INVESTIGATION ON DIFFERENT TRUSS STRUCTURE FOR BRIDGE DESIGN

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ABSTRACT

A truss is one of the major types of engineering structures which provides a practical and economical solution for many engineering constructions, especially in the design of bridges and TRUSS FRAME s that demand large spans. A truss is a structure composed of slender members joined together at their end points. The joint connections are usually formed by bolting or welding the ends of the members to a common plate called gusset. Planar trusses lie in a single plane & are often used to support roof. In this study we are analyzing a 3-dimensional frame of an ongoing live project of a ware house which is analyzed and designed in analysis tool staad.pro and comparative study is performed on different materials used in same geometry. The present work presents a sizing optimization procedure for composite steel-3-dimensinal frames. An evolutionary optimization method is employed to minimize structural cost subject to constraints

Keywords: *Staad Pro, Steel Structure, Optimization.*

INTRODUCTION

There are a variety of structural steel systems available for use in multi-story residential construction. Typical examples include convention beams and girders, Girder-Slab, staggered truss, and stub girder. Conventional beams and girders are not typically used in multi-story residential construction due to the depth and large weight of the members that would be required. The Girder-Slab is a patented framing and floor system developed in the 1990's to compete with the cast-in-place concrete industry. 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.

TRUSS

In engineering, a truss is a structure that "consists of two-force members only, where the members are organized so that the assemblage as a whole behaves as a single object". A "two-force member" is a structural component where force is applied to only two points. Although this rigorous definition allows the members to have any shape connected in anystable configuration, trusses typically comprise five or more triangular units constructed with straight members whose ends are connected at joints referred to as nodes.

In this typical context, external forces and reactions to those forces are considered to act only at the nodes and result in forces in the members that are either tensile or compressive. For straight members, moments (torques) are explicitly excluded because, and only because, all the joints in a truss are treated as revolute, as is necessary for the links to be two-force members.

WIND LOAD

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The radiation effects are mainly responsible for convection current either upwards or downwards. The wind generally blows horizontal to the ground at high speeds. Since vertical components of atmospheric motion are relatively small, the term ‘wind’ denotes almost exclusively the horizontal wind while ‘vertical winds’ are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs, which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground

Very strong winds are generally associated with cyclonic storms, thunderstorms, dust storms or vigorous monsoons. A feature of the cyclonic storms over the Indian region is that they rapidly weaken after crossing the coasts and move as depressions/ lows inland. The influence of a severe storm after striking the coast does not, in general exceed about 60 kilometers, though sometimes,

TRUSS STRUCTURES

Truss elements are one dimensional in their local coordinate system and carry only axial loads due to their pin connections at nodes. This also means that a truss node is only allowed translational degrees of freedom. A truss element needs only a cross sectional area (A) to define its geometry due to the axial load limitation, and its length is determined by the location of its end nodes. A three-dimensional truss element has two local degrees of freedom and six global degrees of freedom, with three translational degrees of freedom at each end of the element.

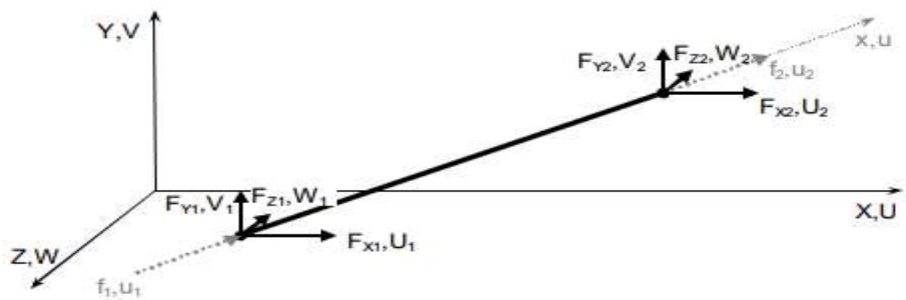
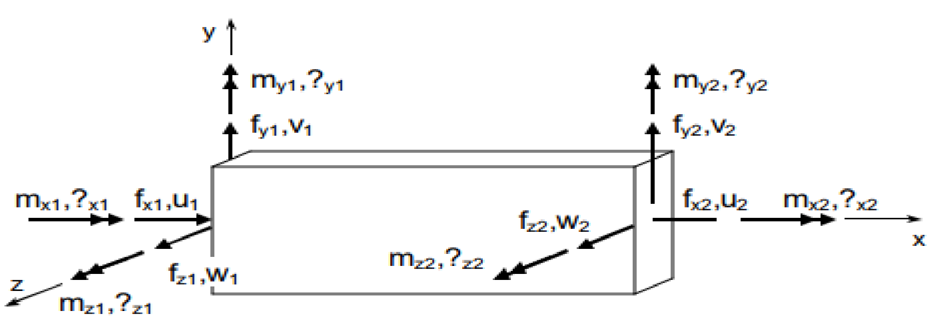


Fig1.4 Truss Element displaying local and global coordinate systems

FRAME STRUCTURES

Frame elements carry axial, bending, and torsional loads due to their rigid connections at nodes. This means that a frame node is allowed all translational and rotational degrees of freedom. Figure 1.5 shows a three-dimensional frame element with its local coordinate system, degrees of freedom, and allowable forces. The transformation from local to global coordinates is analogous to that of a truss element and is not shown in the figure. It can be seen that the frame element has three local coordinate directions, allowing six forces and displacements at each end of the



element.

Fig: 1.5 Frame elements displaying local coordinate system

A frame element requires six dimensional properties to describe its cross section and load carrying capabilities. A cross sectional area (A), two bending moments of inertia (y I & z I), a torsional constant (J), and two section modulus values (Z y & z Z) are needed to calculate a frame element displacement and stress values due to nodal loads.

CONSTRAINTS

Constraints are the conditions that must be satisfied for the design to be acceptable (inequality-one sided, equality-precisely, side bounds on the design parameters) which can also be grouped as:

- Structural constraints
- Controller constraints

Any quantity characterizing the response of the structure, such as stress, displacement, or frequency, may be constrained to preclude a structural failure. Weight, structural natural frequency, tensile/compressive stresses, buckling loads and displacement are the most common type of constraints in structural optimization problems. Weight can be used as either equality or inequality constraint in the optimization problems. It can be also used as an objective in the optimization problem according to definition of the design problem. In structural analysis, weight is used as an objective function since its minimization without losing the structural integrity means money. However, in smart structures it is commonly used as a constraint. The design optimization of structures with fundamental or multiple-frequency constraints is extremely useful when improving the dynamic performance of structures. Modifying a particular frequency can significantly improve its overall performance under dynamic external force excitations. Generally, the control of the critical ranges of the natural frequencies is equivalent to the control of the dynamic response in most narrowband forced excitation problems. A structural optimization under some frequency constraints gives the ability to a designer to control the selected frequencies in a desired fashion in order to improve the dynamic characteristics of the structure. In the linear quadratic regulator (LQR) theory, control gains relating actuator forces to sensor outputs by means of a linear transformation are taken as typical control design parameters.

LITERATURE REVIEW

Yash Patel, Yashveersinh Chhasatia, Shreepal sinhGohil 2016 [1]Many of the steel TRUSS FRAME are made up with orthodox sections of steels which are designed and built by conventional approaches. This directs to weighty or too expensive structures. Tubular steel is the best possible alternatives to the conventional with their comparatively better specifications. Dead weight is tending to be decreased for many structural members so it is clear that because of the tube section, it helps in reducing overall economy. This is regarding the economy, load carrying capacity of all members and their relative safety measures. Economy is the main goal of the present work including comparison of conventional structures with tubular structure for given conditions. Results show that up to 15 to 25% saving in expense is accomplished by using tubular sections. Analysis of shed's elements was carried out by Staad Pro V8i computer software, with manually applying Indian Standards.

M.G.Kalyanshetti, G.S.Mirajkar, (2012)[2] this research involves the economy, load carrying capacity of all structural members and their corresponding safety measures. Economy was the main goal of this study involving comparison of conventional sectioned structures with tubular sectioned structure for given requirements. For study purpose superstructure-part of an industrial TRUSS FRAME is considered and comparison is made. Research reveals that, up to 40 to 50% saving in cost is achieved for square and rectangular tubular sections.

Trilok Gupta, Ravi K. S Harma, (2013) [3] the research involves various kinds of industrial roof trusses by using computer software. It also involves the knowledge regarding steel roof trusses and the design philosophies with worked examples. From the observations they concluded that, the sections designed using limit state methods are more economical than the sections using working stress method. It was observed that the tubular section designed by limit state method was the most economical among the three sections which were used.

Vaibhav B. Chavanet. al. (1990)[4]this research's objective was to estimate the economic importance of the Hollow Sections in contrast with conventional sections. This paper was carried out to find out the percentage economy accomplished using Hollow Sections so as to understand the importance of cost efficiency. The technique used in order to reach the objective involves the comparison of various profiles for different combinations of height and material cross -section for given span and loading conditions. The analysis and design phase of the project was done utilizing STAAD PRO V8i. The results of STAAD analysis were validated with the results of Manual analysis.

Davison and Birkemoe (1982)[5]determined that there are two residual stress gradients in the longitudinal direction, one across the tube face and around the cross section, denoted as membrane, and the other perpendicular to the tube face through the material thickness, denoted as bending. "The perimeter (membrane) residual stress gradient represents the variation in the mean value of the longitudinal residual stress [and] the through thickness (bending) residual stress gradient is the deviation from this mean value normal to the perimeter through the material thickness".

Do daithangET. al. (2009)[6]presented a paper in which, optimum cost design of steel box girder bridge is carried out by varying of closed rectangular and open trapezoidal sections.

A joghataie and M. Takalloozadeh (2009) [7] in their paper proposed new penalty function which has better convergence properties, as compared to the commonly used exterior and interior penalty function. They applied the old and new exterior and interior penalty function in conjuction with the steepest descent method to three-bar truss and ten-bar truss and compared the results. It was shown that the convergence speed and accuracy of the result were improved.

A Csebfalvi and G. Csebfalvi2007[8] proposed a genetic algorithm for discrete weight design of steel planer frames with semi- rigid beam-to-column connections. It was revealed that the results of discrete minimal weight design are highly affected by the applied connection modelling method.

Stanislovaskalantal, Juozas, et al 2010 [9] in their paper, considered the optimal design problems of the elastic and elastic-plastic bars. The mathematical models of the problems, including the structural requirements of the strength, stiffness and stability, are formulated in the terms of finite elements method. The stated nonlinear optimization problems are solved by the iterative method, structures.These problems are formulated as nonlinear discrete optimization problems.

MODELLING

STADD Pro. Software is used in modeling of TRUSS FRAME frames. STAAD stands for Structural analysis and design Program and it is general purpose software for performing the analysis and design of a wide variety of structures. The basic activities which are to be carried out to achieve this goal:
a. Geometry of the structure
b. Providing material and member properties
c. Applying loads and support conditions

Modeling of TRUSS FRAME Frames Using Staad Pro Software

TRUSS FRAME s Frame with the Following Geometrical Types Are considered For Analysis

MODELING OF TRUSS FRAME FRAMES

STAAD-Pro is a general purpose program for performing the analysis and design of a wide variety of types of structures. The basic three activities which are to be carried out to achieve that goal -

- Model generation
- The calculations to obtain the analytical results
- Result verification is all facilitated by tools contained in the program's graphical environment.

MATERIAL AND GEOMETRICAL PROPERTIES

Following material properties have been considered in the modeling

RESULTS AND DISCUSSION

WEIGHT OF TRUSS

Table: 6.1 Weight of truss

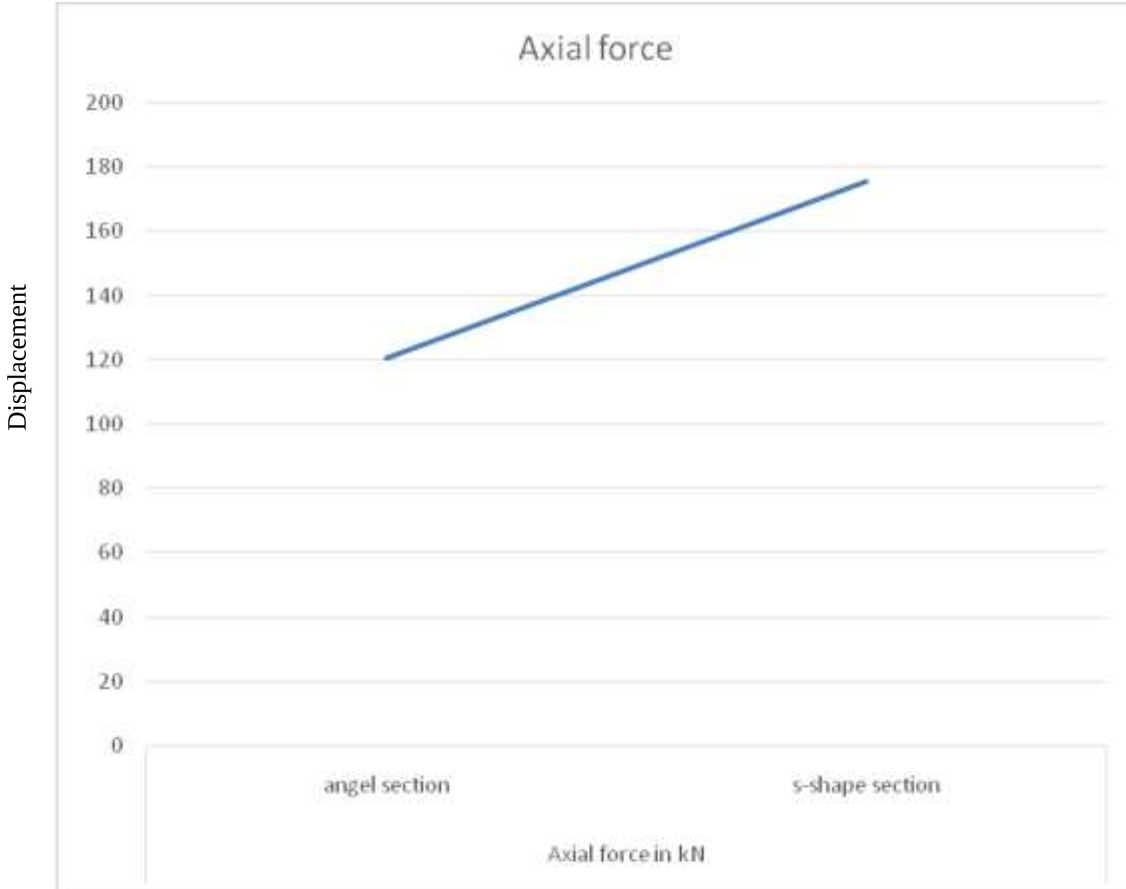
TRUSS SECTION	**MEMBER**	**WEIGHT IN KN**
Bridge With Angel Section With Pipe As Vertical Members	Angels	5.83 KN
	Pipe	3.2 KN
TRUSS SECTION	**MEMBER**	**WEIGHT IN KN**
Bridge With S Shape Section With Pipe As Vertical Members	S- Shape	9.43 KN
	PIPE	3.35 KN

Here results shows that for same loading conditions and geometry of structure there is a wide variation in weight of both the frames due to change in shape of section

Axial Force

Axial force in KN	
Angel section	s-shape section
120.38	175.447

Table: 6.2 Axial force in KN



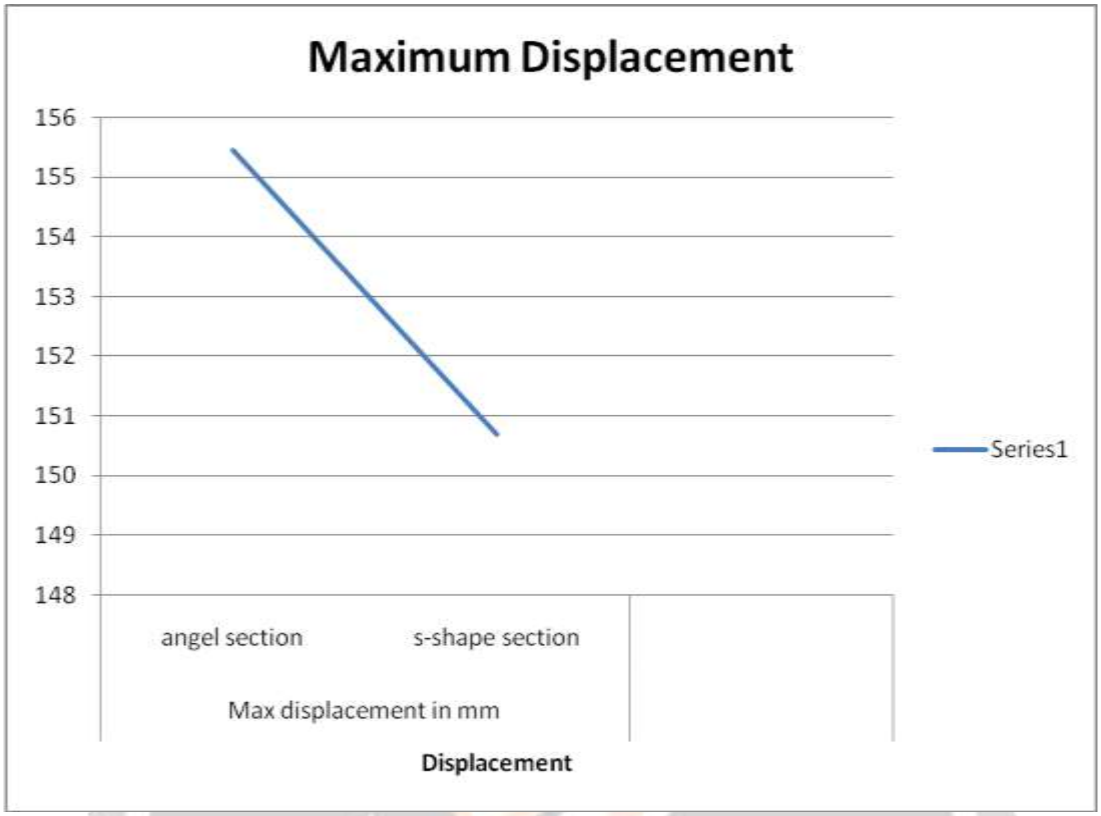
Graph: 6.1 Graph between of maximum axial force(KN)

Here with the same supports applied on both the frame structure with s shape is showing more reactions at support because of its heavy weight.

Maximum displacement

Max displacement in mm	
Angel section	s-shape section
155.46	150.69

Table: 6.3 Max displacements in mm



Graph: 6.1 Max displacements in mm

Here this variation shows that angel shape will show more displacement due to wind load as compared to s shape structure.

CONCLUSION

In present work comparative is done on a 3-dimensional bridge structure for same loadings with different section to find out the best section which will be cost effective, economical and easily available.

- In this work weight is determined, here results shows that angel section is more economical.
- The difference in weight is approx 35% which is really beneficial for a developing country
- This deduction in cost is not disturbing the load carrying capacity of structure.
- Implementation of sections is as per practical use so that we can practically implement it.
- The results shows that angel shape section providing less axial fore which mean vertical members are distributing it properly to each member.

The results shows that angel shape section showing mare displacement as compared to s shape section which is directly indication the less weight of angel section as compared to s shape.

FUTURE SCOPES

- Here the structure consider is a live project of 3d truss ware house applying wind load it can be further done on other truss structures like tower.
- Here wind load is consider further seismic analysis can also be made.
- Here two sections are considered further more sections can be taken.

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