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COMPARISON OF DIFFERENT TYPES OF TRUSSES IN VIBRATION ANALYSIS USING STAAD PRO

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ABSTRACT

This work presents vibration analysis of steel truss bridge under moving loads by using STAAD Pro Software. The proposed bridge is pratt, warren, howe andK type. The bridge length is 250ft. The considered loadings on bridge are dead loads, live loads, wind load, seismic effect and temperature effect.Design calculation of structural steel members are considered according to the design criteria of AISC-ASD Specifications. Deflection checking is carried out in order to ensure that the structure is safe under the various loads. In the vibration analysis, moving loads are considered as harmonic loading and then, vibration effect is analysed. Finally discussions and conclusions are made for this vibration analysis

I. INTRODUCTION

Bridges have built a long time it is very active in the world. Today, modern bridges tend to use high strength materials.

Bridges are very sensitive to dynamic loadings can be exposed to the impact of vibration caused by the dynamic effects such as wind, earthquake and vehicle movement as well as cyclic loading. In addition, vibration can effect safety as well as comfort of users and limit serviceability of the bridge.

Construction of long span bridges has been very active in the world in the past few decades. Today, modern bridges tend to use high strength materials. Therefore, their structure is very slender. As a result, they are very sensitive to dynamic loadings such as wind, earthquake and vehicle movement.

As bridge span gets longer, they become more flexible and prone to vibrate. Vibration can have several levels of consequences; from a potentially hazardous effect (causing immediate structural failure) to a more extended effect (structural fatigue).

In addition, vibration can effect safety as well as comfort of users and limit serviceability of the bridge. Therefore, extensive studies have been carried out to understand mechanisms behind bridge vibration and to reduce this undesirable vibration effect.

II. LITERATURE REVIEW

Mohamad Ibrahim Zaed Ammar et al (2017) studies and focus the effects of vibration of steel truss bridges and finally to suggest future directions of research and innovation. The possibilities of modal properties of global and local vibration method in determining the structural changes in the truss bridges discussed located to the results of finite element analysis.

Ramesh Kumar Dhaka and Pradeep K. Goyal (2017) presents the design of a steel arch bridge which is located at Jaipur using STAAD.Pro. The arch bridge is proposed with 350 meter span and 13.3 meter width with an average height of 29.977 meter in this study. The design is carried out by considering wind load, seismic load, live load & dead load for the arch bridge. The design is carried out as per the Indian Standards and by the help of the structural analysis and design software STAAD.Pro

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M. AllaRangaswamy, E.V. Chandrasekhar (2017) design a flyover in the intersection. The location is at four roads junction at pipeline junction, which is facing major traffic problems due to the construction.

Alpesh Jain and Dr. J.N. Vyas (2016) model a bridge with four different material using ANSYS software and to perform a modal analysis of bridge problem. For all four materials eight node solid element is selected and meshing is done individually for each modal. The material property of each material is selected as per literature database in ANSYS software.

M. Prabu and R.Vijayasarathy (2016) design a bridge and bridge site is located in SANTHA PILLAI GATE, Thanjavur. There exist a railway crossing amidst the state Highway, in order to avoid traffic on that area this proposed bridge is to be constructed. By collecting vehicle population data the necessity of one way road for all two lane road is clearly understood. Precast deck slabs are designed according to IRC CLASS AA TRACKED VEHICLE loadings. The necessary details are provided and bridge is designed according to Indian standard code practices.

S. P. Chaphalkar (2015) studied bridge with two ends fixed one specimen are casted and tested under direct and uni-axial tension. Two types of aggregates (brick and stone) are used to cast the SFRC and plain concrete. The fiber volume ratio is maintained 1.5 %. Total 8 numbers of dog-bone specimens are made and tested in a 1000-kN capacity digital universal testing machine (UTM).

III. GEOMETRY DESCRIPTION

In the present study steel bridge frame is modelled in staad pro in which steel trusses bridge is analysed and optimized, and HS20-44 truck of AASHTO loading is considered as 20 T axle loading, dead load as per 875 part-1 and superimposed live load as per 875 part-2 is applied.

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

Table 1: Property of material

Description	Value
Steel table	Standard section (l100012B50016)
Young’s modulus of steel, Es	2.17x104 N/mm2
Poisson ratio	0.17
Tensile Strength, Ultimate Steel	505 MPa
Tensile Strength, Yeild Steel	215 MPa
Elongation at Break Steel	70 %
Modulus of Elasticity Steel	193-200 GPa

Table 2: Description of Structure

Description	Value
Length of Bridge	50 m
Height of Bridge structure	10 m
Weight of Bridge structure	10 m
No. of bays along length	8
No. of bays along width	1
Section of inclined/ vertical members	I shape
Support type	Pinned support

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IV. MODELLING AND ANALYSIS

Analysis of steel bridge 50 m span expansion to expansion has been considered for the parametric analysis of vehicle critical load position as per HS 20-44 truck of AASTHO loading standard which are analysed with the help of staad pro software. The 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 dead load and live load as per Indian standards.

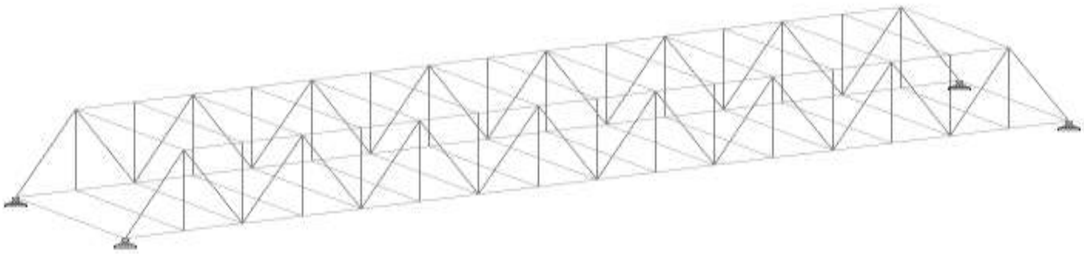

Fig. 1: Pinned support for Pratt type bridge

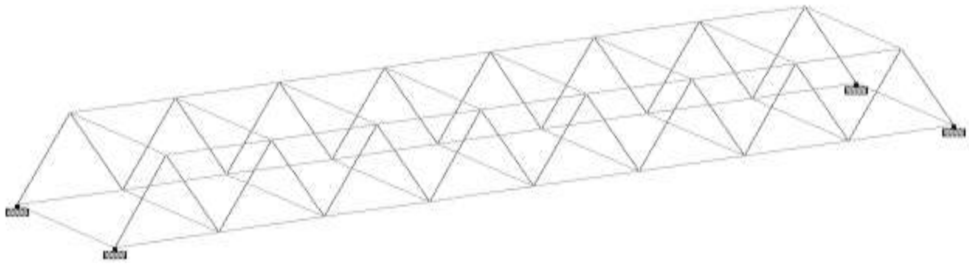

Fig. 2: Pinned support for warren type bridge

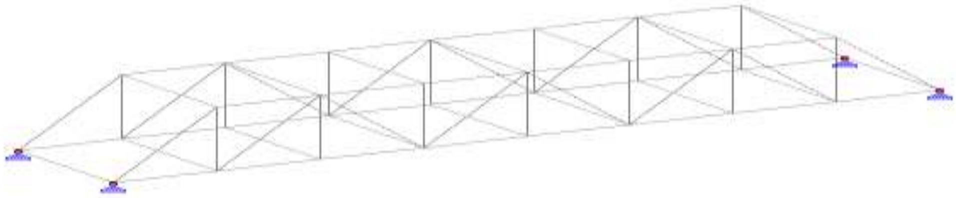

Fig. 3: Pinned support for howetype bridge

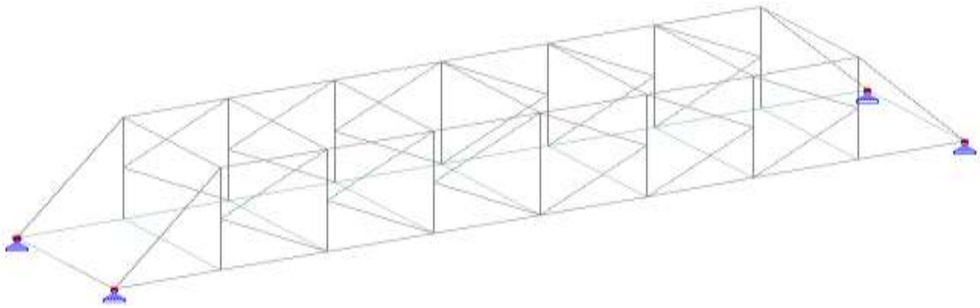

Fig. 4: Pinned support for K type bridge

V. LOAD CONSIDERATION

Considered loadings for the proposed bridge are as follows

1. Dead Load

Gravity load
Concrete slab weight: 100 psf

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2. Live Load

Truck: HS20-44truck of AASHTO

3. Seismic Load

Seismic parameter type: UBC 1997
Seismic zone: 4
Seismic zone factor: 0.4
Soil profile type: 4

4. Temperature effect

Temperature change for axial elongation - 16°F
Temperature difference from top to bottom - 10°F
Temperature difference from side to side – 10°F

5. Wind Effect

Exposure type: Type C
Base wind velocity: 100 mph
Category: I
Structure type: Lattice framework
Common data: ASCE-7, 2002

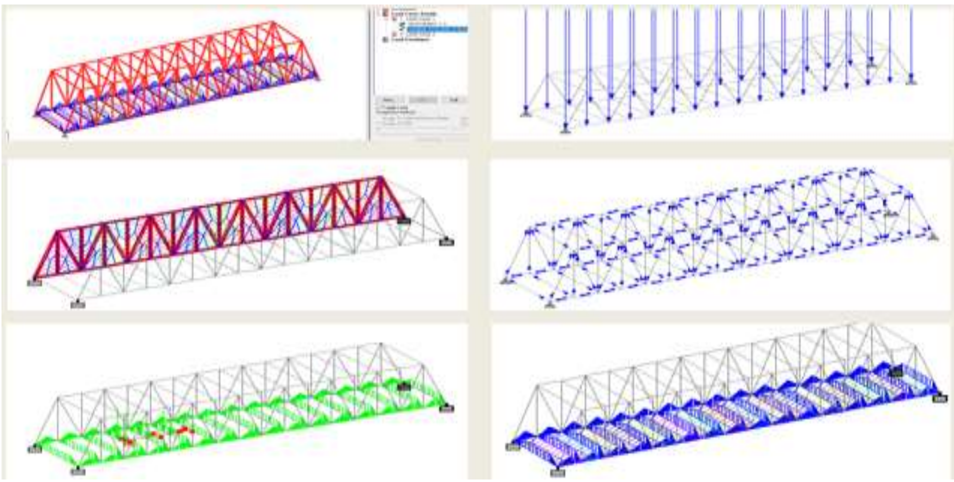

Fig. 5: Various loads

VI. RESULTS AND DISCUSSIONS

6.1 Vibration effect on steel truss bridge under moving load

For the vibration analysis, the influence of vehicle speed, and damping ratio are investigated. First constant, 45mph vehicle speeds are considered to find the significant effect. Finally, the influence of damping ratio on the bridge model is investigated. In this case, damping ratio are assumed 5%, And then, discussion and conclusion are made according to the analysis results. The values of vibration frequency and mode shape of the system are shown in slide 36. The deformed shapes due to various vibration modes are shown in Figs. 6-7.

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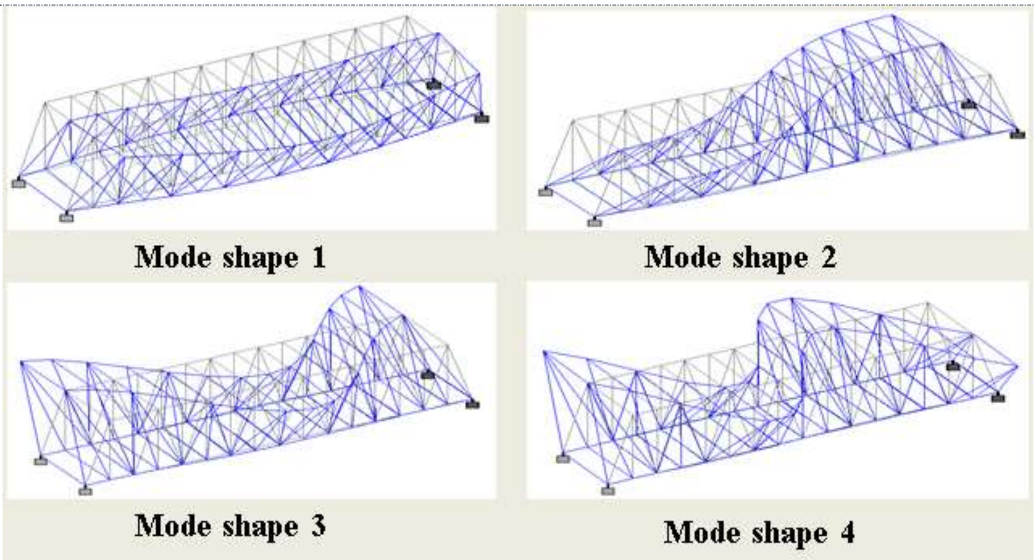

Fig. 6: Deformation of first 4 mode shape for pratttype bridge

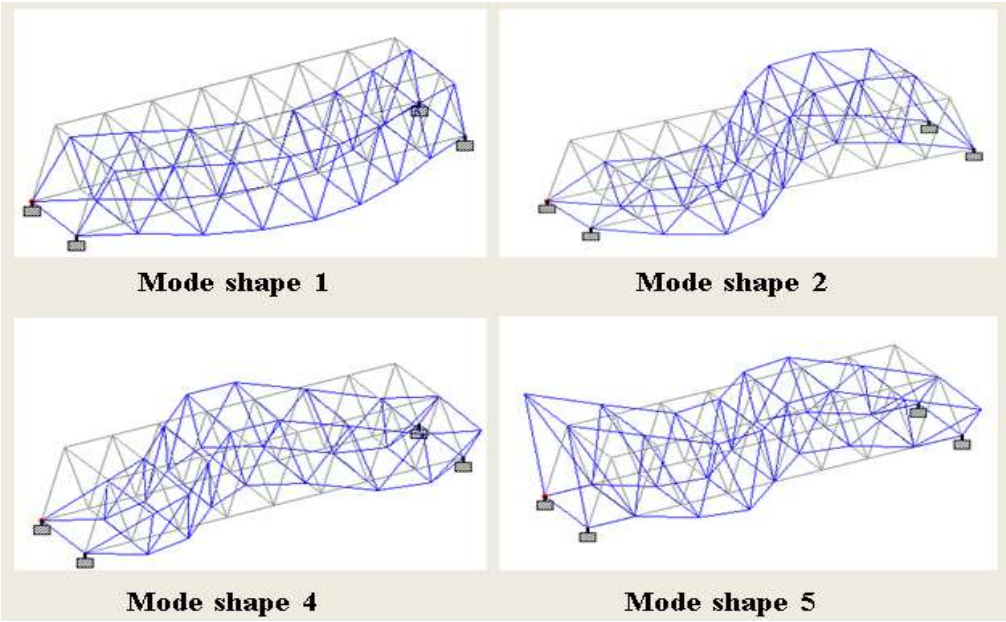

Fig. 7: Deformation of first 4 mode shape for warren type bridge

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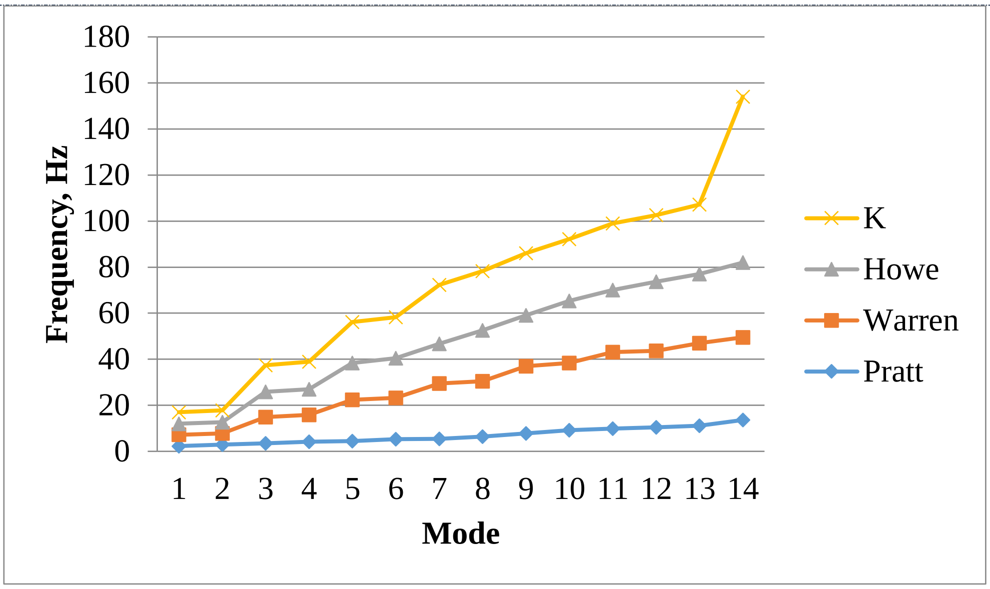

Fig. 8: Frequency vs Mode

6.2 Shear force
Magnitude of shear force for various forms of truss has been plotted in figure number 9, it is determined that in this comparative study maximum shear force is in pratt truss whereas warren type steel bridge shows minimum shear force value which results in balanced section.

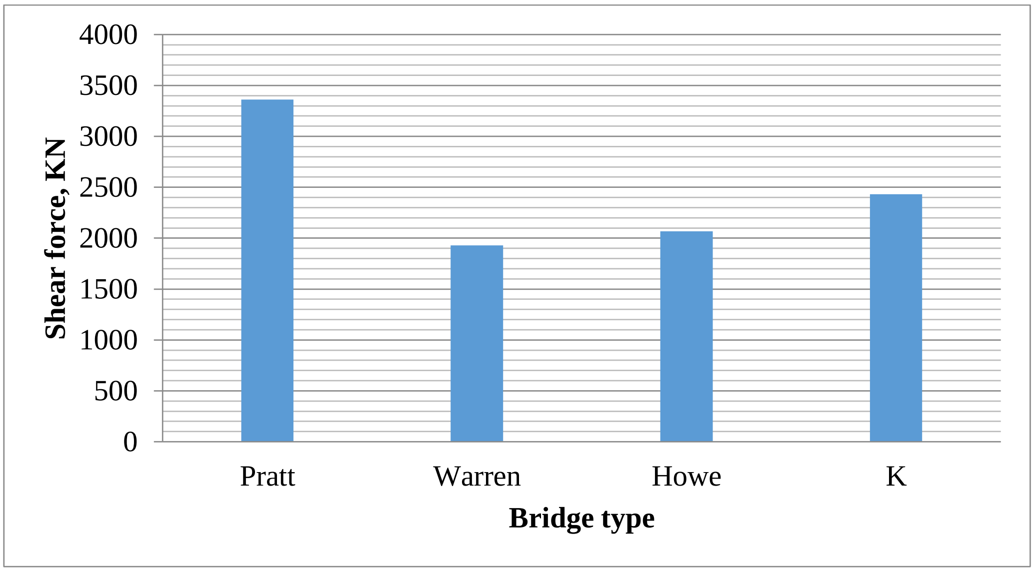

Fig. 9: Maximum Shear force

6.3 Bending moment
Magnitude of bending moment for various forms of truss has been plotted in figure number 10, it is determined that in this comparative study maximum bending moment is in warren truss whereas pratt type steel bridge shows minimum shear force value which results in balanced section.

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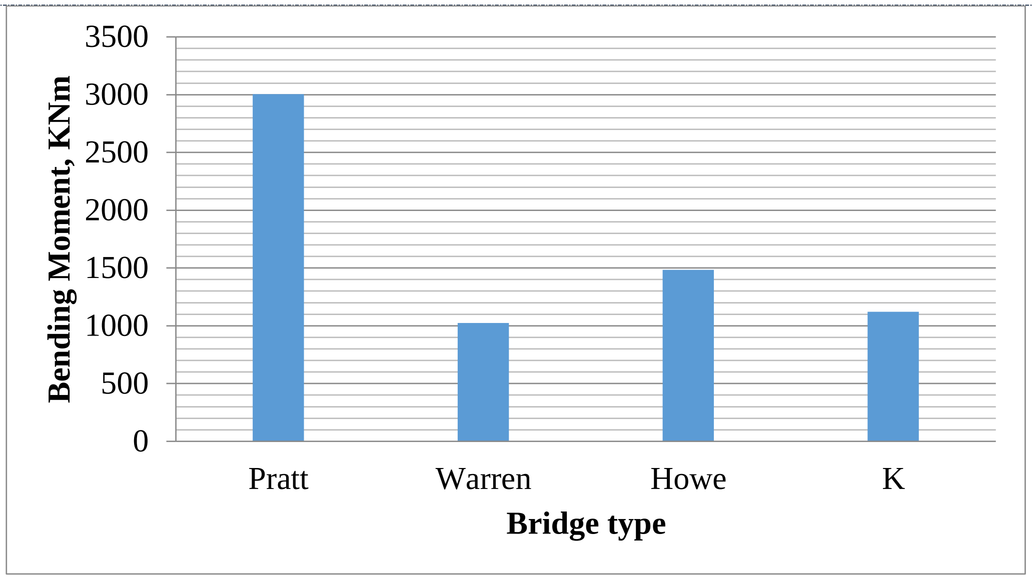

Fig. 10: Maximum bending moment

6.4 Deflection

Magnitude of maximum displacement for various forms of truss has been plotted in figure number 11, below it is determined that deflection is maximum in pratt bridge whereas minimum in warren type steel bridge which indicates that pratt bridge will require more supports as compared to other cases.

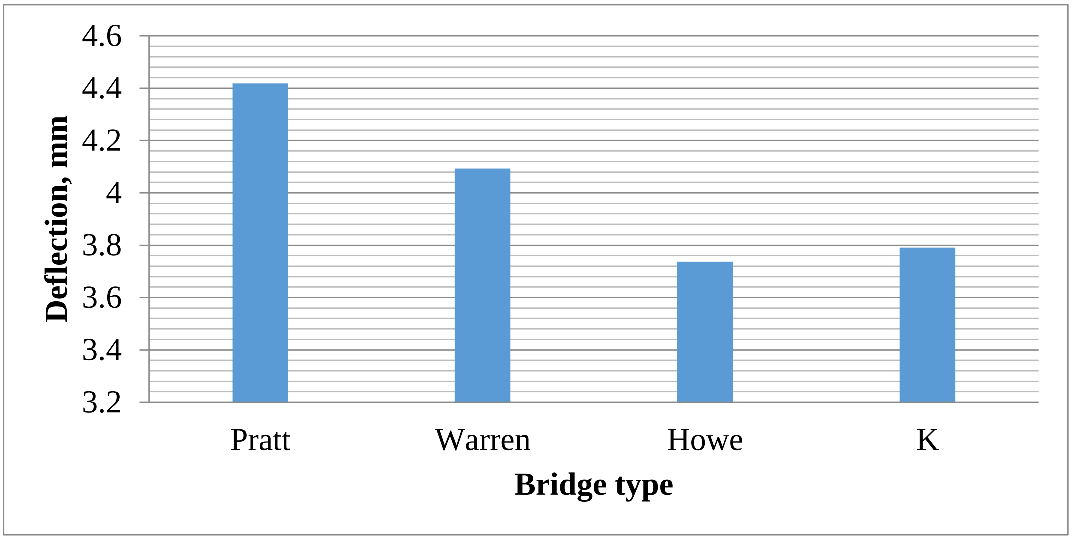

Fig. 11: Maximum displacement

6.5 Steel section weight

Magnitude of steel section weight for various forms of truss has been plotted in figure number 12, it is observed that pratt truss type bridge structure will be more costlier for same loading as compared to other cases whereas warren type bridge will be economical in comparison to other above.

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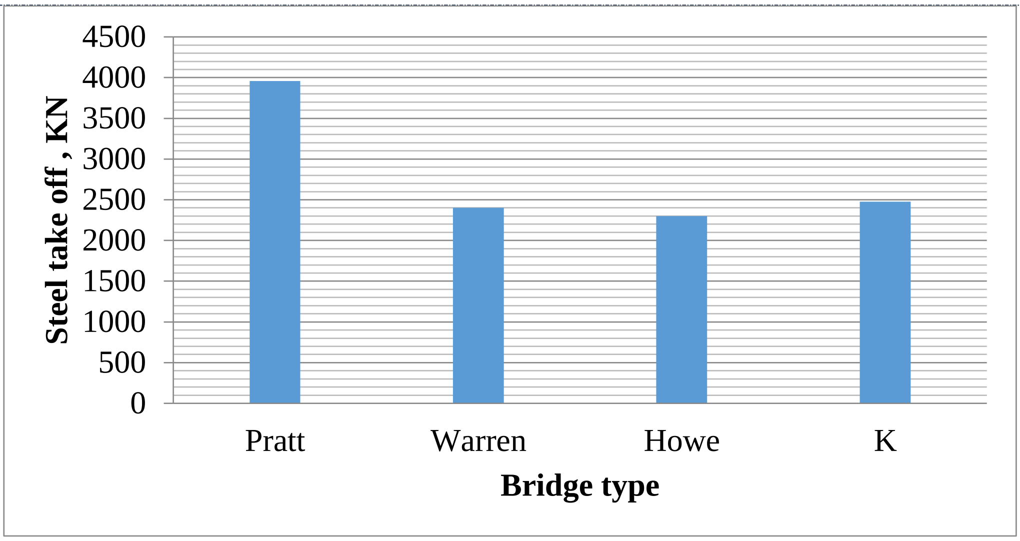

Fig. 12: Steel take off

VII. CONCLUSIONS

We have considered various cases along with dead load & live load for the Steel bridge for analysis by using Staad-Pro software. Following are the conclusions of this study-

1. In this, the influence of vehicle speed and damping ratio are investigated along the bridge vibration. 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. Also, it is observed that vehicle speed is the most significant factor in bridge vibration. The second investigated factor is the effect of damping ratio. In this case, the difference is occurred although it is small in magnitude.
2. It is observed that Maximum deflection is observed in Pratt bridge whereas least in howe, which indicates that in terms of deflection howe is stable than pratt.
3. In terms of unbalance forces warren type truss bridge is more stable showing less shear forces, whereas maximum is observed in pratt truss.
4. The bending moment is more in pratt than warren type bridge.
5. 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 it is observed that out of four bridges 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 pratt type bridge. Hence we can say that warren arrangement is more efficient then pratt arrangement.

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