US 20080302063A1

(19) United States
(12) Patent Application Publication
Braasch et al.
(10) Pub. No.: US 2008/0302063 A1
(43) Pub. Date: Dec. 11, 2008

(54) REINFORCING ROD

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(21) Appl. No.: **12/135,351**

(22) Filed: **Jun. 9, 2008**

(30) **Foreign Application Priority Data**

Jun. 8, 2007 (DE) 102007027015.3

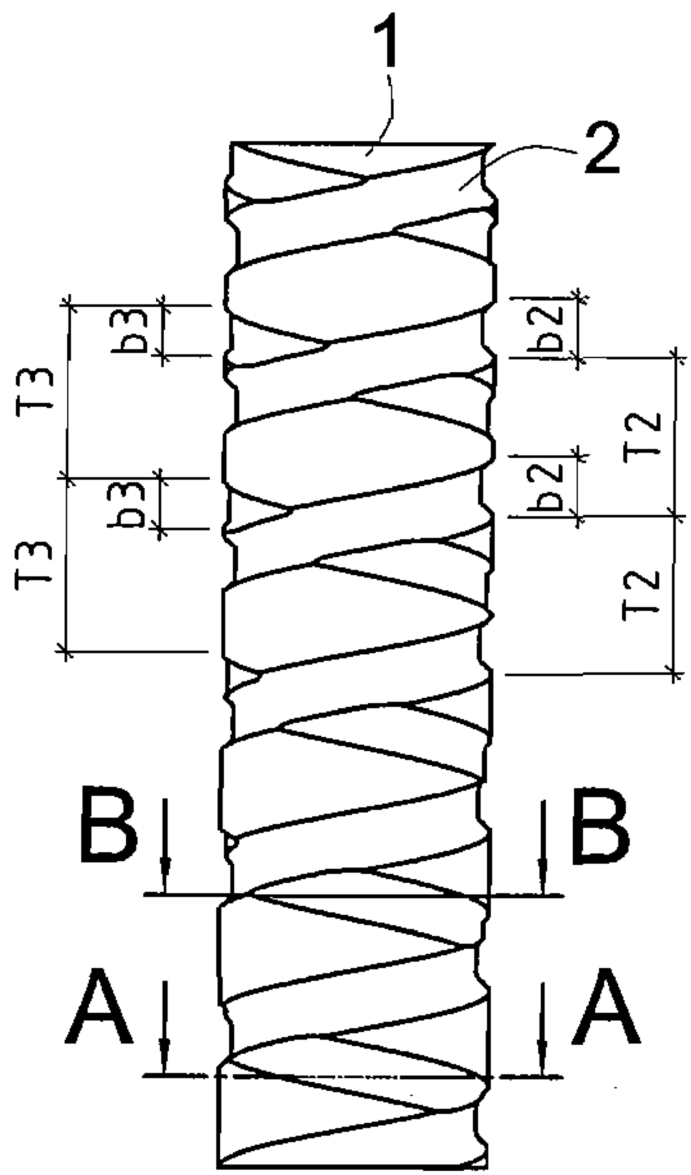
Publication Classification

(51) **Int. Cl.**
E04C 5/00 (2006.01)

(52) **U.S. Cl.** **52/853**

(57) ABSTRACT

A reinforcing rod made from fiber-reinforced plastic is provided on its peripheral surface with profiling projecting outwardly in the radial direction in the form of ribs extending at least across one part of the periphery. The reinforcing rod has ribs with different geometric and/or material properties.



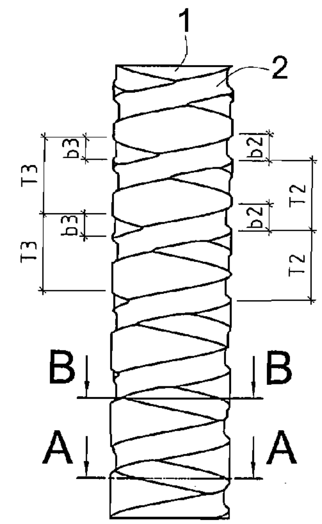


Fig. 1a)

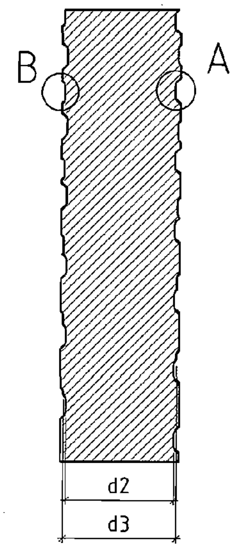


Fig. 1b)

Detail A

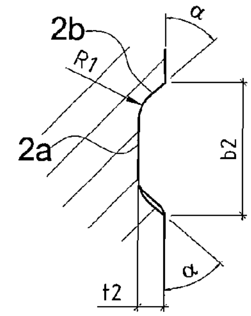


Fig. 1e)

Detail B

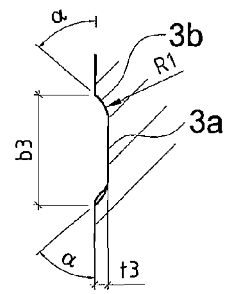


Fig. 1f)

Schnitt A-A

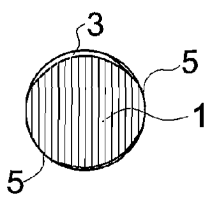


Fig. 1c)

Schnitt B-B

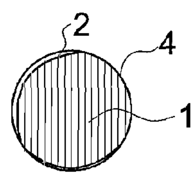


Fig. 1d)

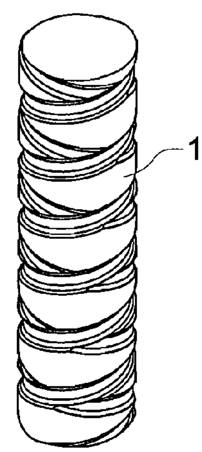


Fig. 1g)

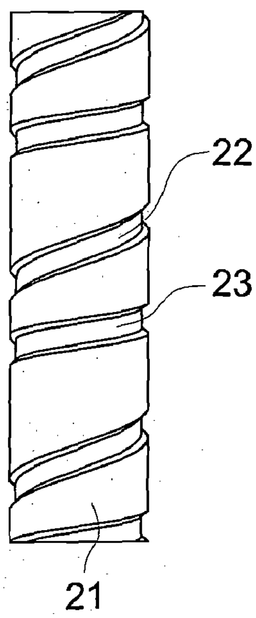


Fig. 2a)

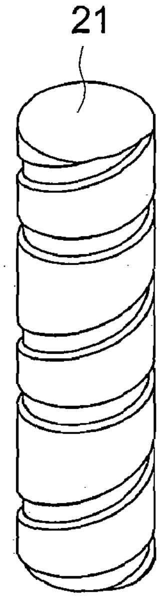


Fig. 2b)

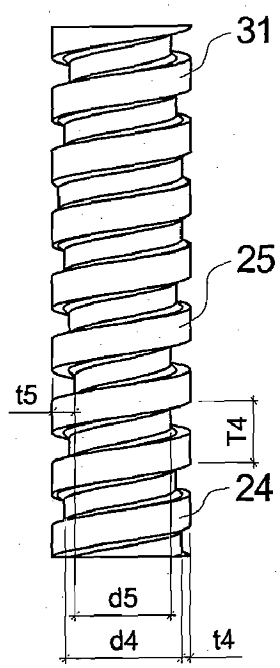


Fig. 3a)

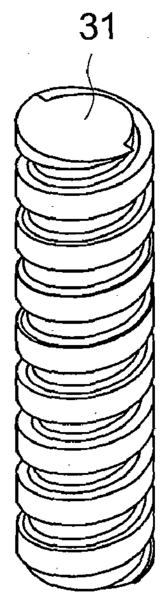


Fig. 3b)

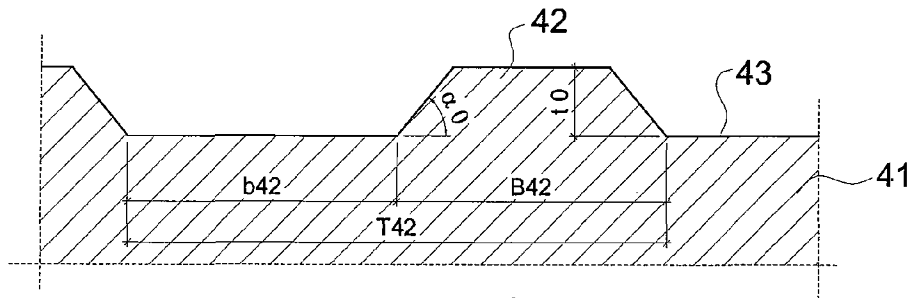


Fig. 4)

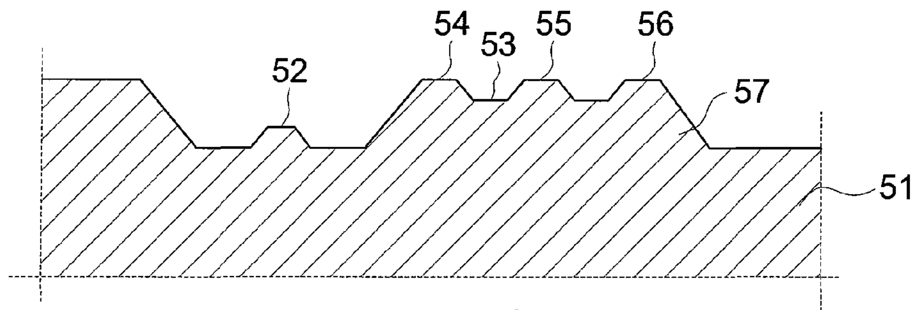


Fig. 5)

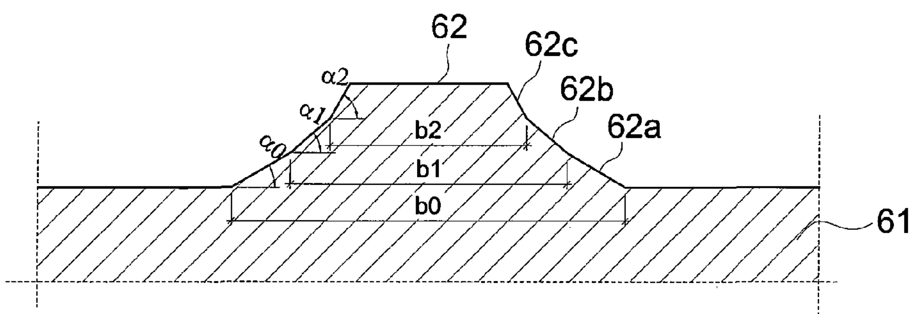


Fig. 6)

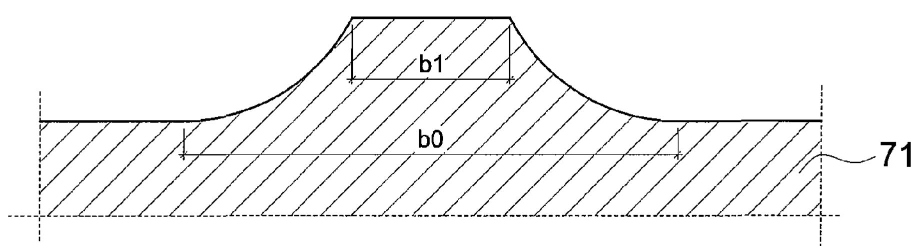


Fig. 7)

REINFORCING ROD

[0001] The invention relates to a reinforcing rod made from fiber-reinforced plastic that is provided on its peripheral surface with profiling projecting outwardly in the radial direction in the form of ribs extending at least across one part of the periphery.

[0002] From DE-A-101 21 021, such a reinforcing rod made from fiber-reinforced plastic is known, which starts with the problem of providing a load-bearing bond with the concrete surrounding the plastic reinforcing rod. Here, in particular, two types of failures, which are to be avoided, come into question: first, the shearing of the ribs as a consequence of axial tensile loads that are too high and insufficient transmission of the effective forces from the concrete into the reinforcing rod and vice versa; second, the risk of the so-called splitting tensile failure in ribs that are too flat, through which, for tensile loads, the concrete surrounding the ribbed reinforcing rod is exposed to a rod circumference that becomes increasingly bigger and the concrete finally bursts open. In DE-A-101 21 021, it is proposed accordingly that the side flanks of the ribs of the reinforcing rod should be arranged inclined at an angle of more than 45° relative to the rod axis and that the axial width of the ribs should be greater than the distance between two adjacent ribs.

[0003] In this way it should be guaranteed that bursting open of the concrete due to angles of the rib flanks that are too flat is prevented and, above all, that the ribs have an adequate bond with the rest of the reinforcing rod.

[0004] This second aspect of the improved bond has been attempted to be realized in other known reinforcing rods such that the rod surface is provided with sanding, thread-shaped windings (see, e.g., EP-A-0 199 348) or twisted sections (or narrowed sections). A common measure, however, consists in cutting trapezoidal threads, which similarly produces ribs—or rather one single thread-shaped, peripheral, continuous rib—in the rod region left between the recesses of adjacent threads.

[0005] Accordingly, the following refers to ribs not only when these project outwardly starting from an inner casing surface with smaller diameter, but also when these—as in the case of notched threads—are made from a part of the rod casing surface and are constructed by recesses machined into this casing surface.

[0006] For a known embodiment, a thread geometry is defined, in which the concrete corbels, that is, the concrete located adjacent to the rod in the region between two adjacent ribs, fail up to a certain strength of the concrete between the ribs. A disadvantage in this thread shape is that for a higher concrete strength, the ribs shear off completely and the remaining bond strength falls drastically. Because concrete continuously stiffens with increasing aging, this can also lead to abrupt failure of the reinforcement when a threshold is exceeded even after a long, undamaged time.

[0007] Typically, in concrete constructions it is attempted to limit crack widths for not only visual, but also mechanical reasons. Because reinforcing rods made from fiber-reinforced plastic (so-called GFK reinforcing rods) have a lower modulus of elasticity than steel and therefore wider cracks are to be expected in GFK-reinforced concrete constructions compared with steel concrete constructions with the same reinforcement content, currently reinforcing rods made from steel are also still used.

SUMMARY

[0008] Starting with these conditions, the present invention is based on the objective of making available a reinforcing rod made from fiber-reinforced plastic of the type noted above, which distinguishes itself through improved properties and which is suitable, in particular, for receiving higher loads. In particular, a reinforcing rod made from fiber-reinforced plastic shall be provided, which avoids the disadvantage of conventional GFK reinforcing rods and in this way helps reduce, for example, the crack spacing and the crack width in the concrete surrounding the reinforcing rod. In this way, advantageously instead of a few large gaping cracks in the concrete, preferably several smaller cracks should be produced, which then create, in addition to a better visual impression, also improved ductility of the concrete component.

[0009] This objective is met according to the invention in such a way that the reinforcing rod has ribs with different geometric and/or material properties. In this way, an order system for different rib properties can be formed, in which the ribs of different orders can be distinguished with respect to geometric parameters such as rib width, rib spacing, rib depth, angle of the rib flanks, rib pitch, etc., or by variation of the fiberglass content, the fiber materials, the fiber orientations, etc., and can supplement their properties.

[0010] Advantageous improvements of the reinforcing rod according to the invention are the subject matter of the dependent claims, whose wording is incorporated into the description by reference, in order to avoid unnecessary repetition of the text.

[0011] Advantageously, the ribs are constructed with different geometric and/or material properties in such a way that they have a different shear load on the rib base. In this way, the mentioned order system of different rib properties advantageously leads to a differentiation with respect to the rib load-bearing capacities.

[0012] The properties of ribs of higher order are preferably selected so that the shear load on the rib base of ribs of higher order is greater than the shear load on the rib base of ribs of lower order.

[0013] Above all it should be guaranteed that the ribs are constructed with different geometric and/or material properties in such a way that, in the load case, they do not fail at the same time and/or under the same load, as is the case, for example, in known reinforcing rods from the state of the art (see, e.g., WO 95/13414) with two thread-shaped, opposite-sense, crossing ribs, which are arranged symmetric in the axial direction. This configuration means symmetric shear loading and thus usually simultaneous failure. If failure at the same point in time and/or under the same load can be prevented, this increases the ductility of the reinforcing rod.

[0014] So that the ribs can be mutually supported or supplemented with different rib geometries and/or rib materials using means and methods according to the invention, they should be arranged at least in approximately the same axial section of the reinforcing rod—either bordering adjacent to each other in the axial direction or spaced apart from each other or mutually overlapping or superimposed.

[0015] In this way, for example, a special advantage is given in that one can combine wide ribs of a first order with narrower ribs of a second or higher order in such a way that the narrower ribs are arranged on the wider ribs on their radial outer side. In this way it can be achieved that in the load case, initially the narrower ribs of second order are sheared off when the stress on the rib bases of these narrower ribs exceeds their shear strength.

[0016] By shearing off these narrower ribs, the contact surface of the reinforcing rod in the region of the remaining wider ribs of first order with the concrete corbel surrounding the reinforcing rod is reduced and thus the load on the rib base of these wider ribs of first order is initially reduced. Thus, the remaining ribs of first order can receive additional loads again until the shear stress also exceeds the shear strength on the rib base of the ribs of first order and leads to their being sheared off.

[0017] With the help of the different rib properties, an "onion peel effect" is essentially produced: certain loads initially lead to damage to the "outer onion peel," i.e., the narrower or outer ribs of higher order. These sheared ribs no longer contribute to the reinforcing rod being able to receive tensile stress in the concrete, but instead lie loosely between the reinforcing rod and concrete, wherein the stress is received by the remaining ribs (of lower order). If the load increases, then, when the associated threshold is exceeded, this leads to a failure of the ribs of the next lower order, etc. Finally, despite damaged, still present, loose "outer onion peels," i.e., ribs of higher order, the bond of the concrete with the "innermost onion peel," i.e., the ribs of first order still remains.

[0018] For this "onion peel effect," what is important is primarily that despite any possible sheared-off ribs of higher order, the remaining load-bearing capacity of the rib(s) of lower order has a defined value, which then provides further load-bearing capacity to the associated reinforcing rod.

[0019] The ribs of different order can be arranged not only synchronously, for example, rotationally symmetric, thread-shaped, or running in opposite senses uniformly across the reinforcing rod, but instead they can also follow different arrangement patterns, for example, with opposite, different slopes up to a point-shaped distribution of the ribs of highest order, which can be formed, for example, by sanding (for positive ribs) or sandblasting (for negative ribs), which has the advantage of higher bond activation for small slip paths. In this way, however, defined properties in the sanded or sandblasted regions should be observed, in order to prevent undefined randomness and thus negative effects in the loaded state.

[0020] Due to the order system of various rib properties according to the invention, when certain load thresholds are exceeded, sudden shearing off of all of the ribs and failure of the entire reinforcement provided by the reinforcing rod does not take place—which is different from rods of the state of the art. Instead, at first only the ribs of highest order that can be loaded least shear off. In this way, the remaining contact surface of the reinforcing rod with the concrete corbels decreases, the slip between the rod and concrete increases, and leads, according to the invention, to very advantageous load-bearing reserves.

[0021] Only when the load increases—for example, when the concrete strength increases over time—do the ribs with the next lower order shear off when the corresponding threshold is exceeded.

[0022] It should be noted that in the state of the art of the steel reinforcing rods, there are already structural shapes, which are aimed at a "stepped failure mode" with the goal of avoiding too much deformation of the steel and of keeping its ductility high. Here, the rod material in the region of the ribs should not fail—as in the present plastic reinforcing rods—but instead the concrete surrounding the rod fails in the region of an individual concrete corbel, before, in a next step, the concrete fails in the region of a larger concrete corbel. While a primary goal in the present invention is to provide a defined residual load-bearing capacity, in this state of the art, due to the stepped failure mode, larger relative displacements of the steel rod relative to the steel concrete component reinforced in this way are desired and allowed, so that the steel concrete component can also be dimensioned under use of local plastic deformation of the reinforcement.

[0023] Thus, in addition, rib geometry for a high-load rib can be provided, which can also be used for concrete with the highest strength and does not lead to rib failure of the reinforcement, but instead at most to a failure of the concrete corbel between the ribs. While ribs with lower strength guarantee a good bond in normal concrete, the high-strength ribs provide a minimum bond strength also for greatly aftercured concrete or overstrength concrete.

[0024] Finally, ribs of different order can be combined in a multiple step rib, which can feature discrete angle jumps or continuous changes in angle. In this way, different rib properties are combined with each other, wherein, in turn, the ribs of higher order have a lower shear strength and fail earlier than the ribs of lower order. In this way it can be prevented that the entire rib shears off at a certain point in time; instead initially one of the fractional sub-ribs shears off, because the stress in the rib base of this sub-rib exceeds the shear strength. Therefore, the contact surface of the remaining sub-ribs with the concrete surrounding them, the so-called concrete corbel, is reduced and thus the load on the rib base of these remaining sub-ribs is reduced. Thus, these remaining sub-ribs can again receive additional loading until the shear stress on the rib base of then the smallest sub-rib is exceeded and leads to its shearing.

[0025] For the production of such a reinforcing rod according to the invention, in addition to the conventional method (such as, e.g., shaping of the ribs during the pultrusion process), milling of the rib geometry in hardened reinforcing rods is also possible, by means of which without great expense many different geometric properties can be achieved. In this way, the basic profile of the reinforcing rod can also have an oval, rectangular, star-shaped, etc. cross section that is different from a circular shape. Likewise, the milling process can be a circular or oval, central or eccentric process. By combining the basic profile of the reinforcing rod and milling process, with very simple means different geometric properties can be achieved and thus various rib strengths can be represented.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0026] Additional features and advantages of the present invention emerge from the following description of various embodiments with reference to the drawing; shown herein are:

[0027] FIGS. **1***a*)-**1***g*) show a first embodiment of a reinforcing rod according to the invention

[0028] in side view—in FIG. **1***a*),

[0029] in vertical section—in FIG. **1***b*),

[0030] in horizontal section along A-A from FIG. **1***a*)—in FIG. **1***c*),

[0031] in horizontal section along B-B from FIG. **1***a*)—in FIG. **1***d*),

[0032] the detail A from FIG. **1***b*)—in FIG. **1***e*),

[0033] the detail B from FIG. **1***b*)—in FIG. **1***f*), and

[0034] in perspective side view—in FIG. **1***g*);

[0035] FIGS. **2***a*) and **2***b*) show a second embodiment of a reinforcing rod according to the invention in side view—in FIG. **2***a*)—and in perspective side view—in FIG. **2***b*);

[0036] FIGS. **3***a*) and **3***b*) show a third embodiment of a reinforcing rod according to the invention in side view—in FIG. **3***a*)—and in perspective side view—in FIG. **3***b*);

[0037] FIG. **4** is a partial vertical section view through a fourth embodiment of a reinforcing rod according to the invention;

[0038] FIG. **5** is a partial vertical section view through a fifth embodiment of a reinforcing rod according to the invention;

[0039] FIG. **6** is a partial vertical section view through a sixth embodiment of a reinforcing rod according to the invention; and

[0040] FIG. **7** is a partial vertical section view through a seventh embodiment of a reinforcing rod according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] In FIGS. **1***a*) and **1***b*), a reinforcing rod **1** is shown with two superimposed rib types. Here, the reinforcing rod **1** is made from a cylindrical basic shape with circular cross section, starting from which first recesses **2** and second recesses **3** extend inwardly in the radial direction, by which overlapping ribs **4**, **5** are formed. The recesses **2**, **3** are arranged running in opposite senses relative to each other, that is, one recess has a right-handed course and the other recess has a left-handed course along the reinforcing rod in the shape of a thread around this rod. The recesses **2** here have a deeper construction than the recesses **3**. The recesses **2** leave ribs **4** therebetween (in fact, a thread-shaped, peripheral, continuous rib **4**). Correspondingly, the recesses **3** leave recesses **5** therebetween which partially also overlap with the ribs **4** due to the mutual overlapping of the recesses.

[0042] In FIG. **1***b*), the surface of the reinforcing rod according to the invention can be seen from the vertical section with the rod diameter d_2 in the region of the recess **2** and the rod diameter d_3 in the region of the recess **3**. Also, two details A, B, which are shown in FIGS. **1***e*) and **1***f*), clarify the different rib or recess shapes. Both recesses have the same flank angle α and the same curvature radii R_1 in the transition region between the recess base **2***a*, **3***a* and rib flanks **2***b*, **3***b*. Only the rib depths t_2, t_3 and the recess widths b_2, b_3 are different just like the rib pitches T_2, T_3 (see FIG. **1***a*)).

[0043] Review of the horizontal section in FIGS. **1***c*) and **1***d*) shows that the recesses **2**, **3** or ribs **4**, **5** produce overall an inhomogeneous surface of the reinforcing rod **1**, which is responsible for the result that different regions have different shear load-bearing capacities and thus overall the load-bearing capacity of the reinforcing rod can be improved.

[0044] FIGS. **2***a*) and **2***b*) show an alternative reinforcing rod **21** with recesses **22**, **23**, which run in the same sense in the shape of a thread along the reinforcing rod **21** and have different slopes. Also in this way, ribs with different geometric properties can be produced, which have different shear loads on the rib base.

[0045] In FIGS. **3***a*) and **3***b*), a reinforcing rod **31** is shown, in which ribs with different geometric properties are provided one within the other. While the rib pitch T_4, that is, the distance between adjacent threads of the thread-shaped, peripheral rib is the same across the entire reinforcing rod, the depth t_4, t_5 of the recess **22**, however, changes across the axial length of the rod. In this way, ribs **24**, **25** with different geometric properties transition into each other continuously and without steps and have correspondingly different load-bearing capacities due to the different rib depth t_4, t_5.

[0046] With reference to FIGS. **4** to **7**, the system of the rib shapes can be clarified. For example, FIG. **4** shows a reinforcing rod **41** with a rib **42** of first order and a recess **43** with a rib depth t_{42}, a flank inclination angle α, a pitch T_{42}, which is the combination of the rib width B_{42} plus the distance b_{42} between two adjacent ribs.

[0047] In FIG. **5**, now for a reinforcing rod **51** of a rib corresponding to the rib **42** of first order from FIG. **4** and also a recess corresponding to the recess **43** from FIG. **4**, a narrower rib **52** of second order and also narrower recesses **53** are superimposed, which form together with the rib of first order an order system made from narrow ribs of higher order **52**, **54**, **55**, **56** and a wide rib **57** of lower order, which carries the narrow ribs. It is not difficult to see that in a loaded case, the narrow ribs shear off more quickly and that, however, when they are sheared off, the wide rib **57** still creates a bond with the concrete surrounding the reinforcing rod and thus the rod **51** does not fail suddenly at the same time in all anchoring sections.

[0048] FIG. **6** and FIG. **7** finally show for reinforcing rods **61**, **71**, multiple-step ribs **62**, **72**, which are likewise the result of superimposing several ribs, wherein the rib sub-regions **62***a*, **62***b*, **62***c* have different flank inclinations α_0, α_1, α_2 and different rib widths B_0, B_1, B_2. In contrast, for the multiple-step rib **72** from FIG. **7**, the transition between the sub-regions of the rib is continuous with continuous changes in width and angle.

[0049] The multiple-step ribs also lead to the result that, if there is doubt, initially the narrowest sub-rib **62***c* shears off earlier than the widest sub-rib **62***a* and thus similarly provides for an improvement of the load-bearing capacity of the associated reinforcing rod **61**.

[0050] In summary, the present invention offers the advantage through formation of ribs with different geometric and/or material properties to improve the connection behavior of fiber-reinforced plastic reinforcing rods, whose application behavior in the load case is to be optimized and thus such plastic reinforcing rods are to be opened up to additional application possibilities. Consequently, a reinforcing rod made from fiber-reinforced plastic is provided, which helps to reduce the crack spacing and the crack width in the concrete surrounding the reinforcing rod, which leads to the described advantages.

1. Reinforcing rod comprising fiber-reinforced plastic, provided on a peripheral surface thereof with profiling projecting outwardly in a radial direction as ribs extending at least across one part of the peripheral surface, the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) with different geometric and/or material properties.

2. Reinforcing rod according to at least claim **1**, wherein the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) with the different geometric and/or material properties are constructed such that, in a load case, they have a different shear load capacity on a rib base.

3. Reinforcing rod according to at least claim **1**, wherein the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) with the different geometric and/or material properties are constructed such that, in a load case, the ribs fail at different times and/or under different loads.

4. Reinforcing rod according to claim **1**, wherein the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) with the different geometric and/or material properties are arranged at least in approximately a same axial section of the reinforcing rod adjacent to each other, bordering each other, with mutual spacing, and/or mutually overlapping one another.

5. Reinforcing rod according to claim **1**, wherein the geometric and/or material properties of the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) are constructed in multiple steps across an axial length of the reinforcing rod (**1**, **21**, **31**, **41**, **51**, **61**, **71**) and/or a periphery thereof.

6. Reinforcing rod according to claim **1**, wherein the different geometric and/or material properties of the ribs (**4**, **5**, **42**, **52**, **54**, **55**, **56**, **57**, **62**, **72**) include rib height (t), rib spacing (b), rib pitch (T), inclination angle (α) of the rib flanks, slope of the ribs, and/or rib shape.

7. Reinforcing rod according to claim **1**, wherein the different geometric and/or material properties of the ribs include different fiber content, different materials of the reinforcing rod and/or fibers and/or different fiber orientations.

8. Reinforcing rod according to claim **1**, wherein the ribs (**62***a*, **62***b*, **6***c*) are combined into a multiple step rib (**62**) constructed one on the other in the radial direction, in which several ribs with different geometric and/or material properties are arranged at least partially superimposed on each other or overlapping.

* * * * *