Comparative Study of design of longitudinal girder of T- Beam Bridge Using IRC 21-2000 & IRC 112-2011

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Abstract – ***The present paper describes the analysis and design of longitudinal girder of the T-beam bridge. In this case analysis is done using SAP 2000 software. After analysis design of the longitudinal girders are done by using IRC:21 and IRC:112 codes. The new unified concrete code (IRC:112) represents a significant difference from the previous Indian practice followed through IRC:21 & IRC:18. The code is less prescriptive and offer greater choice of design and detailing methods with scientific reasoning. This paper presents design of T-beam longitudinal girder design by both working stress method and limit state method and result obtained are compared with both methods. T-beam bridge of 18 m span are designed for class 70R vehicle.***

Key Words: *T-beam bridge, SAP 2000, IRC :21, IRC:112, Area of steel.*

1. INTRODUCTION

T-beam, used in construction, is a load-bearing structure of reinforced concrete with a T-shaped cross section. The top of the T-shaped cross section serves as a flange or compression member in resisting compressive stresses.

IRC 21:2000 code is used for designing RCC road bridges and for precast bridges IRC 18 are used previously before IRC 112 is published. Indian Roads Congress introduces new code of practice for designing of road bridges in India i.e. IRC 112:2011. IRC 21 is based on the working stress method and IRC 112 is based on the limit state method. IRC 112 contains both prestressed and Reinforced Concrete Bridge design. They also mention about working stress method in annexure. The object of issuing new code of practice for the concrete road bridge is to establish a common procedure for design and construction of road bridges in India based on the limit state method.

2. MODELING AND BRIDGE DATA

2.1 Bridge data

Table 1: bridge data

Span of the bridge	18 m
Width of the bridge	12 m
Over all depth	1.83
Thickness of wearing coat	0.056 m
Width of main girder	0.325 m
Width of cross girder	0.3 m
Depth of main girder	1.53 m
Depth of cross girder	1.53 m
Size of the kerb (on both sides)	(0.55 x 0.3) m
No of cross girders	5 no's
Spacing between the cross girders	4.5 m
Spacing between the longitudinal girders	2.65 m
Vehicle class	70R

2.2 Modeling of the T-beam Bridge using SAP

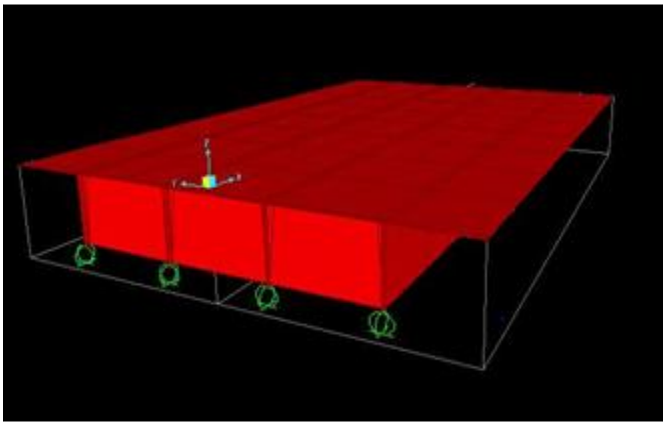

Figure 1: 3D modeling of T-beam bridge by using SAP 2000

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 06 | Sep-2015 www.irjet.net p-ISSN: 2395-0072

3. ANALYSIS AND DESIGN OF RC T-BEAM BRIDGE

3.1 Analysis of bridge

Analysis of the T-beam Bridge is done using SAP 2000. In this paper class 70R vehicle is considered for the analysis of RC T-beam Bridge. Results obtained in the analysis are further used for the design of T-beam bridge.

3.2 Design of T-beam bridge

3.2.1 As per IRC 21:2000 (Working Stress Method)

The governing design equation based on working stress method is given as,

$$M = A_{st}\sigma_{st}(d - \frac{D_f}{2})$$

M= Design bending moment (KN-m)

A_{st}= Area of steel (mm^2)

$\sigma_{st=}$ permissible stress in steel = 200 MPa

d = Effective depth of section (mm)

$D_{f=}$ Thickness of flange = 300mm

3.2.2 As per IRC 112:2011 (Limit State Method)

Formula for calculating area of steel as per IRC:112 is given by

$$x_u/d=1.2-\sqrt{(1.44-(6.68M_u)/(f_{ck}\, bd^2))}$$

If $x_u<D_f$, then section is design as rectangular section. Area of steel is calculated by using following formula

$$A_{st} = \frac{M_u}{0.87 f_y (d - 0.42 x_u)}$$

M_u = Ultimate bending moment

X_u = Depth of neutral axis.

F_y = Minimum yield strength.

d = Effective depth of section.

4. RESULTS AND DISCUSSIONS

4.1 Results

Table 2: Maximum bending moment in the longitudinal girder using SAP 2000

Girders	Maximum B.M (KN-m)	
	Dead load	Live load (70R vehicle)
Left exterior girder	1740.42	2391.75
Interior girder 1	1646.35	1723.63
Interior girder 2	1646.35	1723.63
Right exterior girder	1740.42	-378.33

4.2 Comparison of results

Table 3: comparison of results

Girders	Courbons method		SAP-2000	
	Dead load	Live load	Dead load	Live load
Left exteriorgirder	1676.29	1768.79	1740.42	2391.75
Interior girder	1676.29	1108.63	1646.35	1723.63
Right exterior girder	1676.29	-203.94	1740.42	-378.33

4.3 Comparison of steel quantity for girders by IRC: 21 and IRC: 112

After getting bending moment at different interval from SAP 2000, area of steel is calculated by both code books (i.e. IRC 21 and IRC 112). Area of steel for both exterior and interior girders is calculated as shown below. Also the percentage saving in steel achieved by the limit state method is calculated

4.3.1 Exterior girder steel area

Table 4: Area of steel for exterior girder

Girder c/s	Area of steel for exterior girder (mm^2)		reduction in steel quantity (%)
	As per IRC 21:2000)	As per IRC112:2011	
3	6991.69	5425.23	22.40
6	11804.58	9291.08	21.29
9	12461.90	9827.71	21.13
12	11008.8	8643.85	21.48
15	6991.69	5424.23	22.40
18	----	---	---

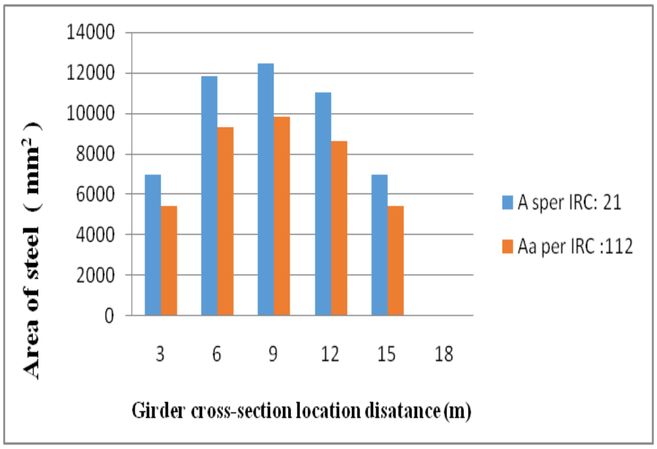

Fig 2: Variation of area of steel for exterior girder at various cross-sections as per IRC:21 and IRC:112

4.3.2 Interior girder steel area

Table 5: Area of steel for interior girder

Girder c/s	Area of steel for interior girder (mm^2)		% reduction in steel area
	As per IRC 21:2000)	As per IRC 112:2011	
3	5769.47	4461.14	22.69
6	8859.60	6912.12	21.98
9	10136.71	7938.39	21.67
12	8859.60	6912.12	21.98
15	5769.47	4461.14	22.68
18	----	----	---

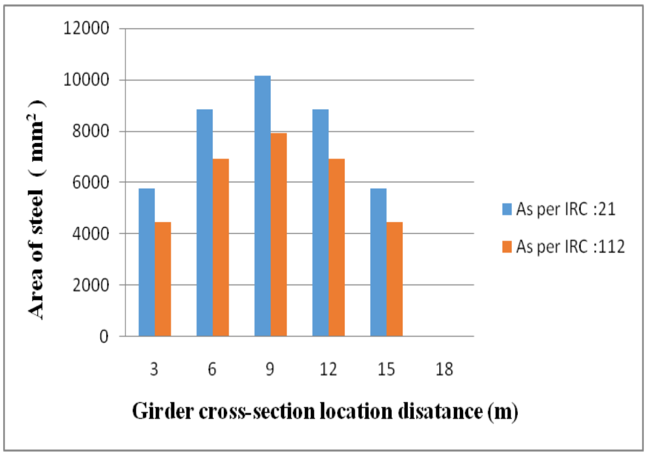

Fig 3: Variation of area of steel for interior girder at various cross-sections as per IRC:21 and IRC:112

From the table 3 and table 4 it is observed that a minimum of 20 percentage of steel is reduces by designing with IRC: 112 instead of designing with IRC:21.

5. CONCLUSIONS

A simple span of T-beam bridge was analyzed by using SAP 2000. Maximum bending moment for class 70R vehicle is obtained. After getting results design of T- beam bridge is done by both method (IRC21 &IRC112). It is noted that results obtained from finite element method is lesser than the result obtained by working stress method. It is also noted that by designing with IRC 112:2011 it is economic compared to IRC 21.

From fig 2 &3 it is noted that area of steel required is less by designed with IRC112 compared with IRC 21.

1. The modeling and analysis of RC T-beam bridge superstrucutre can be efficiently performed using SAP-2000 and results in time saving.
2. The design of concrete bridges as per the provisions of IRC:112-2011 leads to an economical design with a reliable safety margin since the design is based on probabilistic method of design.
3. As compared to IRC:21-2000, designing the girders as per IRC:112-2011, results in saving of longitudinal.

ACKNOWLEDGEMENT

The authors would like to thank Dr. Basavaraj G.Katageri principal of K.L.E.M.S.S.C.ET, Belagavi for their kind support and providing good infrastructure. The authors are grateful to Prof. (Smt) Bharti Chiniwalar, Head of Civil Department, for encouragement and support.

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