

Modular Construction

- The present invention relates to the modular construction of structures which comprise a network of interconnected struts and may be conveniently built up from a plurality of modular components. Such structures have become increasingly popular for roofing large areas such as warehouses, stadiums, public open space, shopping halls and the like as they may be fashioned to span large areas without central supporting columns. Such structures may be either load bearing or primarily decorative and have the capacity to form space frames which clear span in two directions.
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In addition the connection should preferably facilitate erection of an array in situ and thus be self aligning and self supporting.

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It is an object of the present invention to provide, in one embodiment, a structure formed from a plurality of modular components.

- According to this invention, we provide a three
5. dimensional space frame structure comprising a plurality of elongated tubular struts or ties connected together at their ends through a plurality of connectors, each connector comprising a body having in its surface a plurality of screw threaded bores,
10. the axes of which intersect and are inclined to each other, and the end of each strut or tie, which is connected to the end of another strut or tie, having an end piece provided with an axial passage which receives a bolt, the bolt having a head, which acts
15. against the inside of the end piece, and a shank, which is screwed into one of the screw threaded bores of one of the connectors to hold the end face on the strut or tie in mating engagement with the face of the connector body surrounding the bore into which
20. the bolt is screwed, and each strut or tie having an access port in its wall adjacent the end piece to enable an implement to be engaged with the head of the bolt to rotate the bolt and screw it into the bore.
25. Each strut or tie may have a tapered end piece at each of its ends, the passage extending through the end piece. Each end-piece may be integral with the remainder of the strut or tie or a separable portion thereof. The external surface of the end-
30. piece may be of a substantially conical, domed or other substantially smooth external surface which tapers toward an outer extremity or nose.

The tapered end-piece may be formed in a variety of ways and may include a sleeve portion extending

into the tubular strut or tie with the tapered portion extending longitudinally beyond the hollow section.

The end-piece and tubular strut or tie may be secured to one another such as by welding, screw threads,

5. adhesives or other means suitable for the securement and consistent with the materials of which the respective pieces are composed. The end-piece is preferably machined from a solid block.

Preferably the inner face of the end-piece

10. is funnel-like and angled toward the bore. By this means the end of a bolt being fed through the bore from within the strut member is directed toward the bore opening thereby facilitating the insertion of the bolt into the bore. Moreover, the funnel-like
15. inner face of the end-piece allows a powered wrench or like tool to be used in the assembly of the structure.

Preferably the bore comprises a first portion adapted to receive the head of the bolt and a second

20. portion of a reduced size relative to the first portion and adapted to receive the shank but not the head of the bolt; the second portion being positioned outwardly of said first portion, i.e. closer to the outer extremity or nose of the end-piece. Thus
25. the head of the bolt may be at least partly housed within the first portion with the shank extending through the second portion and longitudinally outwardly of the strut member for threadedly engaging a connector according to the invention.

30. The outer surface of the end-piece may be in the form of a cone. Conveniently the outer face is in the form of a truncated cone whereby the nose terminates in an annular mating face. The surface of the mating face may be substantially planar with

the plane extending substantially normally of the longitudinal axis of the strut member.

Each access port may be substantially circular, oval or other convenient shape. Conveniently the

5. access port is of a teardrop like shape with its longer axis extending along the strut member. The broader end of the teardrop may face toward the nearer end-piece of the strut.

10. To minimize the reduction in strength of the strut or tie the access port should be of the smallest practicable size. The radius of curvature of the broader end of a teardrop shaped access port may accordingly be only marginally larger than that of the bolt head to be projected through the bore.

15. The access port may be provided with a cover. The cover preferably seals the port to minimize moisture access. The cover may take the form of a grommett conveniently formed from metal, rubber or plastics materials.

20. The struts or ties may be formed from a variety of materials including steel, stainless steel, plastics and aluminium. The choice of material will depend upon a number of factors including the function of the structures and the desired strength characteristics.

25. When steel components are employed they may be protected against corrosion by galvanising, painting, powder coating and other coatings.

30. Preferably each connector body is substantially symmetrical in shape. Substantially spherical bodies are preferred although faceted spheroids and other shaped bodies may be used. The size of the body with respect to that of the strut members may be varied considerably. The extent of variation may be influenced by such factors as the number, angle, length, and diameter of the threaded passageways and the weight cost and structure of the body.
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The angles between the passageways in any one connector may be varied to suit the geometry of the desired structure.

- The connector body may be hollow or substantially
5. solid and may be conveniently formed from steel, aluminium, stainless steel or plastics materials. The selection of material for any particular application is dependent upon a number of factors including the desired structural strength indoor/outdoor applications, compatability with other components, and
10. the like.

The outer surface of the body may be facettted in the region of the passageways to provide a substantially planar mating surface about each passageway.

15. A counter-bore or counter-sink may be provided at the entrance to each passageway to facilitate mating between the connector and a strut member. The mating surface may be conveniently provided within the counter bore i.e. the mating surface may be below the outer
20. surface of the body.

In a structure according to the invention the nose of each strut or tie may abut a connector.

In an alternative arrangement a spacer may be interposed between the strut or tie and the connector.

25. Preferably the spacer is in the form of a sleeve having an internal diameter sufficient to allow free passage of the bolt therethrough. The external surface

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of the sleeve may be of the same cross sectional shape as that of the strut. Preferably the sleeve is substantially cylindrical.

The end faces of the sleeve may form a complementary angle with the faces of the connector and strut with which they are to abut.

The nose of the strut member may be substantially planar with the plane being substantially normal to the longitudinal axis. The end faces of the sleeve are preferably also substantially planar, with the plane being substantially normal to the longitudinal axis whereby to nest against the nose. In one arrangement a counter-bore or counter-sink may be provided in the nose of the end-piece for receiving one end of a sleeve in accordance with the invention.

15 The optional counter-bore or counter-sink in the connector and/or nose may each be dimensioned to receive a separate end face of the sleeve.

The use of counter-bores or counter-sinks may serve to alleviate the bending and sheer forces on the bolts in an erected structure according to the invention.

The rims of intersection between the end faces and longitudinal wall of the sleeve may each be chamfered.

The sleeve may be a separate component as described above. In an alternative arrangement the sleeve may be affixed to the end of the strut such as by welding or adhesives. In yet another embodiment the sleeve may be formed as an integral part of the strut end piece. In this arrangement the sleeve may appear as an extension of the nose of the end piece.

30. The bolt provided in accordance with the invention may have a partly or fully threaded shank. The head of the bolt may be shaped to receive a spanner or similar tool. Preferably the head is substantially cylindrical with a socket provided in its top face. Such an arrangement facilitates tightening of the bolt using a wrench with a complementary stud and a universal joint, the shank of the wrench projecting out of the strut through the access port. The shank of the wrench may be fitted with a handle for manual operation or may be coupled to an impact drill or similar power tool for rotation of the bolt.

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A first sealing member may also be provided in accordance with the invention. The member is preferably in the form of an O-ring which may be formed from elastomeric, polyurethane, rubber, neoprene or other resiliently deformable material. In use, the sealing member may surround the shank of the bolt adjacent the nose of the strut. The inner rim of the nose and the abutting inner rim of the sleeve or other connector are preferably chamfered and the sealing member may conveniently be situated within the void so
10 formed.

The sealing member may firstly serve the purpose of sealing the strut by acting as a barrier to moisture migrating along the bolt to the interior of a hollow strut. The sealing member may secondly serve the purpose of holding
15 the bolt in place in the end of the strut prior to engagement with the connector.

A second sealing member may optionally be provided between the connector and the sleeve. Preferably a void is created to receive the sealing member in this location
20 by chamfering the neighbouring rims. Where the sleeve is integral with the strut a single sealing member may be provided between the connector and the sleeve.

A seat or washer may be provided for the bolt in accordance with the present invention. The seat or washer
25 may be adapted to receive the shank of the bolt or internal diameter of the washer may be sufficient to allow passage of the shank or the bolt but retain its head. The washer may be positioned between the head of the bolt and the inner face of the end piece. The washer or seat may be of greater
30 diameter than the bolt head. The washer may be of a hardy material to reduce wear. For example the washer may be manufactured in a high tensile steel.

In use, the assembly of the elements provided by the invention may be effected simply and positively as will now
35 be described in relation to one preferred embodiment.

The bolt is inserted head first through the access port with the head being directed up the tube away from the adjacent end-piece. When the bolt is wholly within the tube the tube is angled for the bolt to fall by gravity through
40 the bore.

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The washer or seat when present may be positioned within the end piece prior to insertion of the bolt. Alternatively, the washer may be placed around the shank of the bolt prior to its insertion into the end piece.

5 An O-ring is placed over the protruding shank of the bolt. The bolt is thereby captured within the bore. The sleeve is then placed over the protruding shank and a wrench engages the socket in the head. The other end of the wrench is coupled to an impact drill. The shank of the bolt is
10 entered into the desired passageway of the connector and the bolt rotated by the impact wrench to engage the threads of the passageway. The strut is thereby affixed to the connector. A network of interconnected struts may be built up following the above described procedure by affixing
15 a plurality of struts to each connector.

The present invention will now be more fully described with reference to the accompanying drawings. It should be understood, however, that the following description is illustrative only and should not be taken in any way as
20 superceding the generality of the preceding description.

In the accompanying drawings Figure 1 is a cut-away view of one possible form of elements according to the present invention.

Figure 2 is a schematic representation of one
25 possible form of network incorporating an embodiment of a structure according to the present invention.

Figure 3 is a perspective view of an embodiment of the structure according to the present invention.

In more detail Figures 1 to 3 illustrate a structure
30 according to the present invention comprising a plurality of connectors 1 from which extend a plurality of elongated strut members 2 in a variety of networks. An example of such a network is illustrated in Figure 2.

The elongated strut members 2 include an access port
35 to assist in the assembly of the elements provided by the invention. The elongated strut member 2 includes a tapered end piece 4 at each of its ends. The end piece may be secured to a hollow section of the elongated strut member in any suitable manner. The end piece 4 includes a bore 5 adapted
40 to receive a bolt 6. The bolt 6 thus extends longitudinally

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outwardly from the elongated strut member 2.

The bolt 6 passes through a passage 7 in the form of a sleeve. The bolt then is threadably connected to a threaded passage 8 in the connector

5. 1. As best illustrated in Figure 3 the outer surface of the connector is faceted around the threaded passage to provide a substantially planar mating surface for the passage 7 or elongated strut member 2. A sealing member 10 in the form of an O-ring is provided
10. on the shank of the bolt 6 and is positioned between the nose of the end piece 4 and the passage sleeve 7. The inner rim of the nose and the abutting inner rim of the sleeve 7 are recessed to provide a void for the O-ring 10.

15. A washer 11 is provided between the head of the bolt 6 and the base of the bore 5.

- Finally it is to be understood that various alterations, modifications and/or additions may be introduced into the constructions and arrangements
20. of parts previously described without departing from the spirit or ambit of the invention.



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CLAIMS

1. A three-dimensional space frame structure comprising a plurality of elongated tubular struts or ties connected together at their ends through a plurality of connectors, each connector comprising
5. a body having in its surface a plurality of screw threaded bores, the axes of which intersect and are inclined to each other, and the end of each strut or tie, which is connected to the end of another strut or tie, having an end piece provided with an
10. axial passage which receives a bolt, the bolt having a head, which acts against the inside of the end piece, and a shank, which is screwed into one of the screw threaded bores of one of the connectors to hold the end face on the strut or tie in mating
15. engagement with the face of the connector body surrounding the bore into which the bolt is screwed, and each strut or tie having an access port in its wall adjacent the end piece to enable an implement to be engaged with the head of the bolt to rotate
20. the bolt and screw it into the bore.
2. A structure according to Claim 1, wherein each strut or tie has a tapered end piece at each of its ends, the passage extending through the end piece.
25. 3. A structure according to Claim 2, wherein each end piece includes a sleeve extending from a tapered portion, the passage extending through the sleeve.
4. A structure according to any one of Claims
30. 1 to 3, wherein the inner face of the end piece is funnel-like and leads to the passage.
5. A structure according to Claim 4, wherein the passage comprises a first portion adapted to receive the head of the bolt and a second portion

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of a reduced size relative to the first portion and adapted to receive the shank but not the head of the bolt.

5. 6. A structure according to any one of the preceding Claims, wherein the access port is of a tear-drop like shape with its longer axis extending along the strut or tie, the broader end of the tear-drop like shape being adjacent the end piece.
10. 7. A structure according to any one of the preceding Claims, wherein each body is generally spherical and the outer surface of the body is faceted in the region of the screw threaded bores to provide a substantially planar mating surface around each bore.
15. 8. A structure according to Claim 7, wherein each body further comprises a counterbore or countersink at the entrance to each bore to facilitate mating between the connector and the strut or tie.
20. 9. A structure according to Claim 2 or Claim 3, or any one of Claims 4 to 8 when dependent on Claim 3, wherein each strut or tie has a countersink in the nose of the tapering portion adjacent the sleeve member.
25. 10. A structure according to any one of the preceding Claims, further comprising a sealing member which surrounds the shank of the bolt in each end piece.
30. 11. A structure according to Claim 10, wherein the inner rim of the nose of each elongated strut member and/or the abutting inner rim of the threaded passage of each connector are chamfered.
35. 12. A structure according to Claim 10 or Claim 11 when dependent on Claim 9, in which the sealing member is provided between the tapering portion and the sleeve member.



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13. A structure according to any one of the preceding Claims, further comprising a washer surrounding the shank of the bolt adjacent the head thereof.

14. A structure according to Claim 1, substantially

5. ially as hereinbefore described with reference to the accompanying drawings.
