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(54) PRECAST FOUNDATION STRUCTURE FOR A WIND TURBINE, WIND TURBINE AND ASSEMBLY METHOD OF A WIND TURBINE

(57) The present invention relates to a precast foundation structure for a wind turbine that is independent of the type of ground since a large part of the precast foundation structure is homogenized and wherein the size of a transition structures does not change when the ground conditions do since the precast foundation structure for a wind turbine easily adaptable to the geotechnical conditions of each wind turbine position of the windfarm which allows a significant reduction in time and cost.

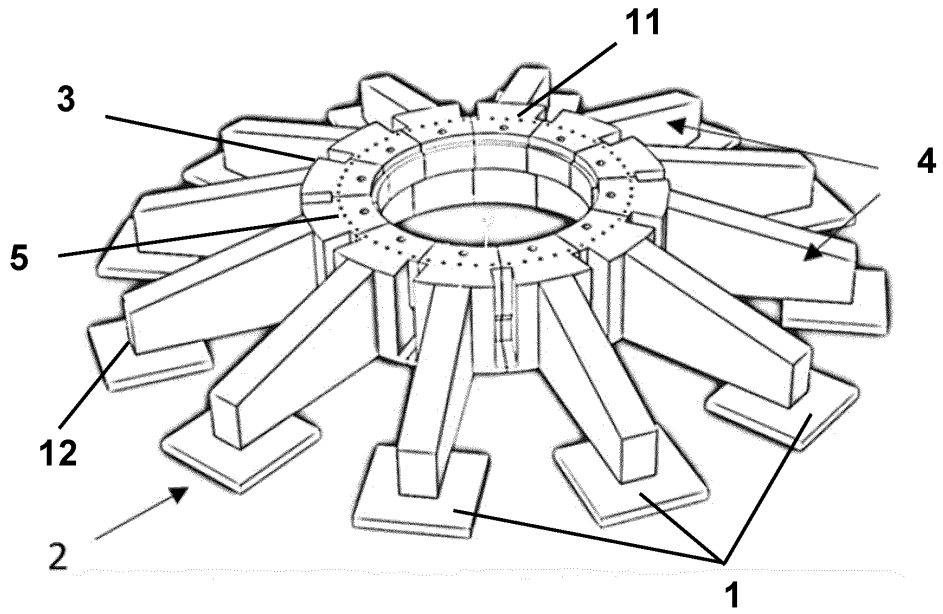

FIG. 1

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Description

OBJECT OF THE INVENTION

[0001] The present invention relates to a precast foundation structure for a wind turbine that is independent of the type of ground since a large part of the precast foundation structure is homogenized and wherein the size of a transition structure does not change when the ground conditions do.

[0002] The object of the present invention is a precast foundation structure for a wind turbine easily adaptable to the geotechnical conditions of each wind turbine position of the windfarm which allows a significant reduction in time and cost.

[0003] The invention also relates to an assembly method of a wind turbine.

BACKGROUND OF THE INVENTION

[0004] As wind turbines grow in height, rotor diameter and rated power, the foundation needed to support them also increases. The cost of the foundation is approximately 16% of the total cost of the wind farm, so any optimization in it has a great impact on the capital expenditure.

[0005] Large wind farms with a large number of wind turbines take up large areas of land so it is common that the mechanical properties of the ground in which they must be installed are different in different areas of a same wind farm. Each wind turbine has its own foundation design associated with it, which allows the loads to be transmitted from the tower to the ground but, when ground conditions change, the entire foundation must be redesigned.

[0006] Document EP2064393B1 discloses a foundation for a tower structure having a central pedestal of the rib on a slab type, the foundation comprising a prefabricated or cast-in-situ rib with a horizontal base having two sides and having a means along the length of the two sides of the horizontal base, or a means, under the base for connecting to and being structurally fixed to a cast-in-situ slab, wherein such means ensure structural continuity of the slab across or under the rib, and the rib has a proximal vertical end having a means thereon for connecting to and being structurally fixed to a cast-in-situ pedestal wherein such means ensure structural continuity of the pedestal to the rib, and post tensioning elements running through the ribs and the pedestal for connecting the ribs to the pedestal under post compression stress.

[0007] US9938685B2 discloses a foundation system for a tower, such as a wind turbine, includes a central hub assembly, a plurality of post-tensioned concrete beams, and an anchoring system associated with each beam, wherein in use the foundation system is arranged so that the bottom surfaces of the concrete beams bear on ground and the anchoring is disposed within the ground.

[0008] However, in the above cited documents the foundation structure is dependent from the type of ground wherein the foundation id disposed in such a way that the size of the ribs or post-tensioned concrete beams must be changed when the ground conditions vary. The precast foundation structure of the present invention solves the aforementioned drawbacks.

DESCRIPTION OF THE INVENTION

[0009] The present invention relates to a precast foundation structure for a wind turbine that is independent of the type of ground since a large part of the precast foundation structure is homogenized and wherein the size of a transition structures does not change when the ground conditions do.

[0010] The precast foundation structure for a wind turbine comprises:

- a footing intended to rest on a ground;
- at least a plinth comprising a surface wherein a tower of the wind turbine is intended to be coupled;
- a transition structure comprising a plurality of ribs that extend radially outward from the surface or from a vertical projection of the surface wherein a tower of the wind turbine is intended to be coupled.

[0011] Optionally, the footing comprises dimensions that are dependent on the features of the ground but are independent of loads transmitted by the tower of the wind turbine.

[0012] According to this, the precast foundation structure for a wind turbine is not determined by any type of terrain and, when the features of the ground changes, instead of a full redesign of the whole foundation, it is only necessary to carry out a specific design of the footing on which to support this foundation structure. In particular, depending on the quality of the ground (maximum permissible stress), the surface of the footing is varied so that the poorer the quality of the ground (lower maximum permissible stress), the greater the surface of the footing in contact with the ground), without the need of modifying the design of the rest of the foundation elements.

[0013] Preferably, the plurality of ribs are precast concrete ribs.

[0014] The precast foundation structure so configured has additional advantages to those explained above:

- most of the foundation structure can be precast (higher control quality and assembly rate);
- the moulds for the transition structure can be reused because they are independent from the footing;
- the transition structure can even be supplied as a part of the wind turbine, wherein the wind turbine manufacturer would assume the manufacturing of this important structural element.

[0015] In particular, the precast foundation structure is easily adaptable to the geotechnical conditions of each wind turbine position of the wind farm, which allows a significant reduction in time and cost.

[0016] For instance, depending on the features of the ground, the footing could consist of a footing itself, a rock anchor, a pile cap of micropiles, but the transition structure would not be modified.

[0017] Optionally, each one of the plurality of ribs comprises a first end defining at least partially the surface or the vertical projection of the surface wherein a tower of the wind turbine is intended to be coupled, and a second end arranged in the footing.

[0018] Preferably, the second ends of the plurality of ribs rest on the footing. More preferably, the second ends of the plurality of ribs rest on the footing without being connected to the footing.

[0019] Preferably, the second ends of the plurality of ribs are integrated into the footing. Also, preferably, the second ends of the plurality of ribs are connected to the footing. Also, preferably, the second ends of the plurality of ribs are placed on the footing.

[0020] When the second ends of the plurality of ribs of the transition structure are integrated into or connected to the footing, there is a structural connection between them. In this case, the bending moment transferred from the wind tower to the footing is translated into vertical forces on the footings themselves having a high lever arm. The advantage of having a structural connection between the transition structure and the footing is that the weight of the footing and the ground located on top of it contribute to guarantee the stability of the wind turbine.

[0021] By contrast, a physical contact but not a structural connection is held when the transition structure is placed on the footing, it is said, only the physical contact does not allow a transference of the bending moment from the transition structure to the footing. The main advantage of not implementing a structural connection between the transition structure and the footing is that design of these last is governed exclusively by vertical forces. In addition, the assembly of the transition structure with the footing is simpler.

[0022] The choice of the footing is carried out according to the type of ground and the loads transmitted by the transition structure. The footing can adopt several forms. For instance, shoes, small independent slabs wherein the number of slabs is equal to the number of ribs of the transition structure), a circumferential ring slab, a piling (or several micro pilings underneath each end of the transition structure or even a combination of a circumferential ring slab (when the number of pilings is higher than the number of ribs of the transition structure. Moreover, the footing could consist, for instance, of footings that could have the same geometry or be different for at least two ribs.

[0023] Optionally, the second end of the of the transition structure is arranged in the footing whilst the rest of the transition structure is in touch with an intermediate element disposed below the lower surface of said transition structure. Preferably, the intermediate element is a flexible element. Also preferably, the intermediate element is a filling material.

[0024] Optionally, the precast foundation structure further comprises a transition footing disposed between the second end of each rib of the transition structure and the footing itself in order to guarantee a smooth transition of the loads from the transition structure to the footing.

[0025] The design of both the transition structure and the plinth is structurally governed by stability criteria such as overturning or no-gap (physical separation of lower face of the foundation from the ground) but it is not governed by geotechnical features of the ground. Dimensions of the transition structure depend on the loads coming from the wind turbine (extrem and quasi-permanent loads), the length of the ribs of the transition structure and its weight, and the total weight of the wind tower.

[0026] On the other hand, dimensions of the footings depend on the extreme loads, the size of the transition structure and also the strength and the elastic properties of the ground.

[0027] Optionally, each first end of the plurality of ribs is intended to be joined to an adjacent first end of an adjacent rib, in order to form a monolithic element. The joints between the first ends of the plurality of ribs can be performed by means of different methods: by filling the joints with concrete or grouting, by using starter rebars and/or shear keys, etc.

[0028] Optionally, the first end of the plurality of ribs constitute the at least a plinth comprising a surface wherein a tower of the wind turbine is intended to be coupled.

[0029] The invention also relates to an assembly method of a wind turbine wherein the wind turbine comprises a precast foundation structure that comprises:

- a footing intended to rest on a ground;
- at least a plinth comprising a surface wherein a tower of the wind turbine is intended to be coupled;
- a transition structure comprising a plurality of ribs that extend radially outward from the surface or from a vertical projection of the surface wherein a tower of the wind turbine is intended to be coupled;

wherein the method comprises:

a step of pouring concrete on the ground in order to manufacture the footing;
a step of attaching the transition structure to the footing;
a step of coupling the tower of the wind turbine to the plinth.

[0030] Optionally, the step of pouring the concrete on the ground in order to manufacture the footing is carried out taking into account the dimensions of the footing, that

are dependent on the features of the ground but are independent of the loads transmitted by the tower.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

Figure 1 shows a perspective view of the precast foundation structure for a wind turbine of the present invention according to a first preferred embodiment.
Figure 2 shows a perspective view of the precast foundation structure for a wind turbine of the present invention according to a second preferred embodiment.
Figure 3 shows a perspective view of a rib of the transition structure of the precast foundation structure for a wind turbine of the Figure 1 or Figure 2.

PREFERRED EMBODIMENT OF THE INVENTION

[0032] In a first preferred embodiment of the invention, the precast foundation structure for a wind turbine comprises:

- a footing (1) intended to rest on a ground (2);
- at least a plinth (3) comprising a surface (5) wherein a tower of the wind turbine is intended to be coupled;
- a transition structure comprising a plurality of ribs (4) that extend radially outward from the surface (5) or from a vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled.

[0033] Optionally, the footing (1) comprises dimensions that are dependent on the features of the ground (2) but are independent of loads transmitted by the tower of the wind turbine.
[0034] Optionally, each one of the plurality of ribs (4) comprises a first end (11) defining at least partially the surface (5) or the vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled, and a second (12) end arranged in the footing (1).
[0035] In a first preferred embodiment shown in Figure 1, each first end (11) of each one of the plurality of ribs (4) defining at least partially the surface (5) wherein a tower of the wind turbine is intended to be coupled is itself a sector of a precast plinth.
[0036] In a second preferred embodiment shown in Figure 2, each first end (11) defining at least partially the vertical projection of the surface (5) of the tower of the wind turbine is intended to be coupled is itself a sector of a precast transition structure and at least a plinth (3) comprising a surface (5) wherein a tower of the wind turbine is intended to be coupled is disposed above said precast transition structure.
[0037] Preferably, the plurality of ribs (4) are precast concrete ribs comprising a central beam (13) disposed between the first end (11) and the second end (12). More preferably, the central beam (13) is made of reinforced concrete or prestressed or post-stressed concrete.

Claims

1. Precast foundation structure for a wind turbine which comprises:

   • a footing (1) intended to rest on a ground (2);
   • at least a plinth (3) comprising a surface (5) wherein a tower of the wind turbine is intended to be coupled;
   • a transition structure comprising a plurality of ribs (4) that extend radially outward from the surface (5) or from a vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled;

   characterized in that the footing (1) comprises dimensions that are dependent on the features of the ground (2) but are independent of loads transmitted by the tower of the wind turbine.

2. Precast foundation structure for a wind turbine according to claim 1 **characterized in that** each one of the plurality of ribs (4) comprises a first end (11) defining at least partially the surface (5) or the vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled, and a second end (12) arranged in the footing (1).

3. Precast foundation structure for a wind turbine according to claim 2 **characterized in that** the second ends (12) of the plurality of ribs (4) rest on the footing (1).

4. Precast foundation structure for a wind turbine according to claim 2 **characterized in that** the second ends (12) of the plurality of ribs (4) are connected to the footing (1).

5. Precast foundation structure for a wind turbine according to claim 2 **characterized in that** the second ends (12) of the plurality of ribs (4) are integrated into the footing (1).

6. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** the footing (1) comprises small independent slabs wherein the number of slabs is equal to the number of ribs of the transition structure.

7. Precast foundation structure for a wind turbine according to any one of the claims 1 to 5 **characterized in that** the footing (1) is one selected from shoes, a circumferential ring slab, a piling or several micro pilings underneath each end of the transition struc-

ture or a combination of a circumferential ring slab when the number of pilings is higher than the number of ribs of the transition structure.

8. Precast foundation structure for a wind turbine according to any one of claims 6 or 7 **characterized in that** the footing (1) has the same geometry for each rib (4).

9. Precast foundation structure for a wind turbine according to any one of claims 6 or 7 **characterized in that** the footing (1) has different geometry for at least two ribs (4).

10. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** it further comprises an intermediate element disposed below a lower surface of the transition structure.

11. Precast foundation structure for a wind turbine according to claim 10 **characterized in that** the second end (12) of the ribs (4) of the of the transition structure is arranged in the footing (1) whilst the rest of the transition structure is in touch with the intermediate element disposed below the lower surface of said transition structure.

12. Precast foundation structure for a wind turbine according to claim 11 **characterized in that** the intermediate element is a flexible element.

13. Precast foundation structure for a wind turbine according to claim 11 **characterized in that** the intermediate element is a filling material.

14. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** it further comprises a transition footing disposed between the second end (12) of each rib (4) of the transition structure and the footing (1) itself.

15. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** each first end (11) of the plurality of ribs (4) at least partially defining the surface (5) or on the vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled, it is intended to be joined to an adjacent first end (11) of an adjacent rib (4), in order to form a monolithic element.

16. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** the first ends (11) of the plurality of ribs (4) constitute the at least a plinth (3) comprising the surface (5) wherein a tower of the wind turbine is intended to be coupled.

17. Precast foundation structure for a wind turbine according to any one of the previous claims **characterized in that** the plurality of ribs (4) are precast concrete ribs comprising a central beam (13) disposed between the first end (11) and the second end (12), being preferably the central beam (13) made of reinforced concrete or prestressed or post-stressed concrete.

18. Assembly method of a wind turbine wherein the wind turbine comprises a precast foundation structure that comprises:

- a footing (1) intended to rest on a ground (2);
- at least a plinth (3) comprising a surface (5) wherein a tower of the wind turbine is intended to be coupled;
- a transition structure comprising a plurality of ribs (4) that extend radially outward from the surface (5) or from a vertical projection of the surface (5) wherein a tower of the wind turbine is intended to be coupled;

wherein the method comprises:

a step of pouring concrete on the ground in order to manufacture the footing (1);
a step of attaching the transition structure to the footing (1);
a step of coupling the tower of the wind turbine to the plinth (3);
wherein the step of pouring the concrete on the ground (2) in order to manufacture the footing (1) is carried out taking into account the dimensions of the footing (1), that are dependent on the features of the ground (2) but are independent of the loads transmitted by the tower.

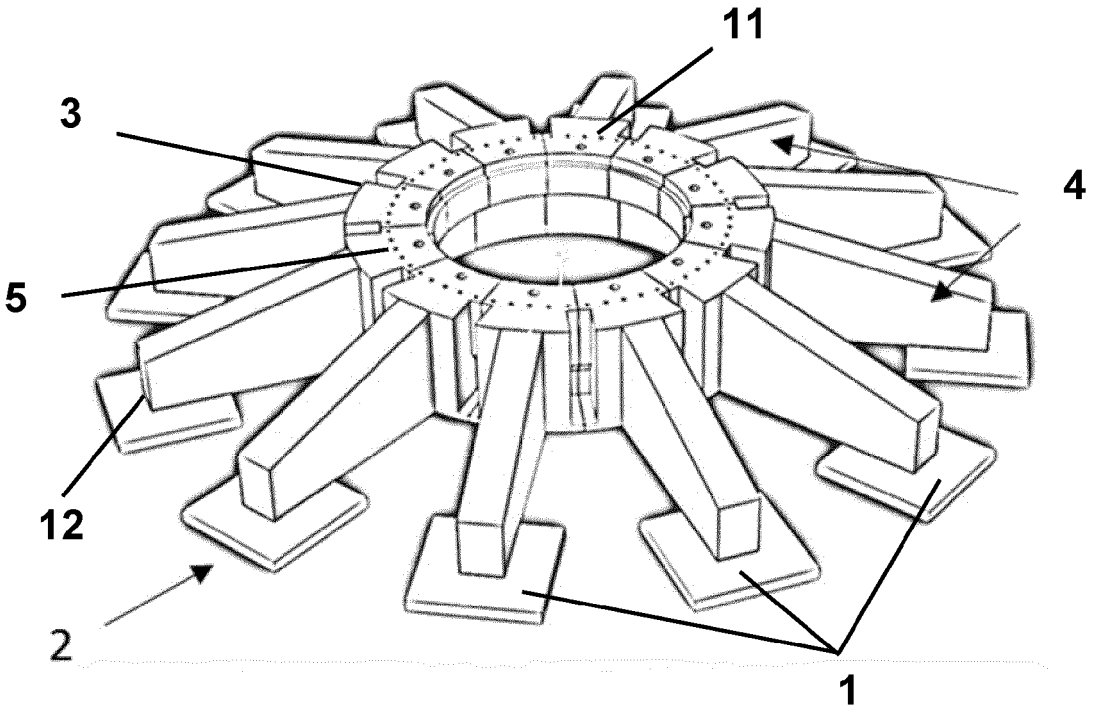

FIG. 1

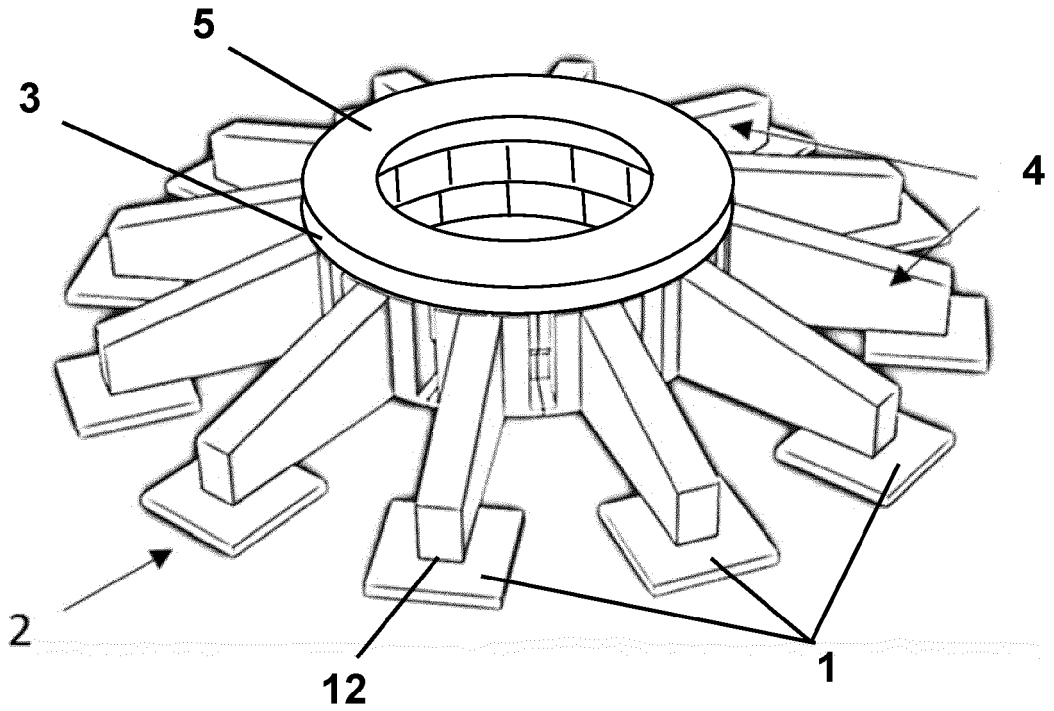

FIG. 2

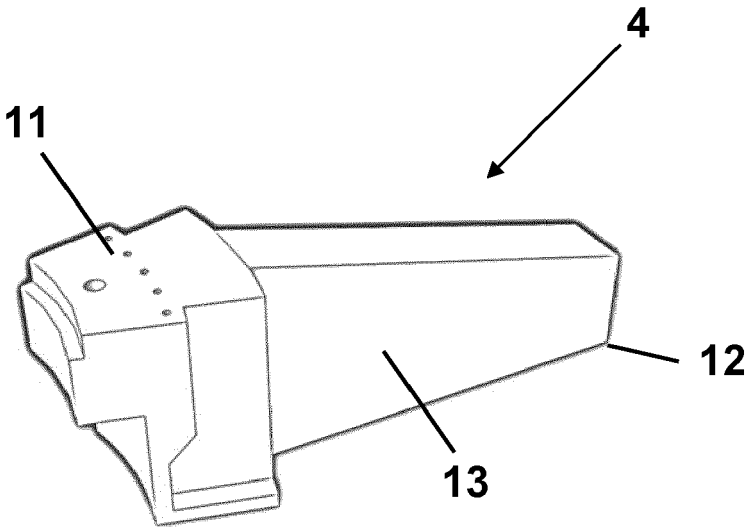

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 19 38 3224

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 July 2020	Stefanescu, Radu

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X : particularly relevant if taken alone
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