Analysis of Different Railway Bridge Sections Considering Seismic a Load as Per Railway Provisions

Anjali Verma[1] Sahu D. L. Sahu[2] Hitesh Kodwani[3]
[1,2,3]Sam College of Engineering and Technology, Bhopal, India

Abstract— India being the largest rail network in Asia and the worlds second largest network operated under a single management with a track length of 1,15,000kms with no major upgradation till date and the same goes with the connecting railway bridges. With time and evolution railway bridges took various shapes with their own advantages and limitations. Railway bridges play a crucial role in ensuring fast and smooth communication and transportation between cities across the country. Consequently, they hold a major role in the economy and infrastructure development of a country. This paper attempts to synthesize the existing research in the field of railway bridges so as to provide a better understanding among the practising engineers and researchers. Excerpts from the research may be utilized for assessing the dynamic performance of railway bridges in the near future with further refinement.

Keywords: Railway, Bridges, Vehicle-Bridge Interaction, Fatigue, Dynamic

I. Introduction

A bridge is a structure, by which a road, railway or other service is carried over an obstacle such as a river, valley, and other road or railway line. The superstructure of a bridge is the part directly responsible for carrying the road or other service. Its layout is determined largely by the disposition of the service to be carried. Supports at convenient locations. A typical configuration of a truss bridge is a 'through truss' configuration. There is a pair of truss girders connected at bottom chord level by a deck that also carries the traffic, spanning between the two trusses.

Vehicle load capacity analysis of a bridge superstructure is required as per Railway specification provision and manuals for standard and specification for Indian rail conditions. Its main purpose is to assure, that bridge is safe for the user or public. By the load capacity analysis, a bridge might be found to be incapable of securely conveying some legal loads. Furthermore when the loads are beyond the range of permit loads need to be utilizing a particular structure, load limit analysis can give answer about which loads are securely satisfactory. STAAD.Pro is efficient and accurate software used for concrete and steel bridge analysis and design.

In the study four different bridge sections are considered they are Pratt truss, Howe truss, rectangular truss and K-type truss sections considered for 200 meter length supported at a distance of 50 m span of the geometry. This has been considered to analyze the bridge for critical load and after analyzing these critical loads, the results will be compared in terms of forces, weight and most importantly cost of each type to determine the most economical section.

A. Bridge Failures

In practice, failures occur in different forms in a material and are likely to be different for steel, concrete, and timber bridges. Common types of failure that occur in steel bridges are yielding (crushing, tearing or formation of ductile or brittle plastic hinges), buckling, fracture and fatigue (reduced material resistance, reversal of stress in welds and connections, vibrations), shearing and corrosion. Huge misshapenings because of effect, influence, rough shaking amid seismic occasions, disintegration of soil in floods or settlement because of extensive soils may initiate disappointment in both steel and solid scaffolds.

The most widely recognized reasons for scaffold disappointment include: overemphasize of basic components because of area misfortune, plan deformities and insufficiencies, long haul weariness and crack, disappointments amid development, inadvertent effects from boats, trains and atypical vehicles, fire harm, seismic tremors, absence of examination and unanticipated occasions .Any one of the above causes may add to connect disappointment or may trigger a breakdown, however disappointments really happen because of a basic mix of burdens. From these disappointments ought to be treated as learning encounters, since when a scaffold breakdown it has positively been stretched as far as possible somehow or another. Along these lines connect breakdown, significantly affect the improvement of the learning of auxiliary activity and material conduct and have prodded examination into specific fields. Reasons for disappointments ought to be distinguished regardless to discover approaches to fix the issue and to evade them later on.

B. Railway Provisions

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.

Bridge rules indicating the heaps for plan of the super-structure and sub-structure of extensions and for appraisal of the quality of existing and proposed spans.

The heaps indicated were mulled over in computing the quality everything being equal, including turntable braces and foot-connects yet barring street connects in which case, the heaps to be considered were as per the Standard Specifications and Codes of Practice .

C. Objectives

The main objectives of the present study are as follows:-

1) To prepare a comparative study between four different steel sections for railway bridge geometry.
2) To make comparative study of these bridges in terms of stability, cost and effectiveness.
3) To determine the most suitable type of steel section in the comparative analysis.
4) To calculate rail loading as per Railway Bridge provisions
5) To assign seismic loading on railway ridge as per railway criterias.

II. LITERATURE REVIEWS

T.Pramod Kumar, G.Phani Ram (July 2015) Here the primary objective of author behind the study was to evaluate the estimate of railways cum Road Bridge so as to determine its economic importance. Separate bridge for roadways and railways in the same place shall consume more funds so author defined a practical solution in order to reduce the cost of construction by proposing a single bridge for both railway's and roadways. The analytical application STADD.Pro Version 8i was used for analyzing and design of the project. This project resulted in reduction of the land acquisition problem and a drastic stabilization in cost of construction due to two separate entities in the same bridge roadways and railways.

R.Shreedhar, Spurti Mamadapur (September 2012) The author here investigated a basic range T-pillar Bridge by utilizing I.R.C. details and Loading (dead loads and live loads) as a 1-D (one dimensional) structure. The author prepared two different models and subjected them to IRC loadings in order to put together maximum bending moment, besides carried out Finite element Analysis using the STADD.Pro of the three-dimensional structure. The outcomes were examined and it was discovered that the outcomes acquired from the Finite element Analysis are lesser than the outcomes conveyed from 1-D (one dimensional) investigation, which expresses that the outcomes received from I.R.C. loadings are preservationist and FEM gives the conservative plan.

Georgios Michas (2012) The author here focused on technological advancement on high speed rails tracks considering various concepts on non-ballasted tracks in order to increase its life cycle. Ballasted tracks being the future of the railways are more practical in today's era being economically efficient for a long term perspective as its was been observed that the cost of constructing slab tracks is significantly higher around 50% but the maintenance cost in comparison to ballasted tracks is just one-fourth.

Amit Saxena, Dr. Savita Maru (April-May, 2013) Here the author explored the variety and cost contrast in T shaft girder and two cells enclose girder in terms of solid amount and infer that cost of cement for T-Beam Girder isn't as quite a bit of two cell Box Girder as amount required by T-pillar Girder, Quantity of steel for T-bar Girder is less so spending plan of steel in T-Beam is less when contrasted with two cells Box Girder Bridge T-Beam Girder is affordable for range length isn't more than 25m however on the off chance that range is in excess of 25 m, so Box Girder is constantly reasonable. This sort of scaffold structure lies in the high torsional unbending nature on account of the shut box area.

Krishnan et. al. (2006) here the author examined the reactions of tall steel development outline structures in situation size 7.9 seismic tremors on the southern San Andreas fault zone. This work utilized three-dimensional, nonlinear limited component models of current eighteen-story moments outline building and overhauled to fulfil the 1997 uniform construction law. The creators found that the mimicked reactions of the first structures demonstrate the potential for critical harm all through the San Fernando and Los Angeles bowls. The overhauled building fared better yet at the same time demonstrated critical disfigurement in a few regions. The elation on the southern San Andreas that spread north-to-south instigated a lot bigger building reactions that the crack that proliferated south-to-north.

III. PROBLEM STATEMENT

In this philosophy, we have utilized STAAD-Pro programming which depends on the utilization of the Finite Element Method. This product is broadly utilized in the field of basic structure and examination. Presently Staad. Pro is especially benevolent for the investigation of various sort of structures and to compute the outcome at each node & element-wise. Investigation for the bridge members arranged the applied measurement geometry of the superstructure which is presented in figure below.

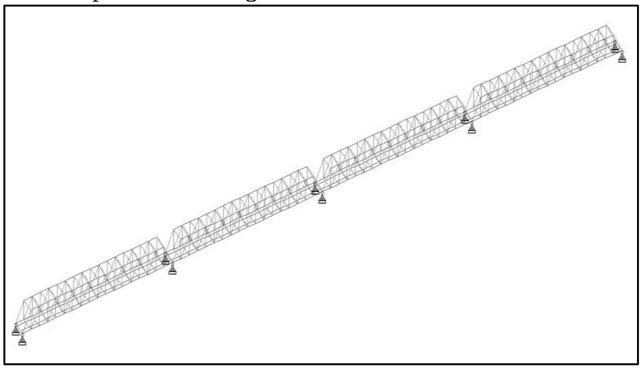


Fig. 1: Steel Bridge model

Four cases has been considered for comparative analysis:

– Howe type railway bridge of 200.00 m length.
– Pratt type railway bridge of length 200.00 m,
– Rectangular type railway bridge of length 200.00 m,
– X type railway bridge of length 200.00 m,

Analysis of railway steel. bridge of 200.00 m span has been considered for the parametric analysis of vehicle critical load position as per railway criterias and loading standard which are analyzed with the help of staad pro software. Proposed steps are as followings:

1) Step 1: Selection the geometry of superstructure by using coordinate system in STAAD Pro or plot over the AUTO CAD, which can be import in Staad-Pro as per dimension of girder, c/c distance of joints, and no of connecting members etc.
2) Step 2: Different type of bridge models are prepared of same dimension and same loadings as per Indian railway standards. modeling of the model considering the above parameters. It is considered that Railway steel type bridge of different types shapes are analyzed for same loading condition. the dimensions like 200 length, 6 meter wide, which include gauge width, sleepers spacing and rail load property and steel material property of the structure as per Indian sections.
3) Step 3: Apply the material property as shown in above figures, after that support condition has been considered at the bearing locations of the superstructure which is pinned / hinged
4) Step 4: After apply the support condition, now the next step to be considered for the Deal Load of the superstructure i.e. "self-weight".
5) Step 5: After apply the Dead Load, loco engine and bogie load and seismic load should be applied.

6) Step 6: After applied all the boundary condition and forces, now the model has to be "Analyze" for getting the results i.e. Axial force, shear force, deflection and support reactions etc.
7) Step 7: after analysis results designing is followed as per Indian Standard 800:2007 steel design and optimization of each case is done to provide its economical section for same loading and geometry in all the cases.
8) Step 8: After optimization process comparative results are drawn in all cases to determine the best one with the help of graph using M.S. Excel.

IV. Modelling

The modelling of the four bridges was done using the application Staad.Pro. and following steps were undertaken:
1) Get ready the input file.
2) Analyse the input file.
3) Post processing the results and verify them.
4) Send the analyzed result to design as per codal provinces.

A. *Geometric Properties of Structure*

S. No.	Description	Values
1	LENGTH OF BRIDGE	200 m
2	Number of bays in X direction	26
3	Number of bays in Z direction	6
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	Flat footed rail shape
10	Support type	Fixed support

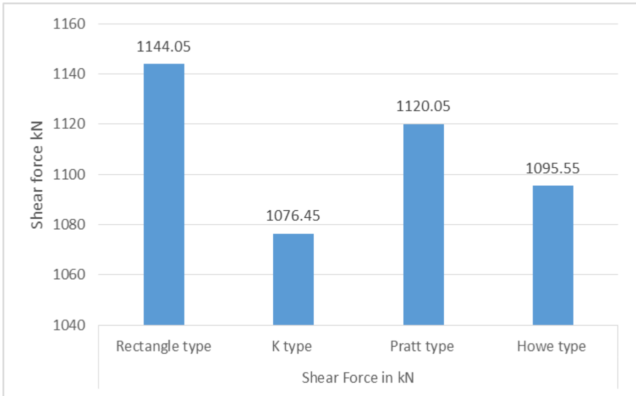
B. *Material Properties of Structure*

S. No	Description	Values
1	Material property	
2	Steel table	Standard sections
3	Young's modulus of concrete, E_c	2.17×10^4 N/mm^2
4	Poisson ratio	0.17
5	Tensile Strength, Ultimate steel	505 MPa
6	Tensile Strength, Yield steel	215 MPa
7	Modulus of Elasticity steel	193 - 200 GPa

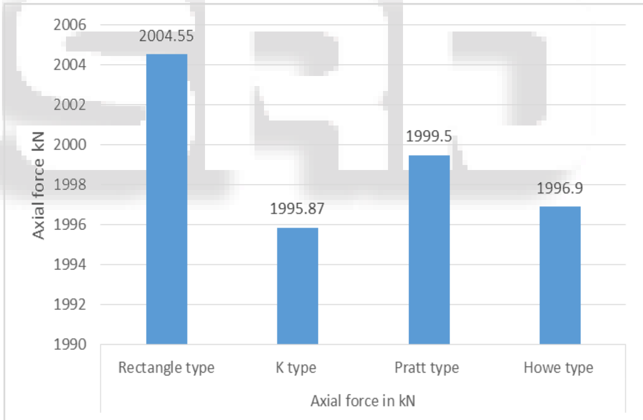
V. Results Analysis

Parameters on which study was done are-
1) Shear force in KN.
2) Axial Force in KN.
3) Bending Moment in KN-m
4) Maximum deflection due to vehical loadings.
5) Support reaction
6) Weight of each section in different bridge type.

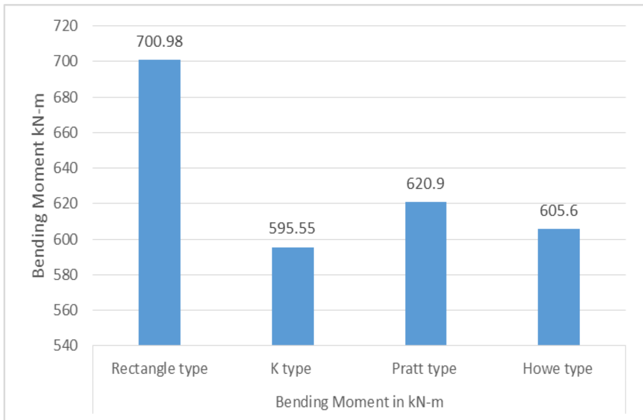
A. *Shear Force*



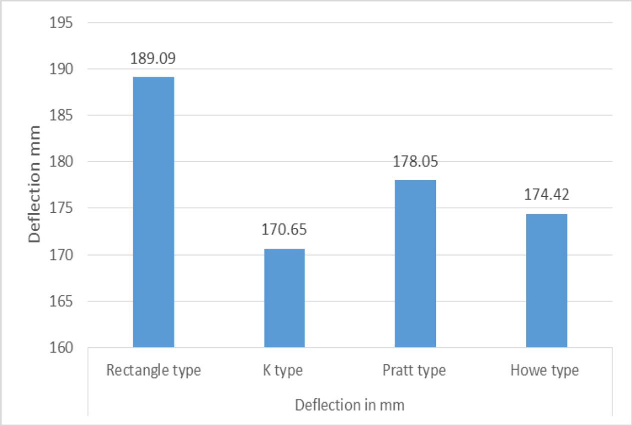
B. *Axial Force*



C. *Bending Moment*



D. Deflection



VI. Conclusion

We have considered railway loco engine load i.e. 32.5 tonne load cases along with brosd gauge type rails and dead load for the R.C.C. bridge for analysis by using Staad-Pro software. Following are the salient conclusions of this study-

A. Deflection

189.09 mm Deflection seen in Rectangular frame bridge whereas as 170.65 mm Deflection seen in K type bridge proving this to be more stable in this case.

B. Maximum Bending Moment

It is observed that maximum bending moment in seen in Rectangular Type Bridge whereas the least bending moment is faced by K Type Bridge.

C. Shear Force

It is observed that maximum shear force in seen in Rectangular Type Bridge whereas the least bending moment is faced by K Type Bridge.

D. Axial Force

For the case of Axial force analysis, we have analysis number of cases for critical the values and observed that out of the four pratt type bridge gives maximum values whereas owe has least value i.e. 4583.729 kN

E. 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.

Here in our study 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

References

[1] Karthiga P, Elavenil S, Kmp D. A Comparison of Road Over Bridge And Rail Over Bridge. The IUP Journal of structural engineering.
[2] Shetty RS, Prashanth MH, Channappa TM, Ravi Kumar CM. Information vibration suppression of steel truss railway bridge using tuned mass dampers.
[3] Xueyi L, Pingrui Z, Feng DM. Advances in design theories of high-speed railway ballastless tracks. Key Laboratory of High-Speed Railway Engineering, Southwest Jiaotong University, Chengdu, China.
[4] Li Z, Zhiyun S. Progress in high-speed train technology around the world. Transport Bureau, The Ministry of Railways of China, Beijing, China. Traction Power State Key Laboratory, Southwest Jiaotong University, Chengdu 610031, China a. Astaneh A. Progressive Collapse of Steel Truss Bridges, The Case of I-35w Collapse, Asla a University of California, Berkeley, USA
[5] Bridge rules (Railway Board). Rules specifying the loads for design of super structure and substructure of bridges and for assessment of the strength of existing bridges.
[6] Indian railway standards-Steel Bridge Code Indian railway standard code of practice for the design of steel or wrought iron bridges carrying rail,road or pedestrian traffic.
[7] IRC: 6-2014 Section –II (Loads And Stesses) standard specifications and code of practice for road bridges.

