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(71) Applicant: **BEKAERT-COCKERILL**
Scheldeboord 10
B-2620 Hemiksem(BE)

(72) Inventor: **Verhagen, Adriaan Hendrik**
Buitenerf 131
NL-4824 HC Breda(NL)

(74) Representative: **Demeester, Gabriel et al**
N.V. Bekaert S.A. Bekaertstraat 2
B-8550 Zwevegem(BE)

(54) Tendons with deferred bonding and method for stressing concrete, as well as prestressed concrete elements.

(57) The tendon comprises a tensionable core (1), an envelope formed by a hardenable composition (2,3) and a shield (4), whereby the hardenable composition (2,3) has a lubricating action and hardens after the core (1) has been tensioned. The hardenable composition (2,3) hardens without the supply of heat whereby its components or preproducts are distributed over various distinct phases, whereby at least one continuous phase of the hardenable composition is provided with lubricating action, which after hardening substantially disappears, and whereby there is also provided a barrier layer regulating the speed of the hardening reaction of the hardenable composition.

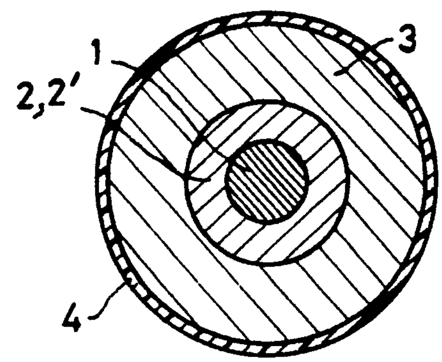

FIG: 1.

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TENDONS WITH DEFERRED BONDING AND METHOD FOR STRESSING CONCRETE, AS WELL AS PRESTRESSED CONCRETE ELEMENTS

The invention relates to a tendon comprising a tensionable core, an envelope formed of a hardenable composition, and a shield, whereby the hardenable composition has a lubricating action and hardens after that the core has been tensioned.

Such tendons are generally known. European Patent Application No. 83 810 431.3 (publication number 0105 839) describes such tendons which are composed of a core around which a hardenable composition is applied, which, in turn, is encased in a synthetic material layer hardened by radiation. When the tendon has been put in its place, the core is tensioned, and subsequently heated by passing an electric current through it so as to harden the hardenable layer around the core. Such tendons are used for making, e.g. concrete structures.

For making such concrete structures two methods of reinforcement can usually be used.

According to the first method, which we shall call the conventional method, a strand, rope or rod is tensioned on a drawing bench ; subsequently, concrete mortar is applied around this tensioned strand, rope or rod, and the concrete is allowed to harden. The hardened concrete then contains a stressed tendon so that the resistance against bending of e.g. the so manufactured beam, is considerably improved.

Another method deals with the so-called post-tensioning of tendons. A rope encased in a shield is placed in a mould to be filed with concrete mortar. Subsequently, the rope is tensioned up to the required stress. In a further operation, cement mortar is injected between the rope and the shield so as to obtain a bond between the shield and the central rope as soon as the mortar is hardened. Such a method is particularly suitable for on-site jobs.

With this kind of post-tensioning, the inside of the shield will preferably be profiled in order to enhance anchorage between the rope and the shield. As soon as the concrete mortar around the shield and the cement mortar inside the shield are hardened, the anchors used for stressing the rope can be removed.

Another method of prestressing consists in using a stressing rope encased in a shield or sheath, whereby the stressing rope is frequently movable inside the sheath (unbonded tendons). On site the tendons are placed in a mould to be filled with concrete mortar and subsequently tensioned. The concrete mortar is then cast and allowed to harden. The tensioning anchors remain in position and provide the required stress in the tendons throughout the life of the structure. This method offers the advantage that in certain cases the stress can be adjusted afterwards when this should be desirable. An obvious disadvantage is that, in the case an anchor breaks, the entire stress may disappear with all its consequences.

It is an object of the present invention to provide an alternative to the method of post-tensioning ropes ; however, without requiring for the complicated operation of injecting cement mortar inside the sheath in which the rope is encased.

A similar improvement is also aimed in the aforementioned European Patent Application No. 0 105 839. An important drawback of the tendons and their applications referred to in said Patent Application is that the synthetic material must be hardened by means of heat. According to said Application, this heat is provided by passing an electrical current through the central tensionable core or through a resistance element specially provided in the system.

However, electrical current heating for such tensioned constructions must be considered as extremely dangerous as this may lead to strength reductions in some cases. It is obvious that any risk of reduced strength in such structures is entirely unacceptable so that heating of the cores of such elements must be avoided.

It is an object of this invention to provide a tendon of the abovementioned type, which, however, does not require the supply of heat to the system, but, in which nevertheless, excellent hardening of the hardenable composition between the stressed core and the sheath is obtained.

According to the invention a tendon of the abovedescribed type is characterized in that the hardenable composition is a hardenable material which does not require the supply of heat and of which the components or preproducts are distributed over various distinct phases ; that at least one continuous phase of the hardenable composition is provided with lubricanting action which after the hardening process substantially disappears and that there also is provided a barrier layer which regulates the speed of the hardening reaction of the hardenable composition.

In a tendon according to the invention there is a combination of three important properties :

(a) the components of the hardenable composition are distributed over various distinct phases ;

(b) at least one phase of the composition has lubricating action ;

(c) the speed of the hardening reaction of the hardenable composition is regulated by the presence of a barrier layer.

A stressing rope according to the invention may be submitted to considerable elongation of the core during stressing ; e.g. 5 % elongation. As will be described further on in greater detail, the rope is tensioned not before the concrete is hard so that during this process the core moves relative to the surrounding concrete.

As a result of the profiled core surface and its movement relative to the concrete and the barrier layer bonded thereto, there will be a blending of the phases of the hardenable composition, so that, after hardening of the system, a homogeneously hardened bond is obtained between the surrounding concrete and the core. The degree of blending of the phases of the hardenable composition during the tensioning process may be influenced by the nature of the core in terms of elongation and surface profile.

By the choice of the barrier layer, it is possible to regulate accurately the speed of the hardening reaction of the hardenable composition, which is distributed over several phases.

In a first preferred embodiment of the tensioning elements according to the invention, the sheath constitutes the barrier layer which consists of a hydrolizable synthetic material.

More specifically, this layer consists of a synthetic material that is hydrolizable in an alkaline aqueous environment, e.g. 100 % esterified polyvinyl acetate. Preferably, said material is as thin as possible to prevent lubricating action after hydrolysis, but, on the other hand, it must be sufficiently thick to serve as a barrier layer during the desired period of time.

It is advantageous that, in this case, the hardenable composition is formed by a layer adjacent to the core which contains a suitable epoxy resin and an adjacent layer containing polyisocyanate.

The action of such a system can be described as follows.

The tendon is placed in a casing, the concrete mortar is poured in the casing and the concrete is allowed to harden. After the hardening process, the tensionable core is tensioned by means of jacks and anchors. As known, during the hardening process, the concrete contains, an amount of strongly alkaline water ; a pH value of 13 is a normal value. The sheath, which is composed of a layer based on, say, polyvinylacetate, will, in the coarse of time, hydrolyse in the alkaline water present in the concrete. Subsequently the alkaline water comes into contact with the polyisocyanate-epoxy resin system lying directly beneath the barrier layer. Under the influence of alkali and water, the polyisocyanate will be converted into a compound containing amino-groups such as, for example, the corresponding primary amine. In combination with the epoxy resin in the system, this amine will now form an epoxy resin-hardening system, whereby the duration of the hardening will depend on the thickness of the polyvinyl-acetate layer and on the concentration of the polyisocyanate in the polyisocyanate-containing layer.

It is evident that the epoxy resin contained in the epoxy-resin-containing layer around the core must have a hydroxyl number 0 in order to avoid premature reaction between the polyisocyanate component of the top layer and the epoxy resin.

Normally, the anchors will not be removed after the hardening process, although this would be possible. It is, however, important to note that the anchors are no longer essential for the action of the tendon. This means that, should the anchors be put out of service owing to e.g. corrosion, the tendon would maintains its normal function thanks to the presence of the hardened bonding synthetic material between the core of the tendon and the hard concrete.

Instead of an epoxy resin, it is also possible to use a polyalcohol in the abovedescribed embodiment so that, after hydrolysis of the barrier layer, the slow reaction between the said polyalcohol and polyisocyanate, with the associated formation of a polyurethane compound is accelerated under the influence of the catalytic action of the alkali metal-ions, which are present in the water of the concrete.

With the application of such a polyurethane system it is evident that an ultimate date of use must be specified.

In the abovedescribed embodiment of the tendon according to the invention, it is advantageous to envelop the entire tendon in a gas-and liquid-tight jacket that can be removed prior to use.

This measure makes it possible to prevent premature reation between the polyisocyanate layer with, for example, water vapour from the atmosphere.

In another advantageous embodiment of the tendon according to the invention, the barrier layer is located between the phases of the hardenable composition and the shield or sheath is formed by an impenetrable inert profiled synthetic material layer.

In that case two situations must be distinguished :

(a) the phases separated by the barrier layer are present in the form of layers at both sides of the barrier layer ;

(b) one of the phases is present in the form of areas surrounded by a barrier layer in a continuous layer of the other phase.

In both abovedescribed cases it is advantageous that the barrier layer regulates the diffusion speed of one or more components of the hardenable composition.

Very advantageously, in suh a case, one of the phases contains an epoxy resin, while another phase may contain an amine compound. A suitable barrier layer may then be composed of polyethylene oxide.

It is evident that the barrier layer may be composed, instead of of polyethylene oxide, of another amine diffusible layer ; however, a requirement is that the barrier layer contains no groups that trigger off a reaction between the barrier layer and the epoxy resin.

It is advantageous that at least one of the phases of the hardenable composition has lubricating action. This can be achieved by adding one or more lubricants or viscocity-reducing agents, such as inert waxes, solvents, silicon products or polytetrafluorethylene products, to the phase concerned.

Also with similar lubricants or viscosity-reducing agents care must be taken that they cannot react with the components of one or more phases of the hardenable composition.

As indicated before in the scope of the invention, it is evident that with the hardenable compositions, care must be taken that the hardening of the system does not go together with a considerable reduction in volume. Indeed, many hardenable synthetic materials have the characteristic of shrinking slightly when being hardened. Usually, such shrinkage phenomena can effectively be counteracted by incorporating adding fillers to one or more phases of the hardenable composition. Such fillers are known to anyone familiar with the art : calcium carbonate, clay, diatomene earth, polyethylene, polypropylene powder, gypsum, etc.

In certain cases however, adding fillers shall not be required. This, indeed, is the case when the hardenable composition is formed by a polyisocyanate and an epoxy resin. During activation of the polyisocyanate, whereby as already said an amine is formed, a molecule of carbon dioxyde per isocyanate group is liberated. Under certain conditions, carbon dioxide may remain trapped in the hardenable composition and so lead to an increase in volume during the hardening process. In this way, it is evident that an excellent filling of the cavity inside the sheath is obtained.

The invention also relates to a method for tensioning concrete under the application of a tendon according to the invention. It is evident that the tendons according to the invention can also be used for making a prestressed concrete element made in a conventional manner in a workshop.

The invention will now be further clarified with reference to the drawing in which :

Figure 1 is a cross-sectional view of a tendon according to claims 1 to 7 ;

Figure 2 is a cross-sectional view of a tendon according to claims 7 to 11, and

Figure 3 is a view of another embodiment of a tendon according to claims 8 to 11.

In Figure 1 a tensionable core is shown with reference number (1) ; reference number (2) represents the first phase of the hardenable composition around the core, while reference number (3) represents a second phase of the hardenable composition. Reference number (4) refers to a barrier layer applied around both phases of the hardenable composition, which layer (4), in this case, also has the function of a sheath or a shield. Preferably, a very thin, additional jacket is applied on this barrier layer (4).

In Figure 2, reference number (5) designates a tensionable core ; a first phase (6) of the hardenable composition is applied around this core ; a barrier layer (7) is applied around this first phase and a second phase (8) of a hardenable composition is applied around this barrier layer (1) ; a shield (9) is applied at the outside.

In Figure 3, reference number (10) again shows the tensionable core ; reference number (11) refers to a first phase of the hardenable composition and reference number (12) to the second phase of the hardenable composition. Reference number (13) refers to the barrier layer located between both phases of the hardenable composition.

With reference to Figure 1, the tendon is applied as follows. After having been freed from the outermost thin inert jacket, if any, the tendon is placed in a mould to be filled with concrete ; the concrete mortar is cast around the tendon and starts to harden ; after complete hardening of the concrete the core is tensioned. During the hardening process of the system, the latter possibly being mixed due to the tensioning, the concrete mortar contains water with a high pH-value, e.g. a pH of about 13. At these high pH-values the barrier layer 4, e.g. polyvinyl acetate, will hydrolyze. During the hydrolysis of the hydrolizable layer, the alkaline water of the concrete comes into contact with a polyisocyanate from the layer 3 so that the polyisocyanate is converted into a mixture of amine compounds. In turn, these compounds can react with the epoxy resin from the layer 2, so that, together with the amine formed from the isocyanate, the epoxy resin forms a solid hard synthetic material. In Figure 2 the situation is slightly different. Here a core 5 is enveloped by, for example, an amine-containing layer 6, which, in turn, is enveloped in a barrier layer 7 consisting substantially of polyethylene oxide. Around that, an epoxy resin layer 8 is applied ; finally at the outer side of the element there is an inpenetrable inert synthetic material layer 9 with profiled surface. After manufacturing the rope the diffusion process of the amine over the barrier layer 7 will start and continue until all epoxy resin has been converted. Under the application of such a rope it will be necessary, through selecting the thickness of the barrier layer 7, to take account of both the required period of time between tensioning the rope and the end of the hardening process, and of the period of time between the manufacturing of the tendon and the applying of the rope. Also in this case, it is possible to achieve, through a correct selection of the profile of the core and the elongation during the tensioning of the core, that a blending of the layers is carried on. In that case, a substantial acceleration of the hardening process can be achieved if care is taken that, during the tensioning operation, the barrier layer is broken down.

Finally, Figure 3 shows that the phase 12 of the hardenable composition is a continuous phase, while the phase 11 is a discontinuous phase, which is distributed in the continuous phase 12. Between both phases there always is a barrier layer in the form of a jacket 13. As concerns the period of time between the hardening of the so formed hardenable system and the manufacturing of the tendon, the same time control is required as described for Figure 2.

Claims

1. A tendon comprising a tensionable core, an envelope formed by a hardenable composition and a shield, whereby the hardenable composition has a lubricating action and hardens after the core has been tensioned, characterized in that the hardenable composition hardens without the supply of heat whereby its components or preproducts are distributed over various distinct phases (2, 3, 6, 8, 11, 12) ; that at least one continuous phase of the hardenable composition is provided with lubricating action, which after hardening substantially disappears, and that there is also provided a barrier layer (4, 7, 13) regulating the speed of the hardening reaction of the hardenable composition.

2. A tendon according to claim 1, characterized in that the shield forms the barrier layer (4) and is composed of an hydrolizable synthetic material.

3. A tendon according to claims 1 and 2, characterized in that the hydrolizable layer (4) is a synthetic material which is hydrolizable in an alkaline aqueous environment.

4. A tendon according to claim 3, characterized in that the hydrolizable synthetic material is polyvinyl acetate.

5. A tendon according to claims 1 through 4, characterized in that the hardenable composition is formed by a layer (2) adjacent to the core and containing a suitable epoxy resin and a surrounding layer (3) of polyisocyanate.

6. A tendon according to claims 1 through 4, characterized in that the hardenable composition is formed by a layer (2) adjacent to the core and containing a suitable polyalcohol and a surrounding layer (3) containing polyisocyanate.

7. A tendon according to any one or more of the claims 1 to 6, characterized in that the tendon is entirely surrounded by a gas and liquid tight jacket which is removed prior to use of the tendon.

8. A tendon according to claim 1, characterized in that a barrier layer (7, 13) is present between the phases of the hardenable composition and that the shield is formed by an inpenetrable inert profiled synthetic material layer (9, 14).

9. A tendon according to claim 8, characterized in that one or both phases of the hardenable composition is (are) continuous.

10. A tendon according to claims 8 and 9, characterized in that the barrier layer (7, 13) is a layer regulating the diffusion speed of one or more of the components of the hardenable composition.

11. A tendon according to one or more of the claims 8 through 10, characterized in that one of the phases contains epoxy resin, that another phase is an amine compound, and that the barrier layer substantially contains polyethyleneoxide.

12. A tendon according to one or more of the claims 1 through 11, characterized in that at least one of the phases is provided with lubricating action by blending this phase with one or more lubricants or viscosity-reducing agents, such as inert waxes, solvents, silicon products or polytetrafluorethylene products.

13. A tendon according to one or more of the claims 1 through 12, characterized in that at least one of the phases forming the hardenable composition contains a filler material.

14. A method for stressing concrete, characterized in that a tendon according to one or more of the claims 1 through 13 is applied.

15. A prestressed concrete element obtained in a known manner under the application of a tendon according to one of the claims 1 through 13.

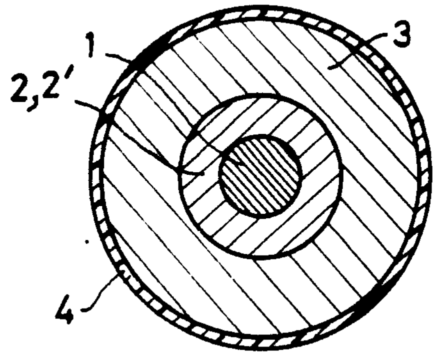

Fig: 1.

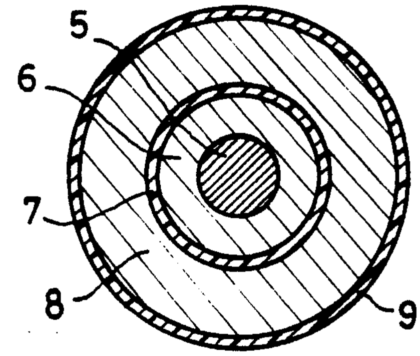

Fig: 2.

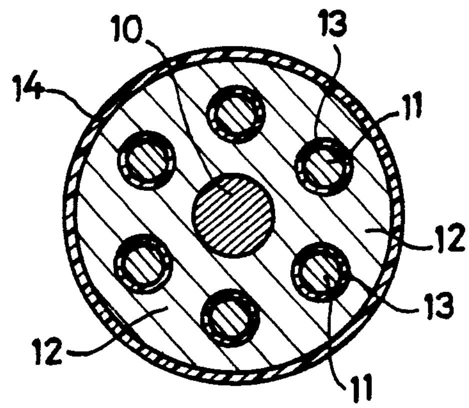

Fig: 3.

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EUROPEAN SEARCH REPORT

Application number

EP 86 20 1601

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.4)
X	GB-A-2 140 480 (PSC FREYSSINET) * Page 1, lines 40-77,101-130; page 2, lines 1-27; claims 1-3,5,8; figures 2,3 *	1	E 04 C 5/08
A		5,7-11,14,15	

A	US-A-3 111 569 (RUBENSTEIN) * Column 2, lines 42-48,60-69; column 6, lines 30-45,60-74; column 7, lines 64-75; column 8, lines 1-7; column 9, lines 41-65; column 11, lines 16-45; column 12, lines 30-40; column 13, lines 34-58-65-69; column 14, lines 3-52,71-75; column 15, lines 1-6; column 17, lines 26-44; column 18, lines 10-15; column 23, lines 59-75; column 24, lines 1-24,43-53; column 42, lines 6-18,62-75; column 43, lines 1-6; figures 3,10,11,12,15,24,27,28,31,32 *	1-3,5-9,11,13-15	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)** E 04 C E 04 G D 07 B

A	GB-A- 935 557 (WELBORN) * Page 2, lines 34-43; page 3, lines 21-71,115-130; page 4, lines 1-17; figure 4; claims 1,3,6 *	1	
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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
THE HAGUE	03-12-1986	HENDRICKX X.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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.4)
A	US-A-3 060 640 (HARRIS) * Claim 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03-12-1986	HENDRICKX X.

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