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IMPROVING THE STRUCTURAL EFFICIENCY OF STEEL TRUSSES BY COMPARATIVE STUDY

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Abstract— There are numerous advantages to using steel trusses instead of traditional wood trusses but the main reasons are simplicity and strength. Using steel can help to create a stronger structure that is able to stand up to not only more weight but also higher winds providing more protection that other options. Steel trusses are merely outlined as triangulation of members to form the stable structure. Triangulation is that the stable configuration mathematically. Though there are several parts of a truss bridge the use of materials is very effective. Elements like iron, wood, steel as well as iron are all used to their highest potential and eadarch of the pieces plays an important role in it. The buildings of a bridge can be a useful option, while compared to other types of bridges. The main objective of this study is to determine the most economical and efficient type of steel truss bridge along with different type of steel. The analysis is carried out in the Staad-pro with reference to the Indian standard code of steel design.

Keywords— Steel Structure, Structural Efficiency, Steel Trusses, Staad-pro, Indian standard code.

1. Introduction

Structural hollow sections possess many advantages over open sections; structural efficiency when subjected to compression, reduced surface area, absence of sharp corners, aesthetic appeal. However, the structural efficiency of trusses formed from tubular steelwork may be compromised by the design of the joints between the chords and the bracing (web diagonal) elements. In order to prevent local failure at a node, the size/thickness of the chords and/or bracing elements may need to be increased above that required to resist the axial force in the member. Thus, the amount of material used along the whole length of individual members is increased to avoid a local capacity problem. Strengthening joints between hollow sections is problematic as access to the inside of the tube is not possible. The design approach that has been adopted for many years is to size the members to resist the axial forces generated in the truss members and then check that the joints between the chords and braces have sufficient capacity without stiffening. Structural engineers face the challenge of designing structures that can support not only the weight of the structure itself but other loads as well, such as forces caused by people, furniture, snow, wind, and earthquakes. The structural framing system should be designed to carry these loads in an efficient manner. Because the cost of construction materials used to build a structural system is often based on the weight of the materials, it is cost effective to use the least amount of material necessary to provide a structure that can safely carry the applied loads. The most efficient structures are strong and lightweight. One measure of the cost effectiveness of a structure is structural efficiency.

1.2 Components of Truss Bridge

The components of a truss bridge are as follows:

1. Top chord/Rail 2. Bottom lateral bracing
3. Floor beam 4. Hip vertical
5. End post 6. Bottom chord
7. Deck 8. End floor beam
9. Strut 10. Portal strut
11. Diagonal 12. Vertical

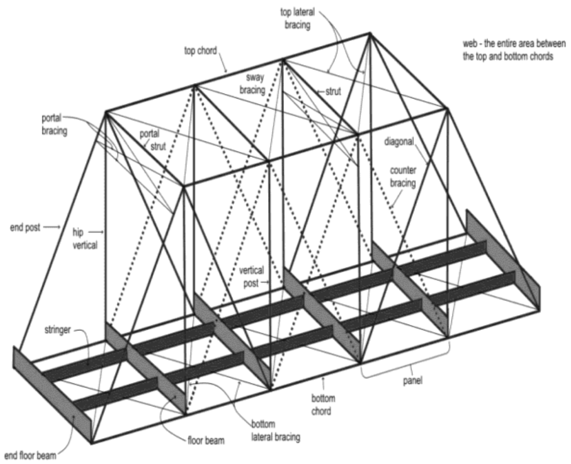


Fig.1 component of bridge

1.3 Objective

1. The main objective of this study is analyzing the different bridge trusses with types of steels.

2. To determine the most efficient type of truss bridge among the Warren type, Patt type and Howe type.

3. To analyze the above truss bridge when subjected to dead load, live load, earthquake load ,wind load Using Staad-pro software.

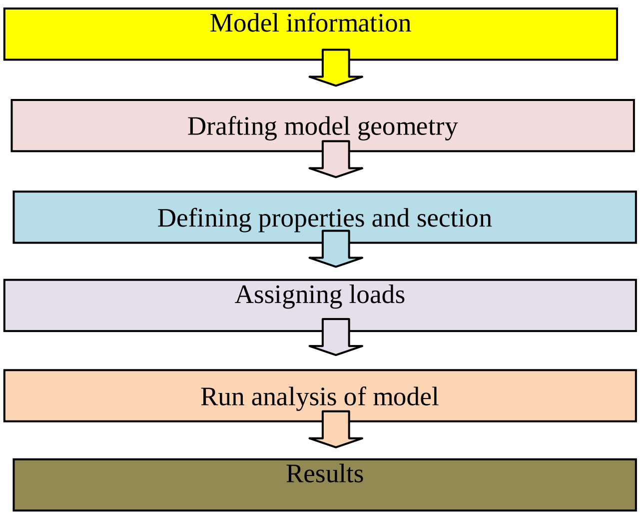
2. METHODOLOGY

2.1 Software

STAAD Pro full form stands for Structural Analysis and Designing Program. STAAD Pro is a structural analysis & design computer program that was being developed by Research Engineers International (REL) at Yorba Linda, California in 1997. Today, STAAD Pro is one of the popular and widely used software for structural analysis and design across the globe by Civil engineers. It supports all types of various steel, concrete, and timber design codes. Using STAAD Pro, civil engineers can design any type of structure, and later share the synchronized model data amongst the entire design team. It ensures on-time and budget-friendly completion of structures and designs related to steel, concrete, timber, aluminum, and cold-formed steel projects, irrelevant to the complexities.

STAAD Pro is one of the most widely used structural analysis and design software products worldwide. It supports over steel, concrete, timber & aluminum design codes. It uses various methods of analysis and design from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non-Linear Analysis) or a buckling analysis. It can also make use dynamic analysis methods from time history analysis to response spectrum analysis. The response spectrum analysis feature is supported for both user defined spectra as well as a number of international codes specified spectra.

Steps Of Modeling Truss in STAAD PRO



2.2 Modeling of bridge

The bridge is modeled in reference to the CONRAIL bridge. The type of truss modeled is warren vertical truss. The length of the bridge is assumed to be 40m. The height of the bridge is about 7m and width of bridge is 15m.Deck slab is provided with a thickness of 200mm.

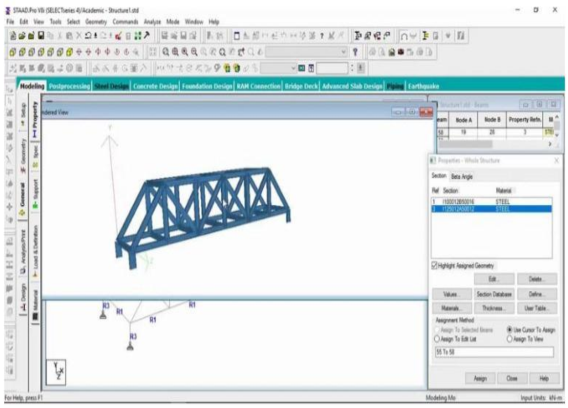


fig.2 Truss bridge model – warren type

Section properties

Table 3.1: Section Properties

Section	Ref. Member Name	Material type
Thickness 200mm	R1	Concrete
I80016B500012	R3	Steel
I80016B500016	R4	Steel
I80016B500020	R2	Steel
I80016B500030	R5	Steel

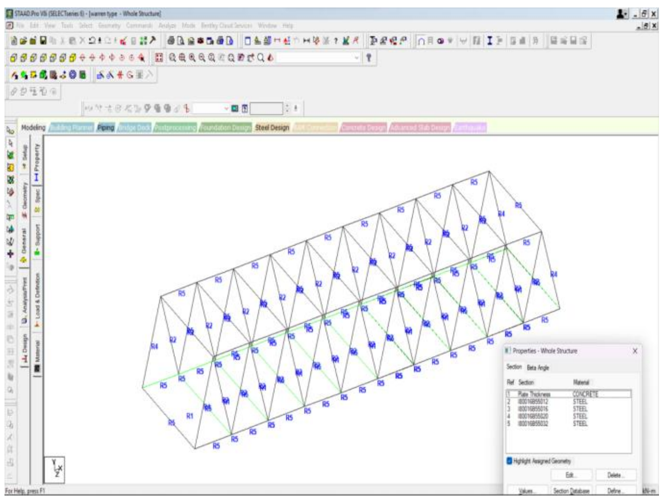


Fig. section properties

3. LOADS AND LOAD COMBINATIONS

3.1 Load case

Dead load of 1 KN is assigned to the total structure and live load of 5 KN as floor load is provided as per IS 875 part 2 imposed loads (code of practice for design loads).

3.2 Seismic load

Seismic load is the strongest load that threatened the bridge in the seismically prone areas. Accordingly, many structures can be exposed to significant plastic deformations and its response can be significantly nonlinear. Nevertheless, the elastic linear methods are usually used for their analysis. The seismic load is assigned with self-weight and floor load of 1KN and 5KN in x, y, z direction. Loading type is defined as ground motion. Direction of seismic load is given as Z direction.

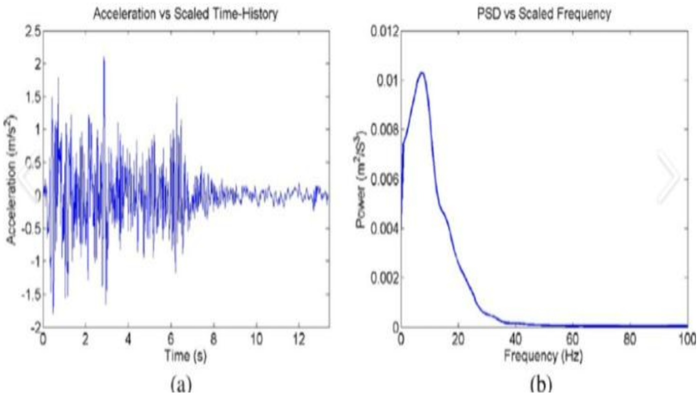


Fig.The scaled El Centro earthquake EW: (a) acceleration and (b) power spectrum density.

Here, Defining the seismic loads Zone IV is considered with reference with IS 1893-2022 with including part 4.

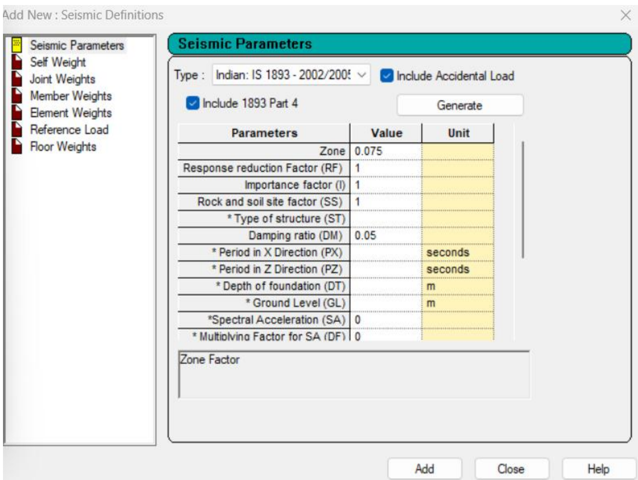


Fig. Seismic parameter defines

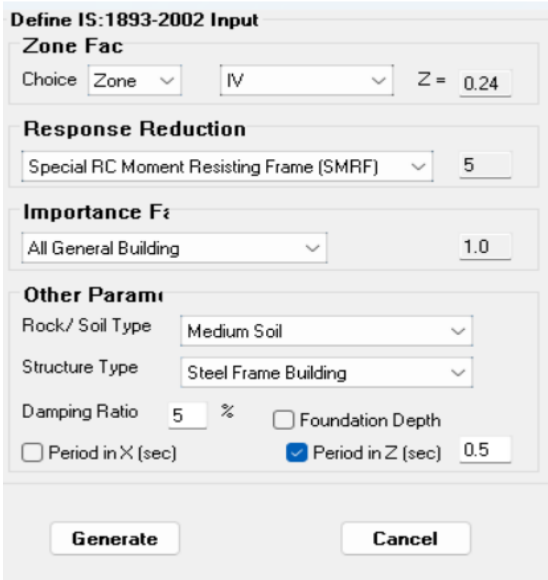


Fig. Seismic load define

3.3 Load combinations

The load combinations provide combined results of load case specified. The various load combinations used are as follows:

1.5(Dead load + Live load)

DL+LL+SL,

Were,

DL - Dead load

LL – Live load

SL – Seismic load

4. RESULTS

4.1 Results with seismic loads

Time Displacement values at the center node of bridge

	x-direction	y-direction	z-direction
Warren type	0.624	1.49	0.435
Patt type	0.005	0.229	0.016
Howe type	0.015	0.007	0.031

Time Displacement graph:

Frequencies For Load Cases

Table 5.1: Frequencies For loads on Warren type truss bridge

MODE	FREQUENCY (CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	4.078	0.24523	2.495E-12
2	4.828	0.20710	9.706E-12
3	5.865	0.17050	1.413E-11
4	7.064	0.14156	9.508E-07
5	7.184	0.13920	3.382E-09
6	8.162	0.12252	3.867E-06

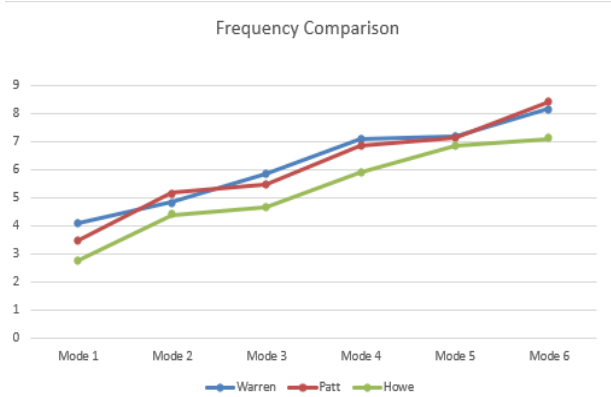
Table 5.2: Frequencies For loads on Patt type truss bridge

MODE	FREQUENCY (CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	3.462	0.28882	4.278E-12
2	5.158	0.19387	5.983E-09
3	5.479	0.18251	4.532E-09
4	6.851	0.14596	8.198E-07
5	7.127	0.14032	4.130E-07
6	8.426	0.11868	5.529E-05

Table 5.3: Frequencies For loads on Howe type truss bridge

MODE	FREQUENCY (CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	2.732	0.36604	1.505E-14
2	4.384	0.22811	1.767E-10
3	4.659	0.21463	2.725E-10
4	5.907	0.16930	3.095E-08
5	6.851	0.15692	1.545E-07
6	7.095	0.14095	2.421E-06

Frequency chart:



5. CONCLUSION

1. The truss bridge has been modeled and analyzed with at seismic zone IV.

2. The response of the Warren, Patt and Howe type truss bridge under various combinational moving and seismic loads are studied.

3. Displacement with respect to time for all three types of truss bridge is analyzed.

4. The type displacement is greater than that of Patt and Howe truss bridge.

5. It was observed that the natural frequency of Warren type and Patt type is greater than the Howe type truss bridge.

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