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COMPARATIVE ANALYSIS OF DIFFERENT TRUSS TYPE RAILWAY STEEL BRIDGE CONSIDERING RAILWAY LOADINGS.

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ABSTRACT

This paper presents the analysis and design of steel truss railway bridge of span 50 m. The bridge with same railway loadings of 32.5 tonne has been assigned in different types of truss sections to determine the best stable and economical section. Analysis and design is completed using tool staad pro to optimize the section and determine best stable sections for comparison. The design of structural members of the truss is done in accordance with provision of Indian railway standard code and Indian roads congress code.

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

I. INTRODUCTION

Bridge is an important structure required for the transportation network. With the fast innovation in technology the conventional bridges have been replaced by the cost effective structured system. For analysis and design of these bridges the efficient methods are available. In this paper comparative study on different type of truss bridge has been presented.

Presently in India, a general type of steel bridge is designed, although at a moderate pattern of Steel bridge is required to rise by the time due to the higher demands for railways traffic and short distance routes.

The main objectives of the present study are to analyze and design truss bridge with railway loadings and to make comparative study of these bridges.

II. LITERATURE REVIEW

T.Pramod Kumar, G.Phani Ram (July 2015) This research's objective was to estimate the economic importance of the railway cum road bridge. This paper was carried out to find out the reduction in cost of construction by providing single bridge for both road as well as railways. The analysis and design phase of the project was done utilizing STAAD PRO V8i. It was observed that the construction of a single bridge reduced the cost of two separate bridges for road and railways, also land acquisition problem is reduced to some extent.

R.Shreedhar, Spurti Mamadapur (September 2012) Analysed a simple span T-beam bridge by using I.R.C. specifications and Loading (dead load and live load) as a 1-D (one dimensional) structure. Finite Element Method 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) 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. For each and every bridge its girder length, width of bridge, deck slab depth, width of web of girder and girder depth are considered for the cost minimization of the bridge system, the structure is modeled and analyzed using the direct design methods. Cost efficient

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problem is formulated in NLPP (non-linear programming problem) by Sequential Unconstrained Minimization Technique. The model is analyzed and designed for an optimization purpose by using Mathematical lab (Matlab) Software with SUMT, and it is capable of indicating precisely with high probability of minimum design variables. Optimization for reinforced cement concrete T-beam girder system is illustrated and the results of the optimum and conventional design procedures are compared. Observed that Significant savings in cost over the normal design can be achieved by the optimization. However the exact saving obtained from optimum design of reinforce cement concrete T-beam girder depend upon the span of slab and grade of material. The cost of girder is directly proportional to grade of concrete.

Georgios Michas (2012) 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 long-term perspective, more economically efficient as observed. Even though the slab track construction costs are 30 % to 50 % higher than the standard ballasted track, the maintenance costs for slab track are one-fourth of those for ballasted track.

Mulesh K. Pathak (January-2014) studies various behaviors like bending, shear, axial & torsion for horizontally curved reinforce cement concrete box bridges considering three dimension FEM using SAP software. This approach simplifies analysis & the preliminary design of curved bridge section. The increase in the torsion for any set of graph is comparatively increases than that of bending moments, shear forces and axial forces which indicate that box section is having high torsional stiffness and is nonlinearly vary with degree of curvature. From the study it is observed that various span, the multiplication factor for variable degree of curvature is varying linearly for axial force & bending moment, which is about 1.20 to 1.30 for 90° curvature. Multiplication factor for torsion moment is varying nonlinearly having 1.80 to 1.90 for 90° curvature, while there is not necessary to apply multiplication factor for shear force.

III. GEOMETRY DESCRIPTION:

In the present study steel bridge frame is modeled in analysis tool staad pro in which steel trusses bridge is analyzed and optimized, and railway loading is considered as 32.5 T axle loading, dead load as per 875 part-1 and superimposed live load as per 875 part-2 is calculated and applied.

The following four four cases for comparison are a.) first howe bridge 50 m length. b.) second is bridge geometry is taken as warren truss 50 m length. c.) third one is bridge geometry is taken as pratt truss 50 m length. d). fourth one is bridge geometry is taken as K type truss 50 m length,

STAAD.Pro is a multipurpose program for analyzing the different forms of structures. The following three activities ar e performed to achieve that goal a). Modeling of the frame using STAAD.Pro. c). The calculations to decide the explanatory results. d). Result check is all empowered by devices contained in the framework's graphical environment.

Table 1: Property of material

S.NO	Description	Value
1	Steel table	Standard sections
2	Young’s modulus of steel, Es	2.17×10^4 N/mm^2
3	Poisson ratio	0.17
4	Tensile Strength, Ultimate Steel	505 MPa
5	Tensile Strength, Yeild Steel	215 MPa

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6	Elongation at Break Steel	70 %
7	Modulus of Elasticity Steel	193-200 GPa

Table 2 Description of Structure

S.NO	Description	Value
1	Length of Bridge	50 m.
2	Number of bays in X direction	12
3	Number of bays in Z direction	3
4	Height of Bridge structure	4 m
5	Width of the bridge section	4 m
6	Bay width in Z direction	5 m
7	Section of inclined members	I.S.A. or I shape
8	Section of vertical members	I.S.A. or I shape
9	Railway track	Double headed shape
10	Support type	Pinned support

IV. MODELLING AND ANALYSIS:

Performance analysis based approach is used to design a steel railway bridge to provide railway loading:

Analysis of railway steel bridge 50 m span expansion to expansion has been considered for the parametric analysis of vehicle critical load position as per Indian railway D.F.C. loading 32.5 tonne loading standard which are analyses with the help of staad pro software. proposed steps are as followings:

1) Model the structure in staad pro v8i.
2) Provide property to the section.
3) Create different types of steel truss bridges
4) Apply Railway loading for broad gauge axel, dead load and live load as per Indian standards.

4.1 Different types of bridge sections considered are as follows:

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4.1.1 Pratt Truss Bridge :

A Pratt truss (fig.1) includes vertical members and diagonals that slope down towards the center, the opposite of the Howe truss. The interior diagonals are under tension under balanced loading and vertical elements under compression. If pure tension elements are used in the diagonals (such as eye-bars) then crossing elements may be needed near the center to accept concentrated live loads as they traverse the span. It can be subdivided, creating Y- and K-shaped patterns. The Pratt truss was invented in 1844 by Thomas and Caleb Pratt. This truss is practical for use with spans up to 250 feet (76 m) and was a common configuration for railroad bridges as truss bridges moved from wood to metal. They are statically determiate bridges, which lend themselves well to long spans.

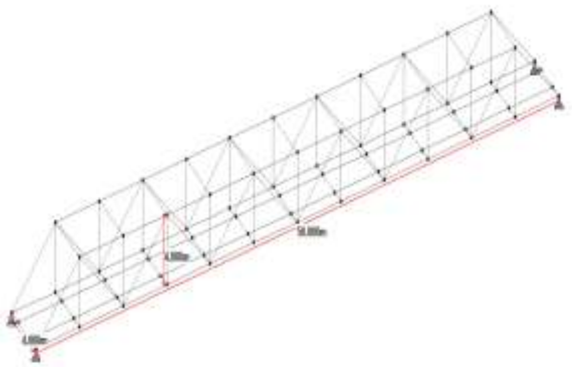

Fig: 1 Pratt Types Bridge

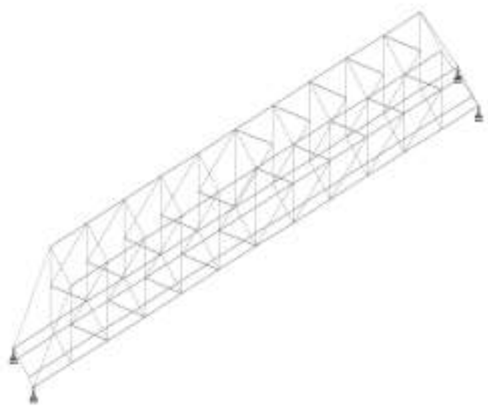

Fig: 2 K-Type Bridge

4.1.2 K-Type Truss Bridge:

A K-Truss (fig.2) is usually used for reinforcing members with high axial compression, not so much for bending; this is because the diagonals take almost nothing of the axial force. Since the diagonals usually have a lower bending stiffness than the chords, they give in more easily. That results in less secondary tensions in the truss.

4.1.3 Howe Truss Bridge

Howe truss (fig.3) is a type of bridge design that was introduced by an American architect William Howe. It utilizes similar design such as Pratt truss, but with a strong difference. Here the diagonal structural beams slope toward the bridge center, while Pratt truss utilizes diagonal beams that slope outward from the center of the bridge. This approach makes diagonal members of Howe truss bridge in compression, while vertical web members are in tension.

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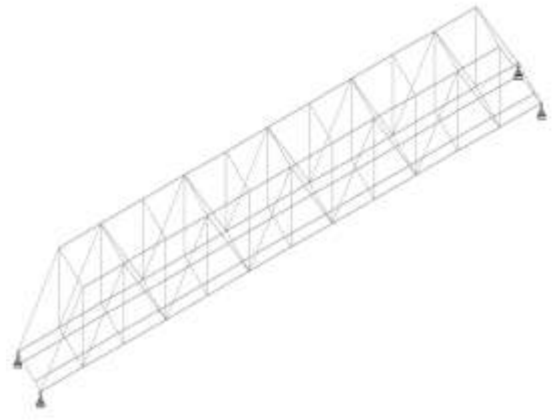

Fig: 3 Howe Type Bridge

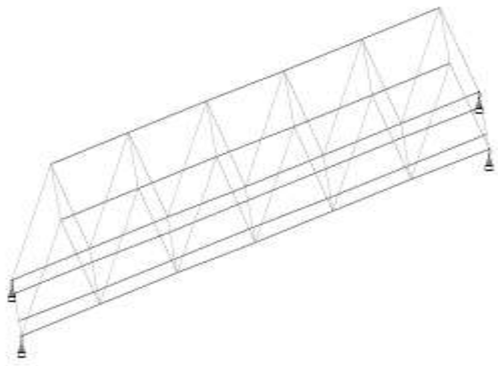

Fig: 4 Warren Type Bridge

4.1.4 Warren Type Truss Bridge

The Warren truss (fig.4) design is distinguished by equal-sized members and the ability of some of the diagonals to act in both tension and compression. The type is generally characterized by thick, prominent, diagonal members, although verticals could be added for increased stiffness. Warren truss bridges gained popularity after 1900, as American engineers began to see the structural advantages of riveted or bolted connections over those that were pinned..

V. RESULTS AND DISCUSSION

1. SHEAR FORCE :

Magnitude of maximum stress for various forms of truss has been plotted in figure number 6 it is determined that in this comparative study maximum shear force is in warren truss where as howe type steel bridge shows minimum shear force value which results in balanced section, therefore maximum unbalanced forces are present in warren type whereas minimum in howe type structure for same loading.

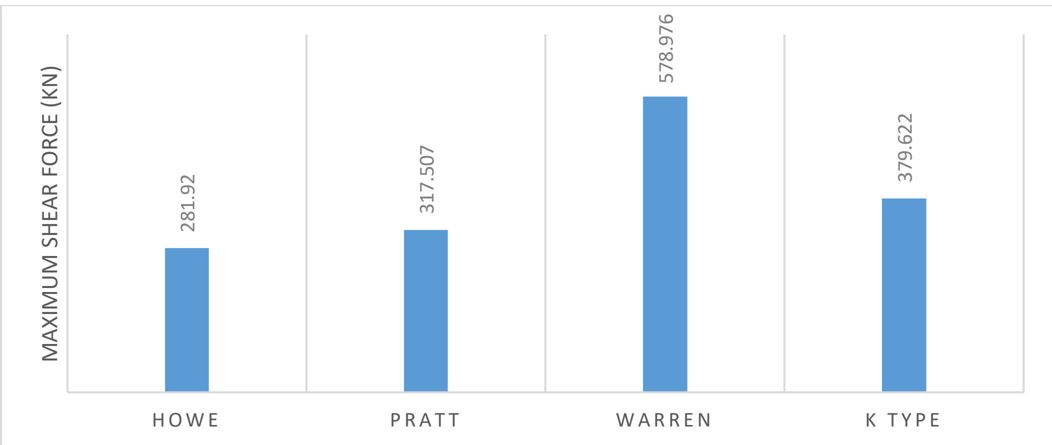

FIG 5: Maximum Shear Force

2. AXIAL FORCE

Magnitude of maximum stress for various forms of truss has been plotted in figure number 6 below it is determined that maximum axial force is generated in pratt type truss whereas minimum in howe type truss which shows that maximum force distribution will be measured in pratt as compared to other cases.

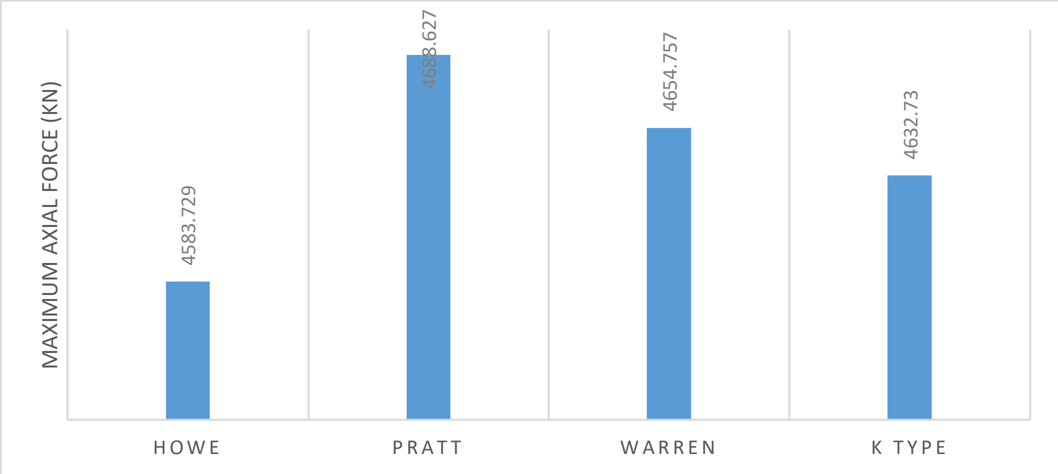

Fig 6 Maximum Axial force

3. DEFLECTION

Magnitude of maximum stress for various forms of truss has been plotted in figure number 7 below it is determined that deflection is maximum in howe bridge whereas minimum in warren type steel bridge which indicates that howe bridge will require more supports as compared to other cases

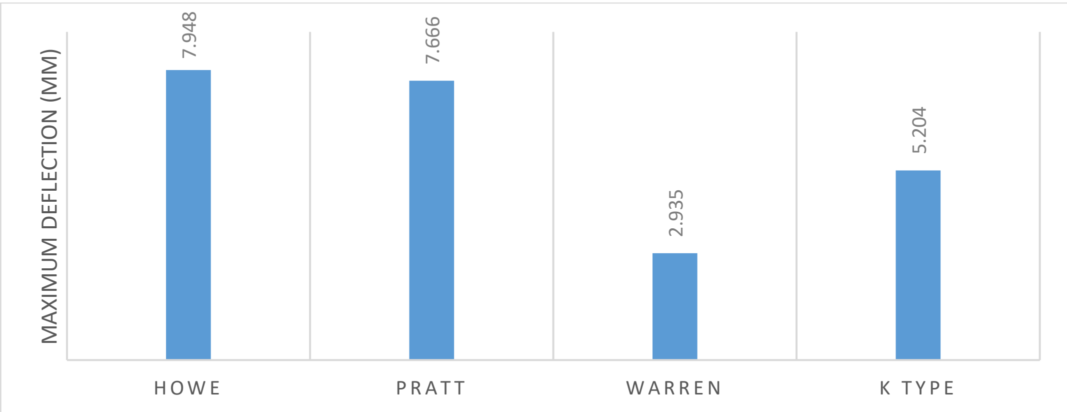

Fig 7 Maximum deflection

4. STEEL SECTION WEIGHT:

Magnitude of maximum stress for various forms of truss has been plotted in figure number 8. it is observed that warren truss type bridge structure will be more costlier for same loading as compared to other cases whereas howe type bridge will be economical in comparison to other cases.

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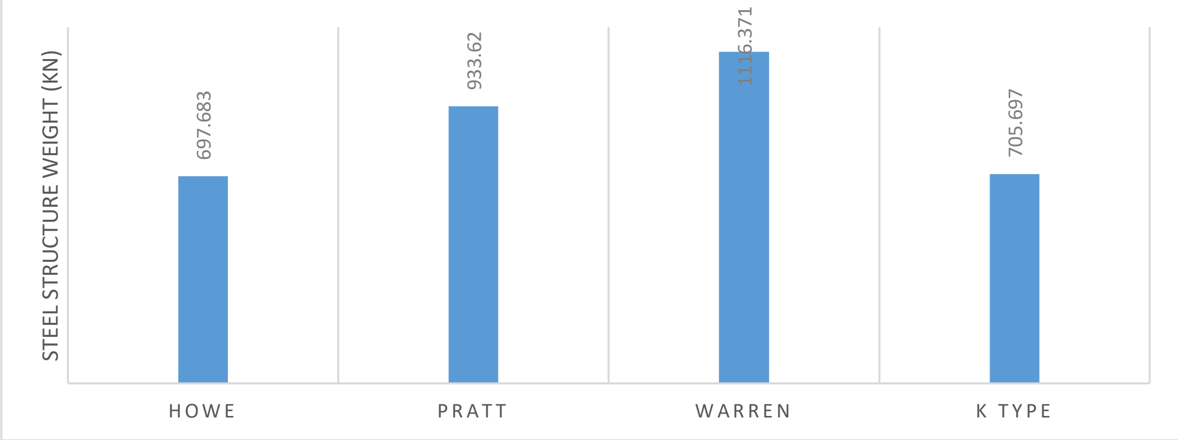

Fig 8 steel section.

VI. CONCLUSION

As discussed in the last chapters, we have considered four vehicle load cases along with dead load & rail load for the Steel bridge for analysis by using Staad-Pro software. Following are the salient conclusions of this study-

1. Deflection:

They observed that Maximum deflection is observed in Howe bridge whereas least in warren, which indicates that in terms of deflection warren is stable than others.

2. Shear Force:

In terms of unbalance forces howe type truss bridge is more stable showing less shear forces, whereas maximum is observed in warren truss.

3. Axial Force:

For the case of Axial force analysis, It is observed that out of the four pratt type bridge gives maximum values whereas owe has least value i.e. 4583.729 kN

4. 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.

In this study they observed that out of all four cases howe type truss bridge shows least values which mean for the same loading it will take less weight of construction material which makes it more economical than others. i.e. 697.683 Newton

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