Analysis of a Steel Truss Framed Structure Considering Lateral Load Using Staad.Pro Software

Shashank Sikariwal[1] Hitesh Kodwani[2]
[1]P.G. Scholar [2]Assistant Professor & Head of Department
[1,2]Department of Civil Engineering
[1,2]SAM College of Engineering and Technology, Bhopal, India

Abstract— Steel structures are generally use in places where long span spacing is required with stability and within time limit. These structures are stable and rigid with easy and early fixation at site. These structures are open structures where wind effect is nominal, rigidity of such structures are comparatively more than RCC structures. These structures are easy to fix and dismantle. These are casted along with bolt or rivet connection which minimizes moment. The Truss Structure consists of members/elements that takes only tension or compression and no bending moment in what so ever form. In the engineering term the Truss is defined as the two-force member, where the members are so assembled that the assemblage works as a single unit. The truss structure is generally provided when we need a large open space. In this study we are presenting linear analysis of three different type of truss arrangement i.e. Flink, Howe and King post for long span open area of dimension35m x 25m. In this study we will also discuss the variations occur due to different type of sections such as ISMB, Channel section and Angle section. For analysis purpose we will use Staad.pro.

Keywords: Steel Structure, Analysis, Truss, Staad.Pro, Steel Sections, Deflection, Cost, Forces

I. Introduction

Steel frames are usually the choice when constructing a larger building that needs a big open space because of the economical aspect and efficiency of building a single-storey unit. However, a problem that might occur is when designing for a cost effective solution the slenderness may be decreased, that in the end may contribute to instability of the entire structure.

A typical frame will in ultimate limit state (ULS) have compression forces and bending moments that are of big concern. The reason for this is that they may cause one element to buckle and deform. Because the elements are connected to each other, this may result in a deformation of the neighboring element which in the end may lead to severe deformations and instability of the entire system of the frame.

It can be said that steel structures are the materials which we utilize in construction industry as a material for preparing sections of steel as per standard shape and sizes according to steel tables. Steel sections are categorize as specific sections with fixed length width and thickness, prepared in industries with standard mechanical properties of steel. These sections are specified as per countries norms allotted in steel codes. These sections are in shape of beam, I shape, angel shape, Channel shape etc.

Steel structures are generally used in roofs of multistory buildings, malls, complexes etc. these steel structures are arranged generally in some well-organized manner which are considered as truss type like pratt truss, king post, waren, howe etc. these shapes are the arrangement of steel structures in horizontal, vertical and inclined phases. Instead of truss arrangements steel shapes are also utilize in composite structures multistory building frames where simple sections are used instead of arrangements. The staggered truss is a non-patented efficient framing system developed in the 1960’s, but has never seen widespread use. However, the system has recently gained attention as it has been used to build a number of mid-rise hotels, apartments, and dormitories. AISC published a Design Guide Series on the staggered truss in 2002. The stub girder system was developed in the early 1970’s primarily for office construction, but it no longer competes economically in today’s construction market due to high labor costs and was never successfully used in residential construction due to the large floor depths.

In this study we are presenting non linear analysis of three different type of truss arrangement i.e. Flink, Howe and King post for long span open area of dimension 35m x 25m. In this study we will also discuss the variations occur due to different type of sections such as ISMB, Channel section and Angle section. For analysis purpose we will use staad.pro.

II. Objectives

1) The main objectives of this study are as follows:
2) To determine the most suitable type of truss arrangement for long span.
3) To determine the type of steel section most effective in resisting deformation.
4) To justify the utilization of analysis tool in steel sections analysis.
5) Long span structures are needed to resist lateral forces over the span length without vertical members at the mid spans, for such structures truss arrangement is more beneficial to distribute tension and compression of each members. Benefits of truss structures are as follows:
6) To provide lateral stiffness to the structure.
7) To minimize structure weight and support divisions.
8) Fast assembling and arrangement at the site.
9) The present investigation will encourage the utilization of steel truss arrangement for long span structures which may be cost effective, easy and fast in assembling.

III. Literature Review

Jyoti .P. Sawant and VinayakVijapur(2013)[Analysis and Design of Tubular and Angular Steel Trusses By Post-Tensioning Method] here the author applied post-tensioning to both angular and tubular trusses with a span of 30m Mansard and Pratt trusses with single and double drape tendons using the analytical tool SAP 2000v15 It was observed that with post tensioning members the pre-stressing force in the members have been reduced. External Post-tensioning was considered in the authors study since the tendons was outside the trusses and examined the trusses for member forces, pre-stressing stresses at 0 deflection observed at the mid-span of the member, this cause reduction in sectional size and weight of the structure.

Post tensioning by external tendon layout was suggested to strengthen and to increase useful life of steel truss. The trusses configuration with different tendon profile for post tensioning the truss with different eccentricities was considered and the effect of post tensioning on member forces, cross section of members and weight of truss is studied in the analytical work.

The results concluded that, in case of truss post tensioned with single drape tendon layout, there was a significant reduction in member forces and cross section members of all the bottom chord as well as top chord and web members. In case of truss post tensioned with Double drape tendon layout, there was a significant reduction in member forces and cross section members of all the bottom chord as well as top chord members and web members. The reduction in cross sections and member forces was more significant in case of double drape tendon layout as compared to single drape tendon layout. In case of Pratt trusses the reduction in cross sections, member forces, pre-stressing forces and weights of the trusses was more significant as compare to Mansard trusses.

Tubular trusses have good aesthetic view when compared to the angular trusses and Angular trusses were labour intensive when compared to the tubular trusses. Tubular trusses had lesser pre-stressing force when compared to the tubular.

Ola Adel Qasim (2017)[Analysis and Design of Steel Truss Stadium]the principle behind the authors study was to analyze and design steel stadium, where the designs were made manual calculations according to (AISC LRFD manual) and compare the results by using STAAD.PRO. The research specified the design and analysis of steel truss stadium using Staad Pro program, with 28 m width and 44 m length and truss high of 9 m. Later, the manual calculus was compared with then data extracted from the analysis on Staad.Pro.

As the project dealt with two design criteria (by hand calculation and by staad pro program) in staad pro two design were used first by checking the adequacy of the section chosen and second, by least weight design. There was a difference between all design criteria which depend on the area of the section that gives different section.

ChetanJaiprakashChitte (2018)[Analysis and Design of Pratt Truss by IS 800:2007 & IS 800:1984] In this study author illustrated the performance of pratt type truss arrangement for long span area by limit state and working stress method considering dead load, live load and sections as per steel table. And in this study they considered lateral pressure (wind) for analysis. The structure was designed under Wind loading with fixed supported condition with a primary objective to provide the method which was economical, more load carrying capacity and high flexural strength. The research paper concluded that the limit state method design provided high load caring capacity with minimum quantity of steel required as compared to working stress method, which results in economical design of truss design (For the same configuration of truss, total percentage saving in weight of steel is by limit state method is 23% as compare to working stress method).

Further conclusions derived from the results were that the consumption of steel is less in LSM with respect to WSM. For same working forces, WSM will require higher steel section than LSM. Limit states design, by providing consistent safety and serviceability, ensures an economical use of materials and a wide range of applications.

IV. METHODOLOGY

1) Step-1: Modelling of the structure in Staad.pro

A Truss arrangement is a combination of structure joined in vertical, inclined and horizontal members working together to distribute compression and tension.

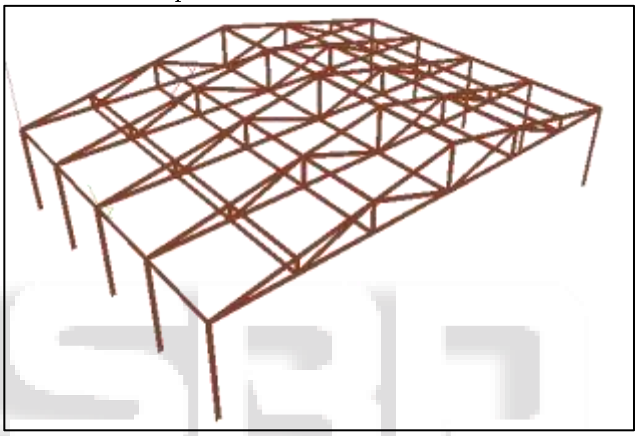

Fig. 1: Modelling of truss in staad.pro

2) Step-2: Assigning Sectional properties and members as per Steel Table.

Staad.pro give us access to Indian steel tables as weel as other countries and companies tables. This helps us to provide suitable section types which are available and valid as per Standard provision.

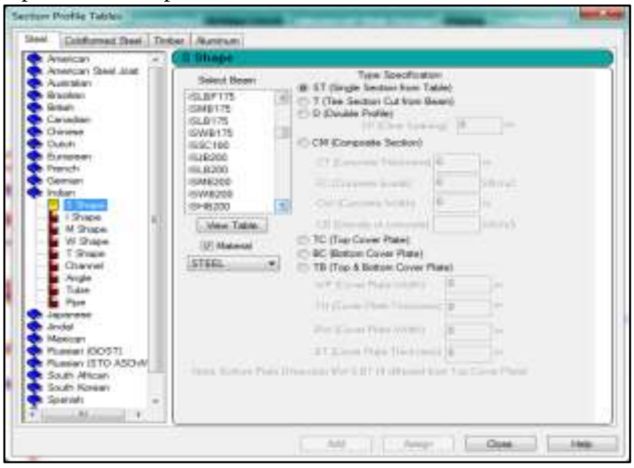

Fig. 2: Steel Table in staad.pro

3) Step-3: Assigning Support Condition

Support conditions are assigned to retrain loads in direction, Supports are provided at the joints using node cursor, these supports are generally assigned at the join and end conditions of the members.

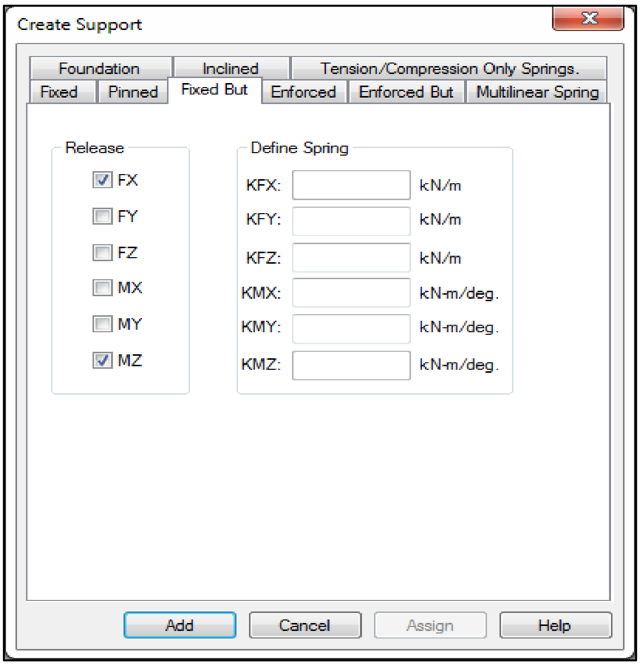

Fig. 3: Fixed end condition

4) *Step-4: Assigning load conditions:*

In this study we are considering Dead load of the structure, super dead load of the shed and other attached members, lateral load considered as per wind pressure in Bhopal region i.e. 39 m/s as per appendix A (I.S. 875-III).

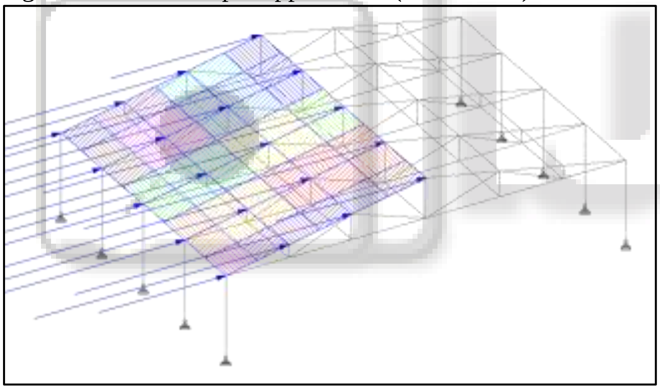

Fig. 4: Lateral load

5) *Step-5: Analysis of structure*

Analysis of structure is done as per finite element analysis considering lateral forces

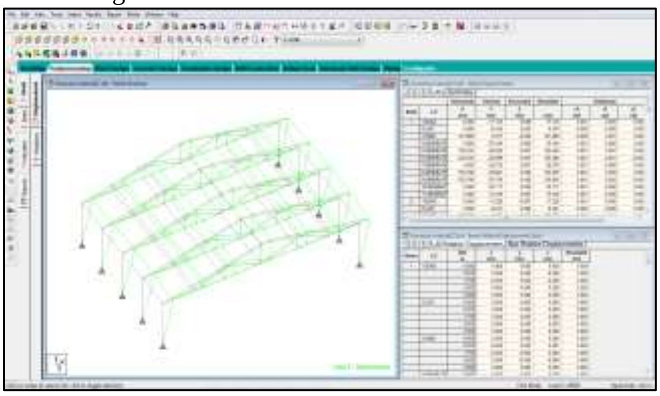

Fig. 5: Analysis

6) *Step-6: Cost*

Cost is analyzed as per S.O.R. 2019

V. FORMULATION

Cases assigned in present study are as follows:

1) *Case I- Howe Truss:*

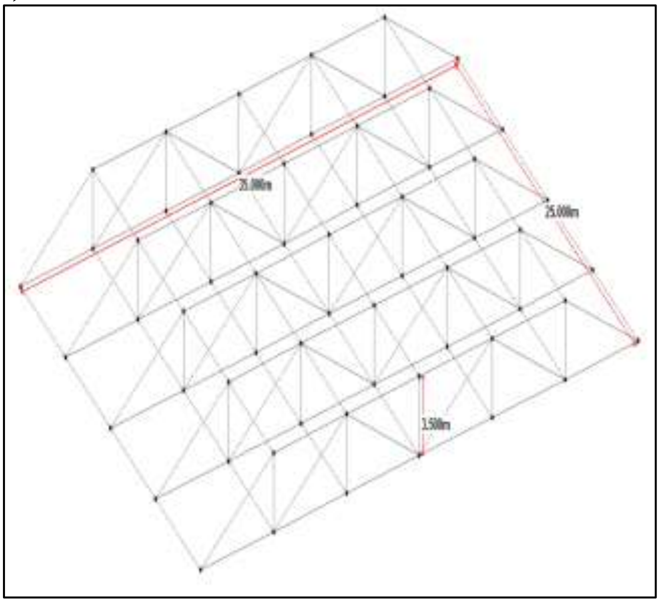

Fig. 6: Howe truss

2) *Case II- King Post Truss:*

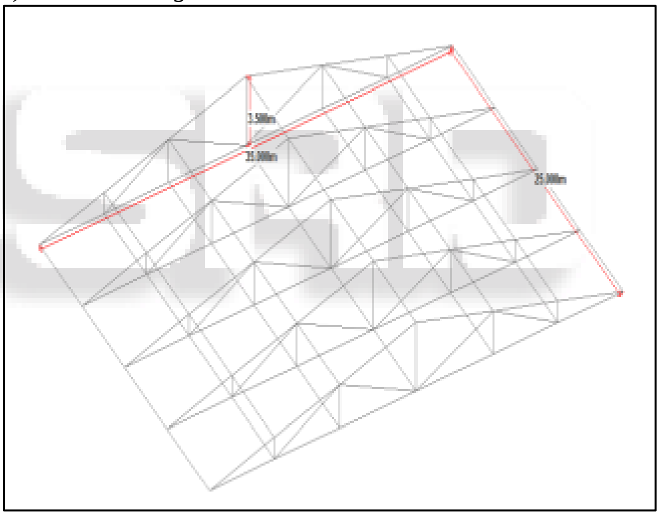

Fig. 7: King post Truss

3) *Case III- Flink Truss:*

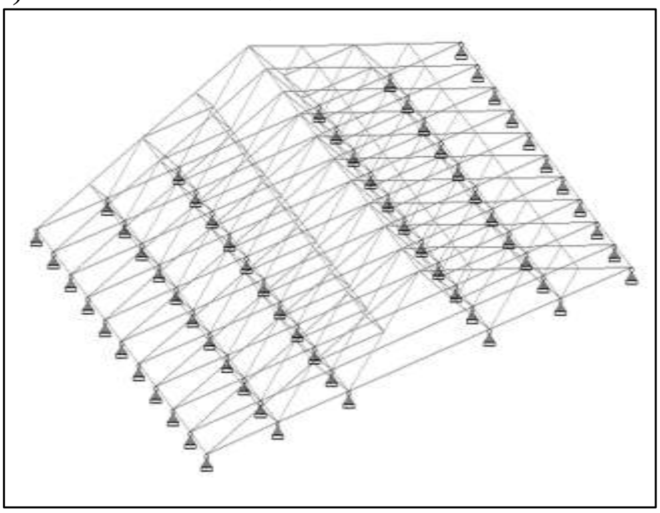

Fig. 8: Flink Truss

Design data of building	Dimension
Plan dimension	25 x 35 m
No. of bay in X direction	6 Bay
No. of bay in Y direction	4 Bay
Typical storey height	3.50 m
Sections	I.S.M.B, CHANNEL & ANGLE
Truss	Howe, Flink& King Post
Grade of steel	Fe-345

Table 1: Geometrical details

VI. ANALYSIS RESULTS

A. *Angle Section*

Angle Section			
S.No.	Flink Type	King Post	Howe Type
S.F. (kN)	33.13	28.13	23.13
A.F. (kN)	1090	1087	1082
Support reaction (kN)	256.09	256.45	252.65

Table 2: Angle Section

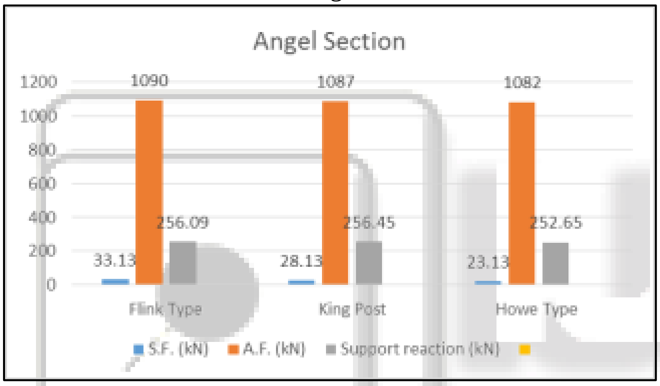

Fig. 9: Angle Section

B. *Channel Section:*

Channel Section			
S.No.	Flink Type	King Post	Howe Type
S.F. (kN)	38.06	35.69	32.55
A.F. (kN)	1094	1090	1088
Support reaction (kN)	259.09	257.45	255.65

Table 3: Channel Section

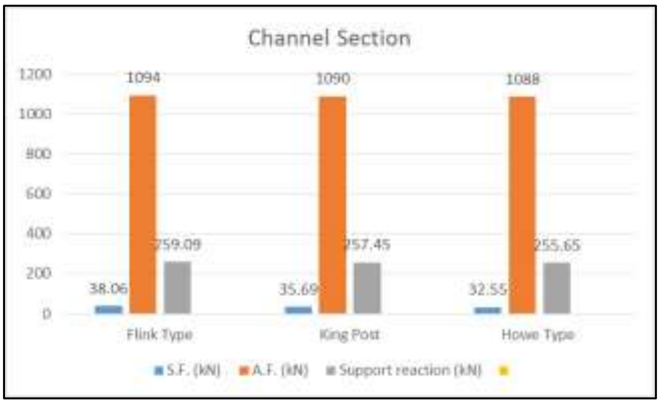

Fig. 10: Channel section

C. *Beam Section:*

Beam Section			
S.No.	Flink Type	King Post	Howe Type
S.F. (kN)	30.65	27.73	20.05
A.F. (kN)	1024	1020	1018
Support reaction (kN)	248	242	239.56

Table 4: Channel Section

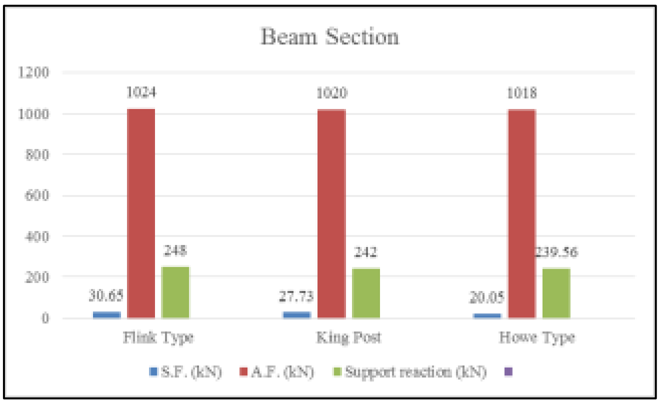

Fig. 11: Beam Section

D. *Cost Analysis*

Cost Analysis				
Section	Truss	Qty KN	Rate/KN	Total Cost
Angle Section	Flink Truss	438.97	470	206316
	King Post Truss	439.21	470	206429
	Howe Truss	411.45	470	193382
Channel Section	Flink Truss	464.85	470	218480
	King Post Truss	437.2	470	205484
	Howe Truss	423.55	470	199069
Beam Section	Flink Truss	461.99	470	217135
	King Post Truss	428.68	470	201480
	Howe Truss	395.37	470	185824

Table 5: Cost Analysis

VII. CONCLUSION

1) It has been observed that stability in terms of resisting axial force and shear force is comparatively 18.5% more in Howe type truss arrangement in comparison to other two types.
2) As observed in above chapter Beam section is best suitable for truss arrangement than Angle and channel section.
3) It is observed that howe type truss arrangement with beam section is comparatively more economical by

14.95% than others. Whereas Flink type truss with channel section is observed as most costly.

4) In this study it is observed that deflection is 4.8% less in beam section than other two.

VIII. SUMMARY

In this study, it is concluded that in truss arrangement Howe type truss is comparatively best suitable whereas in terms of sections beam section is more resistible and economical.

REFERENCES

[1] Jyoti .P. Sawant and VinayakVijapur(2013)[Analysis and Design of Tubular and Angular Steel Trusses By Post-Tensioning Method], JEC&AS, Volume 2, No.8, August 2013

[2] Ola Adel Qasim (2017)[Analysis and Design of Steel Truss Stadium] , IInd edition, 2017

[3] ChetanJaiprakashChitte (2018)[Analysis and Design of Pratt Truss by IS 800:2007 & IS 800:1984] , IJCEM International Journal of Computational Engineering & Management, Vol. 21 Issue 2, March 2018

[4] Chhasatia et.al (2016) [Analysis and Design of Conventional Industrial Roof Truss and Compare it with Tubular Industrial Roof Truss]. IJMPE Volume- 5, Issue-11, Sept. 2016

[5] Heenadewangan&kaushikmajumdar (2018)[a review on comparision of different types of trusses in vibration analysis using staad pro] IJESRT, ISSN: 2277-9655, CODEN: IJESS7

[6] Parmaret. al. (2017)[Analysis of Howe Roof Truss using Different Rise and Span]

[7] DheerajHarod and SumitPahwa(2019)[Static Structural Analysis of Pratt, Flink and Howe Steel Truss using Ansys Software], (IJRASET), Volume 7 Issue III, Mar 2019

[8] Rajatpalya&deependrasinghraghuvanshi (2017) [study on different truss structures for ware house design], IJMPE Volume- 5, Issue-11, Nov.-2017

[9] Upendra Pathak and Vivekgarg (2015)[optimization and rationalization of truss design], IRJET, Volume: 02 Issue: 05 | Aug-2015

[10] Avanti Patrikar& K. K. Pathak(2016)[Fully Stressed Design of Fink Truss Using STAAD.Pro Software]Open Journal of Civil Engineering, 2016, 6, 631-642

[11] AzazPathan (2018)[Design of Large Span Roof Truss under Medium Permeability Condition], IJSTE - International Journal of Science Technology & Engineering | Volume 4 | Issue 10 | April 2018

[12] Pradeepa. S, Monika N.R (2015)[Design And Comparison Of Various Types Of Long Span Roof Trusses]International Journal of Science and Engineering Research (IJ0SER), Vol 3 Issue 10 October-2015

[13] J. Pavan Kumar et. at. (2016)[Quantitative Study of Howe Truss (A- Type) and Parallel Chord Scissor Truss (B- Type) by Applying External Pre-Stressing], International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 01, January-2016

[14] M.Indrajitet. al. (2018)[standardization of truss profile for various span and loading conditions] , ISSI, 2018.

[15] Takao nakazawaet. al. (2004)[dynamic characteristics of king-post truss road bridge made of glued laminated wood], 13th World Conference on Earthquake Engineering