



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 6, June 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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Comparing Truss Types for Railway Steel Bridges under Dynamic Loads on Software

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ABSTARCT: Beam bridges stand out as the most straightforward and ancient bridge design still in use today, enjoying widespread popularity. On the other hand, a truss bridge relies on a truss for its load-bearing structure. Trusses come in various designs, each tailored to specific bridge types and traffic volumes. This research focuses on designing and analyzing diverse bridge structures for railway systems. The trusses, crafted from steel, undergo a comparative study based on outcomes. The study encompasses four truss designs: rectangular, X-type, V-type, and K-type. Utilizing Staad Pro. Software, the results will be evaluated in terms of support reaction, displacement, shear force, and torsion. Both maximum and minimum values will be compared for each case, accompanied by a cost analysis.

KEYWORDS: Railway Bridge, Staad.Pro, Structural Analysis, Steel Section, Truss

I. INTRODUCTION

In India, Economic progress mainly depends on the railway and is considered as the Life line of the Nation. India has the second largest rail network in the world, transporting over four billion people annually and the total figure of existing railway bridges are approx. 1,20, 000. Out of these, 731 are long span open girders, 19014 are rolled steel joist or plate girders. So it can be seen that more than 20% are Steel girder bridges. Due to continuous movement trains, the members and their connections are subjected to repeated loadings due to which the stiffness of the joint gets reduced, which are more prone to fatigue damage.

Analysis of a three-dimensional structure was carried out using STAAD. Pro software both models were subjected to I.R.C. Loadings to produce maximum bending moment. The results were analyzed and it was found that the results obtained from the finite element model are lesser than the results carried from 1-D (one dimensional) analysis, which states that the results obtained from I.R.C. loadings are conservative and FEM gives economical design.

Rajesh F. Kale, N.G.Gore, P.J.Salunke (January 2014)[7]. Studied the cost efficient approach of reinforce cement concrete T-beam girder. His main objective function was to reduce the total cost in the design process of the bridge system considering the cost of materials. The cost of each structural component such as material, man power, cost for reinforcement, concrete and formwork. design methods

Georgios Michas (2012)[8]. Discussed various non-ballasted concepts and some considerations are made in relation to life cycle cost for high speed track. It is concluded that slab track is in a loconcret perspective, more economically efficient as observed.

TT. Pramod Kumar, &G.Phani Ram (2015)[. This present research's goal was to appraise the monetary significance of the railroad cum Road Bridge. This paper was done to discover the decrease in cost of development

II. METHODOLOGY

Classifications of Bridges

On The Basis Of Material:

i. Steel bridges: these types of the bridges are constructed in having long span where moving load is high. They are the primary materials which are used in arches, decks, suspension cables and in trusses.

ii. Concrete bridges: On the basis of material this type is most common used in construction of the bridges. In concrete type there are pre-stressed and reinforce types are bridges are common.



Fig 1:- Image of truss bridge Mumbai-Ahmedabad High Speed Rail Corridor

On the Basis of Life of Bridge:

- i. Temporary bridges: The constructions of these types of bridges are for short span for the use of short time like military bridges etc.
- ii. Permanent bridges: The lives of these types of bridges are 100 or more than that. Permanent bridge are mostly constructed where the life is depends upon their design, load taking capacity etc.

On the Basis of Structural System:

- i. Truss bridges: Members of this type of bridge is steel type truss member which resist forces axial in compression or in tension. The members are constructed in triangular shape.
- ii. Beam having T structure: In this type live load is supported side by side in Reinforced Concrete Beam.

On The Basis Of Function:

- i. Highway bridges: In this type there is vehicle traffic are calculated which is of trucks, Car , Buses, Tanks etc .in highway bridges there are also lane is provide as per Code like single , double etc.
- ii. Railway bridges: Bridges which are constructed for the crossing of railway are known as railway bridges. These bridges are mainly constructed by steel truss.

On The Basis Of Support Condition:

- i. Simply Supported: hinged are simply supported in main girder or in trusses which is fixed in one end and other end is movable, equilibrium condition is provided for the analyzing of the support.
- ii. Continuous Support bridges: the support in this type is continuous which is on main girder or Trusses .in this type the joints expansion are less by this the maintenance is low and it became economical.

. On The Basis Of Span Length:

- i. Short Span: These types of bridges have 50m length due to the short length it is called as short span bridges.
- ii. Long Span: These types of bridges have 200m or more than 200m span length.

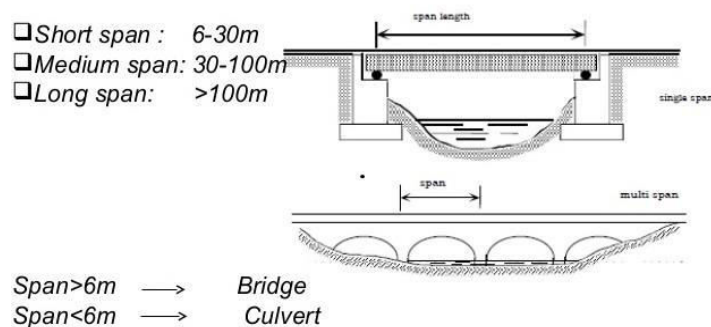


Figure.2: Different span Length Bridge

Reason for Bridge Failures

The reason for the failure of bridge is based upon material of the bridge like timber, steel, concrete, etc. In steel bridge most common failures are fracture, buckling, fatigue, shearing, corrosion and yielding. Others reason in the sub

structure of the bridges during flood soil erosion happen due to which soil is settle and cause failure in both concrete and steel bridge.

Distribution of Load in Steel Truss Bridge

Truss bridges load is transfer from all the members of the truss or all the nodes of the truss. Gravity load which is applied on the truss bridge is inducing by moving vehicle load which are transfer on the supporting piers.

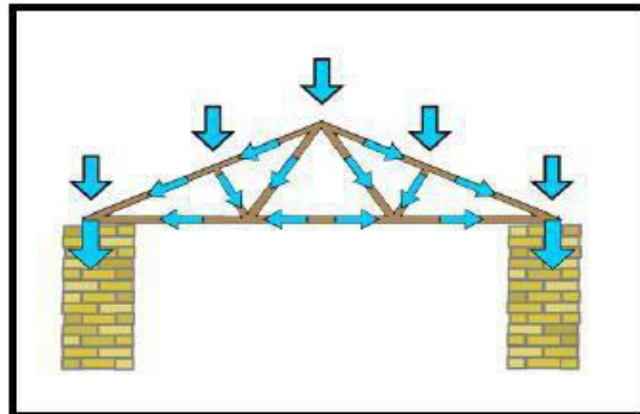


Figure 3: load distribution on truss bridge

Loads on Bridges

(a) The design of steel bridges shall be in accordance with the Indian Railway Standard Code of Practice for the Design of Steel or Wrought Iron Bridges carrying Rail, Road or Pedestrian Traffic (Steel Bridge Code).

(b) The design of concrete bridges shall be in accordance with the Indian Railway Standard Code of Practice for Plain, Reinforced and Prestressed Concrete for General Bridge Construction (Concrete Bridge Code).

When we construct a bridge we have to consider its environment and weight .by the nature of the bridge loads are decided on it. Various loads are act on the bridge but in my case I discuss about those loading which I take for analysis of bridge.

Dead Load

Live Load

Impact load

Forces due to curvature or eccentricity of track

Temperature effect

Dead Load

Dead load is the weight of the structure itself together with the permanent loads carried thereon.

For design of ballasted deck bridges, a ballast cushion of 400mm for BG and 300mm for MG shall be considered. However, ballasted deck bridges shall also be checked for a ballast cushion of 300mm on BG and 250mm on MG.

Live Load

Weight which is applied due to the vehicle movement and pedestrian movement are called as live load. Live load is load which changes with respect of time and load applied also changes. Example of live load is bike, cars, trucks, etc. moving on the bridge are calculated as live load. There are three type of IRS loading which is depends upon the location, purpose, and properties of bridge. Following are the type of loading which is given Railway Bridges including combined Rail and Road bridges- Railway Bridges including combined rail and road bridges shall be designed for one of the following standards of railway loading:

(a) For Broad Gauge - 1676mm –
 “25t Loading-2008” with a maximum axle load of 245.2 kN (25.0t) for the locomotives and a train load of 91.53 kN/m (9.33t/m) on both sides of the locomotives.

(b) For Metre Gauge-1000mm

(i) Modified Metre Gauge Loading-1988 with maximum axle load of 156.9 kN (16.0 t) for locomotives and a train load of 53.9 kN (5.5t) per metre on both sides of locomotives with maximum axle load of 137.29 kN (14.0t) for the trainload.

(ii) Standard M.L. of 1929 for 129.4 kN (13.2t) axle loads and a train load of 37.95 kN (3.87t) per metre behind the engines.

(iii) Standard B.L. of 1929 for 104.9 kN (10.7 t) axle loads and a train load of 37.95 kN (3.87 t) per metre behind the engines.

(iv) Standard C of 1929 for 79.4 kN (8.1 t) axle loads and a train load of 37.95 kN (3.87 t) per metre behind the engines.

(c) For Narrow Gauge-762 mm

(i) 'H' (Heavy) class loading with a maximum axle load of 95.1 kN (9.7 t) and a train load of 27.8 kN (2.83 t) per metre behind the engines.

(ii) 'A' class Main Line loading with a maximum axle load of 79.4 kN (8.1 t) and a train load of 27.8 kN (2.83 t) per metre behind the engines.

(iii) 'B' class Branch Line loading with a maximum axle load of 59.8 kN (6.1 t) and a train load of 27.8 kN (2.83 t) per metre behind the engines.

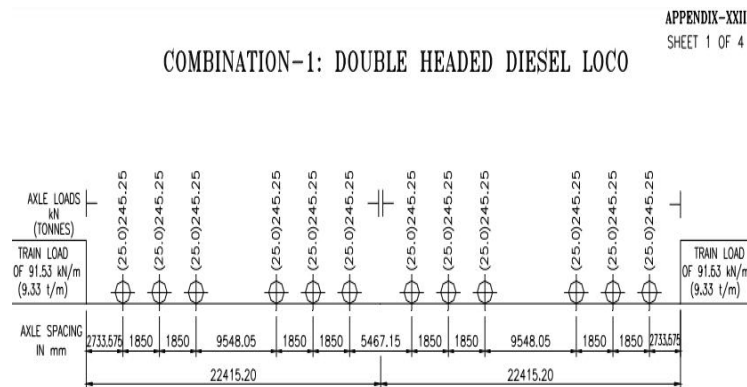


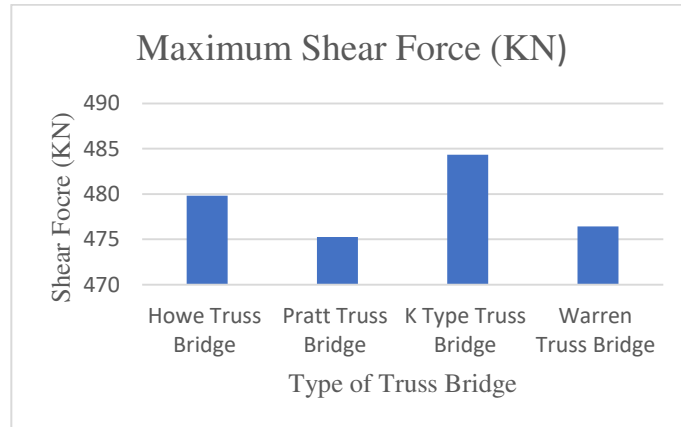
Figure4: Moving Load as per IRS – 25 t loading-2008

III. RESULTS AND DISCUSSION

Graphical Representation of Results \

Table : Maximum Shear Force

Type of Truss Bridge	Howe Truss Bridge	Pratt Truss Bridge	K Type Truss Bridge	Warren Truss Bridge
Maximum Shear Force (KN)	479.81	475.243	484.339	476.419



Graph: Maximum Shear Force of Truss Bridge

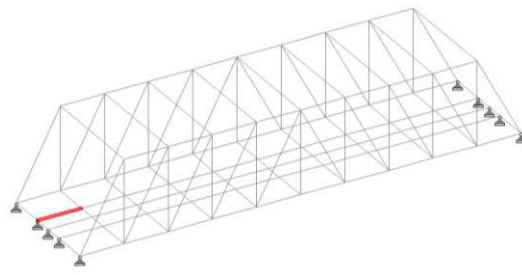


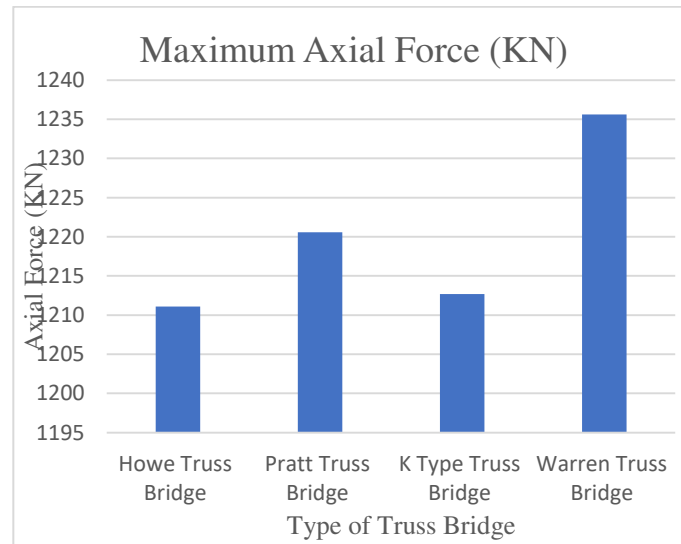
Figure : Maximum Shear Force of Howe Truss Bridge

Axial Force

Magnitude of maximum stress for various forms of truss has been plotted in figure number 4.2 below it is determined that maximum axial force is generated in Warren Truss Bridge whereas minimum in howe type truss which shows that maximum force distribution will be measured in Warren Truss Bridge as compared to other cases.

Table Maximum Axial Force

Type of Truss Bridge	Howe Truss Bridge	Pratt Truss Bridge	K Type Truss Bridge	Warren Truss Bridge
Axial Force (KN)	1211.1	1220.562	1212.679	1235.632



Graph: Maximum Axial Force of Truss bridge

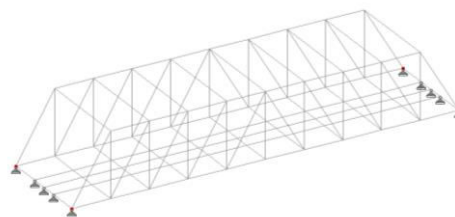


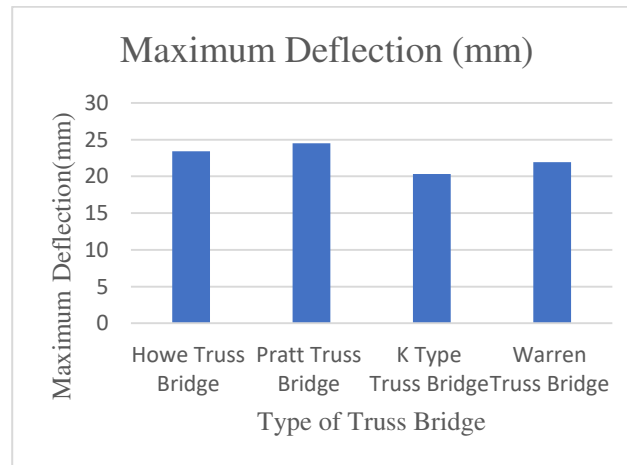
Figure Maximum Axial Force of Howe Truss bridge

Deflection

Magnitude of maximum stress for various forms of truss has been plotted in figure no 4.3 below it is determined that deflection is maximum in Pratt Truss Bridge and followed by howe bridge whereas minimum in K Type Truss Bridge and warren type steel bridge which indicates that Pratt Truss Bridge and howe truss bridge will require more supports as compared to other cases.

Table Maximum Deflection

Type of Truss Bridge	Howe Truss Bridge	Pratt Truss Bridge	K Type Truss Bridge	Warren Truss Bridge
Maximum Deflection (mm)	23.399	24.491	20.33	21.939



Graph Maximum Deflection of Truss bridge

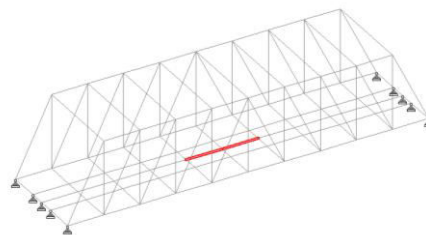


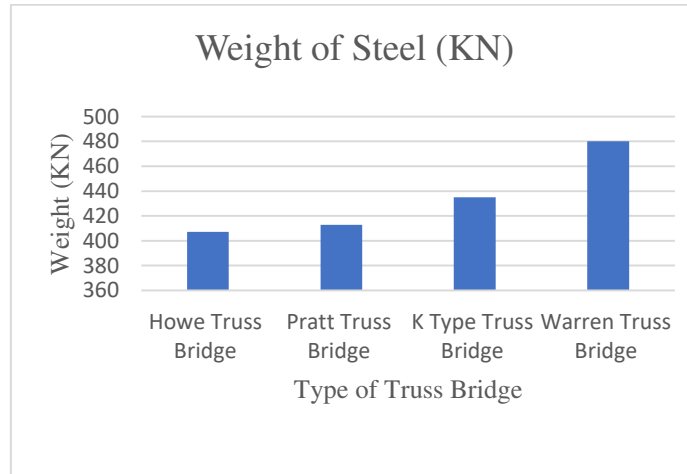
Figure : Maximum Deflection of Howe Truss bridge

Steel Section Weight:

Magnitude of maximum stress for various forms of truss has been plotted in figure number 4.4. It is observed that warren truss type bridge structure will be more costly for same loading as compared to other cases whereas howetype bridge will be economical in comparison to other cases.

Table Weight of Steel

Type of Truss Bridge	Howe Truss Bridge	Pratt Truss Bridge	K Type Truss Bridge	Warren Truss Bridge
Weight of Steel (KN)	407.141	412.869	434.976	480



Graph : Weight of steel for Truss bridge

Comparison of All Section with Respective Cost

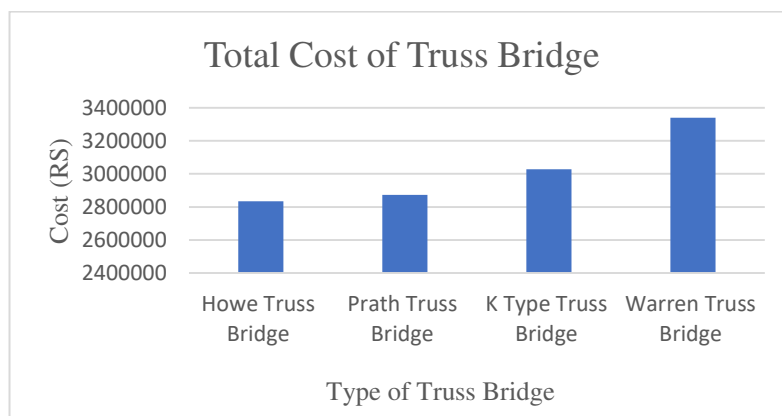
Table : Cost parameters

Sr No	Parameters	Truss Section
1	Material (Rs/kg)	65/-
2	Connections (% with total rate of material)	5% (welded or bolted)
3	Serviceability	As per requirement
4	Workmanship	Skilled
5	Transportation	Depends up on location

Table: Comparison of truss bridge with respective cost

Sr No	Parameter	Howe Truss Bridge	Pratt Truss Bridge	K Type Truss Bridge	Warren Truss Bridge
1	Total Weight of structure (KN)	407.141	412.869	434.976	480
2	Total Weight of structure (kg)	41516.82787	42100.92131	44355.20795	48946.37822
3	Unit weight of Truss (Kg)	70 (Including Fabrication)	65 (Including Fabrication)	65 (Including Fabrication)	65 (Including Fabrication)

A	Rate of material	2698593.811	2736559.885	2883088.516	3181514.584
B	Rate of material connection	134929.6906	136827.9943	144154.4258	159075.7292
C	Total Rate (A+B)	2833523.502	2873387.88	3027242.942	3340590.314



Graph: Total Cost of Truss Bridge.

IV. CONCLUSION

Shear Force: In terms of unbalance forces Pratt type truss bridge and Howe truss bridge is more stable showing less shear forces, whereas maximum is observed in K-Type truss bridge.

Axial Force: 1211.1 KN

Deflection: They observed that Maximum deflection is observed in Pratt truss bridge whereas least in K type truss bridge.

Steel Structure Weight: As India is a developing country therefore there is a need of economical sections to have a cost effective design to bear same loading in lesser cost. The most economical steel truss bridge for Board Gauge railway for loading of IRS 25t Loading-2008 is Howe Truss Bridge as compare to other type of truss bridge.

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