in STAAD

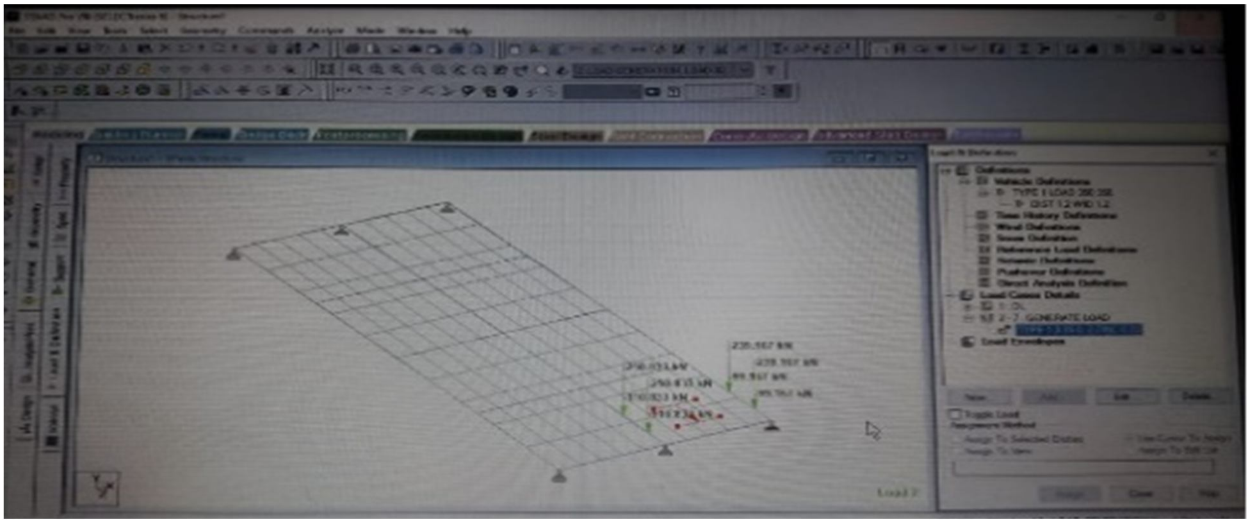

Fig.6: IRC Class AA Loading in STAAD Pro V8i

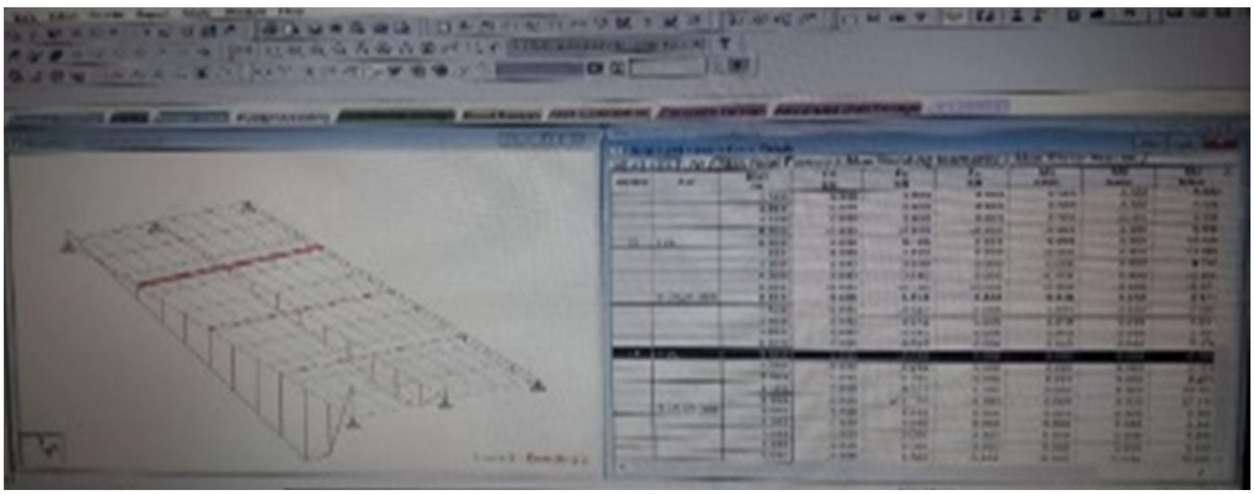

Fig.7: B.M. and S.F. for IRC Class AA Loading

Deck Slab	Shear Force	177.97 KN
	Bending Moment	236.502 KNm
Outer Girder	Shear Force	507.756 KN
	Bending Moment	624.822 KNm
Inner Girder	Shear Force	377.286 KN
	Bending Moment	541.958 KNm
Cross Girder	Shear Force	30.967 KN
	Bending Moment	100.414 KNm

TABLE: 2. Staad Analysis values of B.M. and S.F. for IRC Class AA Loading

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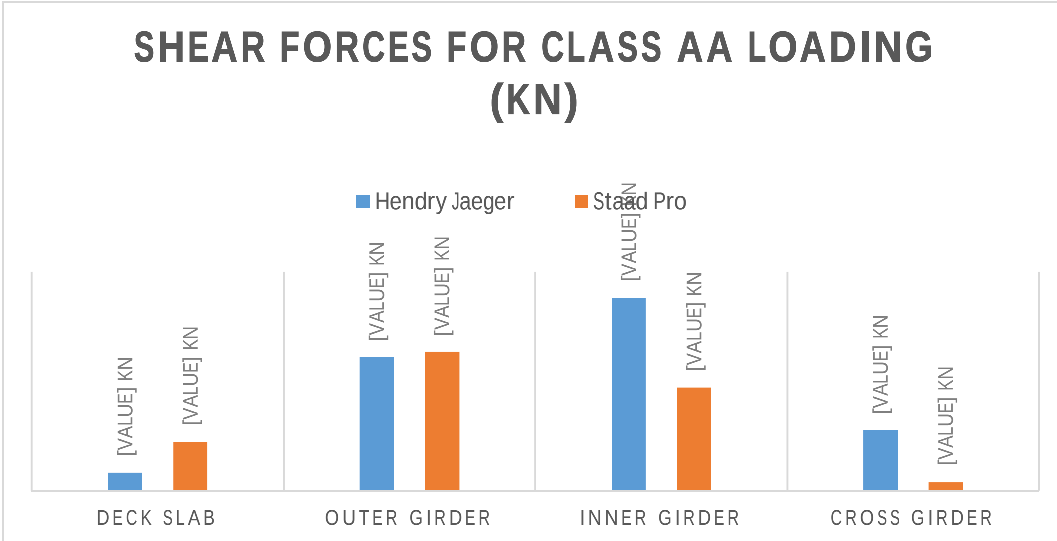
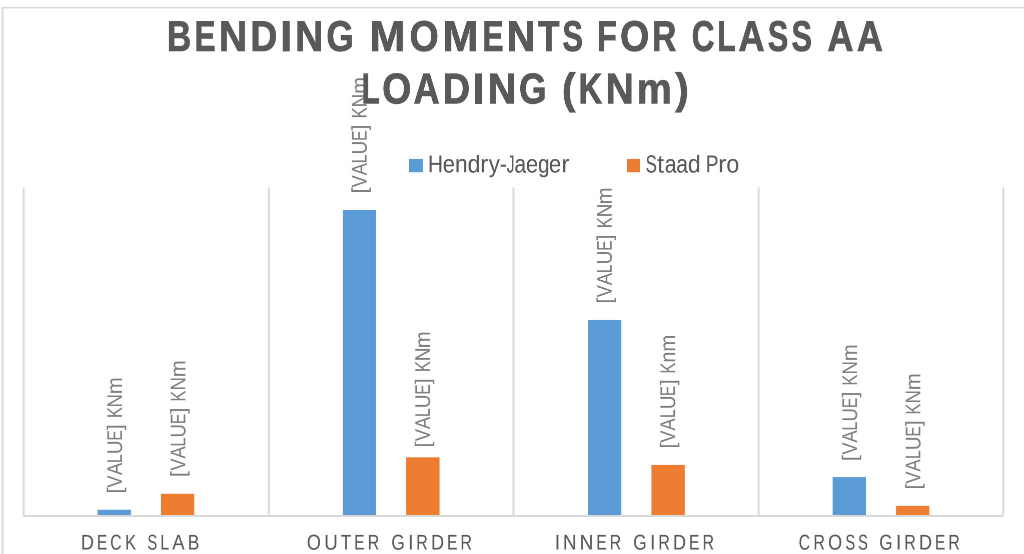
V. COMPARISION OF METHODS WITH GRAPHS



Graph No. 1: Shear Force values for IRC Class AA Loading



Graph No. 2: Bending Moment values for IRC Class AA Loading

VI. CONCLUSION

A. From the given Analysis, it is found that each method has given the highest importance to the Outer girder, second for Inner girder and then for Cross girder.

B. In the overall Analysis, the IRC Class AA loading gives the highest B.M. and S.F. values as compared to all other IRC Loadings.

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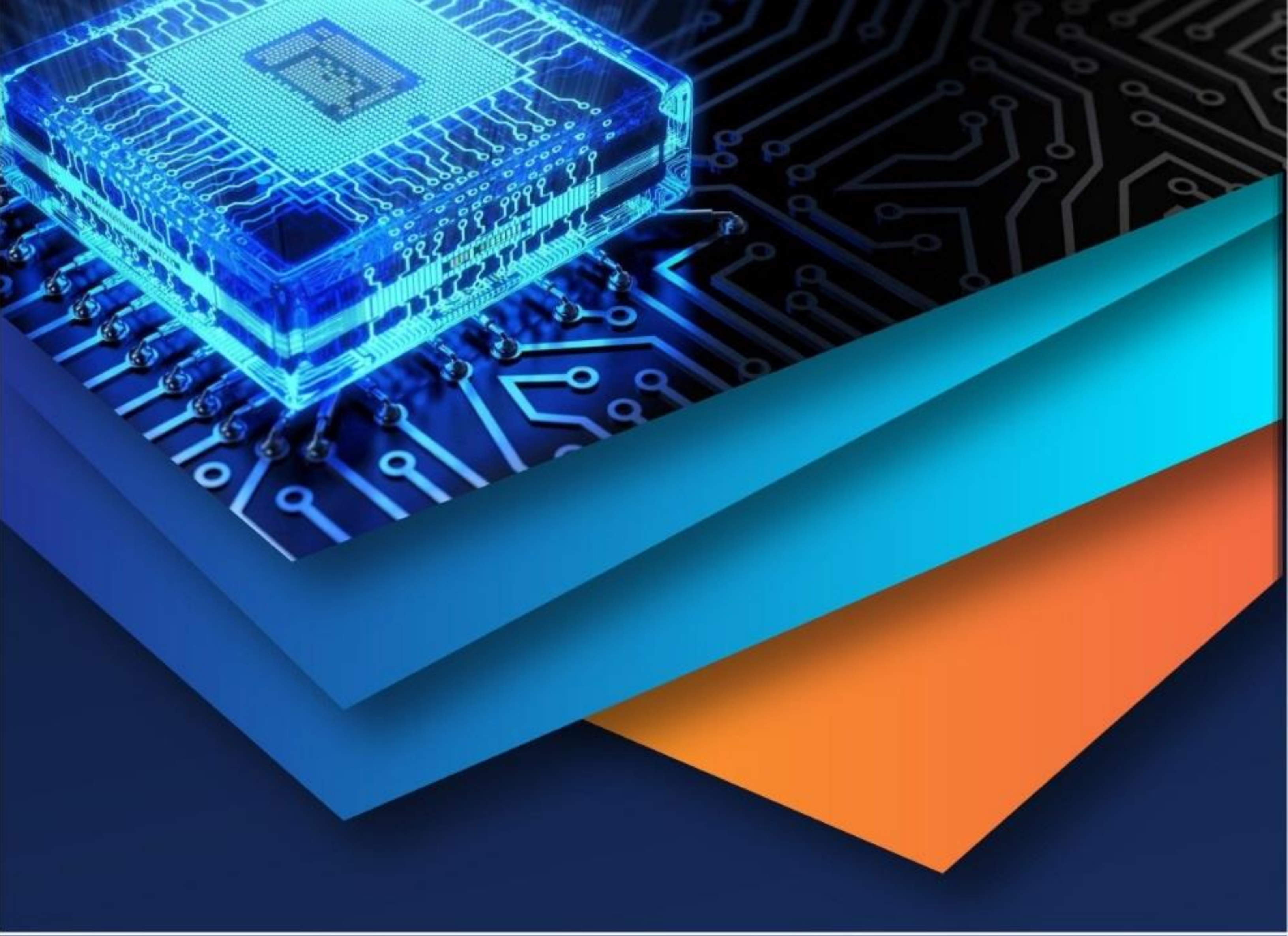

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