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(54) **Stand for prestressing of concrete components.**

(57) A strand for prestressing of concrete components, which strand (10) is made up of at least one central wire (4) and of a plurality of surface wires (1) twined around it, the central wire or wires running substantially without spiral in the longitudinal direction of the strand. The cross sectional area of the central wire (4) has been shaped so, or the strand (10) contains a plurality of central wires so located and dimensioned, that the envelope (6) of the cross section of the strand is made up of a combination of sections of two circles (Y1, Y2) of different radii (R1, R2) and is thus not rotationally symmetric.

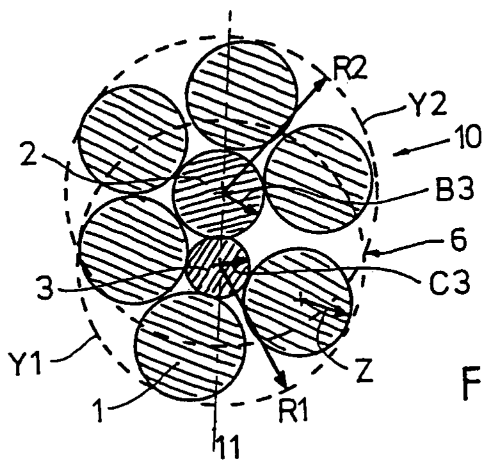

Fig.1

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The invention relates to a strand for prestressing of concrete components, which strand is made up of at least one central wire and of a plurality of surface wires twined around it, the central wire or wires running substantially without spiral in the longitudinal direction of the strand.

Prestressing strands are used in concrete structures in order to obtain pretensioning in the concrete by producing tensile stress in the strand before the casting of the concrete structure. Conventionally a strand is made up of six individual surface wires twined around a central wire. The pretensioning of the strand is of an order of 50-70 % of the ultimate strength. Concrete components such as hollow-core slabs are manufactured by slipforming in casting machines, specifically made for that purpose, onto form tables 90-150 meters long, from which they are after a very short hardening period sawn into components of predetermined length. When releasing the pretensioning the concrete has not yet reached its final strength.

Various machines and methods are used for the casting of hollow-core slabs. Conventional "Canadian" machines cast a mix with high plasticity, and the mix is vibrated during the casting. The cycle of the form in this method is relatively slow, and in this case there are also no problems with the adhesion of the strand to the concrete.

"Finnish" machines are different, and more economical in terms of production technology. In them a hard mix is cast using shear-compacting techniques, without any major vibration. The cycle of the form is rapid, and when a smooth strand is used there do appear problems with its adhesion. Therefore, where these methods are used, a shift has been made to a strand in which the outer wires are profiled, for example in the same manner as in conventional cold-worked concrete reinforcing steels, and by this method the worst slip problems have been brought under control. The adhesion of the strand to the concrete mix should, however, be further improved, considering, for example, concrete slabs of a more demanding fire class, in which the adhesion must hold also during a fire.

The transfer of force between a smooth strand and concrete is based on almost pure shear stress between the strand surface and the concrete. The stress spreads over only a very narrow area of concrete around the strand, and so the failure of adhesion will occur very suddenly, which is highly disadvantageous. The use of surface patterning in the surface wires somewhat widens the area over which the stress from the strand is distributed into the concrete. The effect is thus not very good, and the deepening of the surface pattern to improve adhesion properties also causes problems in manufacturing techniques, since the wire from which the strand is made must be work-hardened to a very high degree, and working it further to deepen the surface pattern is difficult.

Finnish patent application 873196 describes an arrangement in which the surface wires are polygonal and are twined about their longitudinal axis during or after the profiling. Thereby a relatively large adhesion surface is obtained between the outer wires and the concrete, and at the same time, under the effect of the twining, the shape of the strand is made varied in the direction of the spiral, in which case the slipping of the strand in the direction of the screw line of the strand spiral becomes more difficult. Thereupon compressive stress is produced in the concrete under the effect of discontinuity, and the stress considerably promotes the adhesion of the strand by expanding the area of effect of the stress. However, the manufacture of a strand such as this requires machines of a quite specific type for working the surface wire by drawing, the production speed of these machines being presumably quite slow, and so the manufacture will be relatively expensive and may also involve many problems with manufacturing technology.

Finnish patent 73039 proposes a structure in which the core of the strand is made up either of two wires twined around one another, the basis of their cross section being a circle, or of one wire twined about its own axis, the cross section of the wire being flattened, and of surface wires twined around this core, in which case the direction of the spiral of the core is opposite to that of the spiral of the outer wires. In this latter solution the changes of the cross sectional shape in the direction of the spiral of the outer wires are extensive, and the adhesion to concrete is excellent. The manufacture of a strand such as this is, however, quite expensive, since it presupposes two successive stranding steps, one for the core and the other for the surface wires. A corresponding double strand has also been described in the publication US-3 032 963, although by using a triple-wire core. Its targeted use is not the reinforcing of concrete but of automobile tires.

Publication DE-2 044 665 also describes an automobile-tire reinforcement cable which is made up of a multiple-wire core, the wires running in the longitudinal direction of the wire, and of surface wires twined around this core. According to the publication, the cable additionally contains a tie wire wound around the surface wires, the tie wire preventing the unwinding of the strand. This indicates that the stranding is relatively loose, in which case the outer wires remain in the plane of the circle constituting the envelope, and a change of the cross sectional area in the direction of the spiral of the outer wires has not been achieved. It would evidently not have much significance in a material as elastic as rubber; in the targeted use concerned the aim seems to be simply to achieve a maximally large surface area for the steel cable.

The object of the present invention is to provide a strand the cross section of which in the direction of the spiral of the surface wires varies considerably, thus making it possible for the stress transferred from the strand to the concrete mass to spread over a large area in the concrete, which will thus prevent a screw line slip of the strand. It is a further object of the invention to provide a strand of this type which could be manufactured by conventional stranding machines and in one stranding step. This means that the above-mentioned change in the cross section must not be based on a separate stranding of the core or on a specific spiral of the surface wires. Since in a strand the surface wires are hardened considerably even before the stranding step, and the stranding is made tight, in which case the surface wires will follow quite closely the shape of the core, it is one object of the invention that the surface wires will at no point of the stranding be subjected to excessive deformation such as bending, which would reduce the strength of the strand.

The disadvantages described above can be eliminated and the defined objectives can be achieved by using a strand according to the invention, which is characterized in what is stated in the characterizing clause of Claim 1.

It is the most important advantage of the invention that the strand can be manufactured in one step by conventional stranding machines, while nevertheless obtaining a cross section varied in the direction of the spiral of the strand, in which case the strand will have excellent adhesion to the concrete mass. In addition, the strand can be made from conventional hard surface-wire having a round cross section, without the surface wires being damaged during the stranding and the subsequent thermomechanical relaxation.

The invention is described below in detail, with reference to the accompanying figures.

Figure 1 depicts a cross section of one embodiment of the strand according to the invention.

Figure 2 depicts a cross section of another embodiment of the strand according to the invention.

Figure 3 depicts one preferred embodiment of the core of the strand according to the invention.

Figure 4 depicts another preferred embodiment of the core of the strand according to the invention.

The structural principle of the strand 10 according to the invention can be seen in Figures 1 and 2. The surface wires 1 of the strand are wires which have a circle as the basis for their cross section, but which may have commonly used surface textures, ridges or grooves to improve adhesion. The surface wires 1 are thus of the type conventionally used in strands, and they are not described here in greater detail.

In Figure 1 the core of the strand is made up of two separate central wires 2 and 3, which have a circle-based cross-sectional shape, the radius B3 of one central wire 2 being greater than the radius C3 of the other central wire 3. These two central wires 2, 3 of different sizes run without spiral in the longitudinal direction of the strand 10. When the surface wires 1 run helically, tightly drawn, around such a core, in which case the inner surface of the surface wires 1 at each given time follows closely the surface of the central wires, the envelope 6 of the outer surfaces of the outer wires will form a surface combination made up of two cylindrical sections. This is understandable, since the larger-radius central wire 2 constitutes the cross section of the core for one side of the outer surface of the strand and the smaller-radius central wire 3 for the other side. The cross section is thus made up of a combination of sections of two circles having different radii R2 and R1, and is thus not rotationally symmetric with respect to any axis. More particularly, the cross section of the envelope 6 of the strand 10 hereby has only one symmetry plane 11 or 12 at the most, which have been shown in figures 1 and 2. No other symmetry planes or lines can be found in the envelope of the strand. It is clear that the strand according to the invention can also be of the kind that it has no symmetry plane at all. The outer surface of the strand is thus made up of a first cylindrical surface Y1 having the radius R1 and of a second cylindrical surface Y2 having the radius R2, and the distance between the center lines of these cylindrical sections is the sum of the radii of the central wires, i.e. B3 + C3. The strand is thus in the longitudinal direction a combination of two parallel cylindrical surfaces, but the surface wires run helically relative to the cylindrical axes, their cross-sectional area changing periodically as viewed in their spiral direction. In this embodiment the radius B3 of one central wire is preferably 5-15 % greater than the radius C3 of the other central wire 3.

In Figure 2, the effect described above has been produced by using three central wires 2a, 2b and 3 without spiral, the radius C4 of two of them being greater than the radius B4 of the third wire 3. In this case the two greater-radius central wires 2a and 2b together constitute the core of the effectively greater-radius R2 cylinder, and the smaller-radius core wire 3 constitutes the core of the smaller-radius R1 cylinder. The envelope 6 is thus also in this case made up of a cylinder section having radius R1 and a cylinder section having radius R2. The difference as compared with the embodiment of Figure 1 is that the smaller-radius cylinder section is within the larger-radius cylinder section, whereas in Figure 1 the smaller-radius section extends beyond the greater-radius section. When three central wires are used, the proportions of the thicknesses of the central wires may be also other than those described above, for example one of the wires may be thicker than the other two, in which case a strand with an envelope closely resembling the embodiment of Figure 1 is obtained. All the three central wires may also be of different sizes, although in this case defining the effective radii for the cylinder sections will be somewhat more difficult. Thus, preferably the radius of at least one central wire is 5-30 % greater or smaller than the radii of the other central wires. The functioning of such a strand in concrete is, however, always the same when the dimensioning of the central wires is correctly selected.

In certain stranding machines, however, mechanical problems are encountered in the making of a two- or three-wire core. In addition, such a strand structure limits the design of the core, since, when two wires are used, the distance between the wires is absolutely the sum of their radii and in a three-wire case, respectively, always the sum of the radii of two wires. Thus the shape of a core made up of central wires is defined when the diameters of the wires are given. This may cause problems in that the deformation of the surface wires may in places be too great, thus causing damage.

Figure 3 depicts one preferred single-wire variant of the central-wire combination of Figure 1 for the core, and Figure 4 depicts another preferred single-wire variant of the three-wire core of Figure 2. As can be seen from the figures, the single-wire core 4, 5 is triangular in shape and preferably substantially an isosceles, the apex angle of which is α or respectively β. The apex angle is the angle between the straight lines tangent to the rounding of the apex of the triangular shape and to the roundings of the other angles. The rounding radii of the angles of the triangles are B1 and C1 in the case of Figure 3 and B2 and C2 in the case of Figure 4. Especially in the case of Figure 3 it can thus be seen that the roundings of the angles on the side opposite to the apex angle α coincide, forming one rounding B1. The rounding of the apex angle is C1 in magnitude, the sides of the triangle thus being made up of tangents to these two circles when C1 is smaller than B1. These tangents are in this case straight lines. Since the rounding radii B1 and C1 are different in magnitude, this single central wire 4 works in the same manner for forming two envelope circles Y1 and Y2 as do the two central wires of Figure 1. This design of the central wire 4 is, however, considerably more flexible, since the distance S1 between the center points of the circles B1 and C1 can be selected freely and is in this case smaller than the sum of the radii. Furthermore, since the tangent surfaces 7 can be designed not only straight in the manner depicted but also cylindrically convex or in some other shape, it is easy in accordance with the principle of the invention to obtain for the central wire a shape which produces a sufficiently great cross-sectional difference in the direction of the spiral and at the same time a sufficiently small deformation in the surface wire. To illustrate this, a circle having radius A has been drawn around the central wire 4, tangent to the wire. If the central wires were stranded around a circular core having radius A, the result would, of course, be a rotationally symmetric strand. The change of cross section in the direction of the spiral, required by the objects of the invention, is thus implemented using a triangular shape, which in this case is made up of two circles having different radii B1, C1, and the sufficiently slight deformation of the surface wires is achieved by designing the sides 7 of the triangle so that the deviation D1 of the side from the circular shape is sufficiently small and the radii B1, C1 are sufficiently great. These both can also be affected by the distance S1 between the center points of the circles. The said deviation D1 should be within a range of approx. 5 - 45 % of the radius A of the circle drawn around, and preferably within a range of 10 - 30 % of this radius A. Respectively, excessive deformation of the surface wires is avoided by forming the rounding radii B1 and C1 approximately within a range of 40 % - 120 % of the radius Z of the outer wires and preferably within a range of 60 % - 105 % of the radius Z of the outer wires.

In the case of Figure 3, described above, the apex angle α is an acute angle. In the other extreme case the apex angle β may also be an obtuse angle, as in the case of Figure 4. In it, the angles on the side opposite the apex angle β of the triangular central wire 5 have been rounded using radius B2, the distance S2 between the center points of the corresponding circles being greater than the sum of the radii. In this case the rounding radius C2 of the apex angle is smaller than the radii B2. In this case, also, the roundings B2 and C2 are within a range of 40 % - 120 % of the radius of the outer wires and preferably 60 % - 105 % of the radius Z of the outer wires. In addition, the sides of the triangular central wire 5 are curved cylindrically outward, in which case the deviations D3 and D2 between the circle drawn using radius A around the central wire and sides 8 and 9 of the central wire will be sufficiently small so that excessive deformation is not produced in the outer wires. These deviations D2 and D3 are, as above, approx. 5 % - 45 % of the radius A of the circle drawn around the wire, and preferably approx. 10 % - 30 % of this circle radius A. In this case, the rounding radii B2 and the side 8 constitute the core of the envelope having the greater radius R2 according to the invention, and the smaller rounding C2 generates the core of the cylindrical envelope having the smaller radius R1.

It is clear that the alternatives depicted in Figures 3 and 4 can be developed into even more extreme implementations within the limits described above, or intermediate forms of them can be produced.

Thus, in the case of Figure 4, the circles B2 may be even further apart from each other, or they may intersect each other. Likewise, circle C2 may be located further away from the circles B2, or it may intersect both of them. The curvatures of the sides 8 and 9 must in each case be designed so that the dimensions D2 and D3 will be within the given range. Likewise, of course, the radii B2 and C2 must simultaneously be of the defined magnitude. Understandably, intermediate forms of the embodiments of Figures 3 and 4 can be obtained easily by imagining that the circles B2 in Figure 4 are moved gradually towards each other until they coincide, whereupon the implementation of Figure 3 has been arrived at. One further intermediate form is a shape of the type of an equilateral triangle, which may contain any of the roundings described below. When applying the one central wire 5, depicted in principle in Figure 4, it must be understood that the circles B2 which constitute one basis for the rounding may either intersect each other, be tangent to each other or be separated from each other as in the figure. It is clear that also with an alternative in which the radii of the circles B2 are smaller than the radius of circle C, the envelope according to the invention is obtained for a strand. This is understandable for the reason that the greater radius R2 of the envelope is based on the joint effect of the two circles B2 and the side 8 between them, this effect having simply to be effectively greater than the third circle C2.

Claims

1. A strand for prestressing of concrete components, which strand (10) is made up of at least one central wire (2, 3; 4; 5) and of a plurality of surface wires (1) twined around it, the central wire or wires running substantially without spiral in the longitudinal direction of the strand, **characterized** in that the cross-sectional area of the central wire (4; 5) has been shaped so, or the strand (10) contains a plurality of central wires (2, 3) so located and dimensioned, that the envelope (6) of the cross section of the strand will be made up of a combination of sections (Y1, Y2) of two circles having different radii (R1, R2) and is thus not rotationally symmetric.

2. A strand according to Claim 1, **characterized** in that the strand comprises two central wires (2, 3) approximately circular in cross section, the diameters of the wires being of different sizes, and that the radius (B3) of one of these central wires is 5 - 15 % greater than the radius (C3) of the other central wire.

3. A strand according to Claim 1, **characterized** in that the strand comprises three central wires (2a, 2b, 3) approximately circular in cross section, the diameter of at least one of the wires being 5 - 30 % greater or respectively smaller than the radius of the other central wires.

4. A strand according to Claim 1, **characterized** in that the strand comprises one central wire (4; 5) having a substantially triangular cross-sectional shape, each side surface (7; 8, 9) of the wire being at a distance (D1, D2, D3) inward from a circle drawn around the wire, the distance being approx. 5 % - 45 % of the radius (A) of the circle in question, and preferably approx. 10 % - 30 % of the radius (A) of this circle.

5. A strand according to Claim 4, **characterized** in that the triangular shape of the central wire (4; 5) corresponds to an isosceles, the apex angle (α, β) between its equal sides being within a range of approx. 2° - 150°.

6. A strand according to Figure 5, **characterized** in that the angle (α and respectively β) between the equal sides of the triangular shape of the central wire (4; 5) is preferably within the range 5° - 30° or alternatively within the range 90° - 120°.

7. A strand according to any of the above claims, **characterized** in that the radii (B1, C1; b2, C2) of the roundings of the angles of the central wire (4; 5) and respectively the radii (B3, C3; B4, C4) of the central wires (2, 3) are 40 % - 120 % of the radius (Z) of the outer wires and preferably 60 % - 105 % of the radius (Z) of the outer wires.

8. A strand according to Claim 1, **characterized** in that the envelope (6) of the cross section of the strand (10) has only one symmetry line (11; 12) at the most.

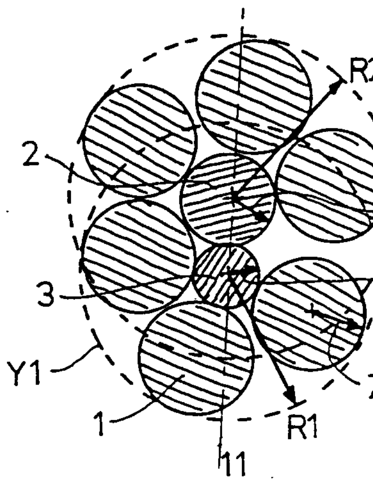

Fig. 1

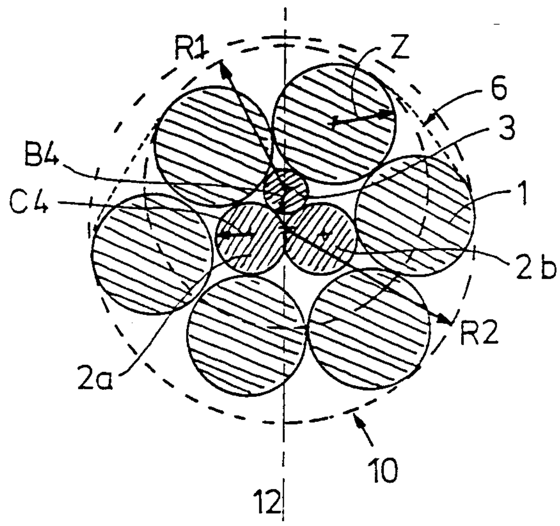

Fig. 2

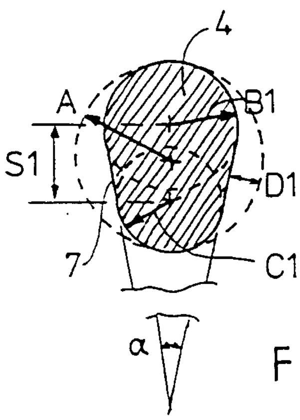

Fig. 3

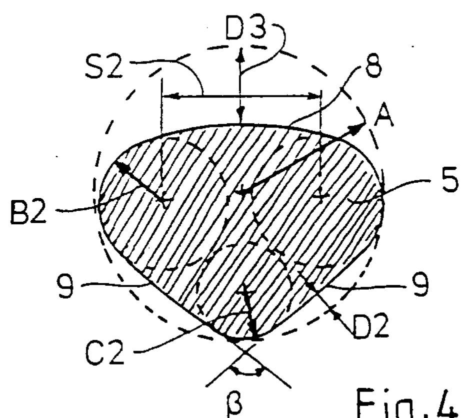

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number

EP 92 10 9078

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.5)
A	DE-A-2 941 541 (CONTINENTAL GUMMI-WERKE) * page 3, paragraph 2; figures 1-3 * ---	1	E04C5/08 D07B1/06
A	US-A-3 778 993 (GLUSHKO) * column 6, line 19 - column 6, line 27; figure 15 * ---	1,4,5,6	
A	DE-C-656 123 (KINTSCHEL) * page 2, line 45 - page 2, line 92; figure 3 * ---	1,2,3	
A	RESEARCH DISCLOSURE no. 319, November 1990, EMSWORTH (GB) pages 1 - 5; 'Steel cord construction' * page 5, paragraph 1; figures 1-5 * ---	1,2	
A	GB-A-299 586 (AMERICAN CHAIN COMPANY) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E04C
D07B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04 AUGUST 1992	HENDRICKX X.

CATEGORY OF CITED DOCUMENTS

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