LEG ASSEMBLY FOR AN OFFSHORE STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my co-pending application Serial No. 09/071,760 filed on May 1, 1998 for "Leg Assembly for an Offshore Structure," the full disclosure of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

The present invention relates to structural components of multi-cord legs and, more particularly, to a leg structure with improved drag characteristics.

Any object exposed to gas or liquid movement is subject to a force acting on exposed surfaces of the object. Drag constitutes a component of the force on such surfaces in the direction of the mean fluid flow relative to the body. When the molecules of fluid contact the solid surface of an object they create friction as the molecules slide along the object.

Drag, as generally understood in aerodynamics and hydrodynamics, imposes limitations upon the top speed of vehicles, missiles and the like. The magnitude of drag increases as the velocity of the moving body is increased. A static body, for example, an offshore structure experiences similar drag forces induced by wind and wave motions. All parts exposed to the air or water streams must be streamlined in order to reduce the drag.

In an effort to reduce drag, as well as make offshore structures less costly, naval architects and designers create leg structures supporting the offshore platforms as a complex web of intersecting hollow metal tubes. It would be ideal to form the leg chords and bracings from thin, lightweight metal. However, the leg weight cannot be

reduced indefinitely, as the structure is also exposed to overturning moments caused by the air and water movement. Therefore, a careful balance must be retained between drag coefficient of the structure and its weight, so as to develop the most optimum inertia response of exposed solid surfaces to the forces induced by wind and wave motions.

One of the examples of the effort to reduce loading on leg structure due to wind is shown in U.S. Patent No. 1,935,095 issued on November 14, 1933 to Arthur W. Lewis entitled "Derrick Construction." In that patent, an oil derrick supported by four leg members is provided with horizontal and diagonal bracing members. Elongated diagonal braces extend between the horizontal girt members and are connected to the horizontal girt members in six-point connection units at the center of the horizontal braces. The main diagonal braces also form a six-point connection unit with the legs at a point midway between the planes of adjacent horizontal girt members. In addition, the patent suggests using auxiliary diagonal braces extending from a corner that connects a horizontal girt to the leg to the main horizontal brace, intercepting that brace at midpoint. Such auxiliary braces, especially in an offshore environment would substantially increase drag and weight of the vessel, increase the cost of the leg construction and the overall cost of the offshore structure.

Many offshore platforms are designed with leg structures extending to the floor of the ocean and anchored or embedded in the floor for supporting a platform raised above the ocean waves. The legs of such platforms carry considerable loads, and particular attention is paid to the weight of an individual leg. The legs are made from non-corrosive metal capable of withstanding overturning moments in order to support the platform at an elevated level. The cost of metal is also a consideration when designing the leg of offshore platform designers. Any reduction in the weight of the legs translates into considerable cost savings to the manufacture and platform owner.

Government regulations also control the quality of leg construction. A recent amendment introduced by the American Bureau of Shipping (ABS) provided for a

change in the drag force coefficient from 0.5 to 0.62. The increase in the required drag coefficient necessitates either provision of heavier leg structures to create the necessary resistance to air and water streams or reconsideration of conventional designs that most often include horizontal bracings and X-shaped diagonal leg bracings.

The present invention contemplates provision of an improved leg design which is in compliance with the new ABS requirements for maintaining the drag coefficient, while at the same time providing cost savings through reduction of the amount of metal necessary for the construction of a leg assembly for an offshore structure.

SUMMARY OF THE INVENTION

It is therefore, an object of the present invention to provide a leg assembly for offshore platforms, with improved drag characteristics.

It is another object of the present invention to provide a leg assembly and an improved bracing structure for offshore platform legs that have less weight in comparison with conventional bracing members.

It is a further object of the present invention to provide leg structures that are more cost efficient to manufacture and operate.

It is still another object of the present invention to provide a leg assembly for an offshore structure that uses a minimum number of bracing members to reduce drag and weight of the offshore structure.

These and other objects of the invention are achieved through a provision of a leg assembly comprising a pair of parallel leg chords divided into a plurality of sections by transverse bracing members. A unit of angular bracing members is secured to the leg chords and transverse bracing members within each section. The unit has a pair of angular bracing members extending at an obtuse downwardly from a transverse member. Another pair of angular bracing members extends upwardly from a transverse bracing member that is located immediately below the first transverse bracing member.

When the units are connected, the bracing angular bracing members form a "double-K" structure, with the angular bracing members attached back-to-back to a

transverse bracing member. The unit of angular bracing members resembles a rhombus when seen at a front elevation. The legs do not have any other auxiliary braces, providing strong support members, while substantially reducing weight and drag of the offshore structure.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to the drawings, wherein like parts are designated by like numerals, and wherein

Figure 1 is a perspective view of an offshore platform using improved leg bracing structure of the present invention.

Figure 2 is an outward profile of an offshore structure that utilizes the improved leg assembly of the present invention.

Figure 3 is a schematic view of a leg chord with an improved bracing members of the present invention; and

Figure 4 is a detail view of the bracing member of the present invention.

DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the drawings in more detail, numeral 10 designates an offshore structure that uses elevated legs 12, 14 and 16 for supporting a work platform 18. The platform 18 is adapted for conducting mineral exploration and production operations offshore. The unit 10 is designed to operate in over 300 feet water depth in harsh environments, while in less challenging environments, the unit can work in up to 400 feet of water.

The unit 10 conventionally uses a jacking system, whereby the platform 18 is elevated above the wave motions by a rack chock and pinion system. The legs 12, 14 and 16 extend downwardly from the bottom of the platform 18, below the water surface 20 to the sea bed 22 to be either embedded in the floor of the ocean or placed on footings 24, 26 to ensure stability of the legs and a relatively fixed position of the platform 18 in relation to the sea bed 22.

The platform 18 conventionally supports a derrick 28 and may be provided with

a helicopter deck 30, as well as crew living quarters 32. Various cranes 34 can be used for riser and export lines, while the hull 36 of the platform 18 is conventionally divided into compartments (not shown) to house machinery, equipment, supplies, liquids and the like.

Turning now in more detail to the leg assembly of the present invention, reference will be made to a construction of the leg 12, bearing in mind that legs 14 and 16 are identical, in all respects to the structure of the leg 12. As shown in the drawings, the leg 12 has three chords 40, 42 and 44. Secured between the chords 40 and 42 are a plurality of bracing members, some of which are oriented perpendicular to the longitudinal axes of the chords while others extend at a predetermined angle thereto.

The leg chords 40, 42 and 44 are provided with teeth (not shown) for engagement with jack-up units and elevation of the platform 18 from a floating condition, in which it is conventionally transported to the site, to an elevated position shown in Figures 1 and 2, that is to an operational height above the water surface 20.

The horizontal braces 46 are arranged in a triangular configuration between the chords 40, 42 and 44 at various vertical levels along the length of the legs. The horizontal bracing members 46 are secured to each chord along a single imaginary plane passing through the center of the bracing members 46.

Conventional leg structures are usually provided with diagonal braces that would extend from one corner to a diagonally opposite corner of a segment of the leg between two adjacent horizontal braces 46. The new regulations, with the increased coefficient of drag forces requires that the braces withstand stronger forces induced by wind and wave motions in order to increase safety of the offshore structures. Conventional approach would be to increase surface or mass of the braces in order to comply with the new regulations. However, such approach is costly and may not be widely accepted by naval architects, manufacturers and platform owners. The present invention contemplates improvement in a conventional design by providing a "double-K" structure of the leg braces.

As shown in more detail in Figures 2, 3 and 4, angular braces are secured to the leg chords 40, 42 and 44 in sections defined by spaced horizontal bracing members 46. A first angular bracing member 50 extends from a mid-point 52 of a horizontal bracing member 46a to a mid-point 54 of a section 56 defined between adjacent horizontal bracing 46a and a horizontal bracing 46b.

A second angular bracing member 58 extends between the mid-point 52 to a mid-point 60 on a leg chord 42 (Figure 3) within the section 56. A third angular member 62 extends from the mid-point 52 to a mid-point 64 in a section 70 above the horizontal bracing member 46a. A fourth angular bracing member 66 extends from the mid-point 52 to a mid-point 68 on the chord 42 within the next adjacent segment 70.

The angular members 50, 58 are secured back-to-back to the angular members 62 and 66 respectively with the horizontal bracing member 46a intersecting the angular members in a manner that can be best seen in Figure 4. In effect, when viewed from a horizontal level, inclined bracing members 50 and 58 form an inverted V-shaped unit attached at the apex to the transverse bracing 46a, while the inclined bracings 62 and 66 form a V-shaped unit attached at the apex to the transverse bracing 46a. The inclined bracings attached to midpoints along transverse bracing members 46 and to midpoints along leg chord sections defined by the transverse bracing members 46 form a rhombus within each section 56, 70, 80, etc.

The bracing members 50 and 66, and the angular bracing members 62 and 58 are connected to the horizontal bracing member 46a at four weld points 72, 74, 76 and 78. Empirical data confirms that these points are critical in establishing a secure, rigid attachment of the angular braces to the horizontal braces. Such system is believed to be more efficient in comparison with a six-point connection system found in prior art.

As shown in Figures 2 and 3, the leg chords are divided into a plurality of segments by the horizontal bracing members 46. The arrangement of the angular bracing members 50, 58, 62, and 66 is repeated for the next section 80 (Figure 3), wherein the angular bracings are designated by respective numerals 50b, 58b, 62b, and

66b. The relative arrangement between the horizontal and angular braces is repeated from section to section. The adjacent chords 40-42, 42-44 and 40-44 are divided into independent sections by horizontal bracing members 46 and are provided with corresponding angular bracing members 50,58, 62 and 66.

While only one leg assembly was described, it should understood that identical leg assemblies are located between leg chords 42 - 44 and 44 - 40. In combination, they provide benefits not available heretofore with conventional leg structures.

The leg structure of the present invention reduces leg drag and storm loads, allows to reduce leg weight, while maintaining a high stiffness to weight ratio. The number of weld points, or fixed connections is reduced to a minimum while the structural integrity of the bracing members remains the same as with the conventional bracings or greater. Additionally, the strength-to-cost ratio is believed to be improved with the leg assembly of the present invention.

As an example, and for illustrative purposes only, it is envisioned that the horizontal space between the leg chords 40 - 42, 42 - 44, and 40- 44 can be approximately 39-40 feet. The chords can be over 500 feet in length, divided into segment portions 56, 70, 80, etc. of about 30 feet by bracing members 46a, 46b etc. The mid-points 54, 60, 64 and 68 will then be at a distance of between 14-15 feet from the horizontal bracing members 46a, 46b, etc. An angle "a" formed between intersecting angular bracings 50, 58 etc. is greater then 90 degrees, such that the angular bracings 50, 58 form an obtuse angle, with a mid-point 52 being at the apex of the angle. A similar angle is formed by the opposing bracings 62, 66, making the connections between the bracings 62 and 66 a mirror image of the connections between bracings 50 and 58. Both horizontal and angular members are formed from heavy pipe lengths, with wall thickness of up to 1" and outer diameter of up to 11".

The horizontal, as well as angular bracing members are formed from non-corrosive material capable of withstanding vertical and horizontal loads, bending moments imposed by the environmental forces acing on the legs as well the loads

associated with the platform structure 18.

While only one embodiment of the present invention was disclosed for illustrative purposes, it is believed that many changes and modifications can be made in the design of the present invention without departing from the spirit thereof. I, therefore, pray that my rights to the present invention be limited only by the scope of the appended claims.

We claim:

1. A leg assembly for offshore structures, comprising:
at least a pair of elongated parallel leg chords;
a plurality of transverse bracing members extending between said leg chords and dividing said leg chords into a plurality of leg sections defined by adjacent transverse bracing members;
a first pair of angular bracing members secured to a midpoint of a first transverse bracing member, each of said first pair of angular bracing members having a free end secured to a leg chord at a midpoint of a leg section below said transverse bracing member; and
a second pair of angular bracing members secured to the midpoint of said first transverse bracing member, and welded to backs of said first pair of angular bracing members, while said first transverse bracing member intersects said backs of said first pair of angular bracing members and said second pair of angular bracing members, each of said second pair of angular bracing members having a free end secured to a leg chord at a midpoint of a leg section above said first transverse bracing member, said angular bracing members being secured to said transverse members at four attachment points, said leg assembly being free from drag-increasing auxiliary braces.
2. The apparatus of Claim 1, wherein an obtuse angle is formed by said first pair of angular bracing members.
3. The apparatus of Claim 1, wherein an obtuse angle is formed by said second pair of angular bracing members.
4. A leg assembly for an offshore structure, comprising:
a pair of elongated parallel leg chords divided into a plurality of sections by transverse bracing members; and
a plurality of inclined bracing members secured in sections between said transverse bracing members, said inclined bracing members defining a rhombus-shaped bracing unit within each of said sections, said inclined bracing members forming a four-point connection with

their respective transverse bracing members, inclined bracing members of one section being attached to backs of adjoining bracing members of an adjacent section, while being trasversed by a respective bracing member, said leg assembly being free from obstructing auxiliary braces.

5. The assembly of Claim 4, wherein each of said inclined bracing members is secured to an adjacent leg chord and to a transverse bracing member.

6. The assembly of Claim 5, wherein a first pair of said inclined bracing members is fixedly attached to a midpoint of a transverse bracing member and extends downwardly from said bracing member.

7. The assembly of Claim 6, wherein a second pair of said inclined bracing members is fixedly attached to a midpoint of an adjacent bracing member and extends upwardly from said adjacent bracing member.

8. The assembly of Claim 6, wherein said first pair of bracing members defines an obtuse angle, with an apex of said angle being at a point of attachment of said first pair of bracing members to said transverse member.

9. The assembly of Claim 7, wherein said second pair of bracing members defines an obtuse angle, with an apex of said angle being at a point of attachment of said second pair of bracing members to said adjacent transverse member.

10. A leg assembly for an offshore structure, comprising:

at least a pair of a parallel leg chords divided into a plurality of sections by transverse bracing members;

an angular bracing unit positioned in each of said sections, said angular bracing unit comprising a first angular bracing member extending downwardly from a first transverse member, a second angular bracing member extending downwardly from said first transverse member, a third angular bracing member extending upwardly from a second transverse bracing member located

immediately below said first transverse bracing member, and a fourth angular bracing member extending upwardly from said second transverse bracing member, said first angular bracing member and said second angular bracing member being fixedly attached to a midpoint of said first transverse bracing member, said third angular bracing member and said fourth angular bracing member being fixedly attached to a midpoint of said second transverse bracing member, said first angular bracing member being welded, back-to-back to a third angular bracing member of an adjacent section, said second angular bracing member being welded, back-to-back to a fourth angular bracing member of the adjacent section, said leg assembly being free from obstructing auxiliary braces between said transverse bracing members and said angular bracing members.

11. The assembly of Claim 10, wherein a free end of said first angular bracing member is fixedly attached to a first leg chord at midpoint between said first transverse bracing member and said second transverse bracing member.

12. The assembly of Claim 10, wherein said second angular bracing member is fixedly attached to a second leg chord at a midpoint between said first transverse bracing member and said second transverse bracing member.

13. The assembly of Claim 11, wherein said third angular bracing member is fixedly attached to said first leg chord adjacent to a point of attachment of said first angular bracing member.

14. The assembly of Claim 12, wherein said fourth angular bracing member is fixedly attached to said second leg chord at a point adjacent to a point of attachment of said second angular bracing member.