

PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Reinforced Concrete Poles, Piles and like Elongated Structural Members

5 We, NIPPON CONCRETE KOGYO KABUSHIKI KAISHA, a Japanese Corporation, of 8—3, 1-chome, Simbashi, Minato-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to elongate concrete poles, piles and like elongated structural members.

15 In general, concrete poles, piles or like long rod-like bodies of concrete are subjected in use to a bending moment which varies in magnitude along their longitudinal axis. This means that different portions of such poles or piles are required to have different ultimate or breaking strengths. Further, with such rod-like concrete bodies, it is undesirable from the standpoint of durability or service life that cracks should form in the surface of such concrete bodies under different loads including the wind pressure to which they are subjected in use and the impacts normally unavoidably given to them at the work site. It has recently been a practice, therefore to use such concrete members in a pre-stressed state, that is, in a state subjected in advance to an appropriate compressive stress. Accordingly, in the manufacture of such rod-like concrete members, 25 wires of high-strength steel are commonly used as axial reinforcement therefor, which wires are held in tension in the concrete members when these members are not subject to outside compressive forces.

40 According to the present invention there is provided an elongate tubular concrete pole, pile or like elongated structural member including an axial reinforcement comprising a plurality of longitudinal tensioned steel wires arranged at equal intervals in a common

circle and each anchored at its opposite ends and a plurality of longitudinal non-tensioned steel wires arranged at regular intervals in the same circle in which said tensioned steel wires are arranged; and an auxiliary reinforcement wound spirally along the outer periphery of said axial reinforcement.

50 For a better understanding of the present invention and to show how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings, in which:

55 Figure 1 is a fragmentary perspective view of a concrete pole, partly broken away,

60 Figure 1A is a fragmentary perspective view, again partly broken away, of the top portion of the concrete pole shown in Figure 1,

Figure 2 is a transverse cross-section taken along the line II—II in Figure 1,

Figure 3 is a transverse cross-section taken along the line III—III in Figure 1A,

65 Figure 4 is, in the main, a schematic development illustrating the arrangement of axial reinforcements in the concrete pole of Figures 1, 1A 2 and 3, the pole itself being shown at the left-hand side of the Figure with the section lines II—II and III—III illustrated,

70 Figure 5 is a fragmentary longitudinal cross-section of another form of pole in which tensioned wires are arranged in two rows, one row including wires radially aligned with wires forming the other row, and

75 Figure 6 is a transverse cross-section taken along the line VI—VI in Figure 5.

80 Referring to the accompanying drawings and particularly to Figures 1 and 1A, reference numeral 10 indicates a longitudinal tubular body of a concrete pole in which a required number of wires 1 that are held in tension in the pole when the latter is not

subject to outside compressive forces extend longitudinally of the pole along its whole length. These wires 1 are arranged at equal intervals in a circle of appropriate diameter and serve to impart a so-called pre-stress to the concrete pole 10. In order to hold these steel wires in this tensioned state, angular anchoring plates of steel 8 and 9, each having anchoring recesses formed therein, are arranged at the opposite ends of the pole length, and the reinforcing wires 1 are anchored to these steel plates 8 and 9 by engaging enlarged heads 11 and 12, formed at the opposite ends of the wires, in the respective anchoring recesses in the adjacent plates. Concrete is then placed in a form and the anchoring plates 8 and 9 are moved away from each other to tension the wires. The procedure and equipment are conventional and well-known in the art as far as they have been described above.

In forming the present pole however, several different lengths of ordinary steel wire are also arranged in the same circle in which the wires 1 are arranged and in a predetermined order, as indicated at 2, 3, 4, 5 and 6, these wires extending upwardly from the bottom end of the pole to points short of its top end. These wires 2 to 6 have a diameter preferably equal to that of the wires 1. The number of such wires 2 to 6 arranged in between each pair of adjacent wires 1 and the respective lengths of the wires 2 to 6 are suitably determined according to the length, diameter and strength required for the concrete pole or pile being fabricated. The wires 2 to 6, unlike the wires 1, are not tensioned during formation of the pole.

Figure 4 is a schematic development of the circumferential arrangement of the wires 1 and the wires of shorter lengths 2, 3, 4, 5 and 6 used in the pole of Figures 1, 1a, 2 and 3. As shown, the steel wires 2, 3, 4, 5 and 6 have respectively successively reduced lengths. The wires 2 to 6 are rough hot-rolled steel wires. For the steel wires 1 that are held under tension in the formed pole, cold-drawn high-strength material is selected to obtain the desired performance.

In addition to the axial reinforcement including the wires 1 and the wires 2 to 6 extending longitudinally of the concrete pole, steel wire 7 of appropriate thickness is spirally wound along the outer periphery of the axial reinforcement formed by the wires 1 to 6 to a complete a cage-like structure, in which structure the wires 1 are all anchored at the opposite ends to the steel plates 8 and 9 and, in the formed pole, are held in tension when the pole is not subject to outside compressive forces. Such a cage structure is used as a composite reinforcement in the well-known centrifugal compaction technique of fabricating long frusto-conical or cylindrical concrete poles such as the pole 10, the wires

1 being held in tension during fabrication of the poles.

Reference will next be made to Figures 5 and 6, which illustrate another form of pole in which additional wires 1a that are in tension when the pole is not subject to outside compressive forces are arranged radially inward of the wires 1 described above to form, with the wires 1, a double row of wires that are in tension. Numerals 2, 3 and 4 in Figure 6 indicate steel wires similar to the wires 2, 3 and 4 provided in the first-described form and differing in length from each other, which wires are not in tension. These wires 2 to 4 are arranged in the same circle as the radially outward wires 1 and, around the circular arrangement of all the wires 1 to 4, a steel wire 7 is spirally wound. In Figures 5 and 6, reference numeral 13 indicates spacers embedded in the body of the concrete pole 10 at points spaced from each other longitudinally thereof. The spacers 13 are each formed with a multitude of holes to receive the reinforcing wires. With the wires 1 and 1a and the tensioned wires 2, 3 and 4 inserted through the spacers 13 as shown, concrete is placed and the reinforcing wires are fixed in place, maintaining their relative positions determined by the spacers. Projections 14 are formed on each of the spacers 13 along the outer periphery thereof especially to serve the positioning purpose.

Thus in the forms described above, rod-like concrete members having a breaking strength varying along their length are obtainable by use of a cage of axial reinforcement including: an indeterminate number of high-strength steel wires which extend the entire length of the rod-like member, which are held in tension when the member is not subject to outside compressive forces, and which are effective to impart a required crack-resisting feature to the latter; a plurality of ordinary-strength steel wires which are untensioned, which have different lengths shorter than the entire length of the rod-like member and, as an auxiliary reinforcement are arranged in combination with the longer high-strength steel wires; and a spiral or hoop reinforcement applied to the combined arrangement of high-strength and ordinary-strength steel wires. In other words, the combined use of tensioned and non-tensioned steel wires enables formation of concrete poles which have a desired crack-resisting feature with a breaking strength varying along the pole axis in a predetermined fashion.

In the form of Figures 5 and 6, the required number of tensioned steel wires is minimal, all of the wires provided being utilized most efficiently to impart the desired crack-resistance to the pole structure.

In the form of Figure 1 to 4, the number of tensioned steel wires is also minimised by utilizing the fact that the exceptionally large



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adhesive force obtainable between the concrete and the rough surface of the hot-rolled steel wires can take a great role in giving the required crack-resisting feature to the product.

Practical tests have shown that in bending tests applied to reinforced concrete poles, primary cracks occur in the concrete surface when the tensile stress reaches a value of approximately 2,400 kg/cm² where the non-tensioned wires used are of cold-drawn steel, but only when the tensile stress reaches a value of approximately 3,200 kg/cm² where the non-tensioned wires of hot-rolled steel are used. Upon the basis of these results, the total quantity of reinforcing steel used can be minimised by determining the total number and quantity of tensioned wires required, due account being taken of the effect on the crack-resistance of the adhesion occurring between the hot-rolled wires and the concrete.

Thus, the rod-like concrete members formed as described herein are provided with satisfactory breaking strength and crack resistance by arranging non-tensioned steel wires so as to give the combined effect of affording a breaking strength comparable to that obtainable with use of tensioned steel wires and at the same time imparting a crack resistance to the rod-like member, as required.

The use of hot-rolled wires in concrete poles as part of the axial reinforcement thereof tends to avoid any severe reduction in crack resistance when such poles are involved in fire, and also to reduce the adverse effects of impacts to which the poles may be subjected.

WHAT WE CLAIM IS:—

1. An elongate tubular concrete pole, pile or like elongated structural member including an axial reinforcement comprising a plurality of longitudinal tensioned steel wires arranged at equal intervals in a common circle and each anchored at its opposite ends and a plurality of longitudinal non-tensioned steel wires arranged at regular intervals in the same circle in which said tensioned steel wires are arranged; and an auxiliary reinforcement wound spirally along the outer periphery of said axial reinforcement.
2. An elongate tubular concrete pole, pile or like elongated structural member as claimed in claim 1, and further comprising a set of tensioned steel wires arranged radially inward of the first-mentioned tensioned steel wires.
3. An elongate tubular concrete pole, pile or like elongated structural member as claimed in claim 1 or 2, in which the tensioned wires are cold-drawn high-strength steel wires, and the non-tensioned wires are hot-rolled ordinary-strength steel wires.
4. An elongate tubular concrete pole, pile or like elongated structural member substantially as hereinbefore described with reference to Figures 1 to 4 or Figures 5 and 6 of the accompanying drawings.

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5 Practical tests have shown that in bending tests applied to reinforced concrete poles, primary cracks occur in the concrete surface when the tensile stress reaches a value of approximately 2,400 kg/cm² where the non-tensioned wires used are of cold-drawn steel, but only when the tensile stress reaches a value of approximately 3,200 kg/cm² where the non-tensioned wires of hot-rolled steel are used. Upon the basis of these results, the total quantity of reinforcing steel used can be minimised by determining the total number and quantity of tensioned wires required, due account being taken of the effect on the crack-resistance of the adhesion occurring between the hot-rolled wires and the concrete.

7 20 Thus, the rod-like concrete members formed as described herein are provided with satisfactory breaking strength and crack resistance by arranging non-tensioned steel wires so as to give the combined effect of affording a breaking strength comparable to that obtainable with use of tensioned steel wires and at the same time imparting a crack resistance to the rod-like member, as required.

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