# AN ANALYTICAL STUDY ON COMPOSITES STEEL STRUCTURES WITH TRUSS OPTIMIZATION

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**ABSTRACT:**
*The weight minimization of planar steel trusses by adopting a differential evolution-based algorithm square hollow sections are considered. The design optimization refers to size, shape and topology. The design variables are represented by the geometrical dimensions of the cross sections of the different components of the truss, directly involving the size of the structure, and by some geometrical parameters affecting the outer shape of the truss. The topology is included in the optimization search in a particular way, since the designer at different runs of the algorithm can change the number of bays keeping constant the total length of the truss, to successively choose the best optimal solution.The analysis results prove the versatility of the optimizer algorithm with regard to the three optimization categories of sizing, shape, topology as well as its high computational performances and its efficacy for practical applications. In particular useful practical indications concerning the geometrical dimensions of the various involved structural elements can be deduced by the optimal solutions: in a truss girder the cross section of the top chord should be bigger than the one of the bottom chord as well as diagonals should be characterized by smaller cross sections with respect to the top and bottom chords in order to simultaneously optimize the weight and ensure an optimal structural behavior.*
*Keywords: Truss, Steel, geometrical dimensions.*

## 1.0 INTRODUCTION:

The composite steel-concrete construction is one of the most economical systems for building and bridge floors, especially for greater spans. To utilize the efficiency of concrete in compression and steel in tension it is necessary to prevent the relative slip between the concrete and the steel element using the shear connectors. Nowadays different types of shear connectors are used. This concerns the welded headed studs, the Hilt brackets and the welded perforated shear connectors In some situations, such as with precast concrete slab or for developing the composite action in non-composite structures, shear connection is developed using bolts Composite systems give the possibility to get spans up to 20 m and the composite trusses are appropriate to meet the requirements for building height limitation, the need to run complex electrical, heating, ventilating, and communication systems and the even greater spans (30 m), what allows for a better use of internal space without restricting columnsThe 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.

**STRUCTURAL STEEL:**

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, GirderSlab, 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.

**Figure: One of the new railway composite truss bridges**

Current study covers principal aspects concerning distribution of the longitudinal shear both in plastic and elastic region with respect to common design. Particular attention is paid to primary parameters influencing the peaks of longitudinal shear above truss nodes in elastic region which are decisive for design of bridges

**Floor trusses:**

First, the behavior of common floor trusses was investigated experimentally testing two identical truss girders of 6 m span and using perforated shear connectors providing "full" shear connection, see Test results of both trusses together with common analytical calculation (as for plated beams) of elastic (Fel) and plastic (Fpl) capacity taking into account real geometrical and material characteristics and full composite action

**Figure: Plastic collapse of composite floor truss**

**OBJECTIVES**:

1) To study steel composite structures 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.

**2.0 LITERATURE REVIEW:**

**[1] 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

**[2] 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 mosteconomical among the three sections which were used

**[3] Davison and Birkemoe (2010)** 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"

**[4] A joghataie and M. Takalloozadeh (2009),** 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 conjunction 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

**[5] Yasuyuki Nagano and T. Okamoto, et al (2015),** 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

**[6] Krishnan et. al. (2006)** In conventional GA based truss configuration optimization, coordinates of joints are considered as variables where number of variables depends on number ofjoints. For truss having large number ofjoints, large number ofvariables will slow down the optimization process. In the present study, only two design variables i.e. depth oftruss and number of panels define large number of possible configurations without joint coordinates. This helps in finding optimum configuration for truss having large number of joints with greater computational efficiency

**[7]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 behavior compared to the conventional x bracing. Also the response modification factor for BRB was greater than the x bracing because of the ductility factor

**[8] Wang Ming, Wen Dong( 2015)**the bridge construction process to install the prefabricated bridge deck, which can make the steel truss and the deck in uniform and reasonable stress, initially putting forward three connection ways: one-time connection; three batches connection; the whole batches connection. Using Midas Civil to create a whole bridge finite element model of space, and analyze these three kinds of coupling methods, obtaining that different connection ways have significant influence on mechanical property of the bridge.The results of the study show that, the bridge deck connected with the steel truss in whole batch connection way can make combination structure in most reasonable stress, more uniform deformation, and can effectively improve the bridge structure stiffness, besides, this connection way will be beneficial to later welding work.

**[9] Dr.G.S.Thirugnanam1, S.DhivyaBharathi (2017)**In Indian code for composite structure covering the shear connector area and they mentioned about the deck sheet properties .Hence the aim of the research is to carry out experimental investigation on steel concrete composite floor slab systemIn case of truss used as beam member we need to concentrate on top chord and bottom chord tension member whereas web member should be strong enough to withstand load applied on the top chord member. Based on the pioneer research most of the failure occurs at truss member joints with trapezoidal deck sheet

**4.0 RESULTS AND DISCUSSIONS:**

| References | study | conclusion |
|---|---|---|
| **]M.G.Kalyanshetti, G.S.Mirajkar,(2012)** | Conventional sectioned structures with tubular sectioned structure for given requirements. | Research reveals that, up to 40 to 50% saving in cost is achieved for square and rectangular tubular sections |
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|---|---|---|
| | dampers | resistant design methods |
| **Krishnan et. al. (2006)** | design variables i.e. depth of truss and number of panelsconfigurations without joint coordinates | optimum configuration for truss having large number of joints with greater computational efficiency |
| **Wang Ming, Wen Dong 2015)** | construction process to install the prefabricated bridge deck, which can make the steel truss | the bridge deck connectedeffectively improve the bridge structure stiffness, besides, this connection way will be beneficial to later welding work. |

A steel-concrete composite column is comprising of either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load bearing member in a composite framed structure. With the use of composite column along with composite decking and composite beams, it is possible to erect high-rise structure in an extremely efficient manner. Complications in the analysis and design of composite structural elements have led numerous researchers to develop simplified methods so as to eliminate a number of large scale tests needed for the design. In the present work also, where possible, a simplified approach was proposed for the design of composite slabs, beams and columnsInvestigation of the longitudinal shear flow distribution in the elastic region of its behavior pointed to importance of stiffness both steel truss chord and concrete slab. The less stiff chord flange the higher node shear peaks above truss nodes must be expected. Wider or thicker concrete slab leads to greater shear flow, however with less pronounced shear peaks due to greater concrete slab stiffness. Common concentration of shear connectors above truss nodes has to be designed with caution. 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 comparing different section for same geometry and loading to determine the most economical section for resisting loads

## CONCLUSIONS:

Composite steel-concrete section is relatively a new design concept in the Indian context and no appropriate updated codes are available for the design ofthe same. A number of programs developed in the present work, not only eliminates the costly experimentation required for the design purpose but also facilitates design with multiple options for the steel sections and shear connectors with adequacy checksBridge decks obtain the maximum compressive stress through connecting with the steel truss by one-time connection after tensioning prestress, but because the bridge decks in the early do not participate in the combined force structure, all the loads are borne by the steel truss

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