Design and Analysis of Bridge Girders using Different Codes

Ravikant
PG Student,
Department of Civil Engineering,
Chandigarh University, Mohali,
Punjab, India.

Jagdish Chand
Associate Professor,
Department of Civil Engineering,
Chandigarh University, Mohali,
Punjab, India.

Abstract:- **The bridges are the super passage or a pathway over the obstacle without changing the alignment of the way beneath. The present study considers the design of bridge girders both longitudinal girders and cross girders. The span of the bridge is taken as 25m in which girders are constructed. The size of longitudinal girders is taken as2000x500 mm and cross girders is 1500x250 mm. There are three longitudinal girders are considered having spacing 2600 mm c/c and cross girders are considered as 5000mm c/c. The design of girders is carried out using the software STAAD Pro. In this study of bridge girder design, three same models are prepared in the STAAD pro and then there loadings are changed according to IRC codes, Euro codes and AASHTO specificationsrespectively. According to these different loading we found the shear force, bending moment and area of steel in longitudinal girder as well as cross girder. The analysis is conducted in STAAD Pro and analysis results are compared with tables and graphs.**

Keywords: Bridge Girder, Longitudinal Girders,Cross Girder, STAAD Pro, etc.

I. INTRODUCTION

Bridge is a structure constructed to provide a passage over the obstacle such as road crossing, river crossing, railway crossing, valley etc. Design of bridge structure is depends upon the use of bridge or function of the bridge. It also depends upon the nature of the region where bridge to be constructed. It depends upon the site conditions, construction material used in the bridge construction, construction methods and financial conditions etc. Due to so speedy growth and development of the technology, the traditional bridges are replaced by the cost effective and new designer bridges. There structure designs are designed so that they has a new look or appearance and there cost of the structure is also economical. For the solution of this problem, structural engineers found these two structural systems of reinforced cement concrete. These are

- Girder bridges
- Prestressed Bridges
- Arc Bridges
- Rigid Frame Bridges

Because we are comparing Girders, so we talk about Girders. The geometry of girders is very simple and also easy in construction. Design of bridge structure is very important task for a structural engineer. It is also a complex task of structural engineers. There are some important factors in case of bridge designing such as span, live load, dead load, length and height. These factors affect the whole concept of the design and selection of the system of structure is always important and the scope of research. In this study we select the span of length 25 m. Therefore, these two factors are important i.e. codal provision and the design details.

The design of the girders is carried out with IRC codes, Euro codes and AASHTO specifications using STAAD Pro. This study compares the shear force, bending moment and area of steel in the design of bridge girders i.e. longitudinal girders and cross girders due to the application of different loading according to IRC codes, Euro codes and AASHTO specifications

II. LITERATURE REVIEW

The study of different journals, thesis and design aspects were done. They consider IS codes, IRC codes, Euro codes, AASHTO specifications and ACI codes.

An important research paper on “Analysis of Bridge girder -2 way Beams” has been published by Vijay Kumar, S.P. & Mohan K. (2017) found that when we are using cross beams or girders the deflection, bending moment & shear force will reduced as compare to the design of girder bridge without cross beams or girders.

Saxena A. & Dr. Maru S. (2013) publish an important research paper on “Comparative Study of the Analysis and Design o T-Beam Girder and Box Girder Super Structure” describe that the T- beam girder is economical than the box girder but box girder is more suitable for long span bridges. Because of their close box sections they have high torsional rigidity.

Chu, K.H. (1971) published “Simply Supported Curved Box Girder Bridge” with the help of finite element method. A study of “Dynamic & Impact Characteristics of Continuous Steel Beam Bridge Decks and Slant-legged Rigid Frame Bridges” was carried out by Wang & Herang (1992). In 2011, N.K. Paul published “Three Dimensional Finite Element Model and Test Them with Loading System of Two Point” to check their behavior of structure of the longitudinal girders of RCC T-beam bridges.

III. METHODOLOGY

i. Description of Bridge Super Structure

The bridge structure considered in this case study has a length of 25 m simply supported over the piers or abutments of the bridge substructure. The thickness of deck slab is 250 mm in all respects. Sizes of longitudinal girders and cross girders are considered as 2000x500 mm & 1500x250 mm respectively.

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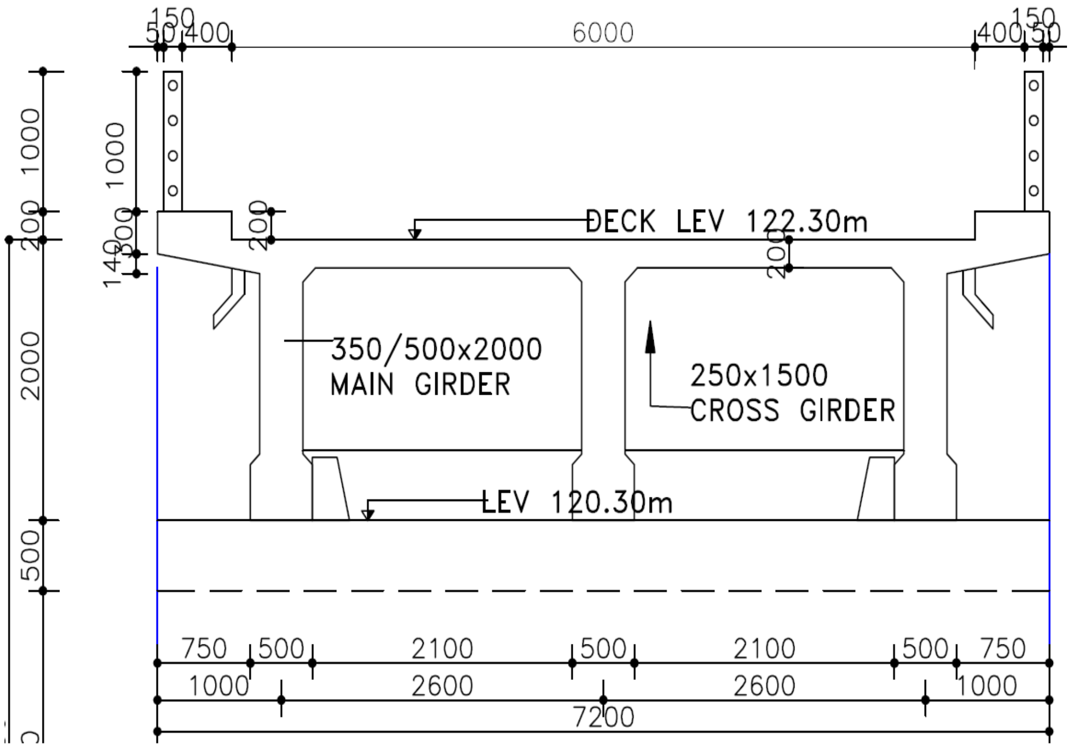
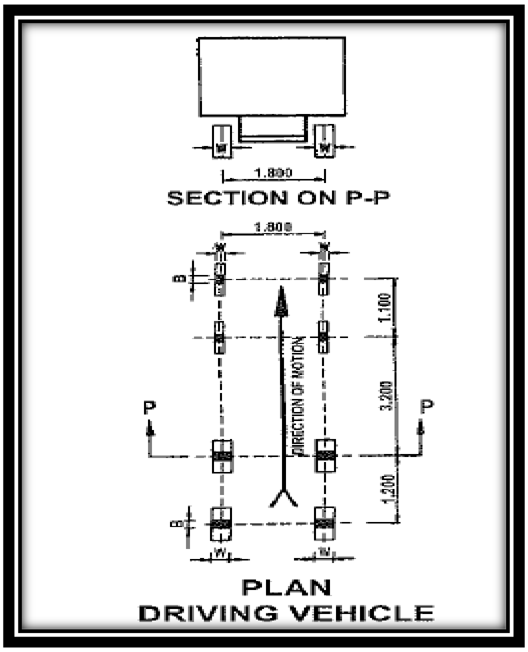


Fig. 1 Cross Section of Super Structure assumed

ii. Design Analysis

The design of bridge girders has been performed for dead and live laods. Dead load of the slab is assumed as 7.5 KN/m² where as dead load of members are considerd in STAAD Pro. For live loads IRC codes, Euro codes and AASHTO Specifications has been prefred and model has been created in STAAD Pro. Schematic diagrams and loadings followed from IRC codes, Euro codes and AASHTO Specifications are shown below

Loadings



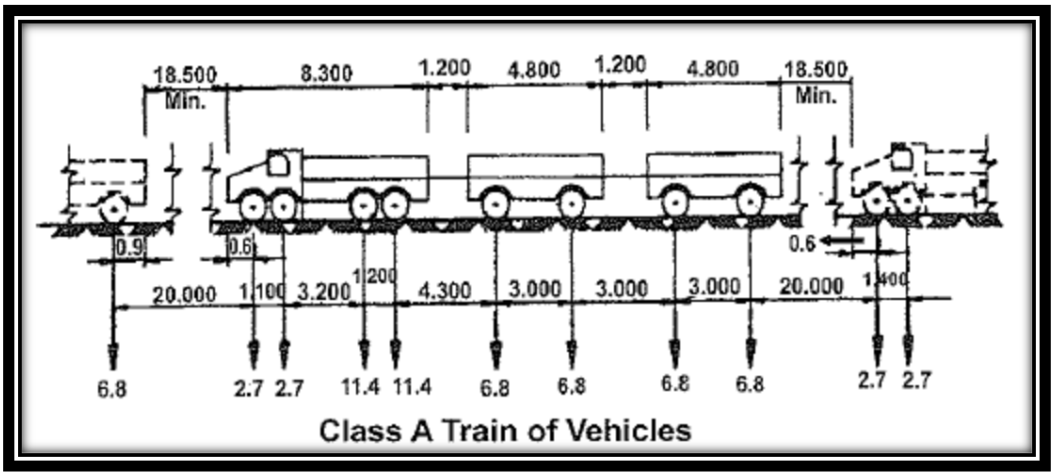


Fig. 2 IRC Class A Loading (Extracted from IRC 6-2010)

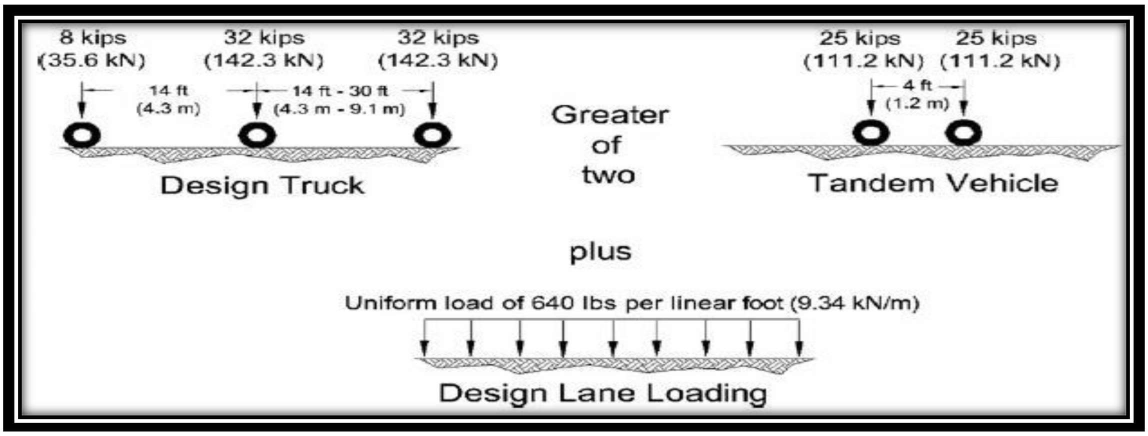


Fig. 3HL-93Loadingfrom AASHTOLRFD Bridgedesign specification

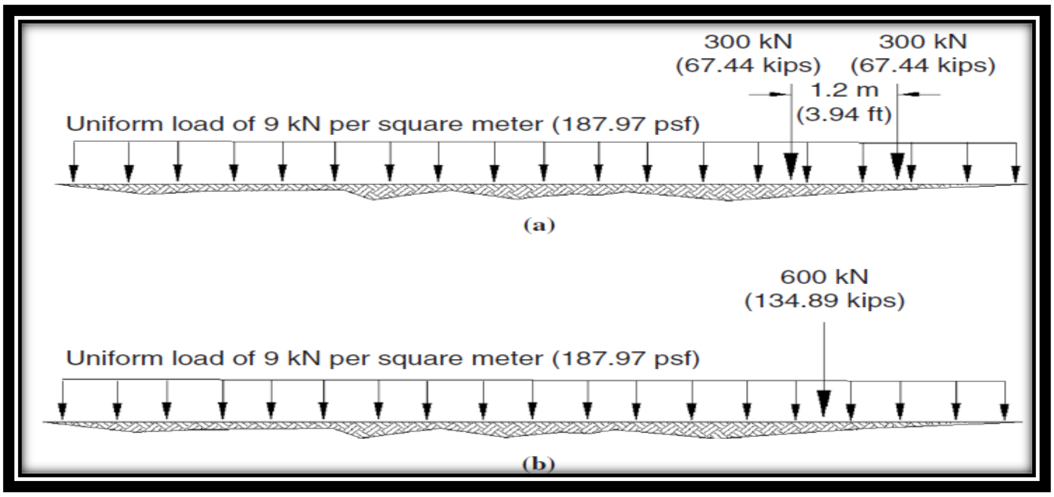


Fig. 4 Model 1 and 2 Loadings from Euro Codes

IV. RESULT ANALYSIS

i. Live Load

Bending moments, shear forces and deflections due to live load of vehicle loading of all codes i.e. IRC Codes, Euro codes and AASHTO Specifications has been calculated and presented graphicaly as shown below

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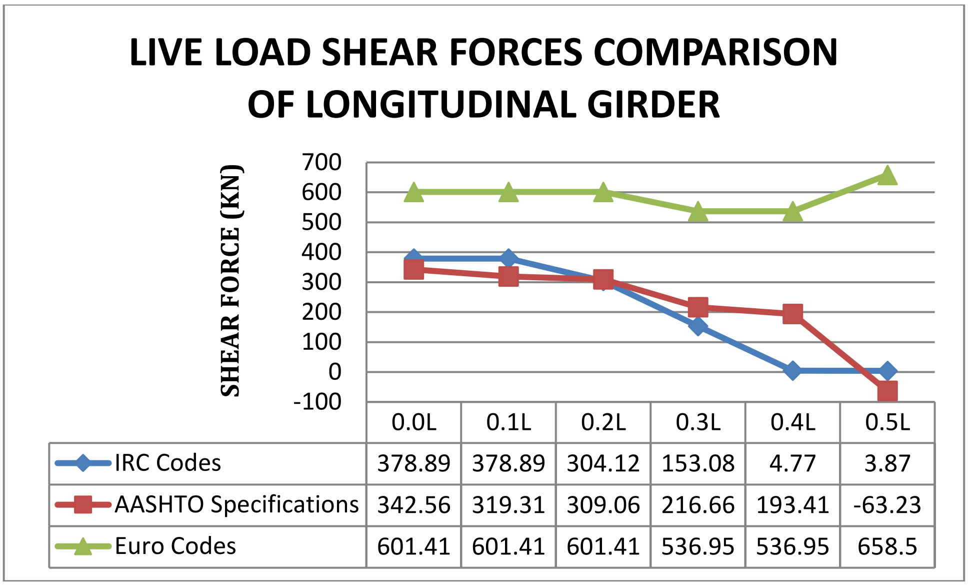
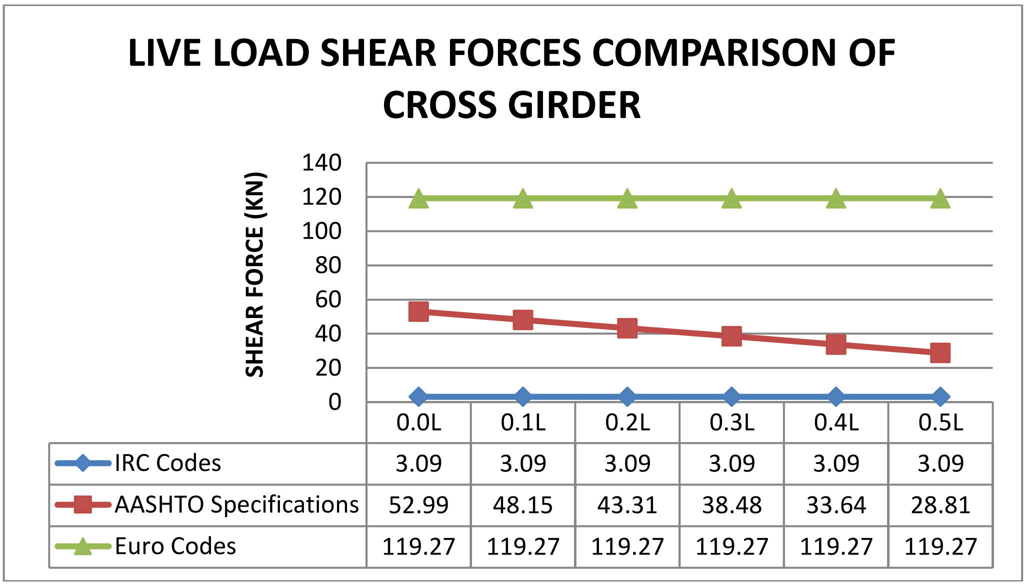


	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	378.89	378.89	304.12	153.08	4.77	3.87
AASHTO Specifications	342.56	319.31	309.06	216.66	193.41	-63.23
Euro Codes	601.41	601.41	601.41	536.95	536.95	658.5

Fig.5 Live load shear forces comparison of longitudinal girder

Shear forces due to live loads on longitudinal girder has been calculated and compared with graph. This analysis shows, at the edges longitudinal girder produced more shear force due to IRC loadings as compare to the shear force produced due to AASHTO Specification loadings but near mid span longitudinal girder produced less shear force due to IRC loadings as compare to the shear force produced due to AASHTO Specification loadings. Other side from this, longitudinal girder produced much more shear force due to Euro codes loadings as compare to both of them.



	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	3.09	3.09	3.09	3.09	3.09	3.09
AASHTO Specifications	52.99	48.15	43.31	38.48	33.64	28.81
Euro Codes	119.27	119.27	119.27	119.27	119.27	119.27

Fig.6 Live load shear forces comparison of cross girder

Shear force on cross girder due to vehicle loadings of different codes i.e IRC codes, Euro codes and AASHTO specifications has been calculated and graphicaly represented. The analysis of this comparison shows shear force on the cross girder is more due loadings of Euro codes as compare to others.

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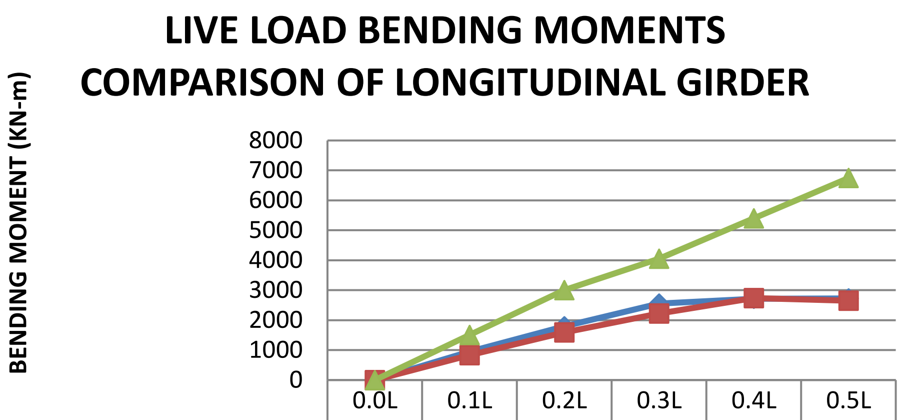
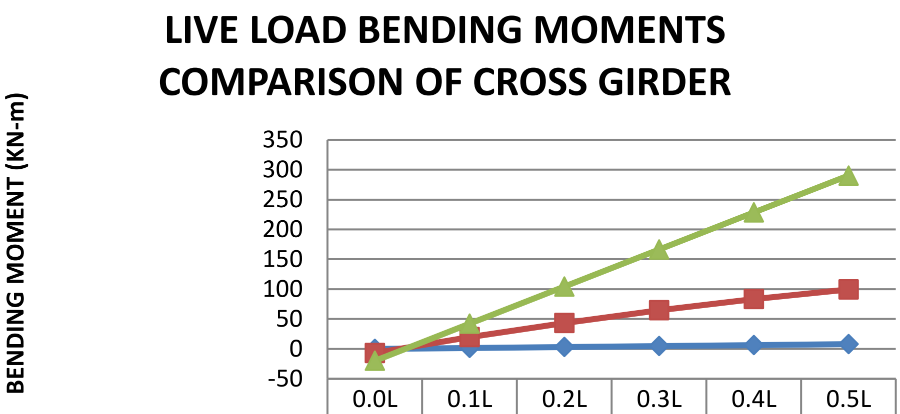


	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	0	947.06	1793.34	2554.73	2716.44	2726.18
AASHTO Specifications	0	826.42	1594.43	2224.65	2737.24	2654.06
Euro Codes	0	1502.12	3005.66	4053.18	5395.56	6744.28

Fig.7 Live load bending moment comparison of longitudinal girder

Bending moment on longitudinal girder is calculated and analysis is shown with graph. Bending moment produced due to different loadings are compared and analyzed. The analysis shows that the bending moment produced due to IRC Code loading and AASHTO Specifications increases gradually with respect to length of girder but in other hand bending moment produced due to the Euro code loading increases rapidly with respect to length.



	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	0	1.61	3.22	4.82	6.43	8.03
AASHTO Specifications	-6.82	19.47	43.25	64.52	83.27	99.51
Euro Codes	-19.99	42.03	104.05	166.07	228.10	290.12

Fig.8 Live load bending moment comparison of cross girder

Bending moment on cross girder is calculated and analysis is shown with graph. Bending moment produced due to different loadings are compared and analyzed. The analysis shows that as we change the loadings from IRC codes, AASHTO Specifications and Euro codes the rate of increment in bending moment increases respectively.

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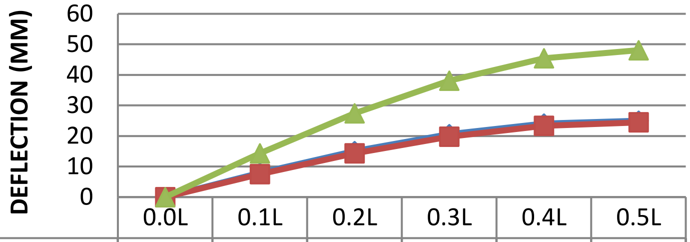
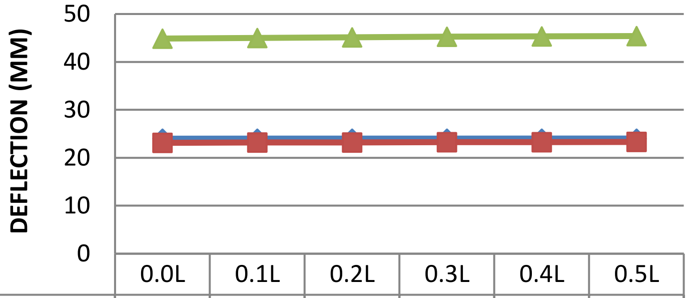


	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	0	7.95	15.09	20.62	24.02	25.00
AASHTO Specifications	0	7.54	14.37	19.8	23.31	24.45
Euro Codes	0	14.34	27.39	38.14	45.40	48.09

Fig.9 Live load deflection comparison of longitudinal girder



	0.0L	0.1L	0.2L	0.3L	0.4L	0.5L
IRC Codes	23.99	24.00	24.01	24.01	24.02	24.02
AASHTO Specifications	23.12	23.18	23.22	23.27	23.30	23.31
Euro Codes	44.88	45.02	45.15	45.26	45.35	45.4

Fig.10 Live load deflection comparison of cross girder

The deflection produces in longitudinal and as well as cross girder due to IRC codes and AASHTO Specifications are some what same but deflection due to Euro codes are almost double as compare to the other two codes. The behaviour and pattran of deflection is same in all results of deflection.

ii. Area of Steel

Design of bridge girders is conducted in STAAD Pro using different vehicle loadings of IRC Codes, AASHTO Specifications and Euro Codes. Maximum value of steel area required is considered in longitudinal girder as well as cross girder.

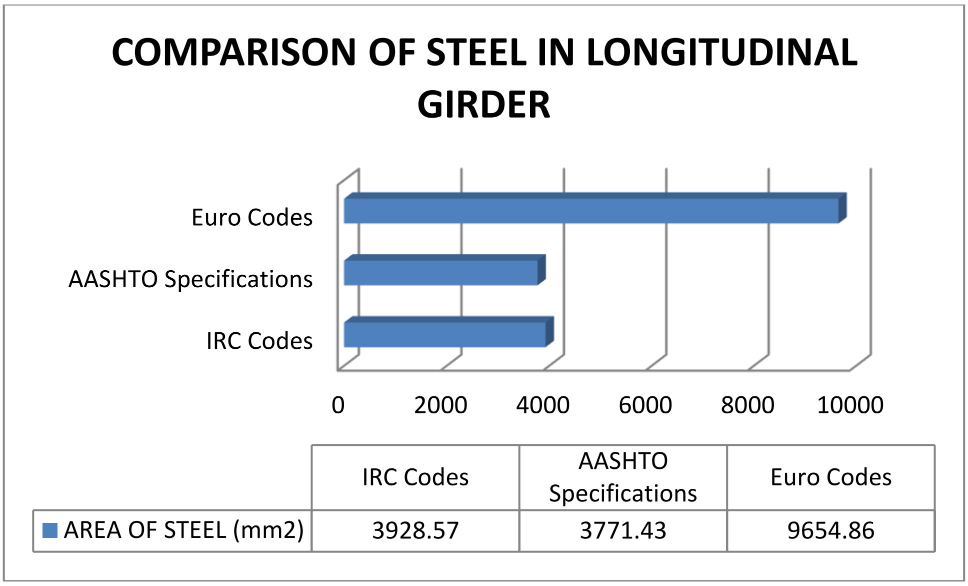


Fig.11 Comparison of steel in longitudinal girder

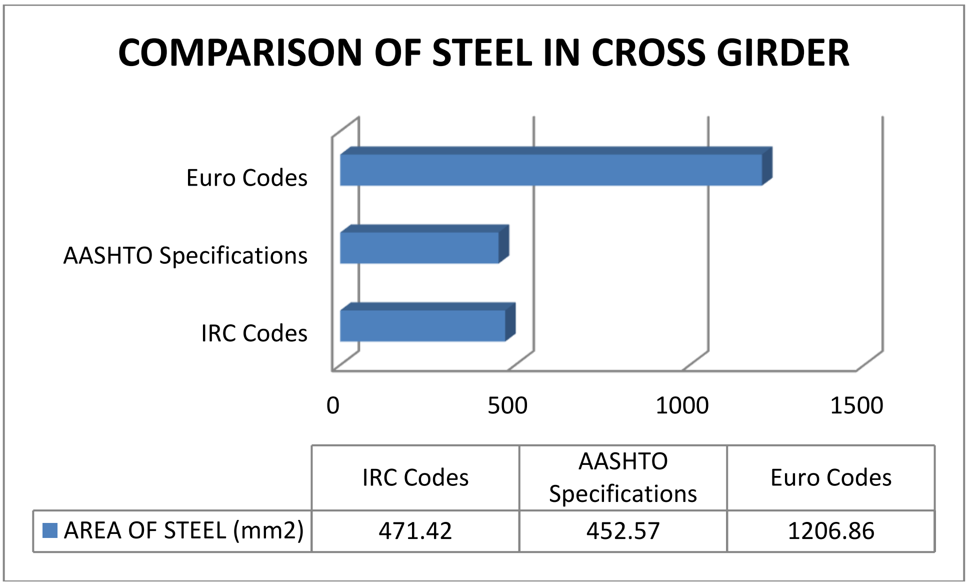


Fig.12 Comparison of steel in cross girder

The graphs presented above shows the comparison of area of steel required in the girders due to different loadings applied as shown above. The analysis results that design of Euro codes provides very much steel as compare to the other two design codes i.e. IRC codes and AASHTO specifications.

V. CONCLUSION

Different loadings are taken from IRC codes, AASHTO specifications and Euro codes. The conclusion of above analysis is as follows

1. In comparison of all three codes, Euro code designs are over reinforced as compare to the other two i.e. IRC codes and AASHTO specifications.
2. In design of bridge girders with Euro codes shear forces, bending moment and deflection are almost double as compare to the other two i.e. IRC codes and AASHTO specifications.
3. Design of bridge girders (up to 25m) using IRC codes are most economical and safer as compare to the other two i.e. AASHTO specifications and Euro codes.
4. IRC codes have the best combination of loading and design methods as compare to the other two i.e. AASHTO specifications and Euro codes.
5. Since the design of bridge girder using IRC codes acquire minimum value of deflection and bending moment so therefore IRC Class A loading is the most economical and optimum loading for the design of bridge girder in INDIA.

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