

LARGE CURVATURE FREE-FORM SURFACE DOUBLE-LAYER ALUMINUM ALLOY AND STAINLESS STEEL COMBINED STRUCTURE SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to the technical field of steel-aluminum combined structures, in particular to a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system.

BACKGROUND

[0002] Existing free-form surface structure systems are mostly implemented by steel structures, but the steel structures are prone to rusting in offshore corrosion environments, resulting in potential safety hazards. In addition, later maintenance of high-altitude steel structure members is relatively difficult. Moreover, large curvature free-form surfaces are often achieved by cast steel joints, which are long in production cycle, difficult to machine, and prone to corrosion. Chinese patent 202010065875.5 discloses a construction method for a continuous multi-span and large-span high-altitude aluminum alloy reticulated shell structure, where the single-layer aluminum alloy reticulated shell structure system referred to therein is a single-layer system, so it is difficult to achieve a large curvature surface radian; the structure system of the patent has high requirements for lower support and layout, and is mainly used for high-altitude corridors, so its use is relatively simple; and the single-layer structure system of the patent cannot express multi-level architecture required for complex models such as fishing nets.

SUMMARY

[0003] Aiming at the problems that the single-layer reticulated shell system in the prior art is difficult to achieve a large curvature surface radian architectural structure and is not corrosion

resistant, the present application provides a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system, which can achieve rich surface modeling consistent with an architectural concept and has good corrosion resistance.

[0004] In order to solve the above technical problems, the technical solution provided by the present application is as follows:

[0005] A large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system includes:

[0006] a lower support system, a lower chord large curvature aluminum reticulated shell, stainless steel supports, and an upper chord aluminum reticulated shell;

[0007] the lower support system includes frame beams located on four sides of the structure system;

[0008] the lower chord large curvature aluminum reticulated shell is of a free-form surface structure and is spliced from a plurality of lower chord aluminum alloy units, and the edge lower chord aluminum alloy units are connected to the frame beams;

[0009] the upper chord aluminum reticulated shell is of a plane structure and is spliced from a plurality of upper chord aluminum alloy units, and the edge upper chord aluminum alloy units are fixedly connected to the frame beams through stainless steel L-shaped adapters; and

[0010] the upper chord aluminum reticulated shell is supported above the lower chord large curvature aluminum reticulated shell through the stainless steel supports.

[0011] Further, a stainless steel joint plate is fixedly connected to an outer side of a connection end of the edge upper chord aluminum alloy unit, and the L-shaped adapter is fixedly connected to the joint plate.

[0012] Further, the edge lower chord aluminum alloy unit is hinged with the frame beam through a position adjustable shear hinged plate.

[0013] Further, the upper chord aluminum alloy units and the lower chord aluminum alloy units

are spliced from rhombic bar units, triangular bar units, or a combination thereof.

[0014] Further, a lower chord connection joint is formed at the connection of the lower chord large curvature aluminum reticulated shell and the stainless steel support, and the lower chord connection joint includes folding angle aluminum alloy lower joint plates, a stainless steel stiffening cylinder, and a stainless steel lower connection plate;

[0015] the folding angle aluminum alloy lower joint plate has the same folding angle pre-molded according to a folding angle of a lower chord bar at the lower chord connection joint;

[0016] the stainless steel stiffening cylinder is mounted axially between the folding angle aluminum alloy lower joint plates on upper and lower sides by planing and jacking, and the stainless steel stiffening cylinder is connected radially to web plates of the lower chord bar through stainless steel radial connection plates and stainless steel ring slot rivets; and

[0017] the stainless steel lower connection plate is riveted to an upper side of the folding angle aluminum alloy lower joint plate, and the stainless steel support is fixed to an upper side of the stainless steel lower connection plate.

[0018] Further, if the folding angle is large, the two folding angle aluminum alloy lower joint plates are fixed to upper and lower flanges of the lower chord bar respectively; and if the folding angle is small, the two folding angle aluminum alloy lower joint plates are not fixed to the lower chord bar.

[0019] Further, the folding angle aluminum alloy lower joint plate is formed into a three-section flat plate structure, the first-section flat plate structure is attached to the lower chord bar on one side of the lower chord connection joint, the first-section flat plate structure is axially perpendicular to the stainless steel stiffening cylinder, and the third-section flat plate structure is attached to the lower chord bar on the other side of the lower chord connection joint.

[0020] Further, an upper chord connection joint is formed at the connection of the upper chord aluminum reticulated shell and the stainless steel support, and the upper chord connection joint

includes aluminum alloy upper joint plates and a stainless steel upper connection plate; and

[0021] the aluminum alloy upper joint plates are fixed to upper and lower flanges of an upper chord bar at the upper chord connection joint respectively, the stainless steel upper connection plate is fixed to a lower side of the aluminum alloy upper joint plate on a lower side, and the stainless steel support is fixed to a lower side of the stainless steel upper connection plate.

[0022] Further, the stainless steel upper connection plate is pre-perforated in a factory and welded and fixed to the stainless steel support, and the stainless steel upper connection plate is connected to the aluminum alloy upper joint plate through single-side blind rivets.

[0023] Further, the rhombic units and/or the triangular units of the lower chord aluminum alloy units can be flexibly combined and spliced into various surface shapes according to architectural boundaries and architectural design requirements.

[0024] Compared with the prior art, the large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system of the present invention achieves the following beneficial technical effects:

[0025] The large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system of the present application is suitable for complex space lattice structures, and particularly can be used for high corrosion environments such as offshore and coastal areas. The structure system is convenient to construct, has high bearing capacity and rotation stiffness, and is light and particularly suitable for space buildings in offshore cities.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] In order to describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces the accompanying drawings required for use in the description of the embodiments or the prior art. Apparently, the accompanying drawings in the following description show some embodiments of the present

invention, and those of ordinary skill in the art may derive other drawings from the accompanying drawings without any creative efforts.

[0027] FIG. 1 is an exploded view of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

[0028] FIG. 2 is a combined view of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

[0029] FIG. 3 is a schematic diagram of connection of an upper chord aluminum alloy unit and a lower chord aluminum alloy unit to a frame beam of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

[0030] FIG. 4 is a schematic diagram of a joint connecting an upper chord aluminum alloy unit and a stainless steel support of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

[0031] FIG. 5 is a cross-sectional view of a joint connecting a lower chord aluminum alloy unit and a stainless steel support of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

[0032] FIG. 6 is a planar view of a joint connecting a lower chord aluminum alloy unit and a stainless steel support of a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system provided by an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0033] In order to make the objectives, technical solutions and advantages of the present invention clearer, the following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are some but not all of the embodiments of the present invention. Based on the embodiments in the present invention, all other embodiments obtained by those of ordinary skill in the art without any creative efforts shall fall within the scope of protection of the present invention.

[0034] As shown in FIG. 1 and FIG. 2, a large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system in an embodiment of the present application is characterized by including:

[0035] a lower support system 1, a lower chord large curvature aluminum reticulated shell 2, stainless steel supports 3, and an upper chord aluminum reticulated shell 4;

[0036] The lower support system 1 includes frame beams 5 located on four sides of the structure system; the structure system of the present application is light as a whole and has low requirements for the lower support system, and the conventional simple frame support system can meet force requirements, so the lower support system 1 is not excessively introduced;

[0037] The lower chord large curvature aluminum reticulated shell 2 is of a free-form surface structure and is spliced from a plurality of lower chord aluminum alloy units 6, and the edge lower chord aluminum alloy units 6 are connected to the frame beams 5;

[0038] The upper chord aluminum reticulated shell 4 is of a plane structure and is spliced from a plurality of upper chord aluminum alloy units 7, and the edge upper chord aluminum alloy units 7 are fixedly connected to the frame beams 5 through stainless steel L-shaped adapters 9;

[0039] In an embodiment of the present application, the upper chord aluminum alloy units 7 and the lower chord aluminum alloy units 6 are spliced from rhombic bar units, triangular bar units, or a combination thereof. The rhombic bar unit is a closed rhombic basic structural unit

formed by connecting 4 aluminum alloy bars end to end. Similarly, the triangular bar unit is a closed triangular basic structural unit formed by connecting 3 aluminum alloy bars end to end. The rhombic bar units and/or the triangular bar units can be flexibly combined and spliced into various free-form surface shapes according to architectural boundaries and architectural design requirements.

[0040] The upper chord aluminum reticulated shell 4 is supported above the lower chord large curvature aluminum reticulated shell 2 through the stainless steel supports 3.

[0041] In an embodiment of the present application, as shown in FIG. 3, a stainless steel joint plate 8 is fixedly connected to an outer side of a connection end of the edge upper chord aluminum alloy unit 7, and the L-shaped adapter 9 is fixedly connected to the joint plate 8; and the edge lower chord aluminum alloy unit is hinged with the frame beam 5 through a position adjustable shear hinged plate 10. The L-shaped adapter 9 is conducive to the transmission of axial force and bending moment of bars. The L-shaped adapter 9 is fixedly connected to the connection end of the edge upper chord aluminum alloy unit (the edge upper chord aluminum alloy unit is understood as an upper chord aluminum alloy unit corresponding to the frame beam 5 of the lower support system 1 on the periphery of the entire upper chord aluminum reticulated shell 4, and the edge lower chord aluminum alloy unit is understood similarly). When mounted to the frame beam 5 at a high altitude, the L-shaped adapter 9 can be adjusted according to the actual position on site and fixed by welding. The aluminum alloy bars and the stainless steel joint plates 8 all use stainless steel ring slot rivets 11, with the advantages of fast mounting, high mounting accuracy, and permanent loosening resistance.

[0042] In an embodiment of the present application, as shown in FIG. 4, an upper chord connection joint is formed at the connection of the upper chord aluminum reticulated shell 4 and the stainless steel support 3, and the upper chord connection joint includes aluminum alloy upper joint plates 12 and a stainless steel upper connection plate 13;

[0043] The aluminum alloy upper joint plates 12 are fixed to upper and lower flanges of an upper chord bar at the upper chord connection joint respectively, the stainless steel upper connection plate 13 is fixed to a lower side of the aluminum alloy upper joint plate 12 on a lower side, and the stainless steel support 3 is fixed to a lower side of the stainless steel upper connection plate 13. The upper chord bar refers to the aluminum alloy bar forming the upper chord aluminum alloy unit 7, and may be an edge of the rhombic bar unit and/or the triangular bar unit.

[0044] In another embodiment of the present application, a lower chord connection joint is formed at the connection of the lower chord large curvature aluminum reticulated shell 2 and the stainless steel support 3, and the lower chord connection joint includes folding angle aluminum alloy lower joint plates 14, a stainless steel stiffening cylinder 15, and a stainless steel lower connection plate 16;

[0045] The folding angle aluminum alloy lower joint plate 14 has the same folding angle pre-molded according to a folding angle of a lower chord bar at the lower chord connection joint; the lower chord bar refers to the aluminum alloy bar forming the lower chord aluminum alloy unit 6, and may be an edge of the rhombic bar unit and/or the triangular bar unit.

[0046] The stainless steel stiffening cylinder 15 is mounted axially between the folding angle aluminum alloy lower joint plates 14 on upper and lower sides by planing and jacking, and the stainless steel stiffening cylinder 15 is connected radially to web plates of the lower chord bar through stainless steel radial connection plates 17 and stainless steel ring slot rivets 11;

[0047] The stainless steel lower connection plate 16 is riveted to an upper side of the folding angle aluminum alloy lower joint plate 14, and the stainless steel support 3 is fixed to an upper side of the stainless steel lower connection plate 16.

[0048] The folding angle aluminum alloy lower joint plate 14 is formed into a three-section flat plate structure, the first-section flat plate structure is attached to the lower chord bar on one side

of the lower chord connection joint, the first-section flat plate structure is axially perpendicular to the stainless steel stiffening cylinder 15, and the third-section flat plate structure is attached to the lower chord bar on the other side of the lower chord connection joint.

[0049] The large curvature free-form surface aluminum alloy double-layer reticulated shell structure system is bound to have many special-shaped bending joints with large folding angles, and conventional aluminum alloy plate joints cannot meet structural force. The present application develops novel aluminum alloy and stainless steel combined joints for this purpose, so as to meet architectural appearance and force requirements and improve the force mode to withstand the joint action of axial force, bending moment, and shear force. The novel aluminum alloy and stainless steel combined joints are the upper chord connection joint and the lower chord connection joint. The structure of the upper chord connection joint is shown in FIG. 4. The stainless steel upper connection plate 13 is pre-perforated in a factory and welded and fixed to the stainless steel support 3, and the stainless steel upper connection plate 13 is connected to the aluminum alloy upper joint plate 12 through single-side blind rivets 18. The single-side blind rivets 18 are used here to solve the problems of narrow mounting space and no locking bolt operation space. The cross section and plane of the lower chord connection joint are shown in FIG. 5 and FIG. 6, respectively. Similar to the upper chord connection joint, the pre-perforated circular stainless steel lower connection plate 16 is connected to the folding angle aluminum alloy lower joint plate 14. In order to achieve large curvature angle transition, the joint plates are pre-molded into joint plates with different folding angles according to the folding angles of the bars by using the characteristic of low elastic modulus of an aluminum alloy material and a mold pressing process. The stainless steel stiffening cylinder 15 with radial connection plates 17 is mounted by planing and jacking, so force is transmitted by close contact. The lower chord aluminum bars are designed respectively according to the magnitude of bar end force. If the folding angle is large, the two folding angle aluminum alloy lower joint plates 14 are fixed to

upper and lower flanges of the lower chord bar respectively. If the folding angle is small, the two folding angle aluminum alloy lower joint plates 14 are not fixed to the lower chord bar.

[0050] Finally, it should be noted that the above embodiments are only for explaining, but not limiting, the technical solutions of the present invention; although the present invention is described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that the technical solutions described in the foregoing embodiments can be modified, or some of the technical features can be equivalently substituted; and these modifications or substitutions do not make the essence of the corresponding technical solutions depart from the spirit and scope of the technical solutions of the present invention.

Claims

1. A large curvature free-form surface double-layer aluminum alloy and stainless steel combined structure system is characterized by comprising:

a lower support system (1), a lower chord large curvature aluminum reticulated shell (2), stainless steel supports (3), and an upper chord aluminum reticulated shell (4);

the lower support system (1) comprises frame beams located on four sides of the structure system;

the lower chord large curvature aluminum reticulated shell (2) is of a free-form surface structure and is spliced from a plurality of lower chord aluminum alloy units (6), and the edge lower chord aluminum alloy units (6) are connected to the frame beams (5);

the upper chord aluminum reticulated shell (4) is of a plane structure and is spliced from a plurality of upper chord aluminum alloy units (7), and the edge upper chord aluminum alloy units (7) are fixedly connected to the frame beams (5) through stainless steel L-shaped adapters (9); and

the upper chord aluminum reticulated shell (4) is supported above the lower chord large curvature aluminum reticulated shell (2) through the stainless steel supports (3).

2. The combined structure system according to claim 1, characterized in that a stainless steel joint plate (8) is fixedly connected to an outer side of a connection end of the edge upper chord aluminum alloy unit (7), and the L-shaped adapter (9) is fixedly connected to the joint plate (8).

3. The combined structure system according to claim 1, characterized in that the edge lower chord aluminum alloy unit (6) is hinged with the frame beam (5) through a position adjustable shear hinged plate (10).

4. The combined structure system according to claim 1, characterized in that the upper chord aluminum alloy units (7) and the lower chord aluminum alloy units (6) are spliced from rhombic bar units, triangular bar units, or a combination thereof.

5. The combined structure system according to claim 1, characterized in that a lower chord connection joint is formed at the connection of the lower chord large curvature aluminum reticulated shell (2) and the stainless steel support (3), and the lower chord connection joint comprises folding angle aluminum alloy lower joint plates (14), a stainless steel stiffening cylinder (15), and a stainless steel lower connection plate (16);

the folding angle aluminum alloy lower joint plate (14) has the same folding angle pre-molded according to a folding angle of a lower chord bar at the lower chord connection joint;

the stainless steel stiffening cylinder (15) is mounted axially between the folding angle aluminum alloy lower joint plates (14) on upper and lower sides by planing and jacking, and the stainless steel stiffening cylinder (15) is connected radially to web plates of the lower chord bar through stainless steel radial connection plates (17) and stainless steel ring slot rivets (11); and

the stainless steel lower connection plate (16) is riveted to an upper side of the folding angle aluminum alloy lower joint plate (14), and the stainless steel support (3) is fixed to an upper side of the stainless steel lower connection plate (16).

6. The combined structure system according to claim 1, characterized in that if the folding angle is large, the two folding angle aluminum alloy lower joint plates (14) are fixed to upper and lower flanges of the lower chord bar respectively; and if the folding angle is small, the two folding angle aluminum alloy lower joint plates (14) are not fixed to the lower chord bar.

7. The combined structure system according to claim 5, characterized in that the folding angle aluminum alloy lower joint plate (14) is formed into a three-section flat plate structure, the first-section flat plate structure is attached to the lower chord bar on one side of the lower chord connection joint, the first-section flat plate structure is axially perpendicular to the stainless steel stiffening cylinder (15), and the third-section flat plate structure is attached to the lower chord bar on the other side of the lower chord connection joint.

8. The combined structure system according to claim 1, characterized in that an upper chord

connection joint is formed at the connection of the upper chord aluminum reticulated shell (4) and the stainless steel support (3), and the upper chord connection joint comprises aluminum alloy upper joint plates (12) and a stainless steel upper connection plate (13); and the aluminum alloy upper joint plates (12) are fixed to upper and lower flanges of an upper chord bar at the upper chord connection joint respectively, the stainless steel upper connection plate (13) is fixed to a lower side of the aluminum alloy upper joint plate on a lower side, and the stainless steel support (3) is fixed to a lower side of the stainless steel upper connection plate (13).

9. The combined structure system according to claim 8, characterized in that the stainless steel upper connection plate (13) is pre-perforated in a factory and welded and fixed to the stainless steel support (3), and the stainless steel upper connection plate (13) is connected to the aluminum alloy upper joint plate (12) through single-side blind rivets (18).

10. The combined structure system according to claim 1, characterized in that the rhombic units and/or the triangular units (6) of the lower chord aluminum alloy units can be flexibly combined and spliced into various surface shapes according to architectural boundaries and architectural design requirements.