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A Review on Steel Structural Analysis for Optimization of Trusses

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Abstract: **Integrated structural analysis and design software packages, which generally work on finite element method for analysis and design, have been gaining popularity in the field of designing since they have reduced the tedious calculation process to a simple process of just giving input values. The result generated is according to the values entered without the consideration of the feasibility. Moreover, optimization of structures has been a lesser used concept in day-to-day working and is independent of design and analysis of the structures. This paper provides a study of various levels of research work done in computational structural analysis. The crust of our review focuses on the analysis of optimization of truss, complex or simple because truss is the most widely used and fundamental building block of any structure.**

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

I. INTRODUCTION

Composite materials have been used extensively to build truss structures owing to their remarkable properties. Composite truss structures have attracted tremendous research interests due to their superior strength and performances, and have been utilized in the construction of civil structures. Considerable efforts have been placed on the development and analysis of truss bridges, which usually consist of concrete and steel. Research works have been focused on material characteristics, truss joint design, and processing and construction of structural components. In the nineteenth century, composite trusses for aerospace applications were investigated [1-3], which are distinctly different from civil structures regarding materials, strength, stiffness, and weight. The effects of prestressed cables in composite structural system were studied [4]. In recent years, experimental study and numerical analysis have been carried out on composite space trusses with prestressed cables made of steel and compression members made of concrete [5,6]. The performances and characteristics of overall composite truss structures have been studied [7, 8]. Although publication works on composite trusses have been found in the literature, further investigation on systematic design and analysis of composite trusses containing pretensioned cables is needed.

The current steel design process consists of two steps, an analysis to determine internal actions such as forces and moments, and a design check for adequate strength, for all individual members and connections. Component-based design is a simplistic process that could be improved to increase efficiency and economy. Advanced analysis completes the analysis and design check in a single step, thereby saving time in the design process. Additionally, advanced analysis directly models factors affecting the structure, such as geometric imperfections and residual stresses, enabling the user to accurately model the structure. Component-based design does not consider the system's ability to redistribute loads, and thus in systems where this is possible the true load carrying capacity is greater than predicted. The current design code uses load and resistance factors to meet a specified level of reliability for each component. As system behavior is different than that of an individual component, the system reliability is not the same as the component reliability. Thus a system resistance factor must be determined in order for the system to meet a target reliability index. Enforcing system reliability will create an economical system which is designed for a specified probability of failure.

Optimization techniques play an important role in structural design, the very purpose of which is to find the best solutions from which a designer or a decision maker can derive a maximum benefit from available resources.

In order to decrease the time needed to prepare the structural truss that meets the requirements of shipping cost, construction and installation, we propose a model for generating self-supporting tower lattice for wind turbines, with computational assistance given some input parameters generates and optimizes the structural design of the towers and foundations based on the internal forces. Topological design variables determine an initial structural layout, whereas shape and sizing parameters give the shape and dimensions of structures respectively [13,14]. The optimum shape and sizes of the structure are then found in the later design stage. This is often called multi-stage optimisation. Nevertheless, it has been found that the better design process is to perform topology, shape, and sizing optimisation simultaneously.

II. STRUCTURAL STEEL

Structural steel is a category of steel used as a construction material for making structural steel shapes[15]. 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 (Brazil, 2000; Faraone, 2003; Faraone and Marstellar, 2002; Levy, 2000; Pollak, 2003). 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 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".

III. LITERATURE REVIEW

Following research work has been carried out in past on optimisation and steel structure designing:

M.G.Kalyanshetti, G.S.Mirajkar, (2012) 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 building 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 [10].

Trilok Gupta, Ravi K. S Harma, (2013) 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 [11].

Vaibhav B. Chavan et. al. (1990) 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 [12].

Davison and Birkemoe (1982) 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"[13].

Do dai thang et. al. (2009) 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 [14].

A joghataie and M. Takalloozadeh (2009), in their paper proposed new penalty function which have 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 [15].

A Csebfalvi and G. Csebfalvi 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 [16].

Stanislovas kalantal, Juozas, et al, 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 [17].

Yasuyuki Nagano and T. Okamoto, et al, 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 building 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 [18].

E. Kalkan and S.K. Kunnath (2004) revealed in their study that the suitability of using unique model combinations to determine lateral load confrigations that best approximate the inter-story depends in multi-story movement resisting frame buildings subjected to seismic loads [19].

Krishnan et. al. (2006) studied the responses of tall steel movement frame buildings 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 building as it, and redesigned to satisfy the 1997 uniform building code. The authors found that the simulated responses of the original buildings indicate the potential for significant damage throughout the San Fernando and Los Angeles basins. The redesigned building 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 building responses that the rupture that propagated south-to-north [20].

Thomas Heaton, et al. (2007) simulates the response of 6 and 20-story steel movement- resisting frame buildings (US 1994. UBC) For ground motions recorded in the 2003 Tokachi-oki earthquake. They consider building 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 buildings designed according to the US 1994, UBC[21].

Sh Hosseinzadeh Seismic evaluation of all steel buckling restrained braces using finite element analysis: this illustrates the study on finite element analysis of ten BRB specimen with varying gap size between the steel core and restrainer. 10mm air gap found to be very effective in dissipating energy. Bi linear FE derived back bone curve of the effective BRB were used to retrofit three 4,8,12 story frames. Static pushover curves of the frames shows that all steel BRB shows a more ductile behaviour compared to the conventional x bracing. Also the response modification factor for BRB was greater than the x bracing because of the ductility factor [22].

IV. OBJECTIVES OF STUDY

1) To study and compare design of warehouse of certain span by using different steel section as a truss.
2) To determine most economic sections among the sections used.
3) To study the geometric and physical advantages different sections.
4) To calculate percentage saving in steel for given structure.

V. CONCLUSION

Literature review discusses briefly the previous work done on the truss on steel structure. From these published work it can be concluded that steel structure is more stable and can be utilized for rapid construction also can be economical by different section. In our study we are considering a ware house construction by steel truss in a Ahmedpur village, Sehore district and comparing different section for same geometry and loading to determine the most economical section for resisting loads.

REFERENCES

[1] S. K. Duggal “Limit State Design of steel structure”.
[2] N. Subramanian “Design of Steel Structures”
[3] C. M. Meera (2013) “Pre-Engineered Building Design of an Industrial warehouse” International Journal of engineering sciences & Emerging Technologies.
[4] Jatin D. Thakar (2013) “Comparative Study of PreEngineered Steel Structure by Varying Width of

structure" International Journal of Advanced Engineering Technology.

[5] A N Dabhade, Dr. S S R choudhary, Dr. A R Gajbhiye in international journal of engineering research and application in vol.2 issue for july august 2012.

[6] Togan Durmaz and Daloglu, Optimization of roof trusses under snow loads given in Turkish Codes, International conference on Engineering Structures, 28-33, (2006)

[7] Anbuchezian .A, Dr. Baskar.G (2013) "Experimental study on cold formed steel purlin sections" Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.3, No.2, April 2013 276

[8] "Plastic collapse analysis of thin walled circular tubes subjected to bending" by S. Poonaya, U.Teeboonma, C.Thinvongpituk, 15 th may 2008.

[9] P. P. Desai and M. R. Shiyekar (2014) "Limit Strength Prediction of Light Gauge Steel I Section by Finite Element Method." Int. Journal of Engineering Research and Applications, ISSN :2248-9622, Vol. 4, Issue 7(Version 4), July 2014, pp.111-114 (2014)

[10] M.G.Kalyanshetti, G.S.Mirajkar, "Comparision between Conventional Steel Structures and Tubular Steel Structures" International Journal of Engineering Research and Application (Ijera) Vol. 2, Issue 6, November-December 2012.

[11] Trilok Gupta, Ravi K. S Harma, "Analys Is of Industrial Shed using Different Design Philosophies" International Journal of Research In Advent Technology, Vol.1, Iss Ue 5, Dec Ember 2013.

[12] Vaibhav B. Chavan, Vikas N. Nimbalkar and Abhishek P. Jaiwal " Economic Evaluation of Open and Hollow Stuctural Sections in Industrial Trusses", Aci Structural Journal, March-April 1990.

[13] Davison, T. A. and Birkemoe, P. C. (1982). "Column behavior of cold-formed hollow structural steel shapes." Canadian Journal of Civil Engineering, 10, 125-141.

[14] http://text.123doc.org/document/2405404-behavior-and-design-of-open-steel-box-girder-bridges-by-up-down-construction-method.htm

[15] A joghataie and M. Takalloozadeh, "Improving Penalty Functions for Structural Optimization", Transaction A: Civil Engineering Vol. 16, No. 4, pp. 308-320, 2009.

[16] A Csebfalvi and G. Csebfalvi, "Optimal design of frame structures with semi-rigid joints", Periodica Polytechnica 2007.

[17] Stanislovas kalantal, Juozas, "Discrete Optimization Problems of the Steel Bar Structures", http://leidykla.vgtu.lt/conferences/MBM_2007/4pdf/Kalanta_Atkoc.pdf.

[18] Yasuyuki Nagano, I Takewaki, T Okamoto, M Tsuji. "Application of Optimum Design Methods to Actual High-Rise Building with Hysteretic Dampers", 12th World Conference on Earthquake Engineering, Paper ID-1463, Pp. No-1-8, 2000, Japan.

[19] E. Kalkan and S.K. Kunnath, "Lateral load distribution in nonlinear static procedures for seismic design", http://erolkalkan.com/Pubs/14.pdf, 2004.

[20] Swaminathan Krishnan, Chen Ji, Dimitri Komatitsch, and Jeroen Tromp, "Case Studies of Damage to Tall Steel Moment-Frame Buildings in Southern California during Large San Andreas Earthquakes", Bulletin of the Seismological Society of America, Vol. 96, No. 4A, pp. 1523–1537, August 2006.

[21] http://www.ecf.caltech.edu/~heaton/papers/Kyoto_buildings.pdf

[22] Sh Hosseinzadeh, B. Mohebi, "Seismic evaluation of all steel buckling restrained braces using finite element analysis", Journal of Constructional Steel Research 119 (2016) 76-84.