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(54) Foundation pile which is made up of a number of pile elements and a pile element.

(57) A foundation pile (1) is made up of a number of prefabricated pile elements (2,3) which are connected to each other and are each provided with a central reinforcement bar (6,7) extending in the lengthwise direction thereof. The pile elements abut with their end faces (4,5) against each other and the reinforcement bars are connected to each other in the lengthwise direction. At least one (5) of every two end faces (4,5) abutting against each other is of an essentially convex configuration, in such a way that from the central axis (9) towards the peripheral edge there is a progressively increasing space between the two end faces. Each pile element (2,3) is provided with an internal circuit reinforcement (10,11) resting against the peripheral edge.

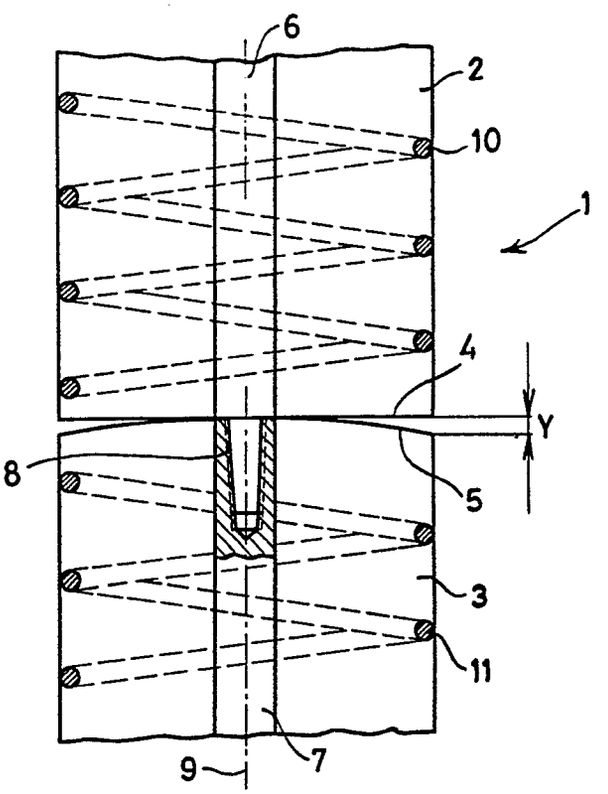

Fig. 1.

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Foundation pile which is made up of a number of pile elements, and a pile element.

The present invention relates to a foundation pile which is made up of a number of prefabricated pile elements which are connected to each other and are each provided with a central reinforcement bar extending in the lengthwise direction thereof, the reinforcement bars of pile elements resting with their end faces against each other in the lengthwise direction being connected to each other.

Such a foundation pile is known, for example from Japanese Patent Specification 61 204 418.

In such foundation piles made up of a number of pile elements the following problems occur:

- When the foundation pile is loaded as the result of a bending moment, the greatest compression stress will occur on the outer periphery of the pile, i.e. at the greatest distance from the central axis of the pile. Depressions consequently occur in the concrete along the outer periphery of the pile, so that there is a risk here of pieces of concrete breaking off.
- Local compression stresses can also occur as a result of unevennesses on the end faces of the pile elements when there is a bending and/or compression load on the foundation pile, which also produces a risk of the concrete breaking off.

The above-mentioned problems occur during the driving in of such foundation piles. In order to eliminate these problems, the above-mentioned Japanese patent provides for a spacer between the pile elements, fitted with an adhesive on one of the end faces resting against each other. However, this solution has the disadvantage that the costs of such pile elements are increased, and when the pile is loaded greater shifts occur between the individual elements.

The object of the present invention is to improve a foundation pile of the type mentioned in the preamble, in such a way that the breaking off of pieces of concrete along the periphery of the end faces of the pile elements resting against each other is avoided in a simple and effective manner.

This object is achieved according to the invention in that at least one of every two end faces connecting to each other is of an essentially convex configuration, in such a way that towards the peripheral edge there is a progressively increasing space between the two end faces lying against each other.

As a result of this convex configuration, the place where the maximum compression stress acts upon the end faces will not be at the peripheral edge, but will be shifted more towards the central axis of the pile element. The risk of concrete crumbling along the outside edge is thereby reduced.

The crumbling of the outer periphery of the foundation pile can according to the invention be prevented even further if each pile element is provided at least at the top end with an internal circular reinforcement resting against the peripheral edge.

This ensures that the maximum compression stress is always inside the circular reinforcement.

According to the regulations, reinforcement bars must always be surrounded by 2.5 - 3 cm of concrete, in order to prevent corrosion of the bars. Providing the reinforcement along the outer periphery of the pile element is a departure from this usual construction. This placing of the reinforcement is based on the idea that these reinforcements along the periphery are functional only during the driving of the foundation pile and subsequent rusting away of these reinforcements constitutes no problem at all, since this means only a minimal weakening of the pile.

In an expedient embodiment of the invention, the convex end face of each pile element has a flat central part.

The present invention is in fact based on the idea of reducing the stresses on the periphery of the end faces of the pile elements during the driving, something which can be achieved by means of the convex configuration of the end faces, or by providing the circular reinforcement as near to the periphery as possible. Depending on the circumstances, it is also possible to combine the two solutions.

The invention is also embodied in a pile element which is obviously suitable for a foundation pile according to the invention.

The invention will be explained in greater detail with reference to the appended drawing, in which:

Fig. 1 shows a longitudinal section of a part of a foundation pile according to the invention, with two end faces of two adjacent pile elements connecting to each other, the convex configuration of one of the end faces being exaggerated, for the sake of clarity; and

Fig. 2 shows on an enlarged scale the curve of an end face of a pile element.

Fig. 1 shows a part of a foundation pile 1, with a top pile element 2 and a pile element 3 lying below it. The top pile element 2 has a bottom end face 4 which rests against the top end face 5 of the pile element 3. The two pile elements are provided with a central reinforcement bar 6, 7 respectively, which are connected to each other by means of a screw threaded connection 8.

As shown in an exaggerated manner in Fig. 1, the end face 5 of the bottom pile element is of a convex configuration, while the end face 4 of the

top pile element 2 is straight. This shaping means that the distance 'y ' between the two end faces increases progressively from the central axis 9 of the pile towards the peripheral edge.

At least the top end of each pile element is provided with a circular internal reinforcement 10, 11 resting against the outer periphery. In the embodiment shown, this reinforcement is formed by a helical bar. It will, however, be clear that interconnected annular elements can also be used.

The shape according to the invention of the end faces resting against each other means that when the pile is subjected to a compression or bending load the maximum compression stress does not occur at the peripheral edge, but a distance inside it.

The reinforcement 10, 11 extending at the outer periphery of the pile elements ensures that the maximum compression stress always falls within this reinforcement, regardless of the configuration of the end faces lying against each other. This arrangement of the reinforcement was not customary until now, because the reinforcement always had to have a covering of 2.5 to 3 cm of concrete, in order to avoid corrosion of the reinforcement. This reinforcement is, however, functional only during the driving of the foundation pile, and the subsequent rusting away thereof has no adverse consequences for the bearing capacity of the pile.

Experiments have surprisingly shown that a foundation pile according to the invention can take greater loads, although the bending rigidity of such a pile is lower. The latter is not, however, a problem in practice.

Fig. 2 shows on an exaggerated scale the development of the curve of the end face 5 of the bottom pile element 3. This figure shows the line 12, the abutting surface to the end face 5 standing at right angles to the central axis 9 of the pile element 3. The distance between the abutting surface 12 and the end face 5 increases progressively from the central axis 9 towards the peripheral edge. The value of (y) is preferably a square function of the distance 'x' from the central axis 9.

In the example shown in Fig. 1 the convex end face 5 of the bottom pile element 3 mates with a straight end face 4 of the top pile element 2. It is, however, also conceivable for the end face 4 also to be a convex or possibly even concave shape. The important factor here is the maximum distance (y) between the peripheral edges of the pile elements connecting to each other. This distance is preferably selected between 0.2 and 5 mm, depending on the diameter of the pile, the load and the intended mechanical properties.

The convex shape of the end face can be manufactured well using a steel mould, with which it is possible to manufacture reproducibly a convex head with a height difference of 0.2 mm.

It will be clear that the invention is not restricted to the embodiment illustrated and described. For example, it is also possible for the central part of the convex end face to be flat and have a convex configuration only along the external periphery.

Claims

1. Foundation pile (1) which is made up of a number of prefabricated pile elements (2,3) which are connected to each other and are each provided with a central reinforcement bar (6,7) extending in the lengthwise direction thereof, the reinforcement bars of the pile elements abutting with their end faces (4,5) against each other in the lengthwise direction being connected to each other, **characterized in that** at least one (5) of every two end faces abutting against each other is of an essentially convex configuration, in such a way that from the central axis (9) towards the peripheral edge there is a progressively increasing space between the two end faces abutting against each other.

2. Foundation pile according to Claim 1, **characterized in that** each pile element (2,3) is provided with an internal circular reinforcement (10,11) resting against the peripheral edge.

3. Foundation pile according to Claim 2, **characterized in that** the reinforcement (10,11) resting against the peripheral edge is in the form of a helical reinforcement bar.

4. Foundation pile according to one of the preceding Claims 1-3, **characterized in that** the convex end face (5) of each pile element (2,3) decreases in height from the central axis (9) towards the outside edge, said height decreasing by a distance (y) which is a square function of the distance (x) from the central axis.

5. Foundation pile according to one of the preceding Claims 1-3, **characterized in that** the convex end face (5) of each pile element (2,3) has a flat central part.

6. Foundation pile according to Claims 1-5, **characterized in that** the maximum distance between the outer periphery of the end faces (4,5) of two adjacent pile elements (2,3) lies between 0.2 and 5 mm.

7. Foundation pile (1) made up of a number of interconnected, prefabricated pile elements (2,3), each of which is provided with a central reinforcement bar (6,7) extending in the lengthwise direction thereof, the reinforcement bars of the pile elements abutting with their end faces (4,5) against each other in the lengthwise direction being connected to each other, **characterized in that** each pile

element (2,3) is provided with at least at the top end with an internal circular reinforcement (10,11) resting against the peripheral edge.

8. Foundation pile according to Claim 7, **characterized in that** the reinforcement (10,11) resting against the peripheral edge is in the form of a helical reinforcement bar.

9. Pile element obviously intended for a foundation pile according to one or more of the preceding Claims 1-8.

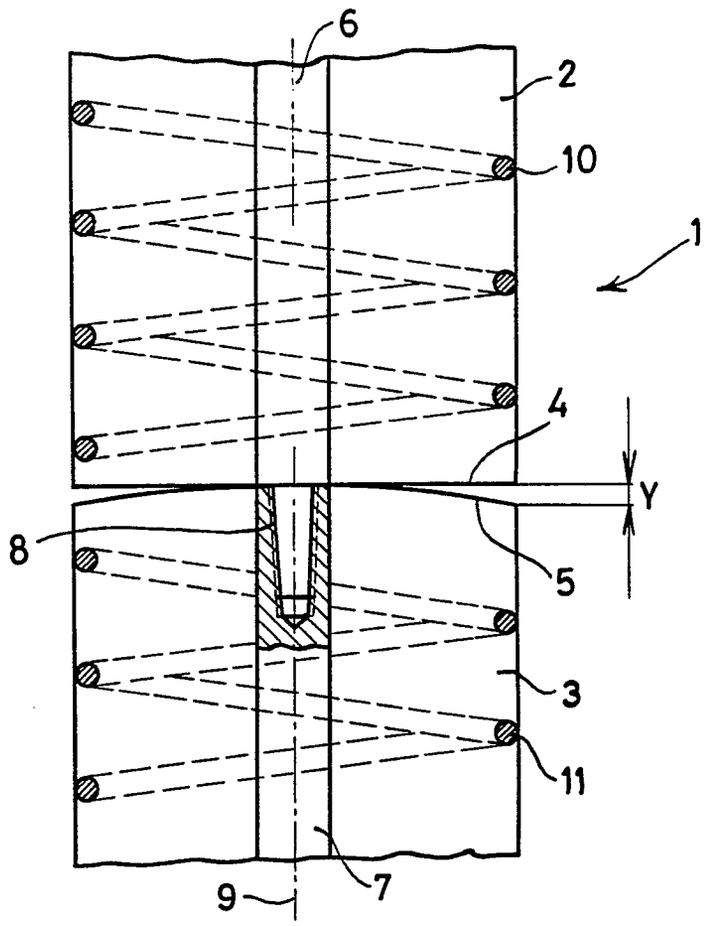

Fig:1.

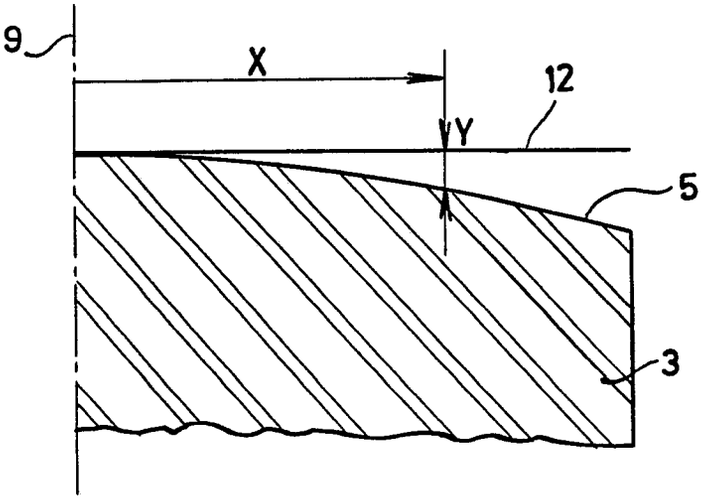

Fig:2.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 20 2912

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 313 (M-437)[2036], 10 December 1985; & JP-A-60 148 920 (SUTORONGU HOORUDO INTERNATIONAL JAPAN K.K.) 06-08-1985 * Complete document *	1	E 02 D 5/52
A	US-A-3 208 228 (PAULET) * Col. 1 (71-72); col. 2 (1-6)(22-26); fig. 1 *	1	
A	DE-A-1 634 652 (VÖLKER) * P. 3; fig. 4 *	1	
A	FR-A-1 044 695 (ZÜBLIN) * P. 2 - left col. - par. 3,4; p. 2 - right col. - par. 1; fig. 1-13 *	1	
A	US-A-3 593 532 (GRAZEL) * Col 4 (48-67); fig. 6 *	1	
A	NL-C- 76 799 (SCHOK BETON) * Col. 1 (43-49); col. (1-11); fig. *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	DE-B-1 298 459 (PLEUGER)		E 02 D
A	US-A-1 839 359 (UPSON)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-01-1990	RUYMBEKE L.G.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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