A REVIEW ON INVESTIGATION ON DIFFERENT TRUSS STRUCTURE FOR BRIDGE DESIGN

[1]Padmesh Agrawal,[2] Dr.Pankaj Singh

[1] M.tech Schlor, Civill Department, SRK University, M.P.India
[2]Professor, Civill Department, SRK University, M.P.India

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

Structural steel is a category of steel used as a construction material for making structural steel shapes. A structural steel shape is a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties. Structural steel shapes, sizes, composition, strengths, storage practices, etc., are regulated by standards in most industrialized countries. Structural steel members, such as I-beams, have high second moments of area, which allow them to be very stiff in respect to their cross-sectional area.

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.

1.2 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.

A planar truss is one where all members and nodes lie within a two dimensional plane, while a space truss has members and nodes that extend into three dimensions. The top beams in a truss are called top chords and are typically in compression, the bottom beams are called bottom chords, and are typically in tension. The interior beams are called webs, and the areas inside the webs are called panels.

A truss consists of typically (but not necessarily) straight members connected at joints, traditionally termed panel points. Trusses are typically composed of triangles because of the structural stability of that shape and design. A triangle is the simplest geometric figure that will not change shape when the lengths of the sides are fixed. In comparison, both the angles and the lengths of a four-sided figure must be fixed for it to retain its shape.

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, it may extend even up to 120 kilometers. Very short duration hurricanes of very high wind speeds called KalBaisaki or Norwesters occur fairly frequently during summer months over North East India.

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. Figure 1.4 shows a three-dimensional truss element with its local and global coordinate systems, degrees of freedom, and allowable forces. The black capital symbols represent global objects, while gray lower case symbols represent local objects. It can be seen that a truss element has only one local coordinate axis (x) originating from one node and extending through the length of the element. The only forces (f1,f2) and displacements (u1,u2) allowed in this local system lie in direct axial placement with the element, and the element has two degrees of freedom. The global coordinate system (X,Y,Z) that is used in the structural analysis then causes each local object to be broken into three equivalent global components. It is then shown that the three-dimensional truss element has six global degrees of freedom, with one for each global coordinate at each end of the element.

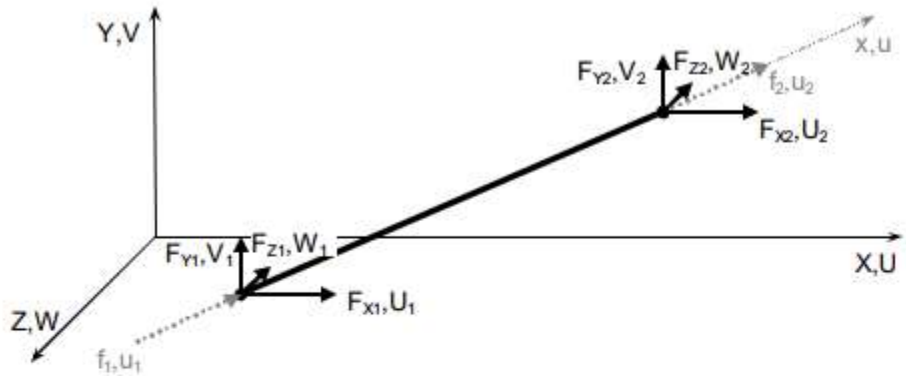

Fig1.4 Truss Element displaying local and global coordinate systems

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. This produces a 12 degree of freedom element capable of resisting loads in any combination of directions, excluding transverse shear and bimoments (McGuire, 2000). Unlike the truss element, the number of degrees of freedom in the frame element remains constant between local and global transformations. Note that the local coordinate axes are not arbitrary in their direction and location. Following the notation used by McGuire (2000) the local x axis coincides with the centroidal axis of the element, the local y axis (weak) defines the minor principal axis of the cross section, and the local z axis (strong) defines the major principal axis of the cross section.

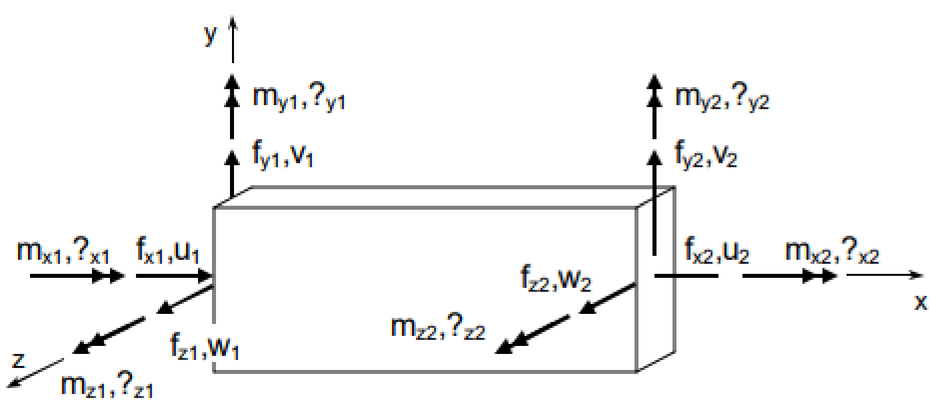

Fig: 1.5 Frame elements displaying local coordinate system

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. The control input, location of closed loop poles, number of actuators and sensors are some common design constraints used by control engineers. Closed loop poles of system effect transient and frequency response of the optimized system. They can be applied as either equality or inequality constraints. Limits on acontrol input are directly related to the available actuator. It usually has a maximum limit, in other words, it is used in optimization problems as an inequality constraint. Some design parameters may have bounds; i.e., cross sectional areas of bar elements must be greater than zero or applied actuator force must be smaller than actuator maximum force capacity. These upper and lower bounds may be entered to the problem as inequality constraints. These type constraints are called side or bound constraints in the optimization terminology. Defining bounds is useful for the search algorithm performance in terms of reduced evaluation steps.

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. Several excel sheets for various structural elements like Purlin, Roof Truss, compression member, Tension member etc. were carried out using Microsoft office excel. Lastly estimation sheet is prepared for each Conventional Roof Truss section as well as Tubular roof truss section.

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.

Yasuyuki Nagano and T. Okamoto, et al [10]presented this paper; the purpose of this to show the practical applicability of a new optimum design method by the authors to an actual high-rise TRUSS FRAME structure with hysteretic dampers. They concluded that it possible to save structural cost and reduce computational cost than the conventional seismic resistant design methods, including iterative dynamic response analysis.

E. Kalkan and S.K. Kunnath (2004)[11] revealed in their study that the suitability of using unique model combinations to determine lateral load congregations that best approximate the inter-story depends in multi-story movement resisting frame TRUSS FRAME s subjected to seismic loads.

Krishnan et. al. (2006)[12] studied the responses of tall steel movement frame TRUSS FRAME s in scenario magnitude 7.9 earthquakes on the southern San Andreas fault. This work used three-dimensional, nonlinear finite elements models of an existing eighteen-story moments frame TRUSS FRAME as it, and redesigned to satisfy the 1997 uniform TRUSS FRAME code. The authors found that the simulated responses of the original TRUSS FRAME s indicate the potential for significant damage throughout the San Fernando and Los Angeles basins. The redesigned TRUSS FRAME fared better, but still showed significant deformation in some areas. The rupture on the southern San Andreas that propagated north-to-south induced much larger TRUSS FRAME responses that the rupture that propagated south-to-north.

Thomas Heaton, et al. (2007)[13] simulates the response of 6 and 20-story steel movement- resisting frame TRUSS FRAME s (US 1994. UBC) For ground motions recorded in the 2003 Tokachi-oki earthquake. They consider TRUSS FRAME with both perfect welds and also with brittle welds similar to those observed in 1994 Northridge earthquake. Their simulations show that the long- period ground motions recorded in the near-source regions of the 2003 Tokachi-oki earthquake would have caused large inter-story drifts in flexible steel moment – resisting frame TRUSS FRAME s designed according to the US 1994,UBC.

Takanori OYA, takashi Fukazawa, et al (2009) [14] in their paper introduced the application of a new type BRB to various structures. The brace has two buckling restraining parts (steel mortar planks), clipping a core plate being under axial forces. These parts are welded together and restrain the core plate of plastic behavior, avoiding the out- of – plane deformation and the buckling.

Charles Seim, Phillip Yen,Jerome S. O'connor(2004)[15]this paper presents a summary of an FHWA/MCEER research project that is developing a new document entitled Seismic Retrofitting Manual for Steel Truss Highway Bridges (Truss Manual). The Truss Manual is still under development, but sufficiently advanced to present excerpts in this paper, for interest only, to researchers and practitioners. The Manual addresses only truss superstructures.

The development and the publication of research papers and manuals of practice, such as this Manual. The Manual lists the various types of trusses, defines three performance levels and two levels of earthquakes with short and long return periods. It presents methods of structural analysis from simple linear-elastic to dynamic, non-linear, time-history, and it presents design criteria to determine the capacity of truss members for determining demand-capacity ratios. The Manual includes examples of retrofit measures.

AzharUddinSumitPahwa(2013) [16] in this paper author compares and provides a study of various levels of research work done in computational structural analysis. The crust of our review focuses on the analysis of truss, complex or simple because truss is the most widely used and fundamental TRUSS FRAME block of any structure.Author gives various techniques and details regarding the analysis of truss , some of them are , study of vibrations in a structure , analysis of Young's modulus , analysis of planar trusses , analysis by means of FEM . We have also seen that finite element method have been used for the analysis of complex trusses and hence require more computational resources which are hard to get for everybody. On the other hand matrix based analysis of trusses yield a better overall performance and thus is more suited for day to day analysis of the program. Hence we propose a structural analysis program which will have all the above features and in addition to that a graphical user interface will be there for easy visualization. Plus the software thus designed could also be used for the study of trusses at undergraduate level for easy visualizations.

António Reis a, José J. Oliveira Pedro (2011) [17] the aesthetic and structural advantages of composite truss bridges were highlight. Composite triangular trusses were discussed; experimental and numerical results were presented. Some main issues for semi-through composite trusses for HSR bridges were discussed based on a recent design case. A double deck composite cable-stayed bridge for the 3rdTagus River crossing in Lisbon was presented.

Yang Yang, Xiong (Bill) Yu (2016) [18] inthis paper author describes the development of a computer vision-based real time displacement measurement system and demonstrated its performance on a large-scale wood truss bridge model. Digital images were captured with a consumer grade video camera. Three common types of computer vision algorithms are compared, including the Lucas-Kanade (LK) template tracking algorithm, inverse compositional (IC) algorithm (an extension of LK algorithm), and Digital Image Correlation (DIC). Application to the model bridge subjected to loading process indicates that the IC algorithm achieves real time displacement measurement. The performance in displacement from computer vision analyses matches the data collected by the conventional displacement sensors, with an average precision of within 1 mm at a distance of

5m away from the structure. The processing speed of the IC algorithm is over 300 faster than the conventional LK algorithm and around 140 times faster than Digital Image Correlation (DIC).

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.

REFERENCES:

[1] M.G.Kalyanshetti, G.S.Mirajkar .Comparison between Conventional Steel Structures and Tubular Steel Structures. International Journal of Engineering Research and Applications.Volume 2 (Issue 6), pp.1460-1464.www.ijera.com/papers/Vol2_issue6/HK2614601464.pdf.

[2] IS 800-1984, Code of practice for general construction in steel.

[3] Code of practice for design loads (other than earthquake) for TRUSS FRAME s and structures (part-1) IS 875-1987.

[4] Code of practice for design loads (other than earthquake) for TRUSS FRAME s and structures (part-2) IS 875-1987

[5] Code of practice for design loads (other than earthquake) for TRUSS FRAME s and structures (part-3) IS 875-1987.

[6] Code of practice for use of steel tubes) for TRUSS FRAME s and structures IS 806, 1968.

[7] Dan Dubina et al (2007).”Analysis and Design of Steel Structure” [Online] Available athttp://104.196.42.98/analysis/analysis-and-design-of-steel-andcomposite-structures.doc.

[8] Gary S. (2010), ”Analysis and Design of Steel Structure” [Online] Available at http://raselpics.ru/steel-design-structures-practice.pdf

[9] IIT-Kharagpur, Design of Steel structures, “NPTEL online material for the students”, Module27. [Online] Available at www.scribd.com/doc/292540965/Structural-Analysis-an-Industrial-TRUSS FRAME

[10] Subramanian.N (2008) “Design of Steel Structure”.

[11] Dayaratnam, S.Chand publications “Design of Steel Structures”.

[12] Prof. S.R.Satish Kumar and Prof. A.R.Santha Kumar “Design of Steel Structures”.

[13] Charles Seim, Phillip Yen,Jerome S. O’connor “Seismic Retrofitting Manual For Steel Truss Highway Bridges” 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 1033

[14] AzharUddinSumitPahwa “Review of Structural Analysis Program for Study of Trusses”International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438.

[15] António Reis a, José J. Oliveira Pedro “Composite truss bridges: New trends, design and research”Eurosteel2011. August 31 - September 2, 2011. Budapest, Hungary

[16] Yang Yang, Xiong (Bill) Yu “Real Time Measurement of the Dynamic Displacement Field of a Large-scale Arch-truss Bridge by Remote Sensing Technology”978-1-4799-8287-5/16/$31.00 ©2016 IEEE.

[17] Mingli W u, Dingyan Xi, ZhenghaoChu“Electromagnetic Shielding Performance of Steel Truss Bridge in Multi-track Electrified Railway” 978-1-4673-7441-5 /15/$31.00 ©2015 IEEE.

[18] Machinery Industry standard of the People's Republic of China. JB/T 9101抋1999Fan rotor balance .Beijing:China Academy of Machinery Science & Technology,1999(In Chinese).