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COMPLETE SPECIFICATION

Reinforcing Bar for Reinforced Concrete Structures.

We, ALEXANDRE SARRASIN AND PHILIPPE SARRASIN, both Swiss citizens, of 17, Rue Haldimand, Lausanne, Switzerland, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

A good reinforcement bar for reinforced concrete structures must offer a certain number of qualities, some of which are contradictory. The best bar will be the one which corresponds to an optimum between the various necessary qualities required. The following are the qualities which such a bar ought to offer.

It must have a high classic limit of elasticity, such as for instance at least 4800 kg/cm², in order to be able to sustain constant loads without risk of creep or permanent elongation, and also have a high ultimate tensile strength, such as for instance at least 5800 kg/cm². At the same time the bar should be sufficiently ductile to enable it to be shaped easily.

In addition, the adherence of the bar to the concrete should be very great, in order to avoid apparent cracks in the concrete and also to avoid in most cases the necessity of forming hooks at the ends of the bar. This adherence cannot, however, be obtained in a satisfactory manner by providing the bar with bulges, owing to the fact that weak points occur at the roots of the latter. In particular, bars with bulges are too fragile for fashioning.

Finally, the bar must be easy to manufacture, and easy to obtain from cheap material, in order that its cost may be moderate.

It is known that these qualities may be obtained by twisting a bar in the cold state. The twisting operation heightens the classic limit of elasticity and the ultimate tensile strength. For instance the values mentioned above may be obtained by twisting a bar of ordinary 37 steel in the cold state. The efficiency of the twisting operation, however, depends first of all on the shape of the cross-section of the bar. The best shape of cross-section for a rolled bar is the circular shape. For a given ductility, it allows a greater degree of twist than any other cross-section. The greatest possible improvement of the fibre which is the farthest away from the axis is therefore realised with the circular shape.

For a given improvement of this exterior fibre, it is also the circular cross-section which gives the best mean improvement for the whole of the bar, as has been confirmed by tests. If k designates the coefficient of improvement (i.e. the relation between the values of the limit of elasticity and the ultimate tensile strength after and before the twisting operation) by twisting of the fibres which are farthest away from the centre, then a mean coefficient of improvement equal to $2/3$ of k is obtained for the whole of the circular cross-section, provided that the rational hypothesis is made that the coefficient of improvement is zero in the centre of the cross-section and varies linearly from the centre towards the periphery. For all the other shapes, the mean coefficient of improvement is less than $2/3\ k$.

Unfortunately, the adherence to concrete of a twisted bar of circular cross-section is not noticeably better than that of an ordinary round bar. This is a grave defect which precludes the use of round twisted bars.

It has also been proposed to employ a twisted bar of non-circular and non-triangular cross-section, in which the bar before twisting is provided with a series of longitudinal flutings or grooves of shallow depth.

The present invention aims at providing a reinforcement bar for reinforced con-

crete structures which, whilst offering practically the same mechanical properties as the properties recalled above of twisted bars of circular cross-section, yet has a better adherence to concrete than the latter. The reinforcement bar for reinforced concrete structures according to the present invention is of the cold twisted type and has a cross-section, the general shape of which approximates to a circle and the periphery of which is a continuous curve having slight undulations, the angle formed between the tangent at a point of inflection of such curve and the radius through this point never being less than 45°. A bar with such a cross-section can be given a degree of twist which is practically the same as that which a bar having a circular cross-section can stand without risk of damage to the superficial fibres, and thus can be made to offer practically the same mechanical properties. In addition, the surface of a bar having the cross-section described offers a series of shallow helical grooves separated by rounded ridges which noticeably increase the adherence of concrete to the bar. In fact, when such a bar is torn from the concrete in which it is embedded, a sheath of concrete remains adhering to the surface of the bar.

The accompanying drawing illustrates, by way of example, two embodiments of the reinforcement bar according to the invention.

Figure 1 is a large scale cross-sectional view of the first embodiment,

Figure 2 is a similar view showing the cross-section of the second embodiment.

The reinforcement bar 1 illustrated in Figure 1 has a cross-section the periphery of which is a continuous, undulated curve 3 with twenty-four uniform, regularly spaced undulations 2. This peripheric curve 3 is inscribable between two concentric circles so that consecutive concave and convex parts of the curve 3 are respectively tangent to two circles, the inner of which has a radius equal to about 0.95 times the radius of the outer circle, and the points of inflection of the curve being situated half-way between the two circles and half-way between two consecutive points of tangence of the curve with these circles, the angle formed between the tangent at a point of inflection and the radius through this point being equal to about 60°, so that the undulations are shallow and gradual. This peripheric curve being continuous, i.e. the tangent in every one of its points being perfectly determined, it therefore offers no singularities such as points of inversion or points of sudden change in direction. Owing to this and to the shallow and gradual character of the undulations, the degree of twist which the bar 1 can stand without risk of damage to the superficial fibres is practically the same as that which can be given to a bar having a circular cross-section without danger to its structure. This means that the pitch of the helically extending rounded ridges and grooves which the surface of the bar 1 offers after twisting, owing to the undulating periphery of its cross-section, can be made smaller than would be the case for a bar the cross-section of which has a periphery offering discontinuities. In addition, owing to the shallow and gradual character of the undulations of the described bar, the quality of its coating with concrete is as good as that of the coating of a circular bar.

The bar described above, owing to the shallow and gradual character of the undulations 2, has a cross-section which differs only slightly from a true circular cross-section, and therefore can be easily obtained by a rolling operation, a bar being passed between rollers having the appropriate profiles to form the ridges and grooves on the surface of the bar, after which this ridged and grooved bar is given the required amount of twist in the cold state. The undulations 2 of the bar described above being shallow and gradual, an amount of twist can be given to this bar which brings the coefficient of improvement due to twisting to practically the same value as that of the coefficient of improvement which can be obtained in a bar of circular cross-section the diameter of which is equal to the diameter of the circle circumscribing the cross-section of the bar 1.

In fact, the avoidance of all sharp angles and of all sudden changes of shape in the curve forming the periphery of the cross-section of the bar illustrated in Figure 1, and the shallowness of its undulations, enable it to withstand without damage a twist giving a coefficient of improvement of the fibres passing through points of the periphery of the cross-section which are farthest from the centre of the circumscribing circle, which amounts to 99% of the maximum coefficient of improvement obtainable in a bar of the same material but having a circular cross-section the diameter of which is equal to the diameter of the circle circumscribing the cross-section of the bar 1. Owing to the shape chosen, the area of the cross-section of the bar 1 in its peripheric part is diminished as little as possible compared to that of a circle in which this cross-section can be inscribed, which also contributes towards the realisation of a coefficient of improvement which is practically equal to that obtainable in a circular bar the diameter of which is equal to that of the circle circumscribing the cross-section shown in Figure 1.

The bar 4 illustrated in Figure 2 also has a cross-section the periphery of which is a continuous, undulated curve 6 with twelve uniform, regularly spaced undulations 5. This peripheric curve is inscribable between two concentric circles so that consecutive

concave and convex parts of the curve 6 are respectively tangent to the inner circle and to the outer circle, the radius of the inner circle being equal to about 0.95 times that of the outer circle, and the points of inflection of the curve being situated half-way between the two circles and half-way between two consecutive points of tangence of the curve with these circles, the angle formed between the tangent at a point of inflection and the radius through this point being equal to about 70°. The undulations being in this case less numerous are consequently relatively shallower than those of the cross-section of the bar illustrated in Figure 1.

It will be remarked that, in the embodiments described, the undulations of the periphery of the cross-section, although relatively shallow, are nevertheless of a depth which is sufficient to give an improved adherence to the concrete, compared to the adherence of bars having a circular cross-section.

What we claim is:—

Reinforcement bar for reinforced concrete structures, twisted in the cold state, characterised by the fact that it has a cross-section the general shape of which approximates to a circle and the periphery of which is a continuous curve having slight undulations, the angle formed between the tangent at a point of inflection of such curve and the radius through this point never being less than 45°.

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772,696 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig.1.

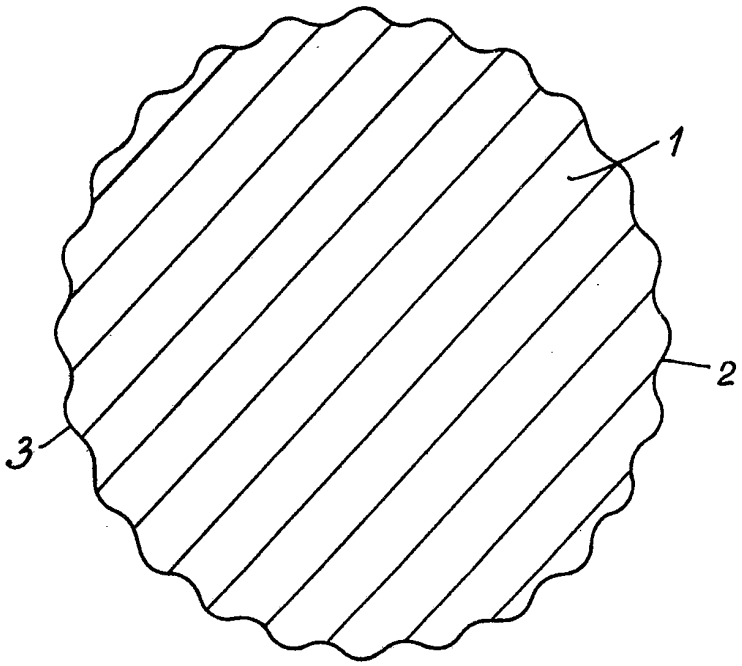

Fig.2.