

Description

This invention relates to space frames.

Where constructions of shallow depth are required to be erected over wide spans with a minimum number of supports and with a minimum of elastic movement under load, space frames are usually considered most appropriate. In most cases a space frame is of double-layer type, comprising upper and lower grids of longitudinal and lateral members or chords, the junctions of chords, or nodes, of the upper and lower grid being interconnected by oblique web members or struts. Usually the lower grid is displaced both longitudinally and laterally relative to the upper grid so that each node of the lower grid is equidistant from four nodes of the upper grid, and is connected to them by four oblique struts. In some space frames, however, the nodes of the lower grid are directly below those of the upper grid so that the axes of the oblique struts are in the axes of the chords they interconnect, and additional vertical struts may interconnect corresponding nodes of the two grids.

Space frames may be modified for the construction of tunnel-vaulted, rather than flat, structures.

A disadvantage of many space frame constructions presently in use is that expensive connectors are used to interconnect chord and strut members at each node, and the fixture of the members to the connectors requires a good deal of time and skilled labour.

The present invention has been devised with the general object of providing a space frame which is simple and economical to manufacture and erect without requiring any costly or elaborate means for interconnecting the space frame members at its nodes. Another object is to provide such a space frame which may be of either of the types mentioned, that is, with each lower grid node connected by similar oblique struts to four nodes of the upper grid, or with the upper and lower grids interconnected by oblique struts in the planes of the interconnected chords of the two grids.

BE-A-895 191 discloses a space frame of the type having upper and lower grids of tubular longitudinal and lateral chord members, and tubular oblique struts with attachment pads at their ends interconnecting nodes at chord intersections of the two grids wherein, at each node,

the chord members are continuous at the nodes and have flattened sections in superimposed relationship,

strut attachment pads are flattened and secured, in adjacent substantially co-planar relationship, to the superimposed flattened chord sections, the flattening of the struts to provide the attachment pads forming a shoulder adjacent each pad;

the pads and chord members being connected at the nodes by a plurality of fastening means each extending through the flattened chord sections and one of the strut attachment pads, at

least two of said fastening means passing through each of said flattened chord sections.

A space frame according to the present invention is characterised in that load distribution plates are provided disposed above and below the assembly of adjacent strut attachment pads and superimposed flattened chord sections, the plate secured to the attachment pads having side edges which bear against said shoulders; said fastening means each extending through the load distribution plates; and in that the flattened section of each chord terminates at each end in V-shaped depressions above and below the chord, and the load distribution plates include such plates above and below each of the said flattened sections with opposed corner portions bearing in each of the said V-shaped depressions.

WO85/01078, which falls within the terms of EPC Article 54(3), (4), 150(3) and 158(1), (2) discloses broadly similar structures in which, however, chord members terminate at nodes.

Preferably the fastening means comprise bolts and nuts, and the load distribution plates include one above, one below and one between the superimposed flattened chord sections. Other features of the invention will become apparent from the following description of preferred embodiments with reference to the accompanying drawings in which:

FIG. 1 is a top view of a node of the lower grid of a space frame according to the invention,

FIG. 2 is a bottom view of the node shown in FIG. 1,

FIG. 3 is a sectional view along line 3-3 in FIG. 1,

FIG. 4 is a sectional view along line 4-4 in FIG. 1,

FIG. 5 is a sectional view of a modified space frame node, and

FIG. 6 is a perspective view of a lower grid node according to another embodiment of the invention.

Referring initially to FIGS. 1 to 5 of the drawings, a space frame, of which one node only is shown, consists of upper and lower grids of tubular longitudinal and lateral chords intersecting at nodes, similar oblique tubular struts interconnecting the nodes of the two grids. The node shown in the drawings is of the lower grid, at which a longitudinal chord 10 is crossed perpendicularly by a lateral chord 11, both tubular chords being flattened, and therefore widened, at the node.

Each of the chords is flattened in such a way that the top and bottom of the flattened and widened section 12 terminates at each end in a V-shaped or right-angled depression 13. Four bolt holes are formed through each flattened section 12.

Each of the oblique struts 14, of lesser diameter than the chords 10 and 11, has each end flattened or deformed in such manner that the flattened extremity is well off-set from the axis of the tube and is bent along a transverse line through an acute angle to form an attachment pad 15, the end of which is mitred or cut away at an angle of about 45° from both sides and is formed with a

bolt hole. Owing to the off-set formation of the strut attachment pads 15 and the angle through which they are bent, each strut 14 is formed with a transverse shoulder or abutment 16 adjacent to each attachment pad 15.

Four bolts 17 with nuts 18 are used to connect rigidly together the two chords 10 and 11 and the four struts 14, together with four load distribution plates. All of the load distribution plates are square with cutaway corners, and with four bolt holes, and comprise a first plate 19; a second plate 20; a third plate indicated at 21 in FIGS. 1 to 4, and, in modified form, at 21a in FIG. 5; and a fourth plate 22.

The four bolts 17 are passed up through the bolt holes of the first load distribution plate 19, the registering bolt holes in the flattened section 12 of the chord 10, the bolt holes of the second plate 20, the bolt holes of the flattened section 12 of the lateral chord 11, the aligned bolt holes of the third plate 21 (FIGS. 3 and 4) or 21a (FIG. 5), the bolt holes of the four strut attachment pads 15, and the bolt holes of the fourth load distribution plate 22, the nuts 18 then being screwed tightly onto the bolts 17.

The flattened section 12 of the longitudinal chord 10 is then reinforced by the first and second load distribution plates 19 and 20, opposite corners of which seat firmly in the V-shaped depressions 13 of the top and bottom of this section, and similarly the second and third plates 20 and 21 reinforce the flattened section 12 of the lateral chord 11. The mitred edges of the attachment pads 15 of the four struts 14 are held in closely abutting adjacent arrangement, as indicated by broken lines in FIG. 1, and the four sides of the fourth load distribution plate 22 bear firmly against the shoulders or abutments 16 of the four struts 14.

The third load distribution plate 21a of the modification shown in FIG. 5 is of such increased thickness that the axes of the four oblique struts 14 meet close to the axes of the chord members. If it is desired that the axes of the longitudinal and lateral chords should lie in the one plane, their flattened sections 12 may be appropriately off-set.

The nodes of the upper grid of the space frame are inverted, relative to the bottom grid node illustrated, but are otherwise similar; except that a single strut 14 is fixed to each corner node of the upper grid, and two struts lead into each node along the sides of the upper grid.

The embodiment shown in FIG. 6 of the drawings is a node of the lower grid of a space frame of the type in which the axes of the struts lie in the planes of the chords they interconnect. A tubular longitudinal chord 23 and a similar lateral chord 24 have flattened sections 25 similar to those before described. Two oblique struts 26 have their extremities flattened, the flattened parts of each being off-set from the strut axis to form an adjacent shoulder or abutment 27, the flattened part then being bent through an angle to form an attachment pad 28 with a square-cut end. There is also provided a vertical strut 29 with an attach-

ment plate 30, formed with bolt holes 31, welded to each end. Bolts 32 are passed through the bolt holes 31 of an attachment plate 30, through registering bolt holes in the abutting attachment pads 28, in an upper load distribution plate 33, in the flattened section 25 of the longitudinal chord 23, in a middle load distribution plate 34, in the flattened section 25 of the lateral chord 24 and in a bottom load distribution plate (not shown), the bolts then being engaged by nuts (not shown). The three load distribution plates are similar to those illustrated in FIGS. 1 to 4 and similarly engage and reinforce the flattened sections of the chords.

Space frames according to the invention will be found to be very easily and economically assembled and, because of the strength and torsional stability of each node, to be very effective in achieving the objects for which they have been devised.

Claims

1. A space frame of the type having upper and lower grids of tubular longitudinal and lateral chord members (10, 11), and tubular oblique struts (14) with attachment pads (15) at their ends interconnecting nodes at chord intersections of the two grids wherein at each node:

the chord members (10, 11) are continuous at the nodes and have flattened sections (12) in superimposed relationship,

strut attachment pads (15) are flattened and secured, in adjacent substantially co-planar relationship, to the superimposed flattened chord sections (12), the flattening of the struts to provide the attachment pads (15) forming a shoulder (16) adjacent each pad;

the pads (15) and chord members (10, 11) being connected at the nodes by a plurality of fastening means (17, 18) each extending through the flattened chord sections (12) and one of the strut attachment pads (15), at least two of said fastening means (17) passing through each of said flattened chord sections (12); characterised in that load distribution plates (19-22) are provided disposed above and below the assembly of adjacent strut attachment pads (15) and superimposed flattened chord sections (12), the plate (22) secured to the attachment pads (15) having side edges which bear against said shoulders (16); said fastening means (17, 18) each extending through the load distribution plates (19-22), and in that the flattened chord section (12) of each chord (10, 11) terminates at each end in V-shaped depressions (13) above and below the chord and the load distribution plates (19-22) include such plates above and below each of the said flattened sections with opposed corner portions bearing in each of the V-shaped depressions.

2. A space frame according to claim 1 wherein the side edges of adjacent attachment pads (15) abut against each other.

3. A space frame according to any one of the preceding claims wherein:

bolt hole. Owing to the off-set formation of the strut attachment pads 15 and the angle through which they are bent, each strut 14 is formed with a transverse shoulder or abutment 16 adjacent to each attachment pad 15.

Four bolts 17 with nuts 18 are used to connect rigidly together the two chords 10 and 11 and the four struts 14, together with four load distribution plates. All of the load distribution plates are square with cutaway corners, and with four bolt holes, and comprise a first plate 19; a second plate 20; a third plate indicated at 21 in FIGS. 1 to 4, and, in modified form, at 21a in FIG. 5; and a fourth plate 22.

The four bolts 17 are passed up through the bolt holes of the first load distribution plate 19, the registering bolt holes in the flattened section 12 of the chord 10, the bolt holes of the second plate 20, the bolt holes of the flattened section 12 of the lateral chord 11, the aligned bolt holes of the third plate 21 (FIGS. 3 and 4) or 21a (FIG. 5), the bolt holes of the four strut attachment pads 15, and the bolt holes of the fourth load distribution plate 22, the nuts 18 then being screwed tightly onto the bolts 17.

The flattened section 12 of the longitudinal chord 10 is then reinforced by the first and second load distribution plates 19 and 20, opposite corners of which seat firmly in the V-shaped depressions 13 of the top and bottom of this section, and similarly the second and third plates 20 and 21 reinforce the flattened section 12 of the lateral chord 11. The mitred edges of the attachment pads 15 of the four struts 14 are held in closely abutting adjacent arrangement, as indicated by broken lines in FIG. 1, and the four sides of the fourth load distribution plate 22 bear firmly against the shoulders or abutments 16 of the four struts 14.

The third load distribution plate 21a of the modification shown in FIG. 5 is of such increased thickness that the axes of the four oblique struts 14 meet close to the axes of the chord members. If it is desired that the axes of the longitudinal and lateral chords should lie in the one plane, their flattened sections 12 may be appropriately off-set.

The nodes of the upper grid of the space frame are inverted, relative to the bottom grid node illustrated, but are otherwise similar; except that a single strut 14 is fixed to each corner node of the upper grid, and two struts lead into each node along the sides of the upper grid.

The embodiment shown in FIG. 6 of the drawings is a node of the lower grid of a space frame of the type in which the axes of the struts lie in the planes of the chords they interconnect. A tubular longitudinal chord 23 and a similar lateral chord 24 have flattened sections 25 similar to those before described. Two oblique struts 26 have their extremities flattened, the flattened parts of each being off-set from the strut axis to form an adjacent shoulder or abutment 27, the flattened part then being bent through an angle to form an attachment pad 28 with a square-cut end. There is also provided a vertical strut 29 with an attach-

ment plate 30, formed with bolt holes 31, welded to each end. Bolts 32 are passed through the bolt holes 31 of an attachment plate 30, through registering bolt holes in the abutting attachment pads 28, in an upper load distribution plate 33, in the flattened section 25 of the longitudinal chord 23, in a middle load distribution plate 34, in the flattened section 25 of the lateral chord 24 and in a bottom load distribution plate (not shown), the bolts then being engaged by nuts (not shown). The three load distribution plates are similar to those illustrated in FIGS. 1 to 4 and similarly engage and reinforce the flattened sections of the chords.

Space frames according to the invention will be found to be very easily and economically assembled and, because of the strength and torsional stability of each node, to be very effective in achieving the objects for which they have been devised.

Claims

1. A space frame of the type having upper and lower grids of tubular longitudinal and lateral chord members (10, 11), and tubular oblique struts (14) with attachment pads (15) at their ends interconnecting nodes at chord intersections of the two grids wherein at each node:

the chord members (10, 11) are continuous at the nodes and have flattened sections (12) in superimposed relationship,

strut attachment pads (15) are flattened and secured, in adjacent substantially co-planar relationship, to the superimposed flattened chord sections (12), the flattening of the struts to provide the attachment pads (15) forming a shoulder (16) adjacent each pad;

the pads (15) and chord members (10, 11) being connected at the nodes by a plurality of fastening means (17, 18) each extending through the flattened chord sections (12) and one of the strut attachment pads (15), at least two of said fastening means (17) passing through each of said flattened chord sections (12); characterised in that load distribution plates (19-22) are provided disposed above and below the assembly of adjacent strut attachment pads (15) and superimposed flattened chord sections (12), the plate (22) secured to the attachment pads (15) having side edges which bear against said shoulders (16); said fastening means (17, 18) each extending through the load distribution plates (19-22), and in that the flattened chord section (12) of each chord (10, 11) terminates at each end in V-shaped depressions (13) above and below the chord and the load distribution plates (19-22) include such plates above and below each of the said flattened sections with opposed corner portions bearing in each of the V-shaped depressions.

2. A space frame according to claim 1 wherein the side edges of adjacent attachment pads (15) abut against each other.

3. A space frame according to any one of the preceding claims wherein:



a load distribution plate (21a) interposed between the strut attachment pads (15) and the superimposed flattened chord sections (12) is of such thickness that the prolongations of the axes of the struts meet at a point within the overlapping chord sections.

4. A space frame according to any one of the preceding claims wherein:

the axis of each of the oblique struts (14) lies substantially in the vertical plane through the axes of the parallel chords (10, 11) which the said strut interconnects.

5. A space frame according to any one of the preceding claims wherein:

a load distribution plate (30) secured on the strut 5 attachment pads is secured in an end of a vertical strut (29) of the space frame.

Patentansprüche

1. Räumliches Rahmen-Tragwerk des Typs, der obere und untere Gitter aus röhrenförmigen Längs- und Seitengurtelementen (10, 11) und röhrenförmigen schrägstehenden Streben (14) mit Befestigungsunterlagen (15) an ihren Enden aufweist, die Knotenpunkte an den Schnittpunkten der beiden Gitter miteinander verbinden, worin an jedem Knotenpunkt

die Gurtelemente (10, 11) an den Knotenpunkten kontinuierlich sind und abgeflachte Abschnitte (12) in einander überlagerndem Verhältnis aufweisen;

Strebenbefestigungsunterlagen (15) abgeflacht und in angrenzendem, im wesentlichen koplanarem Verhältnis an den einander überlagernden abgeflachten Gurtabschnitten (12) befestigt sind, wobei die Abflachung der Streben, um die Befestigungsunterlagen (15) zu schaffen, eine Schulter (16) angrenzend an jede Unterlage bildet;

die Unterlagen (15) und Gurtelemente (10, 11) an den Knotenpunkten mittels einer Vielzahl von Befestigungseinrichtungen (17, 18) verbunden sind, von denen sich jede durch die abgeflachten Gurtabschnitte (12) und eine der Strebenbefestigungsunterlagen (15) erstreckt und wenigstens zwei der genannten Befestigungseinrichtungen (17) durch jeden der genannten abgeflachten Gurtabschnitte (12) geführt sind; dadurch gekennzeichnet, daß Lastverteilungsplatten (19-22) oberhalb und unterhalb der Anordnung von angrenzenden Strebenbefestigungsunterlagen (15) und einander überlagernden abgeflachten Gurtabschnitten (12) angeordnet sind, die an den Befestigungsunterlagen (15) befestigte Platte (22) Seitenkanten aufweist, die gegen die genannten Schultern (16) anliegen; so daß sich jede der genannten Befestigungseinrichtungen (17, 18) durch die Lastverteilungsplatten (19-22) erstreckt und daß die abgeflachten Gurtabschnitte (12) jeder Strebe (10, 11) an jedem Ende in V-förmige Vertiefungen (13) oberhalb und unterhalb des Gurtes auslaufen und die Lastverteilungsplatten (19-22) solche Platten oberhalb und unterhalb jedes der genannten abgeflachten Abschnitte aufweisen, deren gegenüberliegende Eckab-

schnitte in jede der V-förmigen Vertiefungen eingreifen.

2. Räumliches Rahmen-Tragwerk nach Anspruch 1, worin die Seitenkanten von angrenzenden Befestigungsunterlagen (15) aneinander anliegen.

3. Räumliches Rahmen-Tragwerk nach einem der vorhergehenden Ansprüche, worin

eine Lastverteilungsplatte (21a), die zwischen den Strebenbefestigungsunterlagen (15) und den einander überlagernden abgeflachten Gurtabschnitten (12) eingelegt ist, eine solche Dicke aufweist, daß die Verlängerungen der Achsen der Streben sich in einem Punkt innerhalb der überlappenden Gurtabschnitte treffen.

4. Räumliches Rahmen-Tragwerk nach einem der vorhergehenden Ansprüche, worin

die Achse jeder der schrägstehenden Streben (14) im wesentlichen in der vertikalen Ebene durch die Achsen der parallelen Gurte (10, 11) verläuft, die die genannte Strebe miteinander verbindet.

5. Räumliches Rahmen-Tragwerk nach einem der vorhergehenden Ansprüche, worin

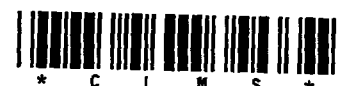
eine Lastverteilungsplatte (30), die an den Strebenbefestigungsunterlagen befestigt ist, in einem Ende einer vertikalen Strebe (29) des räumlichen Tragwerks befestigt ist.

Revendications

1. Structure spatiale du type comportant des réseaux supérieur et inférieur de cordes tubulaires longitudinales et latérales (10, 11) et des entretoises tubulaires obliques (14) avec des supports de fixation (15) à leurs noeuds interconnectant les extrémités aux intersections des cordes des deux réseaux dans laquelle, à chaque noeud; les cordes (10, 11) sont ininterrompues aux noeuds et présentent des sections aplaties (12) superposées,

les supports de fixation d'entretoises (15) sont aplatis et fixés de manière adjacente et essentiellement coplanaire aux sections de cordes aplaties superposées (12), l'aplatissement des entretoises créant les supports de fixation (15) constituant un épaulement (16) proche de chaque support,

les supports (15) et les cordes (10, 11) étant connectés aux noeuds par plusieurs moyens de fixation (17, 18) dont chacun traverse les sections de cordes aplaties (12) et l'un des supports de fixation d'entretoise (15), au moins deux desdits moyens de fixation (17) traversant chacune desdites sections de corde aplatie (12), caractérisée en ce que les plaques de répartition de charge (19-22) sont disposées au-dessus et en dessous de l'assemblage des supports de fixation d'entretoises voisins (15) et des sections de cordes aplaties superposées (12), la plaque (22), fixée aux supports de fixation (15), ayant des bords latéraux qui viennent appuyer sur lesdits épaulements (16), lesdits moyens de fixation (17, 18) traversant chacun les plaques de répartition de charge (19-22) et en ce que la section de corde



aplatie (12) de chaque corde (10, 11) se termine à chaque extrémité dans des dépressions (13) en forme de "V", au-dessus et en dessous de la corde et en ce que les plaques de répartition de charge (19, 22) comprennent des plaques au-dessus et en dessous de chacune desdites sections aplaties avec des parties d'angle prenant appui dans chacune des dépressions en forme de "V".

2. Structure spatiale selon la revendication 1, dans laquelle les bords latéraux des supports de fixation voisins (15) viennent buter les uns contre les autres.

3. Structure spatiale selon l'une quelconque des revendications précédentes, dans laquelle:
une plaque de répartition de charge (21a) interposée entre les supports de fixation d'entretoises

(15) et les sections de cordes aplaties superposées (12) a une épaisseur telle que les prolongements des axes des entretoises se rencontrent en un point dans les sections de cordes superposées.

4. Structure spatiale selon l'une quelconque des revendications précédentes, dans laquelle:

l'axe de chacune des entretoises obliques (14) est situé essentiellement dans le plan vertical passant par les axes des cordes parallèles (10, 11) qui interconnectent ladite entretoise.

5. Structure spatiale selon l'une quelconque des revendications précédentes, dans laquelle:

une plaque de répartition de charge (30) fixée aux supports de fixation d'entretoises est fixée dans une extrémité d'une entretoise verticale (29) de la structure spatiale.

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