A cast node joint for a tower support base

A cast steel or part cast steel ring node 1 for an offshore windmill (Fig 1) or other similar tower support base, which has one or more partial stub extensions A shaped as semi-circular, section protrusions such that connecting tubular secondary legs 2 connect partly to these stubs and partly to the main tower body (5, figure 6) of the windmill, and therefore have mitred connecting ends at different angles.

The ring node, when pre-connected to one or more secondary legs as an assembly, may be mated onto and lowered over a tower pile, pre-installed into the sea-bed. When these secondary legs are also piled in place on the sea-bed, and the ring node fixed in some way to the tower column, the whole assembly becoming a more efficient support structure for an offshore windmill or similar structure (Fig 6).
A NOVEL SHAPE OF CAST NODE JOINT, FOR USE IN THE SUPPORT STRUCTURES OF HEAVILY LOADED MONO TOWERS, INSTALLED OFFSHORE, AND PARTICULARLY THOSE FOR SUPPORTING WINDMILLS

This invention relates to a novel shaped, cast steel ring node joint for connecting tubular members. It would be part of a tower arrangement for supporting a large offshore structure, and would be used for reducing stresses in a highly fatigue critical region of that structure. It would be commonly applied (though not exclusively) to offshore windmill tower support bases (usually though not exclusively tri-pod types) but would also have an application for hydrocarbon production towers sited offshore, or any other similarly heavily loaded structure.

A further novelty of this ring node joint is that when it is used to connect one or more secondary leg members together to form an assembly, the ring could then be located onto and lowered down over a tower pile, pre-installed on the sea-bed. With these secondary legs touching the sea-bed and piled in place, and the ring grouted or fixed in some way to the tower, this would be an economic way to provide extra support for the tower.

The novel, shortened, semi-circular stub section of this ring node may also be applied to conventional multi-leg offshore platform towers, at node points where diagonal brace members join a leg, and particularly where cast nodes are included.

Windmill towers sited offshore, and particularly those in deeper coastal waters, and also where the soil foundation conditions are poor, usually require a type of welded tubular steel tripod base or similar structure, having say two or more secondary legs to support the primary windmill column (see Fig.1.). These types of base supports are very prone to fatigue damage at the nodal junctions. This is particularly so where the power output of the generator is greater than say 3MW. For such high power machines, the column diameters are also large, and they usually include node junctions to accommodate the secondary support legs, which in turn connect to piles driven into the sea-bed. Cast steel nodal junctions are particularly desirable to eliminate the fatigue damage commonly associated with weld fabricated node joints.

Cast Steel nodes for Windmill Tower Support Frames would normally be shaped either as a full circumference of node for the main tubular column member, or as insert segments welded into a rolled plate node (see Fig.2). They are similar to those used on offshore, hydrocarbon production support structures and have stub branches S which have a square cut weld junction Y connecting to the incoming brace, or secondary leg member 2.

This invention relates to a more economic and efficient way of shaping this nodal intersection between the main tubular column of a windmill (or other similar) tower, and its secondary leg.
support braces, which are usually (although not exclusively) two or three in number, and forming a tripod

This invention relates to any cast node used on windmill (or other similar) tower support bases, but particularly to those in the most fatigue prone node marked ‘W’ in fig.1

Because the region where the worst fatigue stresses arise is in the uppermost region marked ‘X’ in Fig 2, one of the primary aims of this invention is to limit the extent of the casting part of this node stub to the upper regions around ‘X’, and therefore save weight and cost.

The stubs ‘S’ of this traditional node shape have a relatively large surface area, and are complex to mould and cast and are therefore expensive. This invention (shown in its various forms in Figs. 3,4,5 & 6) seeks to reduce the surface area of the protruding stub and to simplify the moulding technique used to form the stub. This reduces costs dramatically, whilst still maintaining a fatigue beneficial, radiused fillet in the region ‘X’ shown in Figs. 3,4, & 5

According to the present invention, there is provided a cast steel ring node ‘1’ on the primary column of an offshore windmill (or similar structure) where the protruding cast stubs (for connection to the secondary leg members ‘2’ of the base structure) have their ends (‘A’ to ‘B’) shaped with a semi-circular cross section (rather than the normal full circular stub cross section) and where the incoming secondary leg members ‘2’ interface partly with this cast stub end, but also interface at a different mitred angle ‘B’ to ‘C’, directly with the main column body of the tower. The height of the cast node between ‘J’ & ‘K’ is significantly reduced, when compared to the height ‘G’ to ‘H’ in Fig 2.

Referring to the present invention, there is also provided the opportunity to connect this ring node to the secondary leg members to form a frame (prior to connecting it into the main tubular column) and then to mate it onto and lower it down over a pile pre-installed into the sea-bed, such that when the secondary legs are also secured by piling, and the ring is secured to the first, main column pile, the whole structure becomes a more rigid assembly.

Referring to the present invention, there is also provided the opportunity to neck down the diameter of the ring node from top to bottom (by cone or curve), and also to split the ring vertically or horizontally into a number of segments, which could then be bolted or welded either to each other, or some plate fabrication.

Referring to the present invention, there is also provided the opportunity to include integral ring stiffeners, integral connection flanges, or integral man-way access openings.
A specific embodiment of the invention will now be described by way of example, with reference to the accompanying drawings in which:

Figs 1 & 2 show elevation views of a typical offshore windmill column, supported by a trn-pod base piled into the sea-bed ‘SB’ and having a conventional cast node ‘W’ which will be replaced by the new concepts shown in figs 3, 4, 5 & 6. The extent of the conventional node is between lines ‘G’ & ‘H’, and includes the complete stubs marked ‘S’ in fig 2.

Fig 3 shows the cast ring node invention ‘I’ substituted in the main tower column, with the cast stub end section ‘A’ to ‘B’ only forming a semi-circle, which allows the cast body to be much reduced in height (‘J’ to ‘K’), and the cast stub to be much reduced in length ‘L’.

Fig 4 (the upper view is a section through the stub and the lower view an elevation) shows the cast ring node invention substituted in the main tower column, again with the cast stub end only forming a semi-circle, but with the cast body being reduced in diameter (by cone or curve) from the top to bottom. Optional vertical split joints may also be included.

Fig 5 (the upper view is a section through the stub and the lower view an elevation) shows the cast ring node invention substituted in the main tower column, again with the cast stub only forming a semi-circle, and the cast body reduced in diameter from top to bottom, but with the cast body extending down to accept all the incoming tubular onto its body. Optional vertical or horizontal split joints may also be included.

Fig 6 (upper) shows an elevation view of the novel windmill tower support structure piled into the sea-bed ‘SB’, and Fig 6 (lower) shows a vertical section through the primary column pile ‘3’ and the secondary leg 2. The cast ring node invention ‘I’ is connected to the secondary leg members ‘2’ to form part of a frame. This cast ring node can be mated onto and lowered down over a primary column pile ‘3’, pre-installed in the sea-bed, such that when the ring is fixed to the primary column pile, it becomes a rigid assembly for supporting the main tower and will allow the connection directly to the main windmill tower.

Referring to Fig 2, 3, 4 & 5, instead of the casting stub end ‘S’ being fully sectioned normal to its axis at ‘Y’ (ie square cut as in Fig 2) the stub end is square-cut only up to the apex or centreline of the tubular when viewed in elevation (ie point ‘B’ in Figs 3, 4 & 5). Below this point, the remainder of the secondary leg brace is mitered at a different angle and interfaces directly with the main body column (between points ‘B’ & ‘C’) without the need for a cast stub. In effect the cast stub is dispensed with below point ‘B’, and it is therefore possible to have a very short stub above point ‘B’ (see figs 3, 4 & 5). This semi-circular cross-section cast stub on the ring node will also geometrically allow the main body column height of the cast node to be greatly reduced.
Because the fatigue stresses are usually lower in these regions (‘B’ to ‘C’), it is also possible that the circumferential interface of the lower leg chord with the cast node chord may be terminated below ‘B’ (see Figs 3 & 4), giving a shallow cast node depth, and providing the most economic solution, with a cheaper, rolled plate column extending to somewhere between points ‘B’ and ‘C’.

This new design concept is at variance with existing cast node design practice, because square cut stubs (see Fig 2) have a minimum length at point ‘C’, and stub lengths are obviously much longer than necessary at point ‘A’ for efficient stress reduction performance. By contrast, this invention, allows the minimum cast stub lengths to occur at point ‘B’ and the stub length ‘L’ up to point ‘A’ is much reduced (see Figs. 3, 4 & 5).

A further unique part of this invention is the necking down of the main body diameter of the cast ring node body (by cone or curve). It will be seen from Figs. 4 & 5 that this coning down (from top to bottom) also facilitates the shortening of the cast protruding stub beyond that shown in Fig.3.

This invention also includes the opportunity to use this novel ring node ‘1’ by connecting it initially to the secondary leg members ‘2’ to form a frame assembly as shown in Fig 6, and then to mate the ring onto, and lower it down over a column pile ‘3’, pre-installed into the sea-bed, such that when the secondary legs are also piled into the sea-bed at ‘4’ and the ring node is secured to the primary column pile (say by grouting or hydraulic tube expansion or other method), the whole assembly can be connected to the main windmill tower ‘5’, and can better sustain the bending loads.

This invention also includes the option to slice the main cast node chord horizontally into one or more circumferential layers, say with an interface at point ‘B’. Alternatively, the ring node may be split vertically into several insert segments which are either bolted or welded to another cast part, or to a plate fabricated section.

This invention also includes the option for the cast ring node to have integrally cast circumferential ring stiffeners in the node to further reduce stresses. Also, for situations where the ring node is sited above the maximum sea level, this node can include a flange for bolting the upper part of the windmill tower to the base. This node can also include a reinforced man-way access to the inside of the column, in order to alleviate the fatigue problems associated with such man-way openings.
CLAIMS

1. A ring shaped cast steel node, for connecting the secondary leg members of a support base structure, onto the primary column of an offshore windmill mono-tower (or similar structure) and where the one or more protruding cast stubs are shaped at the ends with a semi-circular cross-section (rather than the normal full circular stub cross section) and where the incoming secondary leg members interface partly with this cast stub end, but also interface at a different mitred angle, directly with the main column body as in figs 3, 4 & 5.

2. A ring shaped cast steel node as described in 1 above where, instead of being connected initially to the main tubular monotower column, it is pre-connected to one or more secondary legs to form an assembly, and the ring is then mated onto and lowered down over a column pile pre-installed into the sea-bed, such that when the secondary legs are piled into the sea-bed and when the cast steel ring is secured to the primary column pile (say by grouting or hydraulic tube expansion or other methods) the whole assembly can assist the monotower to sustain bending loads (see fig 6).

3. A ring shaped cast steel node as described in 1 & 2 above, where the ring body is necked down (by cone or curve) with a reduction in diameter from top to bottom, such that the lengths of the protruding cast stubs are minimised as per figs 4 & 5.

4. A ring shaped cast steel node as described in 1, 2 & 3 above, where the main body ring is split into either circumferential or radial segments, which can either be bolted or welded together (see Figs. 3, 4 & 5) and the various parts can be either castings or pieces of rolled plate.

5. A ring shaped cast steel node as described in 1, 2, 3 & 4 above which incorporates integral stiffening rings, integral flanges for bolted connections or integral, reinforced man-way access openings (see Fig 5).

6. A ring shaped cast steel node as described in 1, 2, 3, 4 & 5 above and shown in figs 1 to 6.
Patents Act 1977: Search Report under Section 17

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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC\textsuperscript{W}:

- E1H; FIT

Worldwide search of patent documents classified in the following areas of the IPC\textsuperscript{07}:

- E02B

The following online and other databases have been used in the preparation of this search report:

- EPODOC, JAPIO, WPI