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(54) Benævnelse: **Horisontal forbindelsesanordning mellem to dele i et teleskopisk vindturbinetårn og fremgangsmåde til installation af samme.**

(56) Fremdragne publikationer:
WO-A1-02/46552
WO-A1-2011/006526
US-A- 4 932 176

DESCRIPTION

FIELD OF THE INVENTION

[0001] The present invention relates to a horizontal joint assembly between two telescopic wind turbine tower portions.

[0002] The primary field of application of the invention is the construction industry, particularly though not exclusively the concrete construction industry, within the renewable or green energy industry, specifically the wind energy industry.

BACKGROUND OF THE INVENTION

[0003] Wind turbine towers are known to be built from at least two sections that are attached to one another and can be formed in turn by a plurality of curved profiles or segments which are attached side by side, creating vertical joints, until closing a section.

[0004] In this configuration, the segments of a wind turbine tower section are further attached to the segments of the section located immediately thereabove by means of horizontal joints.

[0005] If the towers are metallic, said joints can be formed by means of screws or other similar elements, or if they are made of concrete, they can comprise sealants that are applied in the circular ring-shaped space between the two facing edges of successive sections. Said sealants harden and integrally attach the corresponding successive sections to one another in a substantially hermetic manner.

[0006] In this latter case, due to the huge dimensions and weights of the profiles to be attached, said horizontal joints are often complemented with internally reinforced tongued and grooved fixing devices, i.e., fixing devices with a reinforcement arranged essentially within said sections and shared between two successive sections such that it is embedded in the concrete of one of said successive sections and housed in a conduit of the other one of said successive sections and anchored to the latter for fastening both sections to one another.

[0007] Tower sections can also adopt different shapes, such as a cylindrical, oval or polygonal shape, for example. Nevertheless and for the sake of simplicity, hereinafter the description will refer to wind turbine towers made up of tapered or frustoconical cylindrical sections, although it will be understood that the towers can also be made up of oval-shaped sections, polygonal-shaped sections or sections having any other suitable shape.

[0008] Telescopic towers formed from at least two coaxial sections having a different diameter, optionally formed by segments, have recently been proposed.

[0009] Nevertheless, the horizontal joints for attaching wind turbine tower sections currently known in the art and mentioned above contemplate supporting the upper section on the lower section, such that at least one of the faces of said upper section is comprised in the thickness of the lower section, which is incompatible with a telescopic type assembly.

[0010] Therefore there is a need for providing horizontal joint assemblies specific for telescopic type towers which further comply with the huge requirements imposed by the enormous dimensions and weights of the tower portions to be attached, as well as by the demanding dynamic loads in the wind turbine.

[0011] WO 2011/006526 A1 discloses a telescopic tower assembly and method, and WO 02/46552 A1 discloses a tilt-up and telescopic support tower for large structures.

BRIEF DESCRIPTION OF THE INVENTION

[0012] A first object of the invention is, therefore, to provide a horizontal joint assembly specific for telescopic wind turbine towers.

[0013] More particularly, the invention relates to a horizontal joint assembly according to appended claim 1.

[0014] The convention of the "outer face" being the face that is oriented towards the outside of the tower and the "inner face" being face that is oriented towards the inside of the tower is adopted in the present specification. Likewise, "tower portion" is understood as a part of said tower that can consist of both a closed and complete tower section and one or several segments (if there are any).

[0015] A second object of the invention is to provide a method of installing a horizontal joint assembly as described above comprising the steps of:

1. a) Arranging an upper tower portion in the vicinity of the inner face of a lower tower portion, such that the outer face of the upper tower portion is facing the inner face of the lower tower portion;
2. b) Lifting said upper tower portion along the inner face of the lower tower portion until the thickening provided in the outer face of the base fraction of the upper tower portion substantially contacts the thickening provided in the inner face of the head fraction of the lower tower portion;
3. c) Anchoring said head fraction of the lower tower portion to said base fraction of the upper tower portion by means of anchoring means; and
4. d) Pouring a hardenable filler material on the contact surface between the base fraction of the upper tower portion and the head fraction of the lower tower portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] These and other features and advantages of the invention will be better understood from the following description of an embodiment of the invention, given only by way of non-limiting example, with reference to the attached drawings in which:

Figure 1 is a perspective view of a telescopic wind turbine tower ;

Figure 2 is a cross-section view of a first embodiment of a horizontal joint assembly according to the invention;

Figure 3 is a cross-section view of a second embodiment of a horizontal joint assembly according to the invention;

Figure 4 is a cross-section view of a third embodiment of a horizontal joint assembly according to the invention;

Figure 5 is a cross-section view of a fourth embodiment of a horizontal joint assembly according to the invention;

Figure 6 is a view a fifth embodiment of a horizontal joint assembly according to the invention; and

Figure 7 is a cross-section view illustrating a step of the method of installing according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Identical or similar parts are indicated with the same reference number in the drawing.

[0018] Figure 1 shows a telescopic wind turbine tower provided with horizontal joints 100.

[0019] Figure 2 shows a first embodiment of a horizontal joint assembly according to the invention, comprising a lower tower portion 1 provided with a thickening 3 in the inner face of its head fraction and an upper tower portion 2 provided with a thickening 4 in the outer face of it head fraction, the relative position between said thickenings 3 and 4 being such that it defines a considerably horizontal contact surface 5 (of length B) and a considerably vertical contact surface 7 (of length A). Furthermore, both thickening 3 and thickening 4 are provided with a respective vertical through hole for receiving the anchoring means 6 which in this embodiment are a rod securing the lower tower portion 1 to the upper tower portion 2 according to the vertical direction. Respective immobilizing members which are respective threaded nuts and anchoring plates in this embodiment are applied on both sides of said rod 6.

[0020] In this embodiment, a sheath 14 is interposed between the vertical through hole of the thickenings 3, 4 and the anchoring

rod 6. The length A of the considerably vertical contact surface 7 is also significantly greater than the length B of the horizontal contact surface 5.

[0021] A layer 8 of hardenable filler material which is grout in this embodiment is also arranged along the contact surfaces 5 and 7.

[0022] The horizontal joint assembly has three different mechanisms for transmitting stresses, namely: tensile stresses are transmitted through the rod 6, compressive stresses are transmitted by the direct contact of the considerably horizontal surface 5 and the upper part of the lower thickening 4, and finally longitudinal shear stresses are transmitted through the considerably vertical surface 7.

[0023] Figure 3 shows a second embodiment of a horizontal joint assembly similar to that described in Figure 2 except that both the sector of the lower tower portion 1 comprising the thickening 3 and its vicinity, as well as the sector of the upper portion 2 comprising the thickening 4 and its vicinity, are each further provided with respective horizontal through holes for receiving a rod 9 securing the lower tower portion 1 to the upper tower portion 2 in a considerably horizontal direction, immobilizing members which in this embodiment are respective threaded nuts and anchoring plates further being applied on both sides of said rod 9.

[0024] In this second embodiment, a sheath 10 is interposed between each of the horizontal through holes and each of the rods 9.

[0025] Furthermore, the walls of the considerably vertical contact surface 7 are provided with indentations 12 which, like the rods 9, improve the capability of transmitting longitudinal shear stresses.

[0026] Said rod 9 can also be used for provisional fixing tasks during the process of lifting the upper tower portion 1 along the inner face of the lower tower portion 2 by aligning a through hole in which the sheath 11 is housed (made in at least one intermediate point of the upper tower portion 1) with the through hole in which one of the sheaths 10 is housed (provided in the head fraction of the lower tower portion 2) and securing both portions 1 and 2 to one another by means of the rod 9.

[0027] Finally, Figure 3 also shows plates 13 which in this embodiment are intended for fixing the upper tower portion to the lower tower portion by means of rods 9 before applying the hardenable filler material.

[0028] Figure 4 shows a third embodiment of a horizontal joint assembly according to the invention which is substantially identical to that shown in Figure 2, except:

- the through holes provided in the thickening 3 and the thickening 4 run according to an oblique direction; and
- the contact surface 5 is no longer horizontal but rather inclined.

[0029] According to this new configuration, once the rod 6 is introduced through said holes, it would be arranged in an inclined manner with respect to the vertical, which would entail a more direct transmission of stresses. The fact that the surface 5 is inclined also facilitates the flow of the hardenable filler material and prevents the creation of air and/or water pockets during the filling process.

[0030] Figure 5 shows a fourth embodiment of a horizontal joint assembly according to the invention which is substantially identical to that shown in Figure 2 except that the upper end of the thickening 3 of the head fraction of the lower tower portion 1 is inclined such that its inner face is at a greater height than its outer face. This therefore helps rain water (which falls in the direction indicated by the wavy arrow in said Figure 5) to run along said inclined end according to the direction of the cross slope (indicated with an inclined arrow in said Figure 5), making it difficult for rain to enter the joint. A sealing element is also provided in the attachment area for attaching the head fraction of the lower tower portion with the upper tower portion, increasing the water-tightness of the joint assembly.

[0031] Said figure also illustrates how the upper tower portion is provided with a casing 19 for housing the immobilizing members in this embodiment which can be filled with a hardenable material after anchoring to better protect said members.

[0032] Likewise, this embodiment also shows how the anchoring means 6 are embedded in the base thickening of the lower tower portion 2 without providing a sheath.

[0033] Figure 6 show a fifth embodiment of a horizontal joint assembly according to the invention in which the thickening 4 of the base fraction of the upper tower portion 2 is provided with a sinkage 20 which prevents interferences with inner elements fixed to the inner wall of the lower tower portion 1 when lifting the thickening 4. Said sinkage can optionally be filled with hardenable material once the assembly has been completed.

[0034] Figure 7 illustrates a possible way of carrying out lifting step b) for lifting the upper tower portion 2 which consists of fixing haulage means 21 provided with an auxiliary haulage element 15 to the thickening 3 of the lower tower portion 1. Then the auxiliary haulage element 15 is introduced through the sheath 14 and anchored to the thickening 4 of the upper tower portion 2. The haulage means 21 are finally actuated for lifting the upper tower portion 2.

[0035] In this embodiment the haulage means 21 are a lifting jack and the auxiliary haulage element 15 is a wire rope, although it is possible to use other similar technical components.

[0036] The embodiments of the invention herein described have also been given exclusively by way of illustrative and non-limiting example. Other modifications and different embodiments included within the scope of the invention as defined in the attached claims will be evident for the person skilled in the art.

[0037] In fact, it will be obvious for the person skilled in the art, for example, that epoxy mortars and/or resins can also be used as hardenable filler materials and that both rod 6 and horizontal rods 9 can be pretensed or non-pretensed type rods.

[0038] It will also be obvious for the person skilled in the art that the horizontal joint assemblies according to the invention can be provided with windows in the wall of one of the tower portions 1, 2 to allow access to the surface 5.

[0039] Finally, the horizontal joint assemblies according to the invention can be applied to concrete towers, to steel towers and to combined concrete-steel towers.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO2011006526A1 **[0011]**
- WO0246552A1 **[0011]**

PATENTKRAV

1. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner, omfattende hoveddelen af en nedre tårnsektion (f), basisdelen af en øvre tårnsektion (2) og forankringsmidler (6), som er bestemt til forankring af den nedre tårnsektions (1) hoveddel til den øvre tårnsektions (2) basisdel, hvilken øvre tårnsektion (2) også er bestemt til at blive løftet langs indersiden af den nedre tårnsektion (1); hvorved hoveddelen på den nedre tårnsektion (1) er forsynet med en fortykkelse (3) i sin inderside, og basisdelen på den øvre tårnsektion (2) er forsynet med en fortykkelse (4) i sin yderside, således at begge fortykkelser i det væsentlige er i kontakt med hinanden, når det øvre segment løftes; hvorved fortykkelsernes (3) og (4) indbyrdes position er således, at de definerer en i hovedsagen horisontal kontaktflade (5) og en i hovedsagen vertikal kontaktflade (7);
k e n d e t e g n e t v e d , at den i hovedagen vertikale kontaktflades (7) vægge er forsynet med fortykkelser (12), og et lag (8) af hærdbart fyldmateriale er placeret langs kontaktfladerne (5) og (7).

2. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge krav 1,
k e n d e t e g n e t v e d , at den i det væsentlige vertikale kontaktflades (7) længde (A) er signifikant større end den horisontale kontaktflades (5) længde (B).

3. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav,
k e n d e t e g n e t v e d , at fortykkelserne (3) og (4) er forsynet med respektive lodrette, gennemgående huller med henblik på at rumme forankringsmidler (6) deri.

4. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge krav 3,
k e n d e t e g n e t v e d , at forankringsmidlerne (6) er en stang, som fastgør den nedre tårnsektion (1) til den øvre tårnsektion (2) i overensstemmelse med vertikal retning, henholdsvis immobiliseringselementer, som er anbragt på stavens (6) to ender.

5. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge krav 3 eller krav 4,
k e n d e t e g n e t v e d , at et kapperør (14) er indskudt mellem det vertikale, gennemgående hul i fortykkelserne (3, 4) og forankringsmidlerne (6).

6. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav,
k e n d e t e g n e t v e d , at det hærdbare fyldmateriale er cementmørtel, epoxymørtel og/eller kunstharpiks.

7. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav,
k e n d e t e g n e t v e d , at den nedre tårnsektions (1) sektor, som omfatter fortykkelsen (3) og dens omgivelser, og den øvre sektions (2) sektor, der omfatter fortykkelsen (4) og dens omgivelser, hver er forsynet med respektive horisontale, gennemgående huller til modtagelse af en stang (9), som fastgør den nedre tårnsektion (1) til den øvre tårnsektion (2) i overensstemmelse med en horisontal retning, samt immobiliseringselementer, der er anbragt på begge stangens (9) sider.

8. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge krav 7,
k e n d e t e g n e t v e d , at en kappe (10) er indskudt mellem hvert af de horisontale, gennemgående huller og hver af stængerne (9).

9. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav,
k e n d e t e g n e t v e d , at den øvre vindturbinesektion (2) i sin længdeudstrækning er forsynet med i det mindste eet gennemgående hul, i hvilket et kapperør (11) er indføjet.

10. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav,
k e n d e t e g n e t v e d , at de gennemgående huller, der er tilvejebragt i fortykkelsen (3) i den nedre tårnsektion (1) og i fortykkelsen (4) i den øvre tårnsektion (2) strækker sig i skrå retning.

11. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, **kendetegnet ved**, at kontaktfladen (5) er skråtstillet.

12. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, **kendetegnet ved**, at den øvre ende af den nedre tårnsektions (1) fortykkelse (3) er skråtstillet.

13. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, **kendetegnet ved**, at der er tilvejebragt et tætningselement i fastgørelsesområdet med henblik på fastgørelse af den nedre tårnsektions (1) hoveddel til den øvre tårnsektion (2).

14. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, **kendetegnet ved**, at den øvre tårnsektions (2) fortykkelse (4) er forsynet med et afløb (20).

15. Horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, **kendetegnet ved**, at i det mindste én af tårnsektionerne (1, 2) er forsynet med et vindue med henblik på adgang til kontaktområdet mellem sektionerne.

16. Fremgangsmåde til installation af en horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge et hvilket som helst af de foregående krav, omfattende trinnene:

a) Anbringelse af en øvre tårnsektion (2) i nærheden af indersiden af en nedre tårnsektion, således at ydersiden af den øvre tårnsektion vender mod indersiden af den nedre tårnsektion;

b) løftning af den øvre tårnsektion oven over den nedre tårnsektion, indtil fortykkelsen, som er tilvejebragt i ydersiden på den øvre tårnsektions basisdel i det væsentlige har kontakt med fortykkelsen, der er tilvejebragt i indersiden på den nedre tårnsektions hoveddel;

c) forankring af den nedre tårnsektions hoveddel til den øvre tårnsektions basisdel ved hjælp af forankringsmidlerne; og

d) påhældning af et hærdbart fyldmateriale på kontaktfladen mellem den øvre tårnsektions basisdel og den nedre tårnsektions hoveddel.

17. Fremgangsmåde til installation af en horisontal forbindelsesanordning mellem to teleskopiske vindturbinetårnsektioner ifølge krav 16, **k e n d e t e g n e t v e d ,** at løftningstrinnet b) udføres ved hjælp af en løftecylinder (21), der er forsynet med en stålwire (15).

DRAWINGS

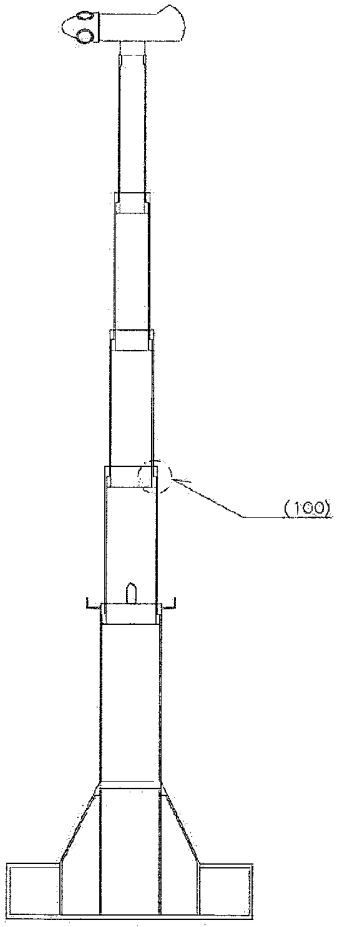

Fig. 1

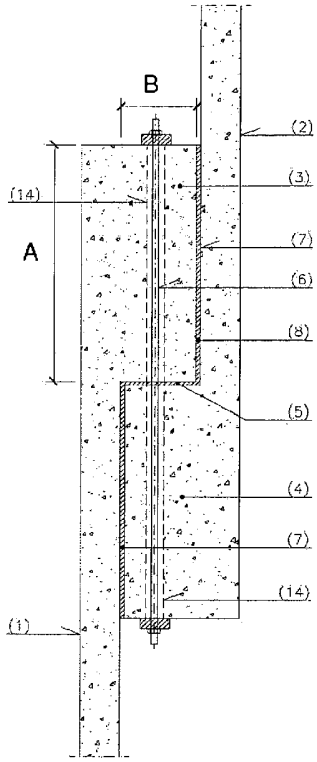

Fig. 2

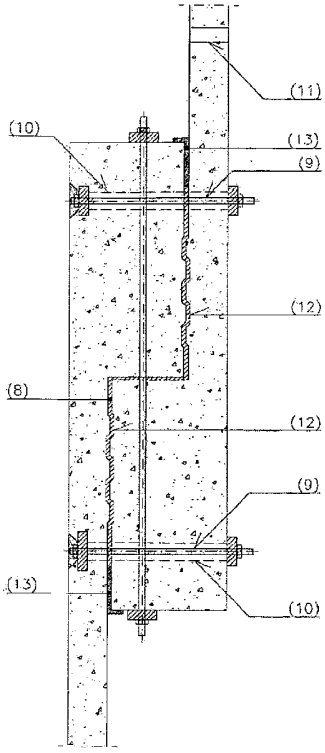

Fig. 3

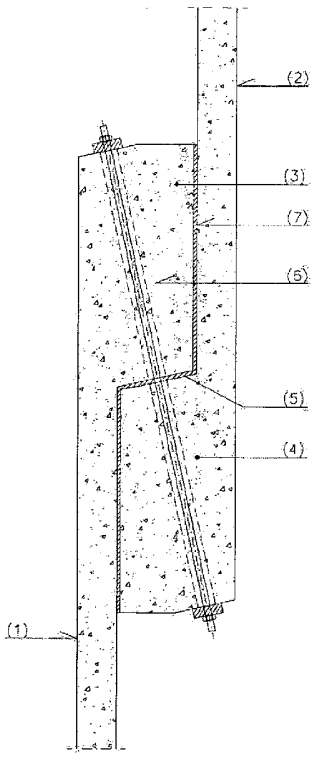

Fig. 4

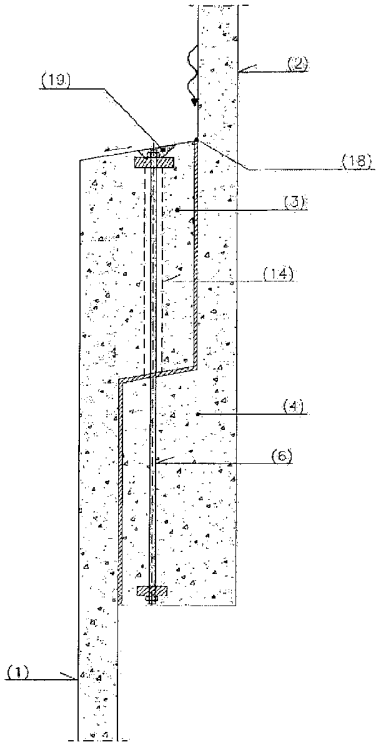

Fig. 5

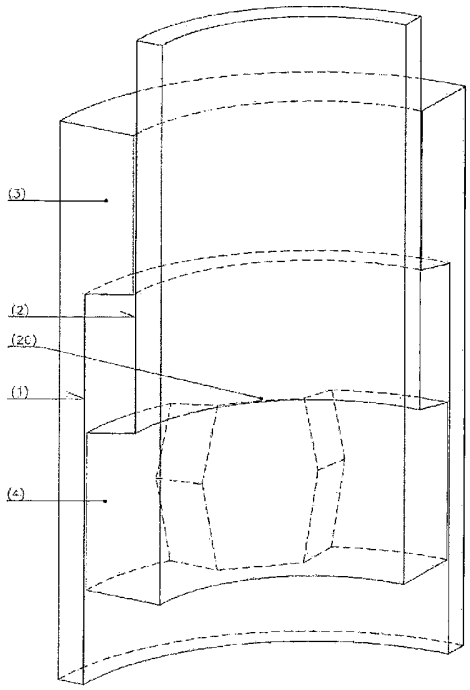

Fig. 6

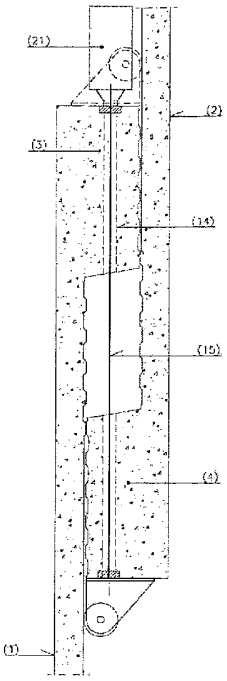

Fig. 7