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A REVIEW ON SPACE TRUSS HAVING DIFFERENT TYPES OF MEMBERS AND THEIR CONNECTION DETAILS

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Abstract:- Although space trusses have been used since 1950's but its use has been restricted due to higher cost compared to one-way beam and framed structural alternatives. This paper presents a review on development of composite space truss developed lately with main objective of overall cost reduction without compromising the structural stability. The disadvantage of conventional type of connectors is that they offer eccentricity at the joints, paper also provides an introduction to different types of connectors avoiding the problem of eccentricity. It has been observed through this review that composite truss greatly affects the truss behaviour. Flatten end elements reduces the eccentricity which in turn improves the truss behaviour.

Keywords: Space truss, Connections, Composite action, Failure pattern, Flattened end

I. INTRODUCTION

The last few decades been marked with extensive use of space truss as this type of structures offers great stiffness and lesser weight and hence can be prefabricated. In addition, it provides pleasant aesthetics and permits to use large open areas such as gymnasiums, airports and exhibition pavilions imparting beauty to those structures. But a failure of Hartford Coliseum space truss in Connecticut in 1978 was witnessed which was an indication of failure in brittle and unstable manner in which excessive buckling of one member can set off a progressive collapse of whole structure.

The main issue which needs to be addressed is the failure pattern of truss, in any case it should be ascertained that failure is ductile and hence many researchers have worked upon this aspect. The best remedy to brittle failure was provided in form of Catrus space truss in which top member were designed as hollow rectangular member, the diagonals as circular members and bottom chord members as flats, composite space truss can provide with an alternative to ensure ductile failure of space truss.

The main difference between space truss systems is choice of structural connections and structural geometry, this paper presents an overview on the behaviour of space truss adopting different connections and geometry.

II. CONNECTION OF TRUSS MEMBERS

Connections include splice plates and splice box used to connect members using simples bolt and nut, example figure 1 and 2. Mero node balls have been used as connectors and member end fittings have been used to ensure sound connection [5], example Fig. 5

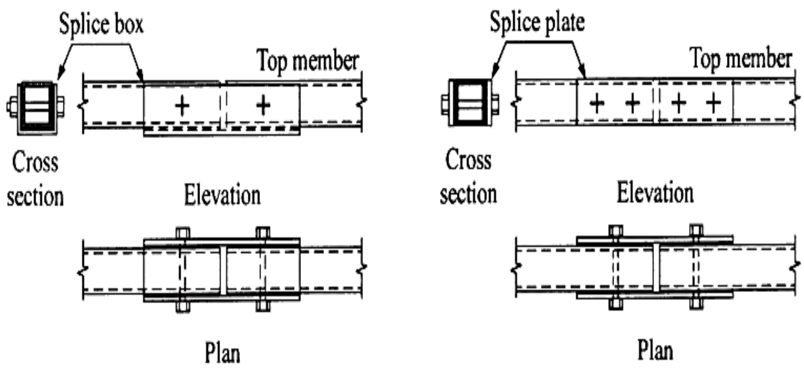

Figure 1: Methods to splice top chord members

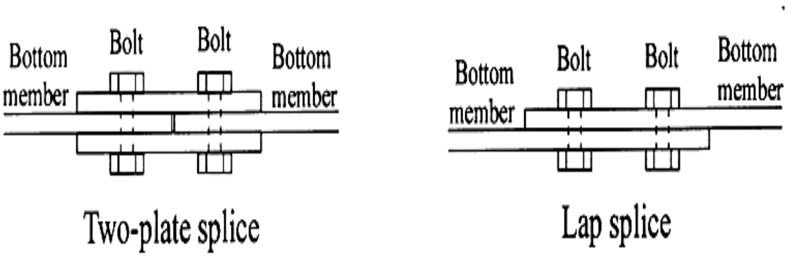

Figure 2: Methods to splice bottom chord members [1]

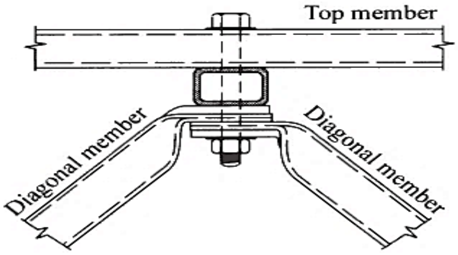

Figure 3: Top chord connection [1]

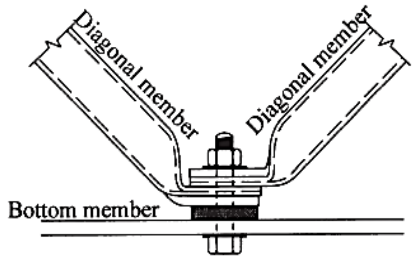

Figure 4: Bottom chord connection [1]

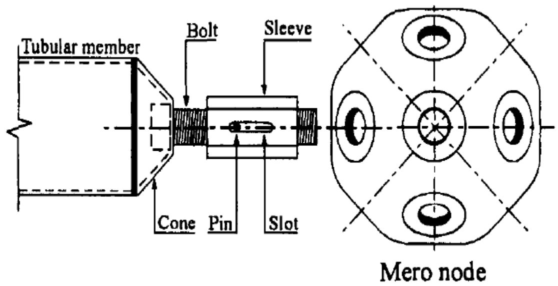

Figure 5: MERO ball connection with end fittings [5]

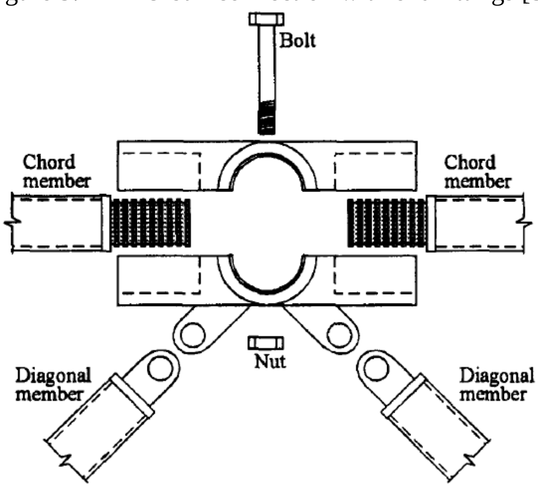

Figure 6: Nodes Joining System [5]

A total number of 45 specimens were tested; 32 specimens of these were flattened (squashed) at the ends and the remaining 13 CHS specimens were taken as control specimen. The flattening process was performed mechanically by placing the ends of the circular hollow sections between two dyes and then flattened. No cracks were observed after this process. Flattening created a transition zone between the circular profile of the tube and the flattened section. The length of the transition zone (L) ranged from1.2d to 1.5d. [13]. Luciano Mendes Bezerra, Cleirton Andre Silva de Freitas, William Taylor Matias, Yosiaki Nagato studied the behaviour of flattened end tubes as it reduces cost, faster assemblage and easy to manufacture, however they result in nodal eccentricities which leads to increase in bending moment and loss of rigidity at connection. They suggested the use of spacers and reinforcement plates to improve its strength [6]. S.A.L. de Andrade, P.C.G. da S. Vellasco, J.G.S. da Silva, L.R.O. de Lima, A.V. D'Este conducted six full scale tests on spatial structures and investigated their structural response, simple eccentric and reinforced eccentric nodes are discussed. The reinforcements were observed to improve load carrying capacity of the truss by reducing displacements and nodal rotations [7]. Alex Sander Clemente de Souza and Roberto Martins Goncalves observed the collapse pattern at joints that occurred due to plastic strains at bar ends, slip among the bars in nodal region and nodal rotations which lead to increase in displacement. Nodal failure began at top failure in vertices where there were worst eccentricity issues [10]. A. S. C. Souza, R. M. Goncalves, C. H. Maiola and M. Malite concluded that the central and lateral nodes do not lead to structure's collapse although they show concentration of stresses at bar ends. However, the theoretical analysis of the corner node showed a good correlation with experimental results, demonstrating the node responsible for structure's collapse [11].

III. MEMBER SPECIFICATIONS AND TRUSS GEOMETRY

Rectangular hollow sections (RHS) have been used in the top chord to resist its dominantly compression forces. Circular hollow sections (CHS) with flattened ends used as diagonal members for their adequate behaviour under both tension and compression. Flat bars used in the bottom chord to resist its tension forces. These members will simply be bolted together using bolted connection [1]. Behaviour of trusses was examined with a constant depth and constant grid size. They reported that the trusses perform well when the angle of inclination of diagonal members is between 40 and 60 degree and they suggested 45 degree and 60mm concrete slab thickness to be more beneficial [3]. Ahmed El-Sheikh described a new space truss system which was known for its low cost, sound structural behaviour and its constructional advantages. RHS, CHS and flat bars were used as chord members. Further chord splices were added to maintain chord continuity and joint simplicity. It is not mandatory to use splices if the members can practically be made longer. Substantial benefits to the performance of the truss system could be achieved by the development of composite action. With the composite action, the top continuum prevented the buckling of top members and relieved them from a large part of their internal forces. [1]. Lakshmikanthan K N, Senthil R, Arul Jayachandran S, Sivakumar P and Ravichandran R studied behaviour of steel truss using MERO node connectors and concrete slab. After detailed study he suggested the angle of inclination of diagonal members to be 45 degrees and square on square double layered grid. He also studied behaviour of truss using various support arrangement [3].Arlene Maria Cunha Sarmanho, Lucas Roquete, Luiz Neiva, Flávio Teixeira de Souza observed that the stiffened flattening eliminated the failure condition in bolding region and induced compression failure on the diagonals by using connecting plates to joint diagonal and chord members [8].M. Dundu conducted tests with variables such as diameter, thickness, length of sections and number of bolts in connection, they observed two failure modes namely Overall flexural buckling (OFB) and Excessive deformation of transition zone (DTZ). OFB occurred in sections with small diameter-to-thickness ratio, large slenderness ratio and high strength of steel whereas DTZ was dominant in sections with larger diameter-to-thickness ratio, small slenderness ratio and low strength of steel [9].

IV. COMPOSITE TRUSS: ENSURING THE COMPOSITE ACTION & FAILURE MODE

A.I. El- Sheikh and R.E. McConnel investigated buckling failure in top chord compressive members of the truss. An experimental study of composite space truss using MERO ball connectors and concrete slab was made. They observed ductile failure in bottom chord members by introducing concrete slab which provides adequate warning of impending failure. [2]. The stud type shear connectors were screwed into the top mero node connectors along with the flat mild steel plate. Theses steel plates runs over the top chord members in order to achieve the composite action. The concrete slab of thickness 50 mm was cast with M25 grade concrete over the space truss of size 3 × 2 m [4]. Thin flat decking sheets are used that are made larger than the panel size, about 100 mm in each direction. After being prepared with four corner holes and connected to the truss top joints through their bolts, they act as membranes to carry the weight of wet concrete of the top slab. To develop adequate shear interaction between the slab and the truss, and to avoid having to weld headed studs onto the top chord members, the bolts of the top joints are fitted head down [1], example figures 7, 8.P. Sangeetha and R. Senthil concluded their study as composite space truss has higher ultimate load carrying capacity, ductile behaviour of truss in experimental setup was achieved without brittle failure, they further observed the difference of 12% between experimental and analytical results of stiffness and deflection [4].

Figure 7: Shear interaction device [1]

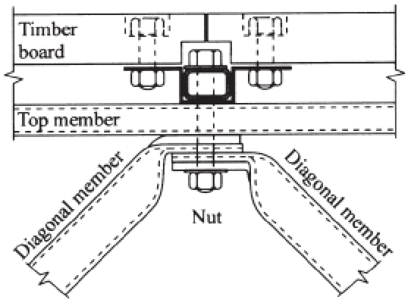

Figure 8: connection between timber board and top joint [1]

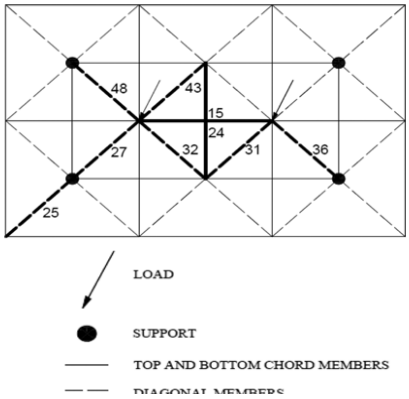

Figure 9: Layout of truss (top view)

V. CONCLUDING REMARKS

Through this study it can be concluded that the composite action of concrete slab and steel truss immensely affects its behaviour. Flattened ended circular sections reduces its strength however it provides fast assemblage and lower erection cost. Suitable shear connectors should be used to establish the composite behaviour. The truss can simply be bolted by using flattened end connection; however, least eccentricities should be generated so as to lower the errors thereby maintaining its structural strength and integrity.

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