

## Analysis and Design of Steel Truss Railway Bridge

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**Abstract-** This paper presents the analysis and design of steel truss Railway Bridge with respective dimensions. To do so, considering two types of truss sections are used in bridges which are Howe and Pratt truss of same span length. The two types of truss sections are analysed by using STAAD Pro Software according to load defined in Indian railway standard bridge rules and further the structural members of the truss bridge has been designed as per the Indian railway standard code in order to evaluate stability and economy of each bridge. The steel weight needed for two truss bridges is assessed from the final design to compare and evaluate their efficiency. These results are compared together in order to identify the most optimal bridge

**Keywords-** Howe truss, Pratt truss, Steel truss railway bridge, STAAD Pro.

### I. INTRODUCTION

Bridge is an important structure which is required for the transportation as well as communication. Steel bridges are broadly classified as plate girder bridges and truss bridges. Long span truss bridges are more economical as compared with plate girder bridges. The design of truss bridges, require an optimization in terms of weight and cost.

The truss bridges are generally preferred for long span railway bridges. The construction of steel truss bridge is faster due to lightness of members and fabrication of joints at site. Presently in India, a general type of steel bridges are designed, but a moderate pattern of Steel bridge is required to rise by the time due to the higher demands for railways traffic.

The main objectives of the present study are to analyse and design truss bridge with railway loadings and to make comparative study of these bridges. In this paper comparative study on two type of truss bridges has been presented.

### II. LITERATURE REVIEW

**2.1 Shubhank Gupta et al (October, 2017)** (1) in their paper entitled " comparative analysis of different truss type railway steel bridge considering railway loadings." This research's objective was to analysis and design of steel truss railway bridge with 50 m span. The railway loadings of 32.5 tone (DFC loading) has been applied in different types of truss sections which determining the best stable and economical section. Analysis and design is done using tool STAAD pro to optimize and determine best stable sections for comparison. The design of structural members of the truss is done according to the Indian railway standard code. They considered four types of truss bridge sections along with dead load and rail load for the Steel bridge for analysis purpose . Following are the salient conclusions of this study- shear Force, axial Force, Deflection, Steel Structure Weight.

**2.2 Mansingh Patil et al (2012)** (2) in their paper entitled "influence of semi rigid joints on fatigue life of steel truss railway bridge" This research's objective was to influence of joint flexibility on the fatigue life of 76.2m truss bridge due to moving load at different speed. In this study, Passenger train (25T P1) is considered as per RDSO. The joint flexibility is taken into account in the analysis, by means of modified joint rotational stiffness. The bridge is modeled in SAP 2000. The reduction of joint rotational stiffness by 5%, 10%, 25% and 50%. They concluded that the reduction of joint rotational stiffness up to 50% has less effect on structural stability of steel truss Railway Bridge.

**2.3 Thiri Phyo et al (June, 2014)** (3) in their paper entitled "vibration effect on steel truss bridge under moving loads" This research's objective was to vibration analysis of steel truss bridge under various moving loads by using STAAD Pro Software. The proposed bridge is warren truss, through type. Load coming on bridge are dead loads, live loads, wind load, impact effect, seismic effect and temperature effect. For vehicle live load, two types of loading (train and truck loadings) are considered.

They conclude that the effect of vibration on steel truss bridge under moving loads. In this along with bridge vibration, influence of vehicle speed and damping ratio are also investigated. First, there is significant difference in bridge acceleration, velocity and displacement under changes of vehicle speed. The higher the speed, the greater the acceleration, velocity and displacement of the bridge. The second investigated factor is the effect of damping ratio. In this case, the difference is occurred although it is small in magnitude. The higher the damping ratio, the lesser the acceleration, velocity and displacement of the bridge. It can be concluded that the proposed steel truss bridge is satisfactory to service.

**2.4 Peeyush Chowdhary et al (Aug, 2016)** (4) in their paper entitled "parametric studies of truss bridges for economic consideration" The cost of structures reduces due to modification of forms and shapes of conventional truss bridges with the increase of span and height of trusses. The paper deals with the comparison of weight of conventional truss bridges with the modified form of two truss bridges. It is observed that the economies of truss bridges are based on different parameters such as span length, panel length, and angle of truss and height of truss bridge. The conventional warren truss bridge is selected as a reference bridge for the comparison of economy with modified camel back parker truss and segmental arch truss bridge. An analysis and design of the selected three bridges are carried out for railway broad gauge main line loading, using working stress method, forces in all members of truss bridges are calculated. Neglecting the seismic and wind effect with end supports as hinged and roller respectively As per the magnitude and nature of forces of members of trusses, the steel sections are provided. All the results in terms of weight are shown in a tabular form for comparison. It is concluded that as the span of truss and height of truss increases, the modified trusses are economical with respect to conventional truss bridge.

### III. TYPES OF TRUSS BRIDGES

#### 3.1 Pratt truss

A Pratt Truss used over the past two centuries as an effective truss method. The vertical members are in compression and the diagonal members are in tension. Top chord member are in compression while bottom chord member are in tension.

#### 3.2 Warren Truss

The Warren Truss is another very popular truss structure system and is easily identified by its construction from equilateral triangles.

#### 3.3 K truss

The K Truss found to be more complicated version of the Pratt Truss. There is main difference that the vertical members have become shortened and improving its resistance against buckling.

Howe truss- Howe trusses are essentially the opposite of Pratt trusses in terms of geometry.

### IV. OUTCOME OF STUDY

#### 4.1 The main objectives of the present study are as follows:

- 1) To analyze and design railway truss bridge with different types of truss sections.
- 2) To analyze the structure using STAAD pro software for various loads acting on the structure.
- 3) To understand the concepts of influence line for the analysis of truss bridge.
- 4) To determine the most cost-effective type of truss section for railway-bridge.

### V. LOAD COMING ON BRIDGE ARE:

The loads to be taken into account in the bridge modelling are presented in the following sections. Some of them are applied vertically to the structure, others horizontally. There are different types of loads acting on bridge are dead load, live load, lateral load etc.

### 5.1 Dead load

As per clause 2.2 of IRS Bridge rules, the dead load is the weight of the structure itself with the permanent loads carried thereon. The dead load consist of weight of stock rails, weight of guard rails, weight of fastening, weight of sleepers per track per meter which to be assigned as udl on the stringers

### 5.2 Live load

The live load on bridge basically consists of the loads of the vehicles (train engines and coaches) that cross the bridge. The live load due to train loadings have been specified in Bridge Rules published by the Railway Board, Ministry of Railways for various types of tracks. These standard loadings consist of number of wheel loads followed by a train of uniformly distributed load. It is cumbersome to analyse the bridge truss using these standard loadings in the form of wheel loads. The Bridge rules have simplified the analysis by recommending the use of equivalent uniformly distributed load (EUDL) for computing the maximum B.M and maximum Shear force. As per clause 2.3 of IRS Bridge rules, 25t Loading -2008 with maximum axle load of 245.2 kN is to be used for broad gauge loading. Thus live load per wheel is 122.6 kN and is applied as moving load with wheel spacing of 1.676 m.

### 5.3 Impact load

As per clause 2.4.1.1 (c) of IRS Bridge rules, the augmentation in load due to dynamic effect should be considered by adding a load equivalent to coefficient of dynamic augment (CDA) multiplied by live load giving maximum stress in the member. The CDA should be obtained as follows and shall be applicable upto 160 kmph on BG.for single track spans:  $CDA=0.15+(8\div 6+L)$  subject to maximum of 1.0 Where L is

- (1) The loaded length of span in metres for the position of the train giving the maximum stress in the member under consideration.
- (2) 1.5 times the cross-girder spacing in the case of stringers (rail bearers) and
- (3) 2.5 times the cross girder spacing in the case of cross girders.

### 5.4 Longitudinal Forces

Where a structure carries railway track, provision as under shall be made for the longitudinal loads arising from any one or more of the following causes: the tractive effort of the driving wheels of locomotives, the braking force resulting from the application of the brakes to all braked wheels. For Railway bridges the value of longitudinal forces due to either tractive effort or the braking force for a given loaded length shall be obtained from as per clause 2.8 of IRS Bridge rules, the Appendices XXIV.

### 5.5 Racking force

When train moves, there is always a small lateral movement of coaches. This lateral movement of coaches cause lateral force, commonly known as racking force. As per clause 2.8 of IRS Bridge rules, lateral bracing of loaded deck of railway spans shall be designed to resist, in addition to wind and centrifugal loads, a lateral load due to racking forces of 5.88 KN/m treated as moving load.

### 5.6 Wind Pressure effect

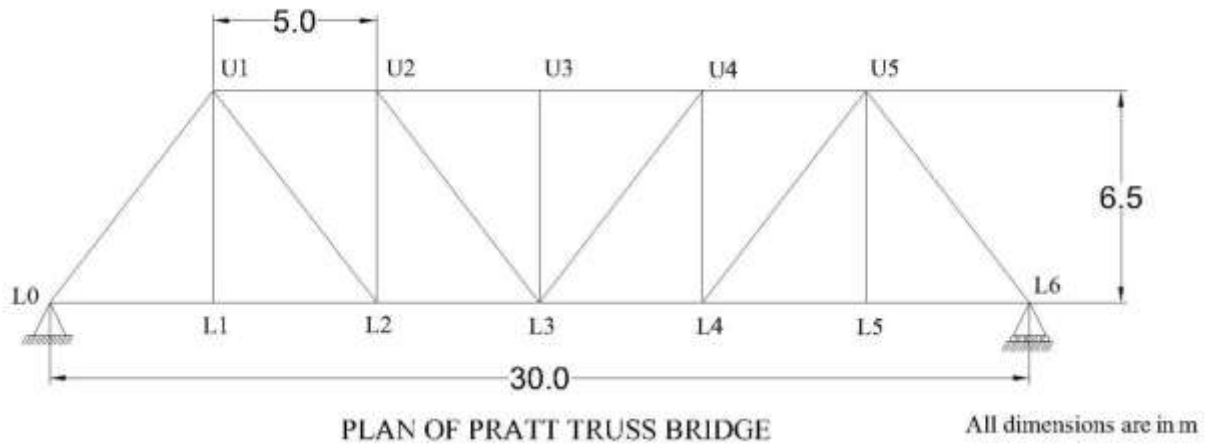
As per clause 2.11 of IRS Bridge rules, the wind pressure are acting at the deck level should be considered on the bridge.

### 5.7 Analysis and design method

Analyses of truss members are done using STAAD.Pro. Tool (Analytically) as well as manually. Maximum design forces for each type member i.e., top chord, bottom chord, vertical, inclined members of truss, stringers, floor beams or cross

beams and bracings of truss are worked out from combination of loads. The combination of loads used is (1) D.L + L.L. + I.L and (2) lateral load + longitudinal load. Hence in this way the various members of super structure of bridge are analysed.

Truss members are axial members that can carry axial compressive force and axial tensile force and the stringers and cross beams carry bending moment. The load system is so placed that the resultant of all the loads is maximum. Maximum forces and moments in longitudinal stringers and cross beams at bottom floor level are calculated based on EUDL for railway loading given in bridge rules for design purpose. The design of structural members of truss, floor beams, stringer beam, sway bracing, portal bracing, top lateral bracing, bottom lateral bracing and joints is done as per Indian railway standard steel bridge code.



**5.8 Forces in the member of the truss due to Dead load, Live load and Impact load**

(+'for Tension and '-for Compression)

Members	Impact factor	Area of ILD	Load kn/m			Forces in member due to			Total force	
			Dead load	Live load	Impact load	Dead load	Live load	Impact load		
Top chord member	U <sub>1</sub> U <sub>2</sub>	0.372	-15.375	8.9	48.289	17.963	-136.837	-742.443	-276.181	-1155.461
	U <sub>2</sub> U <sub>3</sub>	0.372	-17.295	8.9	48.289	17.963	-153.925	-835.158	-310.670	-1299.753
Bottom chord member	L <sub>0</sub> L <sub>1</sub> , L <sub>1</sub> L <sub>2</sub>	0.372	+9.615	8.9	48.289	17.963	+85.573	+464.298	+172.714	+722.585
	L <sub>2</sub> L <sub>3</sub>	0.372	+15.375	8.9	48.289	17.963	+136.837	+742.443	+276.187	+1155.461
Vertical member	U <sub>1</sub> L <sub>1</sub>	0.650	+5.0	8.9	68.886	44.762	+44.5	+344.33	+223.81	+612.64
	U <sub>2</sub> L <sub>2</sub>	0.594	+2.0	8.9	66.217	39.333	-23.25	+132.434	+78.666	+188.85
		0.483	-4.5		58.026	28.026		-261.117	-126.117	-409.484
	U <sub>3</sub> L <sub>3</sub>	--	-	-	-	-	-	-	-	-
Diagonal member	L <sub>0</sub> U <sub>1</sub>	0.372	-15.770	8.9	53.149	19.771	-140.353	-838.159	-311.788	-1290.3
	U <sub>1</sub> L <sub>2</sub>	0.814	-0.63	8.9	84.815	69.293	+84.220	-53.433	-43.654	-12.867
		0.417	+10.093		54.982	22.927		+554.933	+231.402	+879.072
	U <sub>2</sub> L <sub>3</sub>	0.594	-2.523	8.9	66.217	39.333	+28.0706	-167.065	-99.237	-238.231
		0.483	+5.677		58.026	38.026		+329.413	+159.103	+516.586

**5.9 Forces in members due to various effects.**

(‘+’for Tension and ‘-’for Compression)

Members	Due to D.L +L.L +I.L	Due to longitudinal load	Forces due to wind		Overtuning effect	Portal effect	Sway effect	Max. wind effect	Max. forces	
			Bottom lateral truss effect	Top lateral truss effect						
Top chord member	U <sub>1</sub> U <sub>2</sub>	-1155.46			+5.029	+76.21			+71.189	-1226.65
	U <sub>2</sub> U <sub>3</sub>	1299.753			+11.37	+85.83			+74.361	-1374.11
Bottom chord member	L <sub>0</sub> L <sub>1</sub>	+722.585	+490.30	+42.11		+47.66	+8.316		+98.109	+1311.01
	L <sub>1</sub> L <sub>2</sub>	+722.585	+412.02	+109.53		+47.66	+8.316		+165.516	+1300.12
	L <sub>2</sub> L <sub>3</sub>	+1155.46	+367.79	+142.84		+76.21	+8.316		+226.858	+1750.04
Vertical member	U <sub>1</sub> L <sub>1</sub>	+612.64				+24.78		+2.682	+27.468	+640.10
	U <sub>3</sub> L <sub>3</sub>	-				+24.78		+2.682	+27.468	+27.468
	U <sub>2</sub> L <sub>2</sub>	+188.85								+203.925
		-409.484				+12.39		+2.682	+15.075	-424.559
Diagonal member	L <sub>0</sub> U <sub>1</sub>	-(1290.3 +27.418) =-1262.8				+78.17	+13.67 9		+91.679	-1409.57
	U <sub>1</sub> L <sub>2</sub>	-12.867								-59.777
		+879.07				+46.91			+46.910	+925.98
	U <sub>2</sub> L <sub>3</sub>	-235.31								-253.869
	+516.586				+15.63			+15.638	+532.224	

**VI. SUMMARY**

From the analysis it is observed that, the application of exact wheel load may be difficult or complex for theoretical analysis but using the software approach it can easily achieved through very realistic way. The software results are in good agreement with manual calculations and thus the software is validate. Further we go for design of truss sections of the bridge in terms of comparison of steel weight and stability. From the comparison to get best optimal truss bridge.

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