Analysis of Different Truss Bridge to Configure the Best Suited Shape for Practical Implementation

Santosh Kumar Suman[1]* Rakesh Patel[2]

[1] Civil Engineering, SIRTS, M.P. India

[2] Civil Engineering, SIRTS, M.P. India

Abstract – Beam bridges are the simplest and oldest type of bridge in use today, and are a popular type. A truss bridge is a bridge whose load-bearing superstructure is composed of a truss.Various types of different design of truss structure are constructed in bridges depending upon the type of bridge and volume of vehicles passing through it. This research work comprises of design and analysis of different types of bridge structure for railway systems. The different trusses are made from the steel material and a comparative study is done based on the results. For the study four type of truss design is taken in to consideration such as rectangular truss, X-type, V-type, and K-type truss. The results are calculated using Staad Pro. Software and the values are observed. The results are compared based on support reaction, displacement, shear force and torsion. Both maximum and minimum values for all the respective cases have been depicted in the work including cost analysis.

Keywords – Truss, Railway Structure, Staad Pro, Shear Force, Displacement.

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I. INTRODUCTION

In building, a bracket is a structure that "comprises of two-compel individuals just, where the individuals are sorted out with the goal that the array in general acts as a solitary protest". A "two-compel part" is a basic segment where constrain is connected to just two focuses. In spite of the fact that this thorough definition enables the individuals to have any shape associated in any steady setup, brackets regularly include at least five triangular units built with straight individuals whose closures are associated at joints alluded to as hubs. In this common setting, outer powers and responses to those powers are considered to act just at the hubs and result in powers in the individuals that are either elastic or compressive. For straight individuals, minutes (torques) are unequivocally prohibited on the grounds that, and simply because, every one of the joints in a bracket are dealt with as revolute, as is essential for the connections to be two-constrain individuals.

Bracket components are one dimensional in their neighborhood arrange framework and convey just pivotal loads because of their stick associations at hubs. This additionally implies a support hub is just permitted translational degrees of flexibility. A support component needs just a cross sectional region (A) to characterize its geometry because of the hub stack confinement, and its length is controlled by the area of its end hubs. A three-dimensional bracket component has two nearby degrees of flexibility and six worldwide degrees of opportunity, with three translational degrees of flexibility at each finish of the component. Figure 1 demonstrates a three-dimensional support component with its neighborhood and worldwide arrange frameworks, degrees of flexibility, and passable powers. The dark capital images speak to worldwide items, while dim lower case images speak to neighborhood objects. It can be seen that a support component has just a single neighborhood organize pivot (x) starting from one hub and reaching out through the length of the component. The main powers (f1, f2) and removals (u1, u2) permitted in this neighborhood framework lie in coordinate pivotal situation with the component, and the component has two degrees of opportunity. The worldwide arrange framework (X, Y, Z) that is utilized in the basic examination at that point makes every neighborhood question be broken into three identical worldwide parts. It is then demonstrated that the three-dimensional bracket component has six worldwide degrees of flexibility, with one for each worldwide facilitate at each finish of the component.

Fig .1 Truss Structure

Fig .2 Bridge Collapse

A. Bridge failures

The fall of the Tacoma Narrows Bridge is maybe the best recorded and archived connect disappointment in the extension building history. The awesome and delayed disappointment process was caught on broad live film, giving a one of a kind record for the examination board of trustees and in addition for the designing society on the loose. The recording has from that point forward been utilized in structural designing classes all around the globe for instructive purposes. Results of ignoring dynamic powers in the development of suspension scaffolds can be unmistakably watched.

The most widely recognized reasons for connect disappointment include: overemphasize of auxiliary components because of segment misfortune, outline deformities and insufficiencies, long haul exhaustion and break, disappointments amid development, coincidental effects from boats, trains and atypical vehicles, fire harm, tremors, absence of examination and unanticipated occasions .Any one of the above causes may add to connect disappointment or may trigger a crumple, however disappointments really happen because of a basic mix of burdens. From these disappointments ought to be dealt with as learning encounters, since when an extension breakdown it has positively been stretched as far as possible somehow. Consequently connect breakdown, significantly affect the improvement of the information of auxiliary activity and material conduct and have impelled examination into specific fields. Reasons for disappointments ought to be recognized regardless to discover approaches to settle the issue and to evade them later on.

II. LITERATURE REVIEW

Guptaet.al. (2017)[1] Present the investigation and outline of steel support railroad extension of range 50 m. The extension with same railroad loadings of 32.5 ton has been allotted in various sorts of bracket segments to decide the best steady and temperate area. Investigation and configuration is finished utilizing device STAAD star to enhance the area and decide best stable areas for examination. The plan of basic individuals from the support is done as per arrangement of Indian railroad standard code and Indian streets congress code.

Shrivastavaet. al. (2017)[2] This examination exhibits the auxiliary investigation and plan of RCC box compose minor extension utilizing manual approach (i.e. MDM technique) and by computational approach (Staad-star) utilizing IRS - CBC codes. The basic components (top section, base chunk, side divider) were intended to withstand Ultimate Load criteria (greatest bowing minute and shear drive)

Due to different burdens (Dead Load, Live Load, SIDL, LL extra charge, DL additional charge) and workableness criteria (Crack width) and a similar investigation of the outcomes got from the over two approach has been completed to approve the accuracy of the outcomes. Further, it was likewise watched that the investigation utilizing manual count turns out to be extremely repetitive and bulky and for a mind boggling kind of structure, consequently it is a significant complex undertaking to play out the examination physically, so the utilization of computational technique (Staad – expert and exceed expectations sheet) turns into the undeniable decision for plan. The outcomes acquired utilizing MDM technique demonstrates a decent concurrence with the outcomes got from computational strategies.

Sharmaet. al. (2017)[3] Examined that the outline, development and upkeep of physical and normally manufactured condition, including works like extensions, streets, waterways, dams and structures. It is the most established and broadest designing calling. All the designing claims to fame have been gotten from structural building. It is isolated into different sub disciplines including ecological designing, geotechnical building, auxiliary building, transportation building, material building, reviewing and development designing. The standards of all the above building perspectives are connected to the private, business, mechanical and open works activities everything being equal and levels of development.

Hanif (2016)[4] Contemplated that the basic outline includes thought of load cases (box unfilled, full, additional charge loads and so on.) and factors like live load, powerful width, braking power, dispersal of load through fill, affect factor, co-proficient of earth weight and so forth. Applicable IRCs are required to be alluded. The basic components are required to be intended to withstand most extreme twisting minute and shear constrain. This paper gives exchanges on the arrangements in the Codes, contemplations and avocation of all the above viewpoints on plan. The container scaffold can be broke down either by Software or Computational strategies. So it is important to examine the adequacy of results got from both the techniques.

Kumaret. al. (July 2015)[5] This current research's goal was to evaluate the monetary significance of the railroad cum street connect. This paper was done to discover the decrease in cost of development by giving single scaffold to both street and also railroads. The investigation and configuration period of the undertaking was finished using STAAD PRO V8i. It was watched that the development of a solitary scaffold diminished the cost of two separate extensions for street and railroads, likewise arrive securing issue is decreased to some degree.

T. Pramod Kumar, &G.Phani Ram (2015)[6]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 by giving single scaffold to both street and additionally railroads. The examination and configuration period of the undertaking was finished using STAAD PRO V8i.

Pathak (January-2014) [7] examined different practices like twisting, shear, pivotal and torsion for on a level plane bended fortify bond solid box spans considering three measurement FEM utilizing SAP programming. This approach improves examination and the fundamental outline of bended extension segment. The expansion in the torsion for any arrangement of chart is relatively increments than that of bowing minutes, shear powers and pivotal powers which demonstrate that crate segment is having high torsional firmness and is nonlinearly shift with level of ebb and flow. From the investigation it is watched that different range, the duplication factor for variable level of ebb and flow is shifting directly for pivotal power and twisting minute, which is around 1.20 to 1.30 for 90° ebb and flow. Increase factor for torsion minute is differing nonlinearly having 1.80 to 1.90 for 90° ebb and flow, while there isn't important to apply augmentation factor for shear compel.

Kaleet. al. (January 2014)[8] Considered the cost effective approach of fortify bond solid T-pillar support. His principle target work was to decrease the aggregate cost in the planning of the extension framework thinking about the cost of materials. The cost of each auxiliary segment, for example, material, labor, cost for fortification, concrete and formwork. For every last extension its support length, width of scaffold, deck section profundity, width of web of brace and brace profundity are considered for the cost minimization of the scaffold framework, the structure is displayed and dissected utilizing the immediate plan strategies. Cost proficient issue is defined in NLPP (non-straight programming issue) by Sequential Unconstrained Minimization Technique. The model is broke down and intended for an improvement reason by utilizing Mathematical lab (Matlab) Software with SUMT, and it is equipped for showing definitely with high likelihood of least plan factors. Enhancement for strengthened bond solid T-bar support framework is represented and the aftereffects of the ideal and ordinary outline methods are analyzed. Watched that significant reserve funds in cost over the typical plan can be accomplished by the improvement. Anyway the correct sparing acquired from ideal plan of fortify bond solid T-pillar support rely on the range of chunk and grade of material. The cost of brace is specifically relative to review of cement.

III. OBJECTIVE

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

a. To analyze and design steel railway bridge with various types of Steel trusses.

b. To make comparative study of these bridges.

c. To provide a new type of truss system frame developed in this study as an alternative in truss bridge design.

IV. METHODOLOGY

In this methodology, we have used STAAD-Pro software which is based on the application of Finite Element Method. This software is a widely used in the field of structural design and analysis. Now a day this software is very much friendly for the analysis of different type of structures and to calculate the result at every node & element wise. Analysis for the steel truss members, prepared the conceptual dimension geometry of the superstructure which are shown in figure 3.

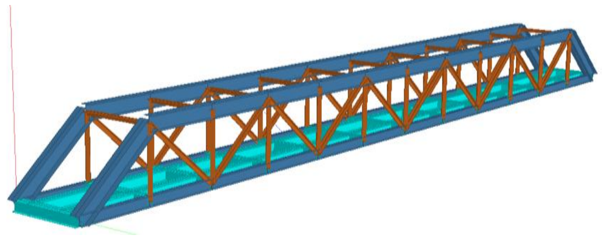

Fig. 3 Steel Railway Bridge

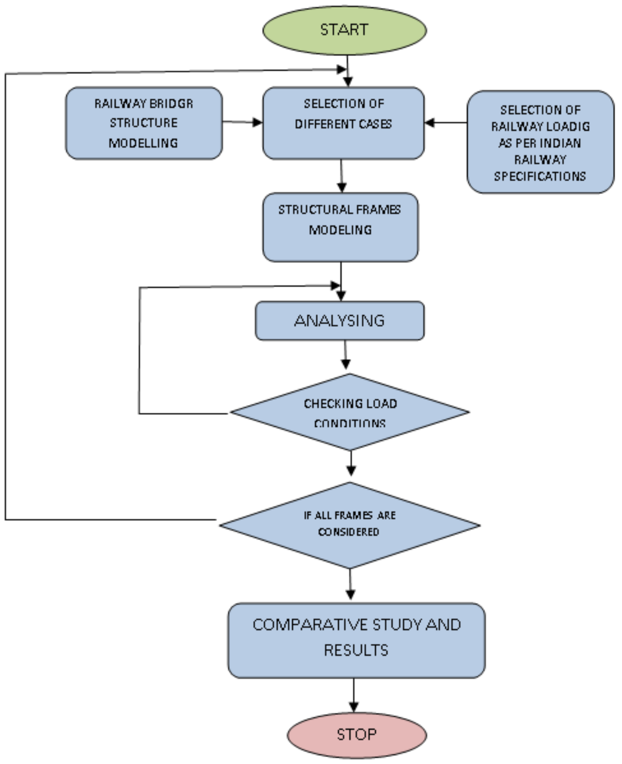

Fig. 4 Flow chart of proposed method of the analysis shown in the Figure: 3.10.

Four cases have been considered for comparative analysis:

- First Rectangular type bridge 75 m length.
- Second is bridge geometry is taken as X type75 m length,
- Third one is bridge geometry is taken as V type 75 m length,
- Fourth one is bridge geometry is taken as K type truss 75 m length,

The accompanying three exercises must be performed to accomplish that objective –

a. Demonstrating of the edge utilizing STAAD. Pro.

b. The figuring to choose the logical outcomes.

c. Result check is altogether enabled by gadgets contained in the structure's graphical condition.

Investigation of railroad steel connect 75 m length extension to development has been considered for the parametric examination of vehicle basic load position according to Indian rail line D.F.C. stacking 32.5 ton stacking standard which are investigations with the assistance of staad professional programming. proposed steps are as followings: **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 bearing, expansion to expansion distance and no. of diaphragm etc. Schematic sketch of the superstructure are shown in below figures.

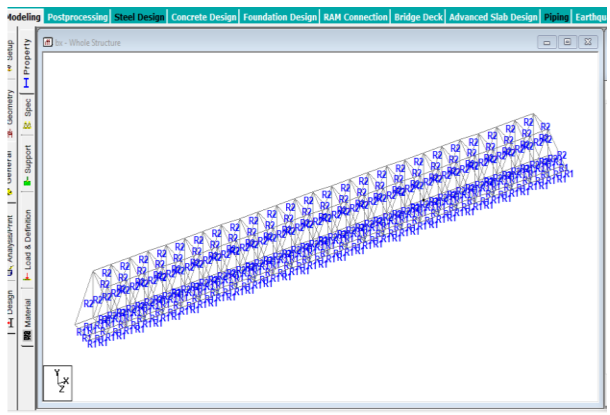

Fig. 5 Truss Bridge Type

Step 2: Different type of truss models are prepared of same dimension and same loadings as per Indian standards. Finite element modeling of the model considering the above parameters. it is considered the railway steel type bridge of different types such as rectangular truss, k-type truss, V type truss and X type bridge types of superstructure define the dimensions like 75 meter length, 4 meter wide, 6 meter girder depth, which include in the girder property and steel material property of the structure as per Indian steel table sections.

A. Different types of bridge sections considered are as follows:

1) Rectangular type Bridge

Journal of Advances and Scholarly Researches in Allied Education
Vol. 15, Issue No. 11, November-2018, ISSN 2230-7540

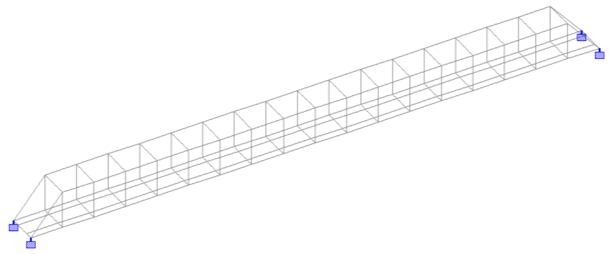

Fig .6 Rectangular Types Bridge

2) K-Type Truss Bridge

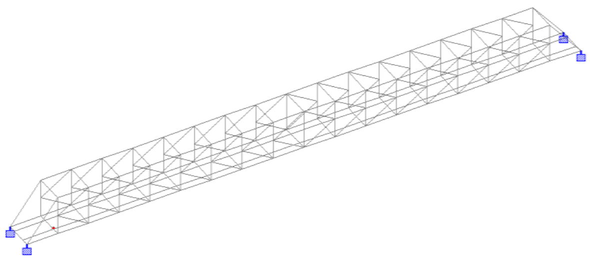

Fig. 7 k-Type Bridge

3) V type Truss Bridge

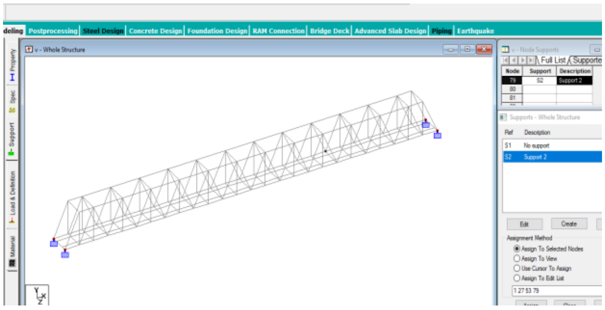

Fig. 8 V-Type Bridge

IV) X Type Truss Bridge

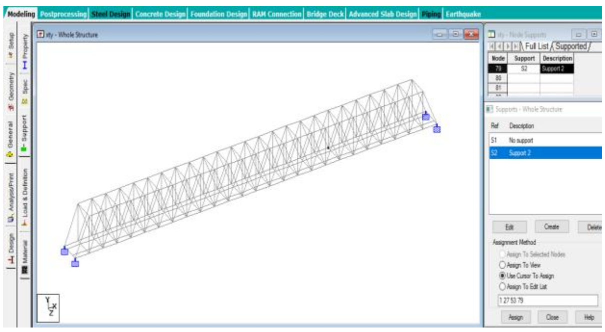

Fig. 9 X -Type Bridge

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 as shown in below figure.

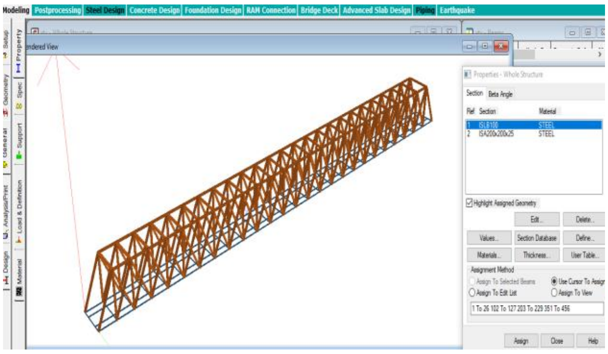

Fig. 10 Assigned properties

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”.

Step 5: After apply the Dead Load, now the next step to be considered for the Equivalent Uniformly Distributed Loads (EUDL) load.

Step 6: After apply the EUDL Load, now the next step to be considered for the Moving Live Load (LL) in which include the Breaking Load and Vehicle Load are as follow:-

(i) DFC LOADING FOR BENDING MOMENT [Eccentric & Concentric]

(ii) DFC LOADING FOR SHEAR FORCE [Eccentric & Concentric]

(iii) Coefficient of Dynamic Augment (CDA) FOR PROVIDED RIAL LENGTH.

Step 7: 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, Maximum displacement and support reactions etc.

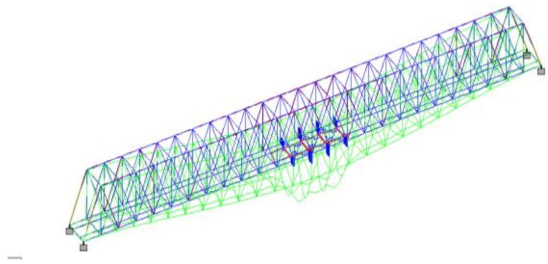

Fig 11 Maximum displacement and Forces

Step 8: after analysis results designing are 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.

Step 9: After optimization process comparative results are drawn in all cases to determine the best one with the help of graph using M.S. Excel.

A. Geometrical properties

The bridge configuration selected is a representative of practical railway bridge that is common in Indian region as per Indian Railway specifications and standards. The bridge is designed to bear 32.5 T axle load. Hence, it needs to be strengthened. Therefore we considered here same railway loading as per railway standard code and same length to determine the best type of steel truss bridge structure in terms of force and Maximum displacement resistance also in terms of economy.

Following geometrical properties has been considered with materials in modeling:-

Table 1 Geometric Properties of Structure

S. No.	Description	Values
1	Length of bridge	75 m
2	Number of bays in X direction	26
3	Number of bays in Z direction	6
4	Height of bridge structure	6 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

The Bridge is of structural plan in X direction is 75 and in Z & Y direction is 4 & 6 meter respectively.

B. Material properties

In this problem standard material properties are considered which is given below in table no .4.2

Table 2 Material Properties of Structure

S. No.	Description	Values
1	Material property	
2	Steel table	Standard sections
3	Young's modulus of concrete, E_c	$2.17x10^4$ N/mm^2
4	Poisson ratio	0.17
5	Tensile Strength, Ultimate steel	505 MPa
6	Tensile Strength, Yield steel	215 MPa
7	Elongation at Break steel	70 %
8	Modulus of Elasticity steel	193 - 200 GPa

V. RESULT

Comparative analysis of all the four cases have been done here in terms of forces, torsion, axial force, displacement and weight of steel to determine the best suited and stable frame. In order to emphasize the differences, loading is considered same and taken from railway specification code for steel bridges in this comparison.

Parameters on which study done are-

1. Shear force in KN.
2. Torsional force in KN-m
3. Maximum displacement due to vehicle loadings.
4. Support reaction
5. Weight of steel in each truss bridge type.

C. Analysis of result

1) Sectional forces

Table 3 Analysis results

S. No.	Description	Values
1	Length of bridge	75 m
2	Number of bays in X direction	26
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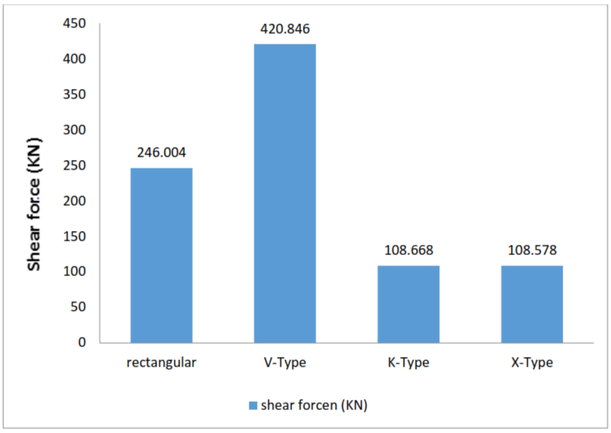
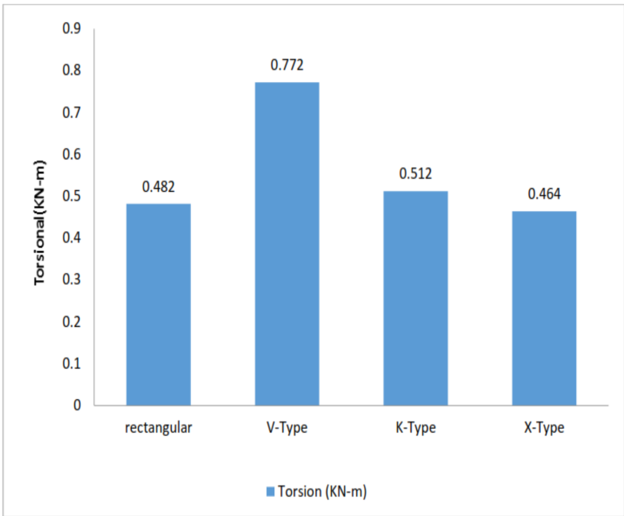
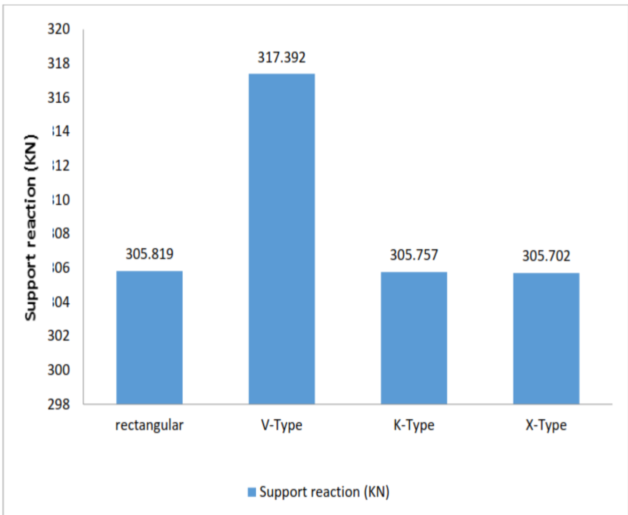


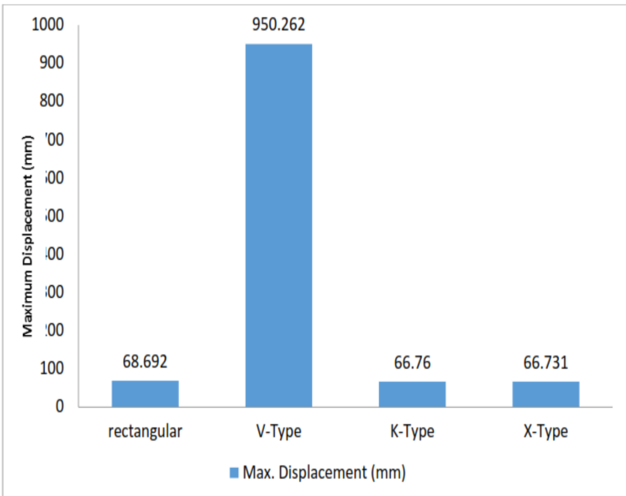
Graph 1 Shear force kN



Graph: 5.2 Torsion kN



Graph 2 Support reactions

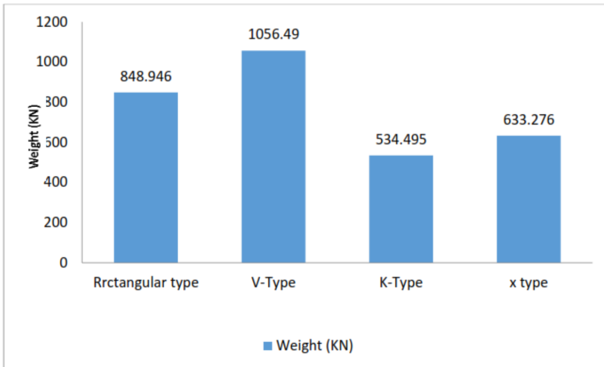


Graph 3 Max. Displacement (mm)

D. Cost Analysis:

Table 4 Cost analysis

Type of section	weight in KN	Rate (per quintal)	cost in Rs.
Rectangular type	848.946	4222.2	3584419.801
v type	1056.490	4222.2	4460712.078
K type	534.495	4222.2	2256744.789
X type	633.276	4222.2	2673817.927



Graph 4 Steel structure weight (kN)

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. For the case of Maximum displacement analysis, we have analysis number of cases for critical the values and observed that out of the four cases X-Type bridge gives minimum values i.e. 66.731 mm

2. For the case of reaction analysis, we have analysis number of cases for critical the values and observed that out of the four cases X-Type bridge gives minimum values i.e. 305.702 kN (Y).

3. For the case of torsional analysis, we have analysis number of cases for critical the values and observed that out of the four cases X-Type bridge gives minimum values i.e. 0.464 kN-m

4. For the case of Shear force analysis, we have analysis number of cases for critical

the values and observed that out of the four V-type bridge gives maximum values which means it is the most unbalance type bridge in comparison i.e. 420.846 kN.

5. It has been observed that the above analysis for all the four parameter (shear force, torsion, maximum displacement and support reaction) has shown approximately the same effect in X-type and K-type trusses. But the major difference is shown in the weight, which is about 15.60%.

6. 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.

7. Here in our study out of all four cases K-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. 534.495 KN.

VII. FURTHER SCOPE OF STUDY

Present study has been considered based on the vehicle load as per railway standards for 32.5 tons loading by using Staad. Pro software and observed the critical placement value for the design in future study followings conditions can be consider:

- Span can be longer.
- Here one lane is considered in future it can be consider as two lanes.
- Wind and seismic effects can be considered in future.

REFERENCES

[1] Shubhank Gupta, Prof. Sudhir S. Bhadauria, Prof. Suresh S. Kushwaha (2017). Comparative analysis of different truss type railway steel bridge considering railway loadings." International journal of engineering sciences & research technology.

[2] Shrivastava Rupesh (2000). "Reinforced concrete design criteria for different loading conditions, IS 456-2000 Principles and Practice" ISSN 4560, 2017, pp. 23-35.

[3] Karthiga Sharma, Elavenil S. and K. Das (2017). "A Comparison of Road Over Bridge And Rail Over Bridge". The IUP Journal of structural engineering, ISSN 2232, pp. 23-31.

[4] Hanif (2016). "slab track design for high-speed analysis for a case study", International journal of civil technology, ISSN-1285, pp. 90-98.

[5] V. kumar, M. M. yasir and Arif (2015). "Structural Developments in Tall Buildings" Currents Trends and Future Prospects. Architectural Science Review, 50.3, pp. 205-223.

[6] T. Pramod Kumar, G. Phani Ram (July 2015). Analysis and Design of Super Structure of Road cum Railway bridge across Krishna river.

[7] K.K. Pathak (2014). Introduction to Structural Motion Control. New York: Prentice Hall.

[8] S.K. Kale, Pingrui ZHAO, Feng DAI (2014). "Advances in design theories of high-speed railway ballastless tracks, Volume 19, Number 3, September 2014, pp. 23-40.

[9] Saxena and Maru (2013). "SLAB TRACK FOR THE NEXT 100 YEARS, Portland Cement Association, Skokie, IL, ISSN 34, pp. 34-42.

[10] Shreedhar and Mamadapur (2011). "Analysis of Dynamic Behavior for Slab Track of High-Speed Railway Based on Vehicle and Track Element" Journal of transportation engineering © ASCE / April 2011 /pp. 227.

[11] Georgios (2012). "Assessment of design parameters of a slab track railway system", Journal of Sound and Vibration 306, pp. 361–371.

[12] Juozas M.G., George P. and Malkhare S.V. (2011). Analysis of box culvert by considering soil structure interaction, Paripex-Indian journal of research, Vol. 1, Issue 4, pp. 71-74.

[13] Yasuyuki and T. Okamoto (2011). "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, ISSN 345, pp. 123-137.

[14] Joghataie and Takalloozadeh (2009). Dynamic Effect of a Moving Truck on a

Culvert, JournalOf Bridge Engineering, Vol. 17, 02, pp. 123-129.

[15] Thang S., Shreedhar R. (2009). Design Coefficient for Single and Two Cell Box Culvert, International Journal of Civil and Structural Engineering, Vol. 3, pp. 475-494.

[16] Thomas, J., and Wilson, P.M. (2007). "Construction Waste Management in India." American Journal of Engineering Research: Vol. 2

[17] R. Krishnan, Prashanth M.H., Channappa T.M., Ravi Kumar C.M. (2006). Information vibration suppression of steel truss railway bridge using tuned mass dampers, ISSN 3565, pp. 76-84.

[18] Kalkan and Kunnath (2004). "Advances in design theories of high-speed railway ballastless tracks", Key Laboratory of High-Speed Railway Engineering, Southwest Jiaotong University, Chengdu, China, ISSN 45, pp. 01-12.

[19] Chavan K. S., Shreedhar R. (1990). Parametric Studies Of Box Culvert, International Journal of Research in Engineering andScience, Vol. 1, 01, pp. 58-65.

[20] Davison and Birkemoe (2009). Analysis of Box culvert by Stiffness Method, journal of Indian Road Congress, Paper No. 555, 189-219.

[21] Csebfalvi (1981). Design Loading For Deeply Buried Box Culverts, IR-02-03, Highway Research Center, Auburn University, Alabama.

[22] 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.

Corresponding Author

Santosh Kumar Suman*

Civil Engineering, SIRTS, M.P. India