(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 633 348 A1**

(12) # EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC

(21) Application number: **94903071.2**

(22) Date of filing: **27.12.93**

(86) International application number: **PCT/JP93/01894**

(87) International publication number: **WO 94/15015 (07.07.94 94/15)**

(51) Int. Cl.[6]: **D07B 1/02**, D07B 1/16, D07B 7/14

(30) Priority: **28.12.92 JP 361318/92**
02.02.93 JP 39557/93
01.10.93 JP 270077/93

(43) Date of publication of application: **11.01.95 Bulletin 95/02**

(84) Designated Contracting States: **DE FR GB IT SE**

(71) Applicant: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**
5-33, Kitahama 4-chome,
Chuo-ku
Osaka-shi,
Osaka 541 (JP)

(72) Inventor: **KIDO, Toshiroh, Itami Works of Sumitomo**
Electric Industries, Ltd.,
1-1, Koyakita 1-chome
Itami-shi,
Hyogo 664 (JP)
Inventor: **NISHIMURA, Yoshifumi, Itami Works of Sumitomo**
Electric Industries, Ltd.,
1-1, Koyakita 1-chome
Itami-shi,
Hyogo 664 (JP)
Inventor: **YAMASHITA, Kenichi, Itami Works of Sumitomo**
Electric Industries, Ltd.,
1-1, Koyakita 1-chome
Itami-shi,
Hyogo 664 (JP)
Inventor: **YAMAMOTO, Susumu, Itami Works of Sumitomo**
Electric Industries, Ltd.,
1-1, Koyakita 1-chome
Itami-shi,
Hyogo 664 (JP)
Inventor: **TANAKA, Ikuo, Itami Works of Sumitomo**
Electric Industries, Ltd.,
1-1, Koyakita 1-chome
Itami-shi,
Hyogo 664 (JP)

(74) Representative: **Kahler, Kurt, Dipl.-Ing.**
Patentanwälte Kahler, Käck, Fiener & Sturm
P.O. Box 12 49
D-87712 Mindelheim (DE)

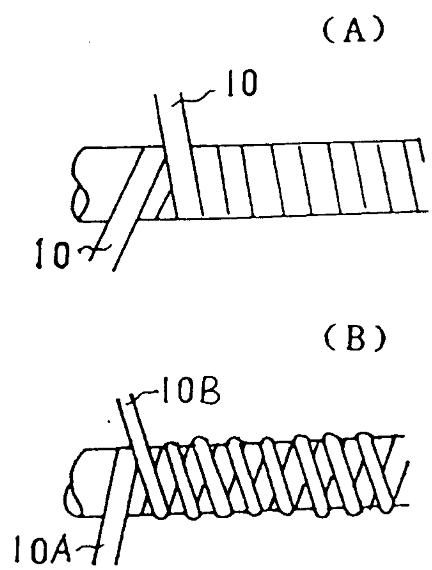
(54) **COMPLEX FIBER STRING AND METHOD OF MANUFACTURING THE SAME.**

(57) This invention relates to a complex fiber string used as a tension member of a PC structure. The characteristics of the present invention reside in that it provides a complex fiber string having a high mechanical strength and produced by heating a thermosetting resin-impregnated fiber core so as to put the thermosetting resin in a semi-hardened state, subjecting the outer circumferential surface of the fiber core to primary wrapping and secondary wrapping with bundled fiber yarn, intertwining a plurality of fiber cores thus obtained, and then

Rank Xerox (UK) Business Services
(3.10/3.09/3.3.4)

heating the intertwined fiber cores so as to harden the semi-hardened thermosetting resin. Another characteristic of the present invention reside in that the bundled fiber yarn for the primary or secondary wrapping of the fiber core is wound therearound in a spaced manner so as to form helical ridges and grooves on the outer circumferential surface of the fiber core, whereby the bonding strength required by a final product as a tension member with respect to a material to which the tension member is to be applied is improved.

F I G. 4



Technical Field

The present invention relates to a fibrous composite rope for use in prestressing members of PC (prestressed concrete) structures in the civil engineering and construction industry or strengthening or reinforcing members for power or communication cables, etc., and more particularly to such a fibrous rope which is obtained by stranding a plurality of fibrous cores or strands impregnated with a thermosetting resin. The "rope" herein referred to is a generic term including in its meaning all ropes, cords and the like stranded materials.

Background Arts

Heretofore, an overwhelmingly major part of prestressing members for PC structures has been shared by steel in the civil engineering and construction industry.

Many improvements have been proposed in such steel-based structural prestressing members, among which Japanese Patent Publication No. Hei 3-28,551 typically discloses one of the most advanced one. Namely, it discloses a prestressing member featuring a high corrosion resistance, good anchorage and workability due to its synthetic resin coating.

However, since such a prestressing member comprises stranded steel wires as its base material, it is heavy in weight and cannot be free from problems caused by magnetism, and if its resin coating is damaged the stranded wires will corrode, resulting in the loss of required mechanical properties.

Meanwhile, there are known various cords and ropes fabricated of fibers or fibrous yarns. Among those, the fibrous composite ropes disclosed in Japanese Patent Publication No. Sho 62-18,679 is known as having a high tensile strength. The disclosed fibrous composite rope is obtained by impregnating a fiber core with a thermosetting resin, covering the outer periphery of the impregnated core with a fiber braid after applying drying powder onto the periphery, and subsequently heating the covered core to cure the thermosetting resin.

In the technique disclosed in Japanese Patent Publication cited immediately above, in which drying powder is used to prevent the thermosetting resin impregnated into the fiber core from leaking therefrom, the drying powder must be applied uniformly in a well controlled quantity, thus rendering the process or production control difficult. If such leakage of the thermosetting resin cannot be prevented, the leaked thermosetting resin will cause such fiber cores to be adhesively bonded to each other when they are brought together in a later stranding or twisting process, consequently to suppress their relative movements, resulting in reduced mechanical strength and flexibility of the resultant rope. Further, the existence of the drying powder will not have a desirable effect on integral adhesion of the thermosetting resin of the fiber core to the fibrous yarns of the braid covering the core. Besides, the thermosetting resin of the fiber core will substantially lose its plasticity when cured, rendering the twisting difficult, and so that a rope stranded of such rigidified cores would have its cores loosened when cut for use.

Disclosure of the Invention

With a view to solving the aforementioned problems of the prior art, the inventors aimed at forming a prestressing material by using fiber-based materials having a high tensile strength and low elongation such as carbon fiber, glass fiber and aramid fiber, instead of using, as base material, stranded steel wires which is not only heavy in weight but poor in corrosion resistance.

The inventors have undertook a series of experiments and research works to successfully obtain a fibrous composite rope having sufficient mechanical properties and satisfiable anchorage to mortar, resins or other anchoring bodies to which the rope is embeddedly anchored.

Namely, according to one aspect of the present invention, there is provided a fibrous composite rope comprising a plurality of fiber cores stranded together, each of said cores being impregnated with a thermosetting resin and having a fiber bundle wrapped around the periphery thereof in one winding direction without clearance between the sides of adjacent turns of the bundle, namely, without wrapping clearance.

Preferably, the present fibrous composite rope may be fabricated by first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping said fiber bundle around the periphery of each said fiber core in one winding direction without wrapping clearance, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

For preventing leakage of the thermosetting resin from the fiber core without semicuring the resin but merely by wrapping the fiber bundle around its periphery in such a manner that no clearance remains between the sides of adjacent turns of the bundle, it would be necessary to strictly control the manufacturing conditions by for example thickening the fiber bundle and controlling its winding force within an appropriate range during the wrapping process. Too thick fiber bundle will increase the diameter of the resultant rope, resulting in reduced tensile strength per cross-sectional area.

According to another aspect of the present invention, there is provided a fibrous composite rope comprising a plurality of fiber cores stranded together, each of said cores being impregnated with a thermosetting resin and having as a primary wrapping member said fiber bundle wrapped around the periphery thereof in one winding direction without wrapping clearance and further having as a secondary wrapping member a fiber bundle wrapped around the periphery of said primary wrapping member in the oppsite winding direction thereto without wrapping clearance.

Preferebly, the fibrous composite rope according to the second aspect of the present invention may be fabiricated by first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping said fiber bundle of said primary wrapping member around the periphery of each said fiber core in one winding direction without clearance between the sides of adjacent turns of the bundle, further wrapping said fiber bundle of said secondary wrapping member around the periphery of said primary wrapping member in the opposite winding direction thereto without wrapping clearance, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

Either of the aforementioned methods may be modified to improve integral adheshion of the fiber core to the fiber bundle wrapping the same, for example, by applying a thermosetting resin to the wrapping fiber bundle internally thereof, or by controlling the semicured state of the thermosetting resin-impregnated fiber core so as to cause the resin to penetrate into the wrapping fiber bundle.

Instead of applying drying powder onto the peripheral surface of fiber core for preventing the thermosetting resin impregnated into the core as in the prior art, the method of the present invention first semicures the thermosetting resin and then wraps the fiber bundle around the core in one winding direction without clearance between the sides of adjacent turns of the fiber bundle. Since it is impossible to prevent the thermosetting resin from leaking in its liquid state and since application of the drying powder is not preferable for the aforementioned reason, the thermosetting resin is first semicured to obtain a highly viscous state which facilitates working. In addition, wrapping the fiber bundle around the fiber core ensures the prevention of resin leakage.

Further, according to the present invention, wrapping the secondary fiber bundle around the foregoing wrapping fiber bundle in the opposite winding direction thereto produces a bidirectionally wrapped fiber core, which allows fabrication of a fibrous composite rope from torsion-free fiber cores. That is to say, wrapping the fiber bundle around the fiber core only in one direction will rather tend to give rotation to the core, leaving a torsion therein. Such a torsion would act to impede even and uniform elongation of constituent fibers and consequently deteriorate mechanical properties of the resultant rope. However, according to the second aspect of the present invention, the secondary wrapping fiber bundle is wrapped around the primary fiber bundle in the opposite winding direction thereto without clearance between the sides of adjacent turns of the fiber bundle, thereby to give counterrotation to the core so as to offset the torsion.

In any of the foregoing two aspects of the invention, the present fibrous composite rope is fabricated by stranding together a plurality of fibrous cores impregnated with a thermosetting resin around which is wrapped a fiber bundle without wrapping clearance, so that spiral peripheral grooves of the rope formed between adjacent cores thereof would not be slackened . Thus, when used as a prestressing member, the present rope will exhibit strong adhesion to anchoring bodies.

If a wedge and a wedge support are used for anchoring a rope end, a fibrous composite rope exhibiting poor adhesion tends to slide on the wedge surface and, in some cases, may slip off the wedge. Even if such a rope exhibiting poor adhesion is anchored by inserting its end in a pipe, pouring a mortar or resin into the pipe to fill the surrounding space of the rope end and curing the mortar or resin, the end tends to slide against such a mortar or resin to occasionally slip off the anchoring pipe. Thus, it is difficult to anchor such a rope with a practicably short anchoring length. Meanwhile, regarding the individual fiber cores constituting the rope which are poor in adhesion, relative slippage may occur between their primary and secondary wrapping members or between the wrapping members and the base core, occasionally resulting in complete slipping off.

Further, according to still another aspect of the present invention, for far improving the adhesion of rope to anchoring bodies, either of the primary or secondary wrapping member may be wound so as to follow a screw thread-like pattern, namely, with a wrapping clearance between adjacent turns of the wrapping member or fiber bundle for obtaining rugged surfaces.

In this manner, wrapping either of the primary or secondary fiber bundle with adjacent turns of the bundle spaced apart from each other brings about a rugged peripheral surface, increasing the pull out resistance at anchoring means to the extent that the rope end can be securely prevented from slipping off when the rope is used as a prestressing member for PC structures.

For the aspect of the present invention described last hereinabove, which of the primary and secondary wrapping members or fiber bundles may be wound with adjacent turns of the fiber bundle spaced apart from each other. For example, the primary wrapping member (inside) may be wound without wrapping clearance, followed by the secondary wrapping member (outside) which is wound with adjacent turns thereof spaced apart from each other, and vice versa. In either case, the resultant fiber core can have a rugged peripheral surface.

Further according to the last aspect of the invention, since one of the primary or secondary fiber bundles is wrapped without clearance between the sides of adjacent turns of thereof in the opposite winding direction to that of the other bundle, leakage of the thermosetting resin as well as torsion can be effectively prevented in the resultant fiber core. Any such residual torsion existing in the fiber core would impede even and uniform longitudinal elongation of the constituent fibers and lead to deteriorated mechanical properties of the resultant rope. The present invention can successfully solve these problems.

Brief Description of the Drawings

FIG. 1 is a schematic diagram showing a manufacturing process used in a preferred example of the present invention, with FIG. 1(A) showing the former half of the process and FIG. 1(B) the latter half;

FIG. 2 is a perspective view showing a state in which a fiber bundle is wrapped around the periphery of a fiber core in one winding direction without clearance between the sides of adjacent turns of the bundle according to the prefeferred example of the present invention;

FIG. 3 is a schematic drawing showing a manufacturing process used in a second and third examples of the present invention, with FIG. 2(A) showing the former half of the process and FIG. 2(B) the latter half;

FIG. 4(A) is a perspective view showing a state in which a primary and a secondary fiber bundles are wrapped around the periphery of a fiber core in two opposite winding directions, respectively, without clearance between the sides of adjacent turns of the respective bundles according to the second preferred example of the present invention, while FIG. 4(B) is a like perspective view showing a state in which the primary fiber bundle is wrapped around the periphery of the fiber core in one winding direction without wrapping clearance, followed by wrapping the secondary fiber bundle in the opposite direction with adjacent sides thereof spaced apart from each other, according to the third preferred example of the present invention.

FIG. 5 is a drawing showing partially in section a tensile tester used for testing the fibrous composite rope according to the present invention to measure pull out resistance (adhesion) to an anchoring body.

Best Mode Carrying out the Invention

Example 1

When using the fibrous composite rope of the present invention as a prestressing member for PC structures, the third example to be described herein later is most preferable for securing sufficient adhesion with a shorter anchoring length. However, the description will be made in the order of the first, second and third examples, because such order would be appropriate for exactly understanding the present invention.

With reference to FIG. 1, especially to FIG. 1(A), showing a manufacturing process according to the first preferred example, initially a plurality of aramid resin fibers or yarns of such fibers having a high tensile strength and low elongation are unwound from the respective feed reels 1 and bundled into a fiber core A. The fiber core A is then fed into a thermosetting resin bath 2 to be impregnated with a thermosetting resin (e.g., unsaturated polyester or epoxy resin). The impregnated fiber core is then passed through a die (or forming mold) 3 to be reduced to a predetermined outside diameter and to remove excess resin, and is subsequently fed into a heater 4. In the heater, the fiber core is heated at about 90 °C for about 30 seconds to cure the thermosetting resin, and then fed into a wrapping machine 5, where a fiber bundle or bunndled yarn 10 (FIG. 2) is wrapped around the peripheral surface of the fiber core A in one winding direction without clearance between the sides of adjacent turns of the bundle. A thermosetting resin, which may be the same or different from the aforesaid thermosetting resin, may be applied onto the fiber bundle 10 on its side coming inside when wrapped, for furthering integral adhesion to the core A. In FIG. 2, is shown the fiber core A wrapped with the fiber bundle 10 without clearance between the sides of its ajacent turns, namely, without wrapping clearance. The resultant fiber core is wound up on a take-up reel 6.

Thereafter, as shown in FIG. 1(B), a plurality of such wrapped fiber cores A are unwound from the respective reel 6 to be fed into a stranding machine 7, where they are stranded together. The resultant stranded rope A is then heated in a heater 8 to finalize or complete the curing of the semicured thermosetting resin, and is subsequently wound up on a take-up reel 9.

Thus, by wrapping the fiber core with the fiber bundle without clearance between its adjacent turns while the thermoseting resin being still in its semicured state, it is possible according to the present invention to surely prevent leakage of the thermosetting resin without using a drying powder as in the prior art and to prevent adjacent fiber cores from directly bonding to each other during the stranding process also as in the prior art. Further, protuberances on the rope surface or like unseemly external appearance caused by leaked resin can be eliminated according to the present invention.

Example 2

Now with reference to FIG. 3, especially to FIG. 3(A), showing a manufacturing process according to the first preferred example, initially a plurality of aramid resin fibers or yarns of such fibers having a high tensile strength and low elongation are unwound from the respective feed reels 1 and bundled into a fiber core A. The fiber core A is then fed into a thermosetting resin bath 2 to be impregnated with a thermosetting resin (e.g., unsaturated polyester or epoxy resin). The impregnated fiber core is then passed through a die (or forming mold) 3 to be reduced to a predetermined outside diameter and to remove excess resin, and is subsequently fed into a heater 4. In the heater, the fiber core is heated at about 90 °C for about 30 seconds to cure the thermo-setting resin, and then fed into a wrapping machine 5A, where a fiber bundle or bundled yarn 10 is wrapped as a primary wrapping member around the peripheral surface of the fiber core A in one winding direction without clearance between the sides of adjacent turns of the bundle. Then, the fiber core A is fed into another wrapping machine 5B, where another fiber bundle 10, as a secondary wrapping member, is wrapped around the fiber core A also without wrapping clearance but in the winding direction opposite to that of the primary wrapping member. A thermosetting resin, which may be the same or different from the aforesaid thermosetting resin, may be applied onto the fiber bundle 10 on its side coming inside when wrapped, for furthering integral adhesion to the core A.In FIG. 4(A), is shown the fiber core A wrapped with the primary and secondary fiber bundles 10 without clearance between the sides of its ajacent turns. The resultant fiber core is wound up on a take-up reel 6.

Thereafter, as shown in FIG. 3(B), a plurality of such wrapped fiber cores A are unwound from the respective reel 6 to be fed into a stranding machine 7, where they are stranded together. The resultant stranded rope A is then heated in a heater 8 to finalize or comlete the curing of the semicured thermosetting resin, and is subsequently wound up on a take-up reel 9.

Thus, by wrapping the fiber core with the fiber bundle without wrapping clearance while the thermoseting resin being still in its semicured state, it is possible according to the present invention to surely prevent leakage of the thermosetting resin to prevent adjacent fiber cores from directly bonding to each other during the stranding process as in the prior art. Further, in this preferred example, the bidirectional wrapping effectively eliminates torsion of the fiber core.

As a material for the fiber core of the present invention, carbon fiber, glass fiber or the like may be used in addition to the aforementioned aramid resin fiber. Also, the wrapping fiber bundle used for the present invention may be made of an aramid resin fiber, vinylon fiber or polyester fiber. For a prestressing member for PC structures, it is preferable to use an aramide fiber to improve alkali resistance of the resultant rope.

Example 3

In the similar manner, the process of the aforementioned Example 2 shown in FIG . 3 is repeated, except that a secondary wrapping fiber bundle is wound by the wrapping machine 5B with its adjacent turns spaced apart from each other on a primary wrapping fiber bundle wound by the wrapping machine 5A without clearance between the sides of adjacent turns of the bundle in the winding direction opposite to that of the secondary wrapping member. In this example, the resultant core has a rugged peripheral surface.

In FIG. 4(B) is shown the resultant fiber core of Example 3 comprising the primary wrapping fiber bundle 10A wound inside without wrapping clearance and the secondary wrapping fiber bundle 10B wound around the periphery of the primary fiber bundle in the opposite direction thereto with its adjacent turns spaced apart from each other. Either one of the wrapping fiber bundles which is wound with wrapping clearance (fiber bundle 10B in the instant example) may vary from the other bundle which is wound without clearance (bundle 10A in the instant example) in at least one of a group of items including the number of fibers or yarns, shape, pitch, or wrapping tension of the bundle.

Like the aforementioned Examples 1 and 2, a thermosetting resin, which may be the same or different from the aforesaid thermosetting resin, may be applied onto these fiber bundles 10A and/or 10B on their sides coming inside when wrapped, for furthering integral adhesion to the core A.

Further, the mode of winding the primary and secondary wrapping members may be reversed from Example 3, namery, the primary member disposed inside may be wound with wrapping clearance, followed by winding the secondary member without wrapping clearance. In addition, a third fiber bundle may be wrapped around the periphery of such a fiber core that is bidirectionally wrapped with fiber bundles as in Example 2. In such a case, the resultant fiber core would have an increased diameter.

In the same manner as in the aforementioned Examples 1 and 2, a plurality of resultant fiber cores having a rugged peripheral surface are then stranded together and heated to be formed into a fibrous composite material having a rugged outer peripheral surface and exhibiting good adhesion to anchoring means, as intended by the present invention. Differential height between the top and bottom of the rugged peripheral suraface of the wrapped fiber core, as viewed in its cross section, is apploximately 0.5 mm in Example 3, although it may preferably ranges from approximately 0.3 to 0.8 mm.

Tensile Test

By using the processes of the aforementioned Examples 1 and 2, 7 wrapped fiber cores, each 4.2 mm across, were stranded together to fabricate samples of fibrous composite ropes of the respective preferred examples. The base fiber core was prepared by bundling 18 aramid resin fibers of 6,000 deniers, and the core was impregnated with a thermosetting resin, the proportion of fiber to thermosetting resin being 65 % by volume of fiber. As the thermosetting resin, a vinyl ester resin was used, and an aramid resin fiber as the wrapping fiber.

Each specimen of the fibrous composite ropes has its opposite ends secured to a tensile tester and its tensile load was measured. The tensile tester used is shown in FIG. 5. As shown in the drawing, the tester had a pair of cylindrical anchoring jigs or fixtures, in which the opposite ends of the specimen 13 was inserted and mortar 11 was filled to fix the respective ends. Then, the tester exerted a tension on the specimen by pulling the same in the opposite directions, and the maximum tensile load was measured for evaluation. In FIG. 5, the reference numeral 14 denotes a crosshead, 15 a plate, and 16 a rubber plug, respectively.

As described hereinabove, the specimen of Example 1 was prepared by using fiber cores each wrapped with only a primary fiber bundle wound in one direction therearound without winding clearance, and the specimen of Example 2 was prepared by using fiber cores which are obtained by further wrapping a secondary fiber bundle around the resultant fiber core of Example 1 in the opposite winding direction without wrapping clearance. For comparison, another specimen was prepared, as a comparative example, by wrapping only a primary fiber bundle in one winding direction without wrapping clearance around a thermosetting resin-impregnated base fiber core without semicuring the resin, and stranding together a plurality of such wrapped fiber cores with the resin leaked out to the surfaces.

Each specimen was set on the tester under the following conditions and tested for tensile load.

Anchoring jig size:	30 mm I.D., 500 mm long
Jig filler:	mortar cured for 5 days

The test results are given below. The specimens of the preferred examples all showed a significantly higher tensile load than the comparative example. This evidently shows good applicability of the preferred examples of the present invention to a prestressing member for PC structures and to reinforcing members for power and communication cables.

Specimens	Tensile load (kN)
Example 1	165
Example 2	175
Comparative example	100

This improvement achieved in the preferred examples of the present invention would be attributable to positive prevention of the resin leakage by wrapping the periphery of the thermosetting resin-impregnated fiber core with the fiber bundle in the semicured state of the resin and to prevention of slackening of the peripheral spiral grooves of the rope by completing the curing of the semicured resin after stranding. Especially, in Example 2 employing bidirectional wrapping, torsion of the fiber cores is prevented to effectively further the improvement.

Adhesion Test

Except the anchoring jig 12 had a shorter length, the same equipment as that in the aforementioned tensile test was used to measure a tensile load, as a allowable tensile load, at which the specimen had its end slipped off the anchoring jig. In this test were used a specimen of Example 3-1, as one preferred example, prepared by using fiber cores wrapped with a primary fiber bundle without wrapping clearance and a secondary fiber bundle with wrapping clearance, and a specimen of Example 3-2, as another preferred example, prepared in a manner reverse to Example 3-1, namely, by using fiber cores wrapped with a primary fiber bundle with wrapping clearance, followed by a secondary fiber bundle wrapped without clearance. Besides, a comparative example was prepared in the same manner as in the preceding tensile test, namely, wrapping only a primary fiber bundle in one winding direction without wrapping clearance around a thermosetting resin-impregnated base fiber core without semicuring the resin, and stranding together a plurality of such wrapped fiber cores.

The anchoring jigs were set as follows:

Jig size:	30 mm I.D., 200 mm long
Jig filler:	mortar cured for 5 days

The test results are as shown below, where the allowable tensile load is given in terms of index based on the allowable tensile load of the comparative example taken as the reference index 100. The preferred examples, particularly, Example 3-1 adopting the secondary fiber bundle wound with wrapping clearance exhibits excellent adhesion.

Specimens	Allowable tensile load
Example 3-1	180
Example 3-2	140
Comparative example	100

Industrial Applicability

As fully described hereinbefore, the present invention provides a fibrous composite rope having superior mechanical properties, fabricated by a novel method in which leakage of the thermosetting resin impregnated in the fiber core can be prevented without fail, so that adjacent cores are prevented from being directly bonded to each other in the subsequent stranding stage. Particularly, in the present invention, the drying powder used in the prior art for preventing leakage of the thermosetting resin impregnated in the fiber core can be eliminated together with the process step for its application to the fiber core.

Furthermore, bidirectional wrapping of the fiber bundles can prevent torsion of wrapped fiber cores, resulting in a fibrous composite rope having more excellent mechanical properties. Besides, if either the primary or secondary wrapping member is wound with wrapping clearance in the bidirectional wrapping configuration, high adhesion can be assured to anchoring means.

Heretofore, an overwhelmingly major part of prestressing members for PC structures has been shared by steel. Meanwhile, the fibrous composite rope according to the present invention has a high tensile strength comparable with PC steel members in addition to such features as high corrosion resistance, nonmagnetizability and light weight which are not provided by PC steel members. Thus, the present invention has as expected increasingly wide applications, including marine structures, PC structures for linear motors, etc.

Claims

1. A fibrous composite rope comprising a plurality of fiber cores stranded together, each of said cores being impregnated with a thermosetting resin and having a fiber bundle wrapped around the periphery thereof in one winding direction without wrapping clearance.

2. A method of manufacturing a fibrous composite rope, comprising the steps of first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping a fiber bundle around the periphery of each said fiber core in one winding direction without wrapping clearance, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

3. A fibrous composite rope comprising a plurality of fiber cores stranded together, each of said cores being impregnated with a thermosetting resin and having as a primary wrapping member a fiber bundle wrapped around the periphery thereof in one winding direction without wrapping clearance and having as a secondary wrapping member another fiber bundle wrapped around the periphery of said primary wrapping member in the opposite winding direction thereto without wrapping clearance.

4. A method of manufacturing a fibrous composite material, comprising first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping a fiber bundle as a primary wrapping member around the periphery of each said fiber core in one winding direction without wrapping clearance, further wrapping another fiber bundle as a secondary wrapping member around the periphery of said primary wrapping member in the opposite winding direction thereto without wrapping clearance, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

5. A fibrous composite rope comprising a plurality of fiber cores stranded together, each of said fiber cores being impregnated with a thermosetting resin and having as a primary wrapping member a fiber bundle wrapped around the periphery thereof in one winding direction without wrapping clearance and having as a secondary wrapping member another fiber bundle wrapped around the periphery of said primary wrapping member in the oppsite winding direction thereto with wrapping clearance so as to form a rugged peripheral surface.

6. A method of manufacturing a fibrous composite material, comprising first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping a fiber bundle as a primary wrapping member around the periphery of each said fiber core in one winding direction without wrapping clearance, further wrapping another fiber bundle as a secondary wrapping member around the periphery of said primary wrapping member in the opposite winding direction thereto with wrapping clearance so as to form a rugged peripheal surface, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

7. A fibrous composite rope comprising a plurality of fiber cores stranded together, each of said fiber cores being impregnated with a thermosetting resin and having as a primary wrapping member a fiber bundle wrapped around the periphery thereof in one winding direction with wrapping clearance to consequently form a rugged peripheral surface and having as a secondary wrapping member another fiber bundle wrapped around the periphery of said primary wrapping member in the oppsite winding direction thereto without wrapping clearance.

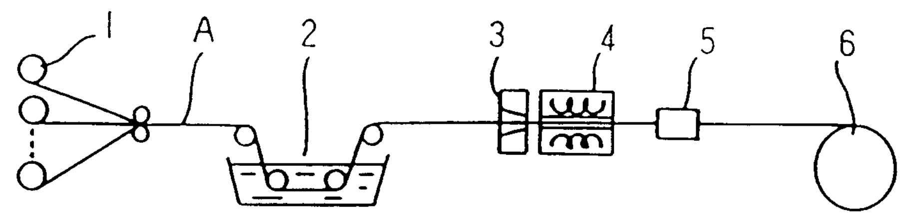
8. A method of manufacturing a fibrous composite material, comprising first heating the thermosetting resin-impregnated fiber cores so as to semicure the resin, then wrapping a fiber bundle as a primary wrapping member around the periphery of each said fiber core in one winding direction with wrapping

clearance to conseqently form a rugged peripheral surface, further wrapping another fiber bundle as a secondary wrapping member around the periphery of said primary wrapping member in the opposite winding direction thereto without wrapping clearance, stranding a plurality of the resultant fiber cores together into a rope form, and subsequently heating the stranded rope to finalize the curing.

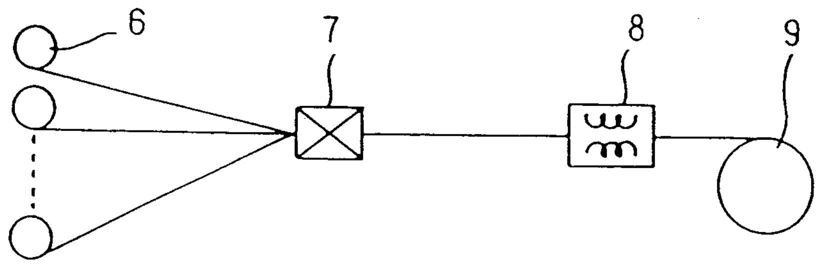
9. A prestressing member for PC structures, comprising a fibrous composite rope as set forth in any one of the preceding claims 1, 3, 5 or 7.

F I G. 1

(A)



(B)



F I G. 2

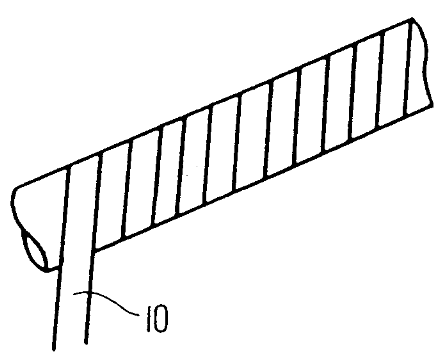
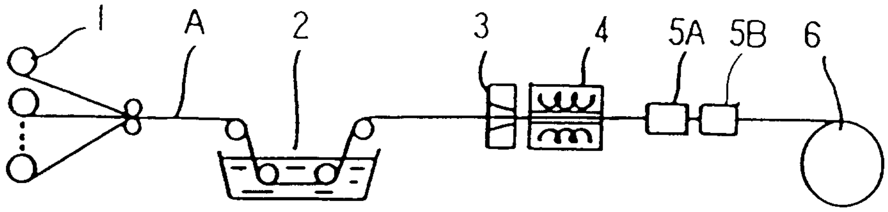


FIG. 3

(A)



(B)

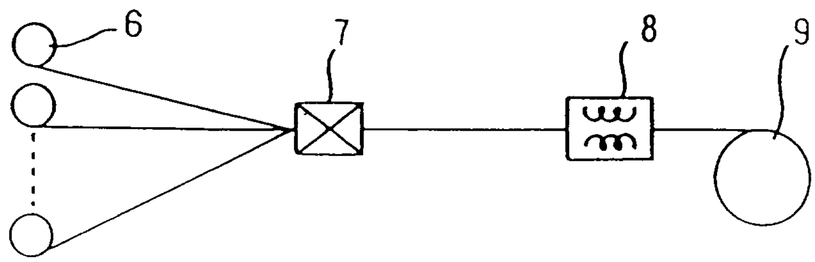
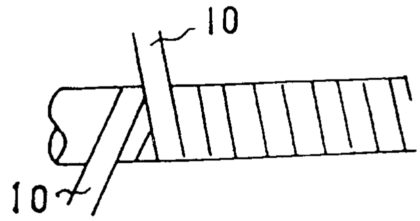


FIG. 4

(A)



(B)

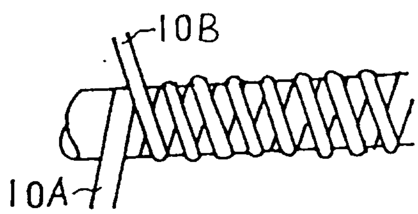
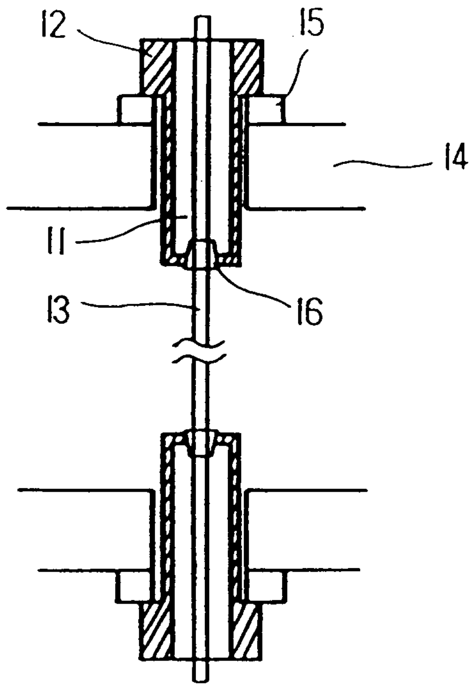


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP93/01894

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^5 D07B1/02, D07B1/16, D07B7/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^5 D07B1/00-9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1993
Kokai Jitsuyo Shinan Koho 1971 - 1993

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, U, 55-26070 (Fujikura Ltd.), February 20, 1980 (20. 02. 80), (Family: none)	1-9
A	JP, A, 53-134953 (Uozu Seikosho K.K.), November 25, 1978 (25. 11. 78), (Family: none)	5-9
A	JP, U, 49-119554 (Ikuo Ichiki), October 14, 1974 (14. 10. 74), (Family: none)	5-9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
March 9, 1994 (09. 03. 94)	March 29, 1994 (29. 03. 94)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.