(19) Europäisches Patentamt
European Patent Office
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(11) **EP 3 889 369 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.10.2021 Bulletin 2021/40

(51) Int Cl.:
E04C 5/07 *(2006.01)*

(21) Application number: **20213285.8**

(22) Date of filing: **11.12.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **16.12.2019 BE 201905907**

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Remarks:
Claim 19 is deemed to be abandoned due to non-payment of the claims fee (Rule 45(3) EPC).

(54) REINFORCING ELEMENT FOR CONCRETE

(57) Reinforcing element (1) for concrete, wherein this reinforcing element (1) comprises a bundle of resin-impregnated fibres, wherein the reinforcing element (1) successively comprises a first end section (2), a central section (3) and a second end section (4), wherein the bundle of fibres is twisted at the position of the central section (3).

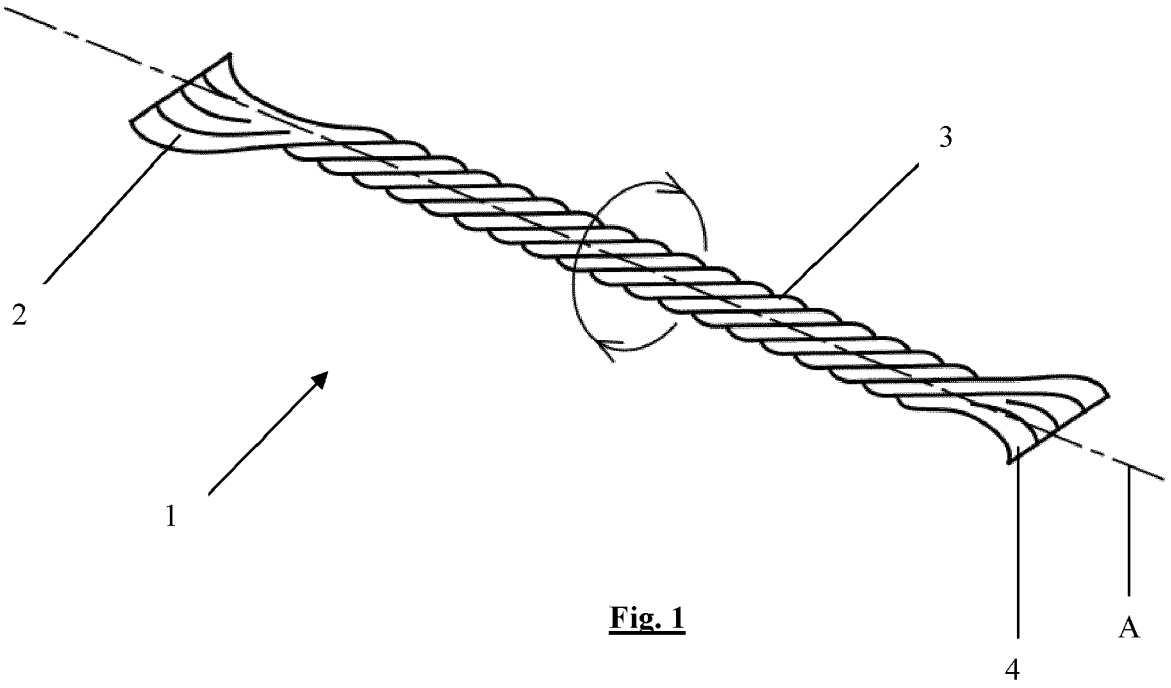

Fig. 1

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Description

[0001] The present invention relates to a reinforcing element for concrete, wherein this reinforcing element comprises a bundle of resin-impregnated fibres.

[0002] The present invention also relates to an assembly of such reinforcing elements and concrete comprising reinforcing elements.

[0003] The present invention also relates to concrete comprising reinforcing elements and a method for manufacturing a concrete construction.

[0004] There are different types of reinforcing elements for concrete. Thus, relatively large elements made from steel such as steel wire, steel reinforcement mats, etc. may be used. Since fitting these relatively large elements is laborious, smaller reinforcing elements are also available which are mixable with concrete and are mixed in with the concrete during production and mixing of the concrete, such as steel fibres. By means of steel fibres, it is also possible to give the concrete a certain degree of strength, but the use of steel fibres also has drawbacks. Thus, these steel fibres are inter alia prone to corrosion at the level of the concrete surface and the specific weight of steel fibres is greater than that of concrete. As a result thereof, steel fibres are less readily mixable with concrete, so that the distribution of steel fibres in the concrete is usually not uniform. Also, due to the force of gravity, steel fibres will start to sink while the concrete sets, as a result of which the concrete will comprise fewer steel fibres at the top than at the bottom. There is also a risk of these steel fibres protruding from the concrete or becoming exposed after the top layer has eroded, as a result of which animals may hurt themselves on these protruding steel fibres or tyres may be punctured as a consequence of these protruding steel fibres. Concrete which is reinforced with steel fibres is therefore not usable with architectural concrete or visible concrete, in animal sheds or at locations with a considerable amount of vehicle traffic.

[0005] Currently, use is made of glass fibres or plastic fibres to reinforce concrete. These glass fibres are treated, for example coated, in order thus to protect the fibres against the alkaline conditions which prevail in concrete. As a result of the treatment, the fibres become chemically resistant. These fibres mainly prevent the formation of cracks and more specifically the formation of hairline cracks in concrete and only contribute little to the strength of the concrete.

[0006] It is therefore an object of the invention to produce a reinforcing element for concrete, wherein this reinforcing element does not have the drawbacks of steel fibres, but which does contribute greatly to the strength of the concrete.

[0007] This object is achieved by providing a reinforcing element for concrete, wherein this reinforcing element comprises a bundle of resin-impregnated fibres, wherein the reinforcing element successively comprises a first end section, a central section and a second end section, wherein the bundle of fibres is twisted in the central section. Preferably, this reinforcing element only consists of a first end section, a central section and a second end section.

[0008] Here, the bundle of fibres comprises plastic fibres, glass fibres, basalt fibres, flax fibres or carbon fibres or a mixture of two or more of the abovementioned fibres.

[0009] The central section, which in this case is twisted, extends between the two abovementioned end sections. Preferably, the bundle of fibres is not twisted, or only to a minimal degree, at the position of said two end sections. Due to the central section being twisted, the fibres are under tension here and, in addition, due to the specific design of these reinforcing elements, in which the twisted central section is clamped between said two end sections, the central section will readily be able to absorb tensile stress in the concrete and these reinforcing elements will not only be able to withstand the formation of cracks, but will also contribute significantly to the strength of the concrete. The bundle of fibres preferably comprises glass fibres. These fibres do not corrode and have a specific weight which is relatively similar to the specific weight of concrete, so that they are readily mixable with the concrete and will not settle. If these reinforcing elements protrude from the concrete at certain locations, they are not dangerous to animals and tyres will not become punctured when they are being driven over them, so that concrete comprising these reinforcing elements is also usable as architectural concrete or visible concrete, in animal sheds and/or at locations with a large amount of vehicle traffic.

[0010] The bundle of fibres is twisted in the central section. Thus, in its central section, the bundle of fibres is turned in a specific direction of rotation and the bundle of fibres is thus twisted. Such a reinforcing element can easily be formed by starting with a bundle of fibres, in which case all the fibres extend along the same longitudinal direction, being a roving, wherein the bundle of fibres is then twisted locally in order thus to form it into a reinforcing element with said central section. Preferably, the reinforcing element extends in a longitudinal direction, at least at the position of the central section. The reinforcing element preferably has a total length of between 10 mm and 100 mm. The central section may have a virtually circular cross section with a diameter of between 0.5 mm and 2 mm. These reinforcing elements are preferably produced as follows. A long bundle of fibres, for example a roving, is used to start with. This roving is then successively, from the start to the end of the roving, impregnated with a resin and twisted locally. The roving may be placed in an oven in order to cure the resin. The resin may also be a UV curable resin, in which case UV light can be used to cure the resin instead of an oven. As a result of the twisting, the resin will be absorbed even better, thus resulting in an improved impregnation. After the resin has cured, the roving comprising resin is cut into pieces in order to form said reinforcing elements.

[0011] Preferably, the central section extends in a lon-

gitudinal direction and the fibres are twisted in the central section.

[0012] In a preferred embodiment, the fibres are twisted at between 10 and 50 twists per m (twists per metre, TPM) in the central section, still more preferably between 20 and 40 twists per m and the most preferably twisted at virtually 30 twists per metre. The widest range virtually corresponds to a twisting rate between 0.25 and 1.25 twists per inch (TPI, turns per inch, twists per inch).

[0013] In a preferred embodiment, the bundle of fibres is flattened at the position of at least one of said end section. In this case, said end section is a flattened end section. Furthermore preferably, the bundle of fibres is flattened at the position of both said end sections. The bundle of fibres is twisted in its central section and preferably has a virtually circular or an oval-shaped cross section. Due to the fact that at least one end section is flattened, the central section is under more tension and is very readily able to fulfil its function which consists in providing additional strength to the concrete. In addition, concrete is readily able to mechanically adhere to flattened elements, as a result of which the at least one said flattened end section provides a good adhesion to the reinforcing element by the concrete, as a result of which the reinforcing element is readily able to contribute to the strength of the concrete.

[0014] Furthermore preferably, the fibres are largely in a non-twisted position at the position of the at least one said flattened end section.

[0015] Also furthermore preferably, the fibres extend largely successively next to each other in the same straight or curved plane at the position of the at least one said flattened end section. In this case, the fibres form a large surface to which the concrete can adhere.

[0016] Also furthermore preferably, the central section extends in a longitudinal direction and said flattened end section is deflected with respect to said longitudinal direction or said flattened end section makes an angle with said longitudinal direction. In this case, the concrete is even better able to adhere to said flattened end section, since it is not in line with the central section, but is deflected from the central section or makes an angle with the latter. Thus, the flattened end section here also provides good adhesion for the concrete. Preferably, the bundle of fibres is flattened at the position of both said end sections. If both end sections are deflected from or make an angle with the central section, then this is preferably in an opposite direction. This results in a very good adhesion to the concrete as a result of which the reinforcing element is very readily able to absorb stresses in the concrete.

[0017] In a highly preferred embodiment, the fibres are glass fibres. Glass fibres do not corrode. Due to the fact that the glass fibres in this case are impregnated with a resin, they are also very durable and do not deteriorate when they are situated in concrete. Glass fibres have a small degree of expansion, as a result of which the risk of cracks appearing in the concrete is reduced. Glass fibres are not prone to stick together and have a specific weight which corresponds to that of concrete, as a result of which they are readily mixable with concrete in a homogenous manner and they do not settle in the concrete. Glass fibres are not dangerous to animals or cause punctures in tyres. Preferably, the resin comprises an epoxy resin, a polyurethane resin or a polyester resin. Preferably, the resin is an epoxy resin, a polyurethane resin or a polyester resin. These resins ensure that the fibres are protected against the alkaline conditions in the concrete, as a result of which the fibres are not damaged by the concrete and can thus give the concrete strength for a sufficiently long time.

[0018] In a highly preferred embodiment, the resin is a water-absorbing resin. These reinforcing elements are configured to be mixed with concrete, before or while the concrete is being poured, that is to say when the concrete is still in a liquid condition. Thereafter, the concrete containing the reinforcing elements sets. In the liquid condition, the concrete contains a large amount of water. Since the resin is water-absorbent, the resin will consequently start to absorb water. As a result thereof, the resin will soften and the fibres may deform. Thus, the bundle of fibres may become slightly untwisted at the position of the central section and thus become longer. During curing of the concrete, the absorbed water will also leave the resin and the fibres will want to return to their original shape. The central section will want to return to its twisted shape and will thus become less long, as a consequence of which it will exert a certain prestress to the concrete and thus provide additional strength to the concrete. As a result, concrete comprising these reinforcing elements has a very high tensile strength.

[0019] Furthermore preferably, this resin is able to absorb at least 1 time its volume in water, still more preferably is able to absorb at least 3 times its volume in water and most preferably is able to absorb up to 5 times its volume in water. This results in a significant increase in weight of the reinforcing element when adding the reinforcing element to wet concrete which is annulled when the concrete sets.

[0020] Preferably, the weight of the resin accounts for 10 to 30 percent of the total weight of the reinforcing element. Still more preferably, the weight of the resin accounts for 15 to 25 percent of the total weight of the reinforcing element. Preferably, the reinforcing element only comprises the bundle of fibres and the resin, so that the weight of the bundle of fibres then preferably accounts for 70 to 90 percent of the total weight of the reinforcing element. If the resin is a water-absorbing resin as described above, this means that when the reinforcing element has been added to wet concrete, an increase in weight of for example 20 to 120% occurs because of the absorption of water. During setting of the concrete, the water leaves the reinforcing element and the latter regains its original weight.

[0021] The object of the invention is also achieved by providing an assembly of reinforcing elements for con-

crete, wherein this assembly comprises reinforcing elements as described above. The advantages and preferred embodiments described above for the reinforcing elements according to the invention also apply to this assembly according to the invention.

[0022] Preferably, said reinforcing elements according to the invention comprise a first group of reinforcing elements in which the central section of this first group of reinforcing elements is twisted in a clockwise direction, and a second group of reinforcing elements in which the central section of this second group of reinforcing elements is twisted in a counterclockwise direction. There are in this case therefore reinforcing elements with a central section which is twisted in a clockwise direction and reinforcing elements with a central section which is twisted in a counterclockwise direction. There are thus central sections which twist to the right and central sections which twist to the left. Therefore, there are at least two types of reinforcing elements with a different direction of rotation. The direction of rotation is the direction of the first end section towards the second end section. Preferably, the first end section and the second end section are configured differently in this case, so that there is a clear difference between the first and the second end section. Thus, the first and the second end sections may be flattened along surfaces which make an opposite angle with or are deflected from the central section or the end sections may each be flattened in a different way. Preferably, the construction of the reinforcing elements from the first group is virtually identical and, also preferably, the construction of the reinforcing elements from the second group is virtually identical. Concrete which is mixed with this assembly will have a high tensile strength, since the reinforcing elements will ensure that tensile stress is absorbed in all kinds of different directions/senses. Even if the mixture is not homogenous, this assembly will still result in a concrete of sufficient strength. An additional advantage is the fact that such an assembly can be produced in very simple manner. This is due to the fact that it is possible to take one long bundle of fibres (roving) and treat it with a resin, successively twist the fibres in a clockwise direction, flatten them, twist them in a counterclockwise direction, flatten them, etc. In this way, one long roving is produced which can then be cut at the position of the flattened portions in order thus to obtain a said assembly of reinforcing elements. The advantage of successively twisting in opposite directions of rotation is that there is no risk of the roving being twisted excessively and breaking.

[0023] Furthermore preferably, the first group of reinforcing elements accounts for 10 to 90% of all reinforcing elements. Still more preferably, the first group of reinforcing elements accounts for virtually 50% of all reinforcing elements.

[0024] Also furthermore preferably, the second group of reinforcing elements accounts for 10 to 90% of all reinforcing elements. Still more preferably, the second group of reinforcing elements accounts for virtually 50% of all reinforcing elements.

[0025] In a highly preferred embodiment, the reinforcing elements only comprise reinforcing elements according to the invention. Then, a number of reinforcing elements is purchased and added to the concrete prior to or during the production thereof. If desired, it is obviously also possible to add yet other reinforcing elements which do not form part of the assembly according to the invention.

[0026] The object of the invention is also achieved by providing concrete comprising reinforcing elements, wherein these reinforcing elements comprise reinforcing elements according to the invention and, still more preferably, wherein these reinforcing elements form part of an abovementioned assembly according to the invention.

[0027] The object of the invention is also achieved by providing a method for manufacturing a concrete construction, wherein concrete is produced and reinforcing elements are mixed in with this concrete while the concrete produced is still in its liquid state in order to produce a liquid mixture, wherein this liquid mixture is poured into the desired form and this mixture is allowed to set in order to form the concrete construction, wherein the reinforcing elements comprise reinforcing elements according to the invention. Preferably, these reinforcing elements form part of a said assembly according to the invention.

[0028] Preferably, the resin of the reinforcing elements is a water-absorbing resin, so that this resin absorbs water when the concrete is still in a liquid state and thus the bundles of fibres of the reinforcing elements become slightly untwisted at the position of the central section and become longer, and wherein, during setting of the concrete, the absorbed water leaves the resin and the bundles of fibres return to their original shape in order thus to form a concrete construction comprising prestressed concrete.

[0029] The present invention will now be described in more detail by means of the following detailed description of a preferred embodiment of reinforcing elements and an assembly according to the present invention. The sole aim of this description is to give illustrative examples and to indicate further advantages and features and can therefore by no means be interpreted as a limitation of the area of application of the invention or of the patent rights defined in the claims.

[0030] In this detailed description, reference numerals are used to refer to the attached drawings, in which:

- ***Fig. 1*** shows a perspective view of a first embodiment of a reinforcing element according to the invention;
- ***Fig. 2*** shows a perspective view of a second embodiment of a reinforcing element according to the invention;
- ***Fig. 3*** shows a side view of a portion of the reinforcing element illustrated in Fig. 1 and a portion of the reinforcing element illustrated in Fig. 2;
- ***Fig. 4*** shows a side view of two portions of reinforcing

elements according to a third embodiment;

- ***Fig. 5*** shows a side view of two portions of reinforcing elements according to a fourth embodiment;
- ***Fig. 6*** shows a side view of two portions of reinforcing elements according to a fifth and a sixth embodiment.

[0031] In the figures, different embodiments of reinforcing elements (1) according to the invention are illustrated. All these reinforcing elements (1) comprise a bundle of glass fibres which is impregnated with an optionally water-absorbing epoxy resin. The reinforcing elements (1) consist of, successively, a first end section (2), a central section (3) and a second end section (4). At the first and the second end sections (2, 4), the bundle of fibres is flattened, so that these comprise straight surfaces or curved surfaces. At the position of the central section (3), the bundle of fibres is twisted in such a way that the central section (3) extends in a longitudinal direction (A), has a circular cross section and comprises between 10 and 50 twists per m.

[0032] At the position of the end sections (2, 4), the fibres extend next to each other and are hardly twisted, if at all. In the first, the second and the third embodiment illustrated in Figs. 1 to 4, the end sections (2, 4) are flattened in such a way that they curve with respect to the longitudinal direction (A). In the fourth embodiment, illustrated in Fig. 5, the end sections (2, 4) extend along a plane which extends in said longitudinal direction (A) of the central section (3). In the fifth and sixth embodiment, the end sections (2, 4) are flattened and deflected from the central section (3) in such a way that they comprise three successive parts, respectively a first part which curves with respect to the longitudinal direction (A), a second part which extends virtually parallel to the longitudinal direction (A) and a third part which is deflected from the second part.

[0033] The reinforcing elements (1) illustrated in Figs. 1 and 2 and the reinforcing elements (1) illustrated in Fig. 6 preferably form part of an assembly of reinforcing elements (1), wherein this assembly comprises virtually 50% of reinforcing elements (1) of the first embodiment or the fifth embodiment and comprises virtually 50% of reinforcing elements (1) of the second embodiment or the sixth embodiment. In the first and the fifth embodiment, the central section (3) is twisted in a clockwise direction, viewed from the first end section (2) towards the second end section (4), and in the second and the sixth embodiment, the central section (3) is twisted in a counterclockwise direction, viewed from the first end section (2) towards the second end section (4). Since the assembly comprises virtually 50% of central sections (3) which are twisted in a counterclockwise direction and comprises virtually 50% of central sections (3) which are twisted in a clockwise direction, this assembly is very suitable to be mixed with concrete in order to provide additional strength to the concrete. The reason for this is that, even in case of a less homogenous mixing of the reinforcing elements (1) in the concrete, the reinforcing elements (1) will absorb the tensile stress in different directions and senses, as a result of which concrete comprising this assembly is very strong.

Claims

1. Reinforcing element (1) for concrete, wherein this reinforcing element (1) comprises a bundle of resin-impregnated fibres, **characterized in that** the reinforcing element (1) successively comprises a first end section (2), a central section (3) and a second end section (4), wherein the bundle of fibres is twisted in the central section (3).

2. Reinforcing element (1) according to Claim 1, **characterized in that** the fibres are twisted at between 10 and 50 twists per m in the central section (3).

3. Reinforcing element (1) according to one of the preceding claims, **characterized in that** the bundle of fibres is flattened at the position of at least one said end section (2, 4).

4. Reinforcing element (1) according to Claim 3, **characterized in that** the fibres are largely in a non-twisted position at the position of the at least one said flattened end section.

5. Reinforcing elements (1) according to Claim 4, **characterized in that** the fibres extend largely successively next to each other in the same straight or curved plane at the position of the at least one said flattened end section (2, 4).

6. Reinforcing element (1) according to one of Claims 3 or 5, **characterized in that** the central section (3) extends in a longitudinal direction (A) and said flattened end section (2, 4) is deflected with respect to said longitudinal direction (A) or makes an angle with said longitudinal direction (A).

7. Reinforcing element (1) according to one of the preceding claims, **characterized in that** the resin is a water-absorbing resin.

8. Reinforcing element (1) according to Claim 7, **characterized in that** the resin is able to absorb at least 1 time its volume in water.

9. Reinforcing element (1) according to one of the preceding claims, **characterized in that** the weight of the resin accounts for 10 to 30 percent of the total weight of the reinforcing element (1).

10. Reinforcing element (1) according to one of the preceding claims, **characterized in that** the fibres are

glass fibres.

11. Reinforcing element (1) according to one of the preceding claims, **characterized in that** the resin comprises an epoxy resin, a polyurethane resin or a polyester resin.

12. Assembly of reinforcing elements (1) for concrete, wherein this assembly comprises reinforcing elements (1) according to one or more of Claims 1 to 11.

13. Assembly according to Claim 12, **characterized in that** said reinforcing elements (1) according to one or more of Claims 1 to 11 comprise a first group of reinforcing elements (1) in which the central section (3) of this first group of reinforcing elements (1) is twisted in a clockwise direction, and a second group of reinforcing elements (1) in which the central section (3) of this second group of reinforcing elements (1) is twisted in a counterclockwise direction.

14. Assembly according to Claim 13, **characterized in that** the first group of reinforcing elements (1) accounts for 10 to 90% of all reinforcing elements (1).

15. Assembly according to Claim 13 or 14, **characterized in that** the second group of reinforcing elements (1) accounts for 10 to 90% of all reinforcing elements (1).

16. Assembly according to one or more of Claims 12 to 15, **characterized in that** the reinforcing elements (1) comprise only reinforcing elements (1) according to one or more of Claims 1 to 11.

17. Concrete comprising reinforcing elements (1), **characterized in that** the reinforcing elements (1) comprise reinforcing elements (1) according to one or more of Claims 1 to 11.

18. Method for manufacturing a concrete construction, wherein concrete is produced and reinforcing elements (1) are mixed in with this concrete while the concrete produced is still in its liquid state in order to produce a liquid mixture, wherein this liquid mixture is poured into the desired form and this mixture is allowed to set in order to form the concrete construction, **characterized in that** the reinforcing elements (1) comprise reinforcing elements (1) according to one or more of Claims 1 to 11.

19. Method for manufacturing a concrete construction according to Claim 18, **characterized in that** the resin of the reinforcing elements (1) is a water-absorbing resin, so that this resin absorbs water when the concrete is still in a liquid condition and thus the bundles of fibres of the reinforcing elements (1) become slightly untwisted at the position of the central section (3) and become longer, and wherein, during setting of the concrete, the absorbed water leaves the resin and the bundles of fibres return to their original shape in order thus to form a concrete construction comprising prestressed concrete.

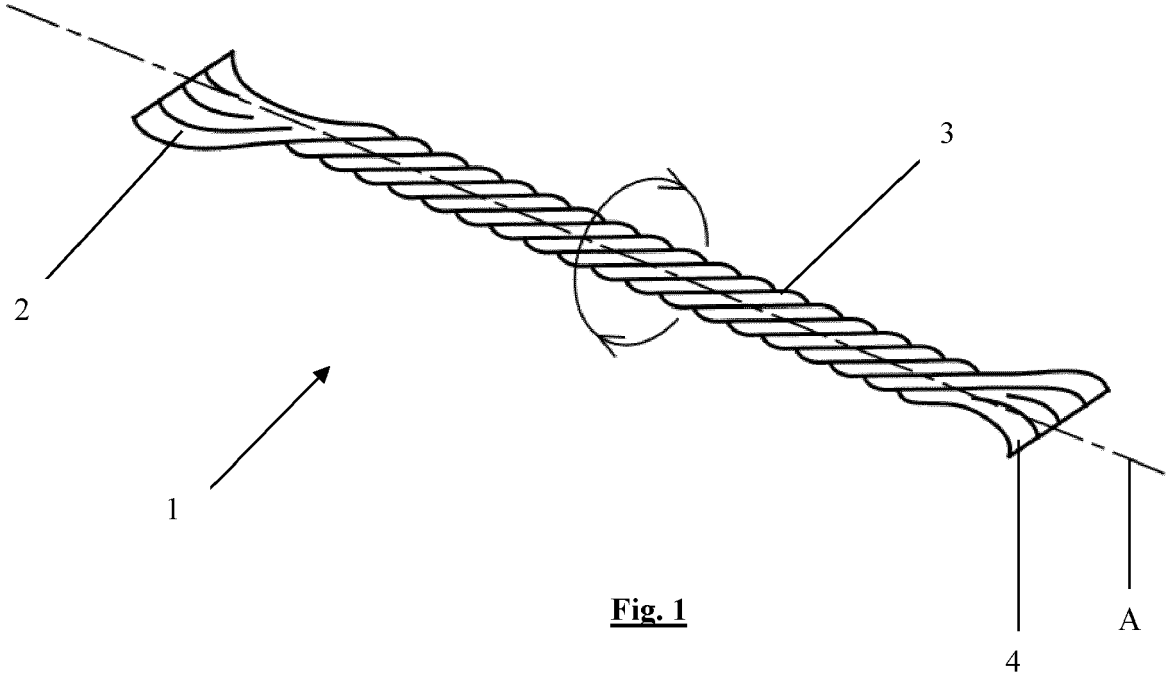

Fig. 1

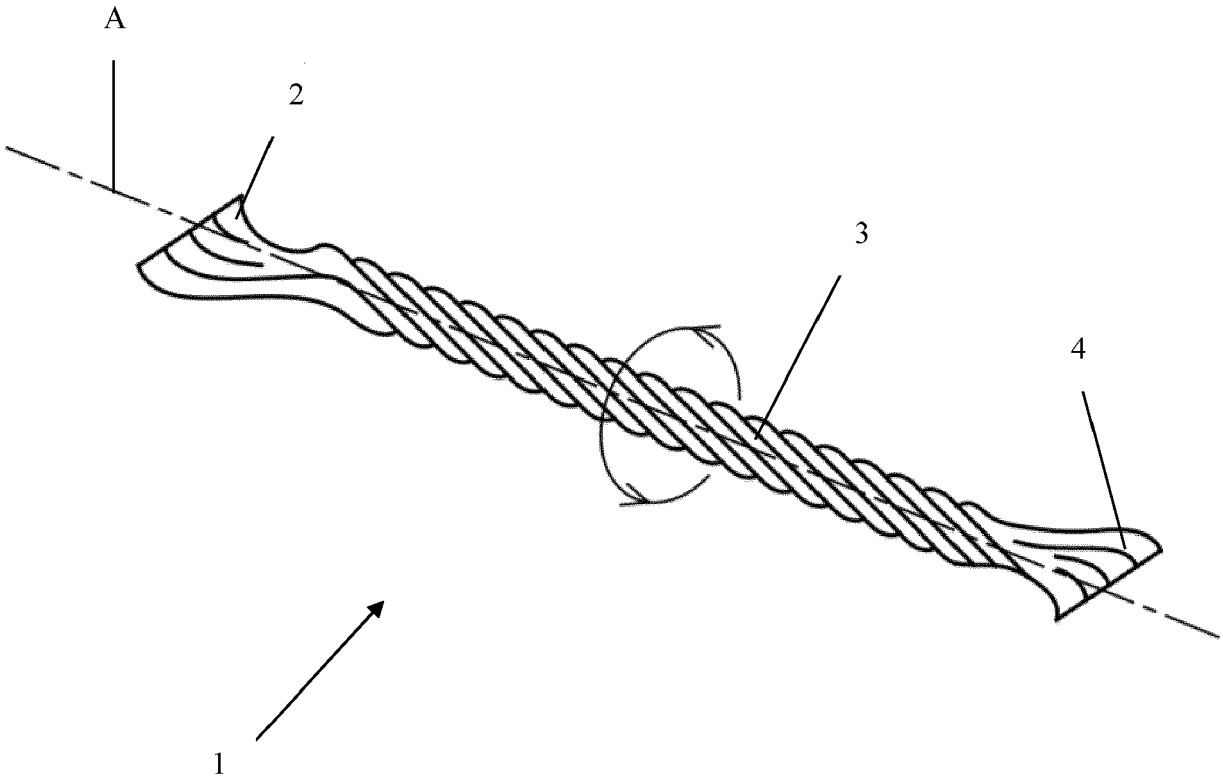

Fig. 2

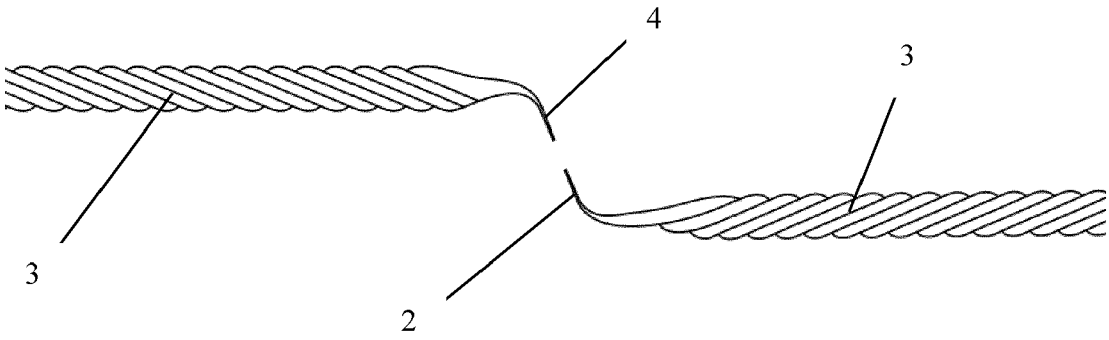

Fig. 3

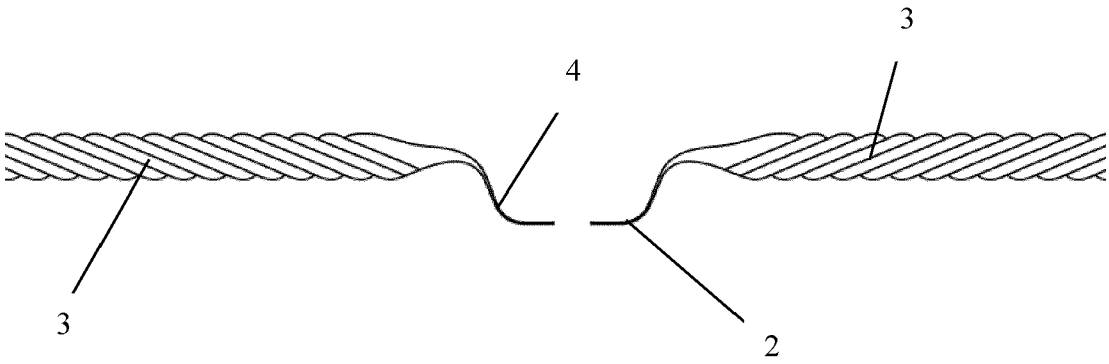

Fig. 4

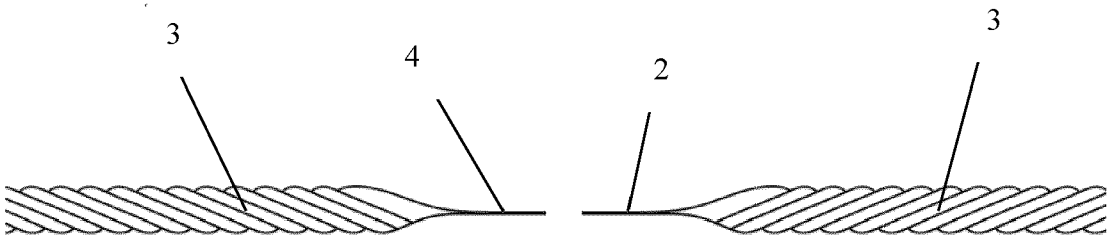

Fig. 5

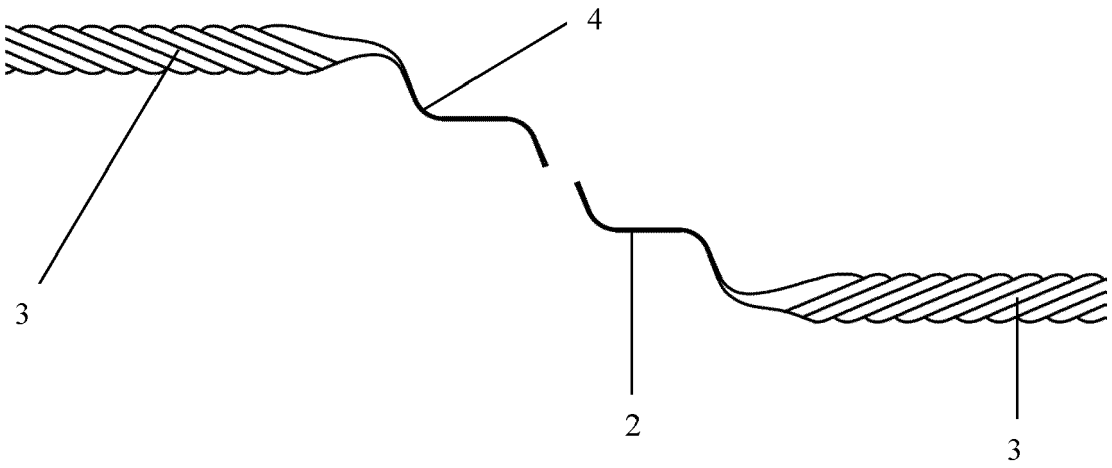

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 3285

DOCUMENTS CONSIDERED TO BE RELEVANT

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1	X	WO 2012/053901 A1 (REFORCETECH LTD [IE]; STANDAL PER CATO [NO]; MILLER LEONARD W [NO]) 26 April 2012 (2012-04-26) * page 1, line 4 - page 19, line 33; figures 1-5 *	1-18	INV. E04C5/07
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3	X	WO 2017/171668 A1 (KORDSA TEKNIK TEKSTIL ANONIM SIRKETI [TR]) 5 October 2017 (2017-10-05) * page 2, line 20 - page 9, line 16; figures 1-3b *	1-6, 11-18	
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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	31 August 2021	Dieterle, Sibille

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 20 21 3285

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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