

JOINING OF SPACEFRAME COMPONENTS

The present invention relates to components for use in the construction of spaceframes.

The general principles of spaceframe structures made from an interconnected network of chord members, such as tubes and shafts, and nodes is well known and various systems have been described in the literature and used in practice particularly for the construction of roofs and temporary structures such as exhibition stands. Two or three dimensional grids may be built up from such networks and used to form for example triangular beams and roofing made up of barrel vaults or domes using geodesic or arch girder geometry.

Typically such constructions use chord members made from tubular steel pile. Although such pipes may be hot dip galvanised to protect the surface from corrosion, this protection may not completely extend to the hollow inside of the pipe, since there will be air in the pipe when it is dipped into the zinc bath. Therefore corrosion remains a problem with any type of steel component. It is therefore preferable to use an intrinsically corrosion resistant material such as aluminium alloy for the spaceframe members. This has a further advantage as it is relatively lightweight and chord members can be produced to any desired length by extrusion.

Technical problems also arise in the design of the connection of the chord members to the nodes. Depending upon the structure, it may be necessary to connect as many as twelve chord members to a single node. In order that this should be possible, it is necessary to keep the design of the joint between the chord member and the node as compact as possible.

Since spaceframes are frequently used in temporary structures, it is also desirable that in the connection be de-mountable so that the components can be re-used. Nevertheless, the joint must not work loose as a result of vibration of the structure.

- 5 The joint to be described is intended to be used with a node of conventional design which is essentially a spherical or polygonal aluminium node in which threaded recesses have been prep-bored at the required orientations in order to allow assembly of the required chord members to the node.
- 10 Various joint designs have been suggested. In a typical prior art design a bolt is held captive by its head in the end of a closed tubular chord member. The captive bolt has a threaded end which is received in a threaded bore of the node. The bolt is rotated by means of a nut carried on the outside. This type of joint is shown for example in US-A-4313687,
- 15 4872779, 4991371, 5051019, 5054950, GB-A-2243852, WO-A-91/12383 and EP-A-0461450. In all these joints there is either the risk that the captive bolt will fall out of engagement with the hole in the end of the chord member or means must be provided for permanently securing the bolt in position at the end of the chord member. This makes the chord members
- 20 with their integral joint components relatively expensive and restricts the use of chord members of varying lengths - which restricts the designs that can readily be implemented. The nut assembly used to rotate the bolt in order to make and release the connection is often of complex design in order to reduce the risk of the joint working loose.
- 25 A joint design for use with steel space frame members is disclosed in GB-A-2197417. This design required a threaded projection to be welded to the end of a chord member. In this joint design all of the components of which were made of steel which was preferably hot-galvanised as part of the manufacturing process.

The present invention provides an aluminium alloy chord member in combination with a joint assembly for use in connecting the chord member to a node; in which the joint assembly comprises a threaded projection integrally formed at one end of the chord member, a bush having a threaded bore adapted to be screwed onto said threaded projection, and a bolt having a head and a threaded end, adapted to be received in a threaded recess in a node, the head of the bolt being retained in the bore of the bush inwardly of the threaded projection of the chord member in use; wherein the screw thread which connects the chord member and the bush and the thread which connects the bolt and the node are of differing pitches.

The use of an aluminium alloy chord member allows the threaded projection to be integrally formed by contrast to the design shown in GB-A-2197417 where the threaded projection was welded to the chord member. The use of differing pitches facilitates breaking or making the connection between the joint assembly and either the chord member or the node without disturbing the other connection.

The bush and bolt are preferably also formed of aluminium alloy.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a longitudinal section through a chord member fitted with joint assemblies at either end;

Figure 2 is a transverse cross-section through the chord member of Figure 1;

Figure 3 is a longitudinal section through a bush;

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Figure 4 is a side view of a shoulder bolt;

Figure 5 is a perspective view of the threaded bush and shoulder bolt joint assembly; and

5 Figure 6 is a perspective view showing a chord member assembled to a node by means of a joint assembly.

The essential building blocks of a spaceframe structure are chord members 2 and nodes 4. The chord members 2 are connected to nodes 4 by means of joints each made up of an assembly of a conical threaded bush 6 and a shoulder bolt 8.

The basis chord member 2 is an extruded aluminium alloy tubular pipe member with threaded projections at each end 10. These members may be formed with various diameters in dependence upon the load on the structure. As shown in Figure 2, the tubular pipe 12 of the chord member 2 is formed of two concentric cylinders 14, 16 joined together by spaced webbs 18. This type of construction is ideal for both compression and tension applications. The radius of inertia can be adjusted according to the design requirements by varying the diameter and thicknesses of the two concentric cylinders 14, 16.

The inner concentric cylinder, 16 is reinforced by additional ribs or ridges 17 of material adjacent the junction of each webb 18 with the inner cylinder 16 in order to facilitate extrusion of the member. It will be noted that the junctions of the webbs with both cylinders are radiused and the webbs 18 are tapered outwardly. It will be appreciated that the dimension and detail of the cross-section may be adjusted to allow for satisfactory extrusion of the section in significant lengths with a consistent cross-sectional profile.

The hollow threaded projections 10 are provided with an external left hand thread in this embodiment. These threaded projections 10 engage with a similarly threaded internal bore of the bush 6 which is used to form the joint assembly between a chord member and a node.

The bush 6 has a cylindrical part surrounding a first cylindrical bore 22 which adjoins a smaller diameter coaxial second bore 21 to provide a complete through bore. The outer part of the bush adjacent the bore 21 is conically shaped. The thread 20 on the bush does not extend the whole height of this first internal bore 22 in order to allow space for the reception of a base flange or head 24 of the shoulder bolt 8.

The shoulder bolt 8 has a cylindrical part 26 which extends from the base flange 24 and fits loosely within the second bore 21 in the threaded bush. The height of the cylindrical section 26 of the shoulder bolt 8 is such that when inserted within the internal bore 22 of the bush 6 with the base flange at the top of bore 22, the section

26 projects by, in this embodiment, about half its length. On this projecting part two opposite flats 28 are formed in order to allow the shoulder bolt to be gripped by a wrench or spanner sleeve for assembly and disassembly of the connection, between the joint assembly and the node 4. The cylindrical part 26 has a screw threaded end 30 which adjoins the cylindrical part 26 at a shoulder 27. The end 30 has a right hand thread in this embodiment which engages with a corresponding thread in a recess 32 in the node 4.

The node 4 is an aluminium alloy sphere in which appropriately configured radial threaded recesses are provided in order to allow any required configuration of chord members to come together at the node. The surface of the sphere is machined flat 34 around each recess in order to provide a seat for the corresponding shoulder 27 of the cylindrical part 26 of the shoulder bolt 8 where it joins the threaded end 30. Provision of flats on the surface of the sphere also allows for greater tolerance of fitting and facilitates manufacture.

The size of the spherical node 4 is determined by the magnitude of the forces to be transmitted across it. The size is also dictated by the need to avoid interference between the various chord members connected to the node. In order to allow a range of structures to be built from a set of components, it is desirable to provide a standard range of sizes for the node and chord members. A suggested range includes chord members and corresponding joint assemblies which have diameters of 38 mm, 42 mm, 48 mm, 60 mm, 75 mm, 89 mm and 101 mm. This range is quoted by way of example only and larger sizes could readily be produced.

Six spaced blind bores 40 are provided around the external periphery of the cylindrical part of the conical bush 6. These blind bores allow the conical bush to be gripped firmly by an appropriate tool in order to assemble and disassemble the connection between the joint assembly and a chord member.

The use of screw threads of opposite senses in the two parts of the joint assembly enables the two connections to be assembled and

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disassembled independently of one another. Although a left hand thread has been described for the connection between the chord member and the bush, it will be appreciated that this could be a right hand thread. However, this would require a left hand thread on the connection between the bolt and node and this would require the use of non-standard nodes. As well as making the sense of the threads connecting the shaft 2 to the threaded bush 6 and the shoulder bolt 8 to the node 4 in opposite senses, it is also preferable to provide the threads with different pitches. For example the threaded connection between the shaft and bush may be a 2 mm pitch and the threaded connection between the shoulder bolt and node may be a 3 mm pitch. In this way incorrect connections can be avoided.

The components are all preferably made from a light weight aluminium alloy such as 6061-T6 containing magnesium and silicon. The 6061-T6 alloy has a density of  $27.2 \text{ kgm}^{-3}$  compared to  $78.5 \text{ kgm}^{-3}$  for a typical steel. Since the 0.2% proof stress for 6061-T6 aluminium alloy is  $265 \text{ N mm}^{-2}$  compared to  $275 \text{ N mm}^{-2}$  for steel, the dead load of a large span structure is capable of being reduced by almost half in comparison to steel.

The extruded surface of the shaft and joint assembly components may be left with its natural finish. Alternatively, the surface may be polished and dyed, painted or powder coated for different effects.

CLAIMS

1. An aluminium alloy chord member (2) in combination with a joint assembly for use in connecting the chord member (2) to a node; in which the joint assembly comprises a threaded projection (10) integrally formed at one end of the chord member, a bush (6) having a threaded bore (20, 22) adapted to be screwed onto said threaded projection (10), and a bolt (8) having a head (24) and a threaded end (30), adapted to be received in a threaded recess (32) in a node (4), the head of the bolt being retained in the bore (22) of the bush inwardly of the threaded projection (10) of the chord member in use; wherein the screw thread which connects the chord member (2) and the bush (6) and the thread which connects the bolt (8) and the node (4) are of differing pitches.
2. An assembly as claimed in claim 1, wherein the screw thread which connects the chord member and the bush and the thread which connects the bolt and the node are of opposite senses.
3. An assembly as claimed in any one of the preceding claims wherein the bush and bolt are made of aluminium alloy.
4. An assembly as claimed in any one of the preceding claims, wherein a cylindrical section (26) joins the head to the threaded end in the bolt.
5. An assembly as claimed in claim 4, wherein flats (28) are formed on the cylindrical section (26) of the bolt to allow it to be rotated.
6. An assembly as claimed in any one of the preceding claims, wherein the bolt (8) has a shoulder (27) which seats against a flat (34) around the recess in the node when the joint is fully assembled.



7. An assembly substantially as herein described with reference to the accompanying drawings.

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