

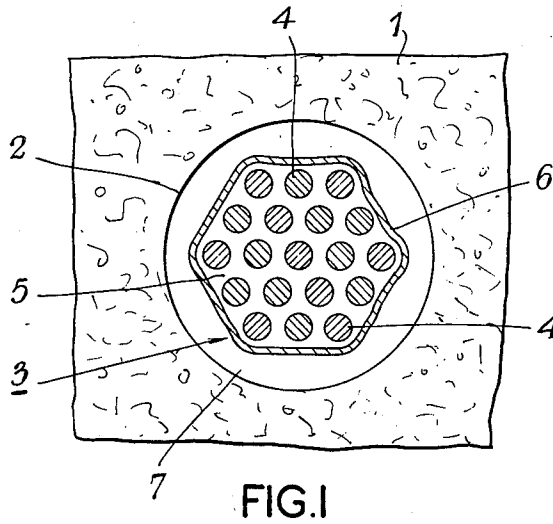
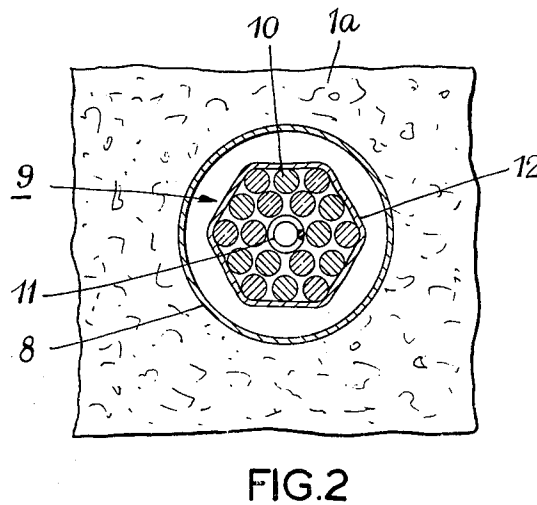
Oct. 30, 1962

A. J. HARRIS

3,060,640

CABLES FOR PRESTRESSING CONCRETE

Filed June 11, 1959



INVENTOR
Alan James Harris
BY *Johnson and Kline*
ATTORNEYS

1

3,060,640

CABLES FOR PRESTRESSING CONCRETE

Alan James Harris, London, England, assignor to Span
Tendons Limited, London, England
Filed June 11, 1959, Ser. No. 819,609
4 Claims. (Cl. 50-135)

The present invention relates to the pre-stressing of concrete constructions and has for an object to provide an improved pre-stressed tendon for reinforced concrete and method of manufacturing such tendons. A further object of the invention is to provide an improved method of constructing a pre-stressed concrete member.

Tendons consisting of a number of high tensile wires arranged together in a group are commonly used for applying a pre-stressing force to pre-stressed concrete members. Such tendons are usually placed inside open grooves or closed ducts which are later filled with cement grout.

Certain advantages are gained by increasing the number of wires forming each individual tendon. For example, the cost of sheathing a number of tendons each having a large number of wires is smaller than the cost of sheathing the same number of wires included in a large number of smaller tendons. Also, in general, wires of smaller diameter can be made of higher tensile steel than wires of larger diameter, and thus for a given cross-sectional area of steel a tendon formed of a large number of wires of small diameter will exert a greater tensile force than a tendon made of a smaller number of wires of larger diameter.

The disadvantage of using large numbers of wires in a single tendon lies in the difficulty of protecting these wires against corrosion and in ensuring that the tensile force in the inner wires in the tendon is transferred through the anchorage to the concrete member being pre-stressed, because with a large number of wires gripped by friction there is a tendency for the inner wires in the tendon to slip.

The usual technique adopted for protecting the wires against corrosion and also for bonding them together and to the walls of the groove or duct, is to inject a grout consisting of a mixture of hydraulic cement, for example Portland cement, and water under pressure into the interstices between the separate wires of the tendon and between it and the walls of the duct or groove. This has always been carried out after the tendon is fixed in position within the concrete member and almost invariably after the cable has been tensioned. It is usually only possible to inject the grout from each end of the member and so long as the wires are so few in number that they can lie in a single annulus forming an axial passage between them, it is quite simple to inject the grout. When more wires are used than can lie in a single annulus in a tendon of given diameter, however, the interstices between the wires are very small and it is difficult to make the grout penetrate between and around all the wires along the whole length of the tendon and, in consequence, many of the wires are likely to remain unprotected and unbonded over some parts of their surface.

The present invention enables this disadvantage to be largely overcome.

According to the present invention in a method of making pre-stressed concrete members hardenable filler material in an unhardened condition is placed in the interstices between the separate wires of a pre-stressing tendon so as to cover the surfaces of the wires and protect them against oxidation before the cable is fixed in position in the concrete member which is to be pre-stressed. Dry cement or a dry mixture of cement and sand is preferably used as the filler material since this is readily available in places where prestressed concrete

2

members are being manufactured. The tendon may be fixed in position in the concrete member while the cement or mixture of cement and sand is still dry. In cases where the only risk of corrosion of the wires is from moisture, the filling may be left dry. If moisture then penetrates into the cable, it will combine with the cement or the mixture of cement and sand and cause this to set and form an impermeable protection in the same way as if the spaces between the wires had been filled with grout. If the filling is left dry, however, there is no certainty that bond between the wires of the tendon will be established.

Alternatively, a small passage may be left within or around the group of wires forming the tendon and running along the whole length thereof. After the tendon has been placed in position, either water or a very thin grout formed by a mixture of cement with a large proportion of water, can be injected into this passage. The water or very thin grout penetrates along the passage and wets the dry filling material much more readily than a normal thick mixture of grout will penetrate between the wires.

The water combined with the filling material which then sets hard. When water alone is injected, the ends of the passage may be blocked by a plug of mortar after the injection of the water is complete; alternatively, injection of a thin grout or subsequently injection of grout into the passage after the injection of water, results in the passage being completely filled.

The water or grout may be injected into the passage in the tendon at any time after the tendon has been fixed in position and either before or after tensioning. It is important that the filling material should not harden before the tendon is in its final position in the concrete member since once the filling material has hardened, the tendon would be of such stiffness that it could not be readily bent into its required position. Once it is in this position, however, the change of curvature which occurs as a result of tensioning the tendon is very slight and the stiffness of the tendon therefore presents no inconvenience.

The filling of the interstices between the wires in the tendon holds the wires rigidly in position relative to each other whether the filling material has hardened or not, provided that the tendon is wrapped with sheathing material of appreciable tensile strength to prevent the wires separating.

This also enables the group of wires to be gripped and firmly anchored at its ends by the frictional effect of transverse forces acting on the tendon as a whole. These transverse forces are transmitted to the inner wires in the tendon by the filling material which conveniently is one which is extremely hard and has a high co-efficient of friction on the wires, so that under the influence of the transverse anchoring force, a substantial longitudinal frictional force is developed on the inside wires in the tendon. One such filling material is aluminous cement. To enable the grip of the filling material to be developed to the utmost, it is desirable for the filling material to have hardened completely before the transverse anchorage force is applied to the outside of the tendon, so that the effect of adhesion may be added to that of friction.

When hydraulic cement, for example Portland cement, or a mixture of this cement and sand is used as the filling material, a difficulty arises because the volume occupied by the filling material when wet, may be slightly less than when it is dry. This is because of the phenomenon commonly known as bulking. Thus, when the water is injected into the hydraulic cement, or hydraulic cement and sand mixture there will be a slight shrinkage so that the interstices between the wires of the tendon are no longer

completely filled. This difficulty may be overcome in any one of several different ways as follows:

(a) Each wire in the tendon may be completely surrounded by a layer of filling material consisting of hydraulic cement, or cement and sand so that all the wires are separated from each other by a small thickness of the filling material. Since the proportion of the total cross-section of the tendon occupied by the filling material is generally as little as about 15 percent, the gross shrinkage will be small and the filling material will not crack away from the surface of the wires because the wires, due to the shrinkage of the filling material between them, move slightly closer together, particularly if the wires are surrounded by a binding sheath under tension.

(b) The filling material may be mixed with a substance causing expansion on setting, for example aluminum powder. By this means, a compressive force will be exerted by the sheathing surrounding the tendon, when such sheathing is used, as the filling material sets. This causes a corresponding transverse compression in the wires and the filling material which will increase the longitudinal frictional forces generated between the separate wires.

(c) The filling material may be mixed with a liquid which does not cause setting when the filling material is placed in the interstices between the wires. This liquid then facilitates the compaction of the filling material. The liquid must be either volatile, for example carbon tetrachloride, so that it evaporates from the filling material to allow water to be injected later, or it must be miscible with water so that water can be injected later and will mix with and displace the liquid. For this purpose, for example, glycerol or alcohol may be used.

(d) The filling material may be compacted by pressure, for example by wrapping the tendon after the filling material has been placed in the interstices between the wires, with a binding which is applied under tension. For this purpose, steel strip may be used as a binding.

(e) The filling may be compacted by a high frequency vibration.

(f) The hydraulic cement, for example Portland cement, may be mixed with coarser particles so that the shrinkage on setting is reduced. These particles may be inert, for example silica or coarse sand, or they may themselves have hardenable properties, for example coarser ground particles of cement or particles of pozzolanic material such as fly ash.

Instead of using hydraulic cement, or a mixture of this cement and sand as the filling material, any filling material in powder form which is caused to harden on the addition of a setting liquid may be used. Certain powdered synthetic resins have these properties and set hard in the presence of a setting liquid. The setting of such filling material may be accelerated by heat which can be applied either by heating one or both the ends of the tendon after it is in position within the concrete member and allowing the heat to be conducted along the tendon, or by heating the tendon along its whole length by passing an electric current through it.

A pre-stressing tendon constructed according to the invention may be employed in prestressed concrete in any of the known ways e.g. it may be inserted inside a rigid sheath which protects it from bonding to the concrete in which it is cast or it may be threaded through a preformed hole or duct. In both cases, the water or other fluid needed to cause the setting of the filling material in the tendon may be injected along the annular space between the tendon and its sheath or duct, the wrapping of the tendon being made sufficiently permeable to permit the water or setting fluid to penetrate through to the wires of the tendon. A butted spiral steel strip or a fabric wrapping are suitable wrappings for this purpose. Alternatively the water or other setting fluid may be injected into a passage formed lengthwise of the tendon itself as for example by replacing one of the wires of the tendon by a close coiled helical spring.

A bond may be established between the tendon as above described and the walls of the rigid sheath or duct by injecting the annular space between tendon and the sheath or duct with a setting composition such as cement and water. The bond of this injected composition to the tendon may be improved by roughening the external surface of the tendon wrapping, or by employing a corrugated wrapping.

Two embodiments of the invention are illustrated in the accompanying diagrammatic drawings in which:

FIGURE 1 is a partial transverse section through a concrete member having positioned therein one form of pre-stressing tendon according to the invention, and

FIGURE 2 is a similar sectional view showing an alternative form of pre-stressing tendon.

Referring firstly to FIGURE 1, there is shown at 1 a partial transverse section of a concrete member provided with a lengthwise extending duct 2 for receiving a pre-stressing tendon.

Positioned within the duct 2 and spaced from the wall thereof is a pre-stressing tendon indicated generally at 3. The tendon 3 is formed by a plurality of high tensile wires 4 closely spaced or in touching relation, the interstices between the wires being filled with dry cement 5 and the tendon completed by a permeable fabric wrapping 6. The tendon is formed by passing wires from supply reels through a vibrating box filled with dry cement powder and as the wires coated with the cement emerge from the box, the wrapping 6 is applied by means of a conventional taping machine.

After the tendon has been positioned in the duct 2, water is injected into the annular space 7 between the peripheral surface of the tendon and the wall of the duct. The water penetrates the wrapping 6 and mixes with the cement powder coating the wires 4 so that subsequent setting of the cement bonds the wires together. After the tendon has been placed under tension to pre-stress the concrete, a setting composition of cement and water is injected into the space 7 and bonds the tendon to the wall of the duct 2.

In the construction of FIGURE 2, the tendon-receiving duct is formed by a rigid sheath 8 embedded in the concrete 1a and the tendon 9 is formed of a plurality of high tensile wires 10 surrounding a helically wound wire 11 providing a central passage extending longitudinally of the tendon. As in the case of the construction of FIGURE 1 the interstices between the wires 10 are filled with cement powder but in the construction of FIGURE 2 the wires are surrounded by a metal tape wrapping 12 providing an impermeable cover to the tendon.

After positioning the tendon 9 in the rigid sheath 8 water is injected at one or both ends of the central passage formed by the helical wire 11 and wets the cement powder which then sets and bonds the wires 10 one to another and to the wrapping 12.

Cement grout is then injected between the wrapping 12 and the rigid sheath 8 to bond the tendon to the sheath.

What I claim is:

1. A prestressing tendon for use in prestressing a concrete construction consisting of a hollow sheath adapted to be embedded in said concrete construction, a plurality of untensioned wires extending longitudinally of the sheath with the wires being arranged in predetermined positions relative to each other and to the sheath, and hardenable cementitious filling material in powdered form in its unhardened condition, the filling material occupying the interstices between the wires and between the wires and the sheath, said filling material being hardened only by the addition thereto of a hardener, said untensioned wires being adapted to be tensioned to apply a stress to said concrete construction, and means comprising a helically wound core disposed within said wires for introducing the hardener to the hardenable filling material after the wires have been tensioned to harden the filling material.

5

2. The invention as defined in claim 1 wherein the hardened cementitious filling material comprises a dry cement powder and sand.

3. The invention as defined in claim 2 wherein the hardenable cementitious filling material includes aluminum powder adapted to expand upon setting of the filling material whereby compressive forces will be exerted on the wires and filling material by the sheath to increase the longitudinal frictional forces generated between the separate wires.

4. The invention as defined in claim 1 wherein the hardenable filling material includes a volatile liquid incapable of hardening the filling material whereby said filling material in powdered form can be compacted in the sheath and around said wires.

5 1,690,467
1,706,671
2,580,174
2,671,158
2,751,660
10 2,921,463

6**References Cited in the file of this patent****UNITED STATES PATENTS**

Weaver	Nov. 6, 1928
Lotz	May 26, 1929
Henderson	Dec. 25, 1951
Rubenstein	Mar. 2, 1954
Nakonz	June 26, 1956
Goldfein	Jan. 19, 1960

FOREIGN PATENTS

926,505	France	Apr. 21, 1947
497,447	Canada	Nov. 3, 1953