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(54) REINFORCING BAR JOINT

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(57) **ABSTRACT**

A reinforcing bar joint **1** includes a sleeve **2** having an elliptic section, and a wedging means **4**. The wedging means **4** is composed of wedge members **4*a***, **4*b*** which are pressed into between reinforcing bars **5*a***, **5*b***. The press-in positions of these wedge members **4*a***, **4*b*** are spaced away from each other so that the reinforcing bars **5*a***, **5*b***, the sleeve **2**, and the wedge members **4*a***, **4*b*** are integrated in the area lying between the press-in positions. This can also move the points of action of tensile forces acting on the reinforcing bars outward, thereby increasing the distance between the points of action and reducing the amount of rotation of the sleeve **2**.

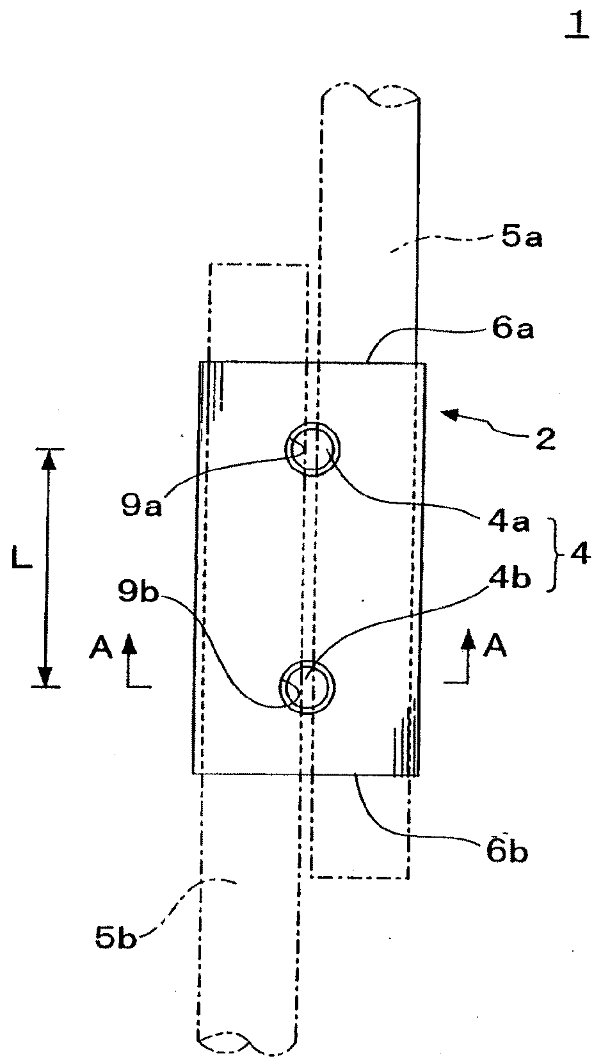


FIG.1A

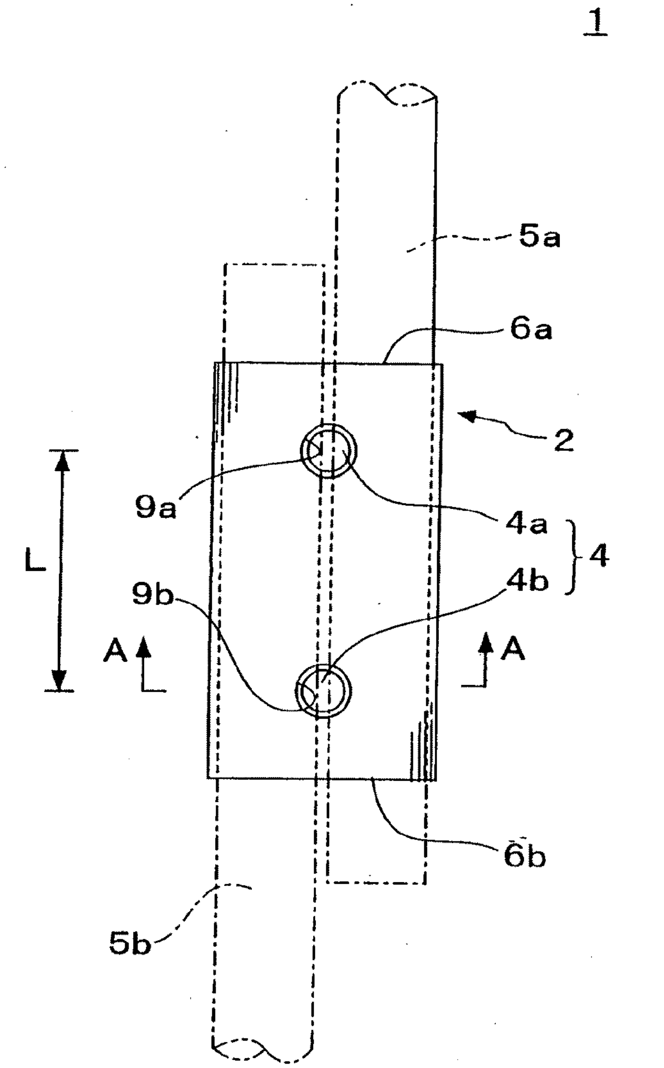


FIG.1B

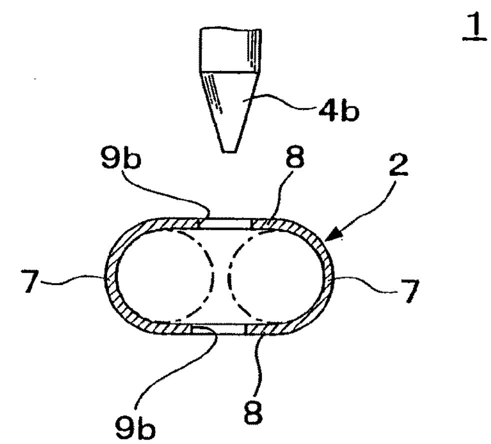


FIG.2A

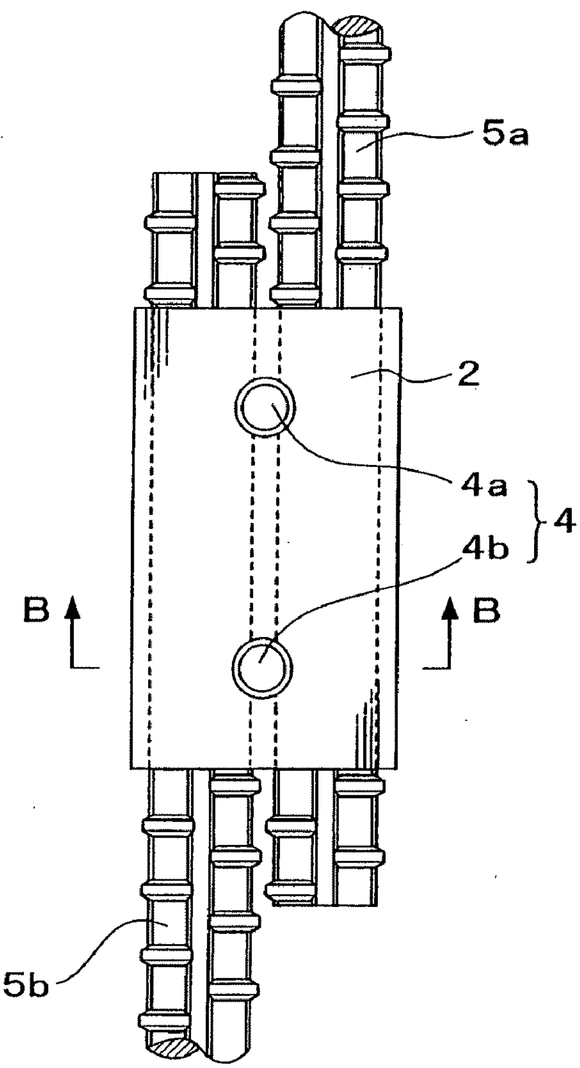


FIG.2B

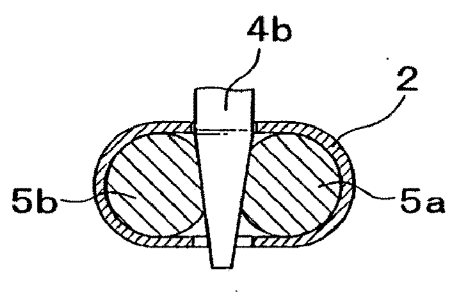


FIG.3A

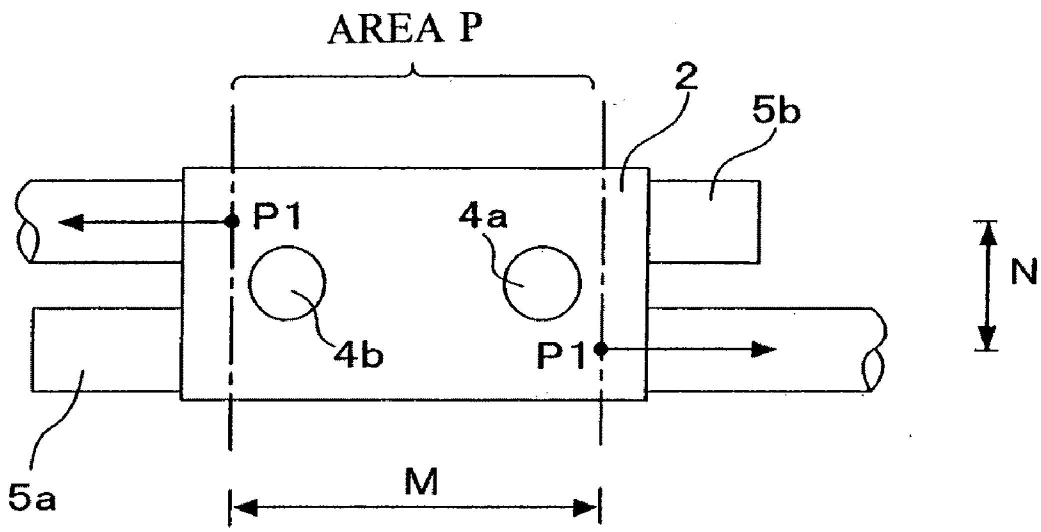


FIG.3B

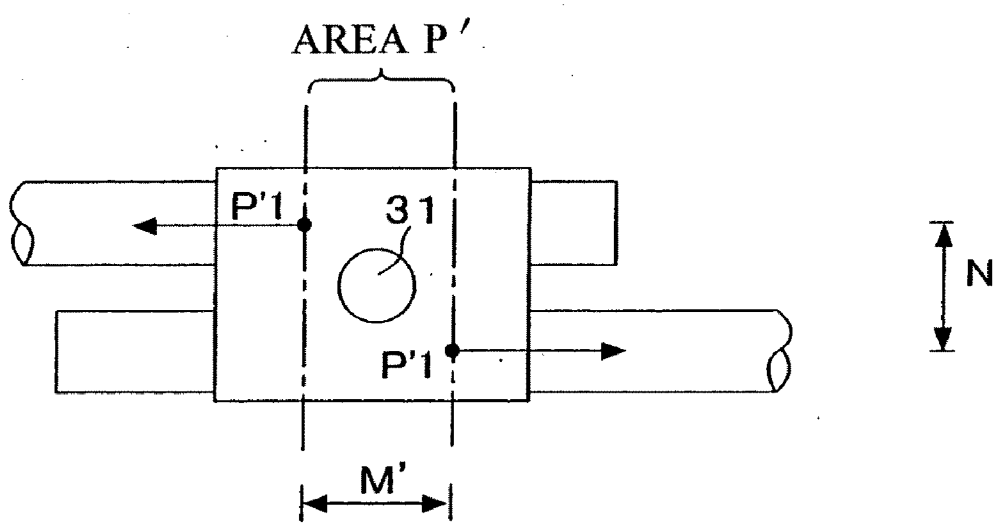


FIG.4A

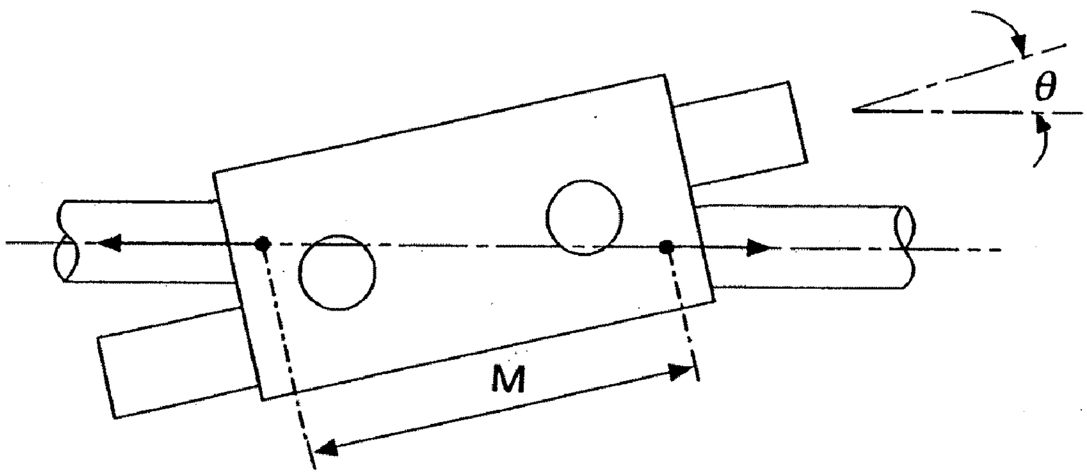


FIG.4B

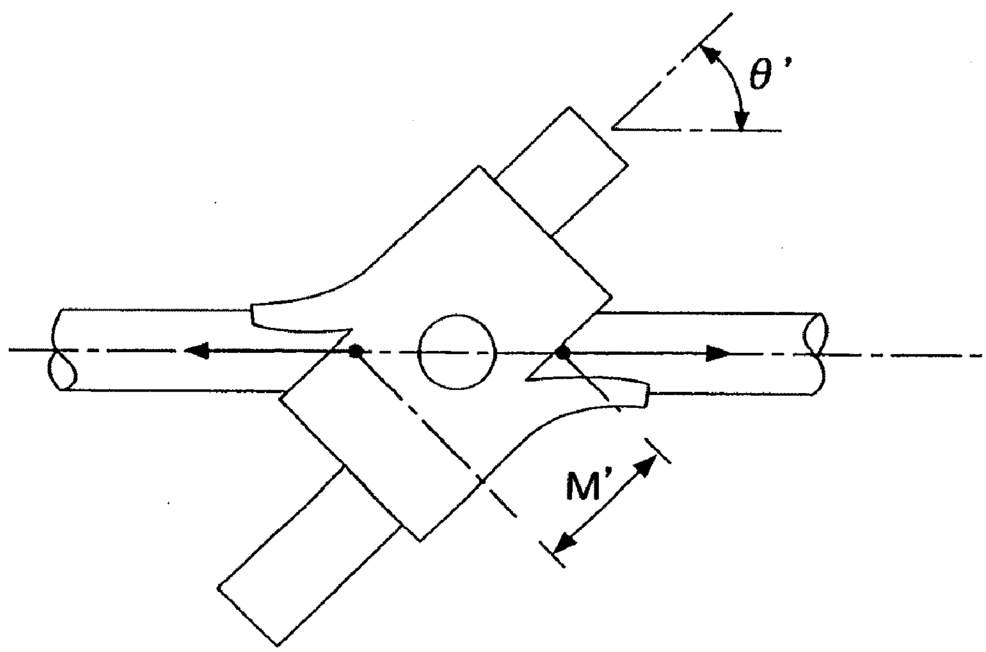


FIG.5

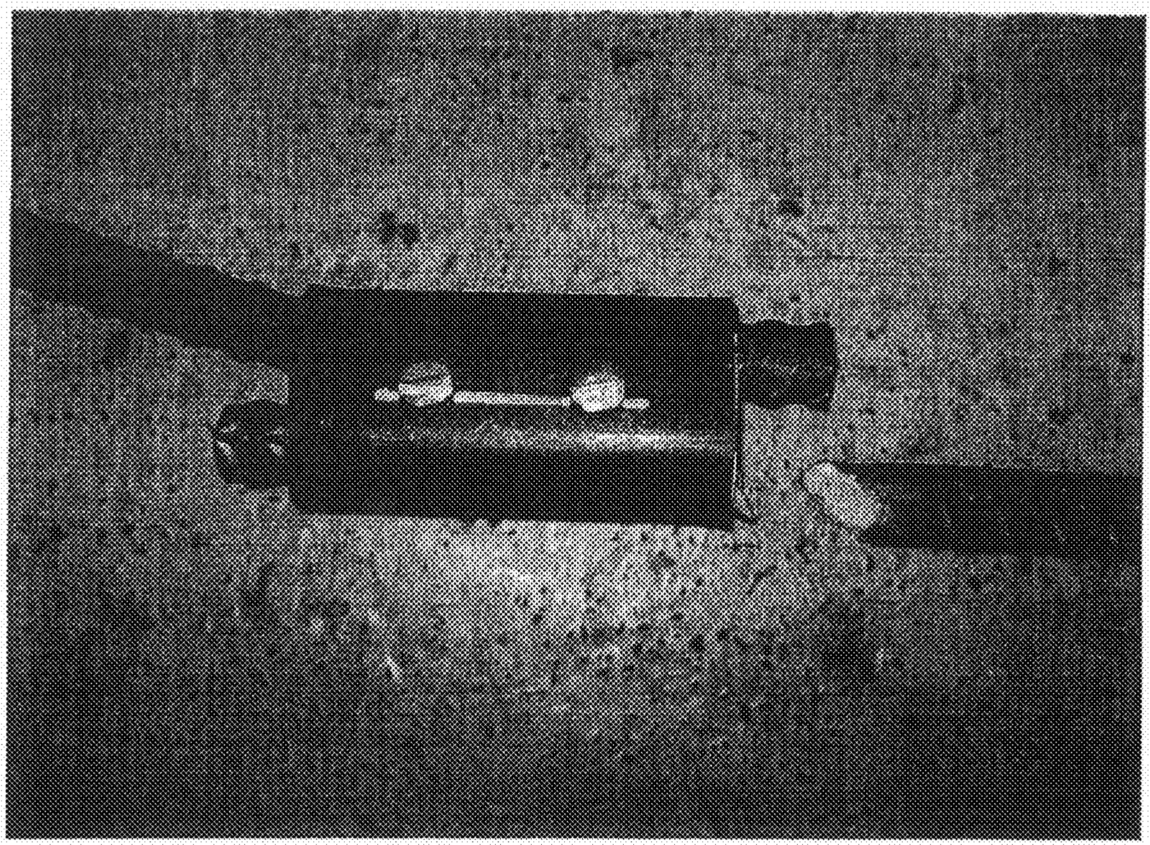


FIG.6

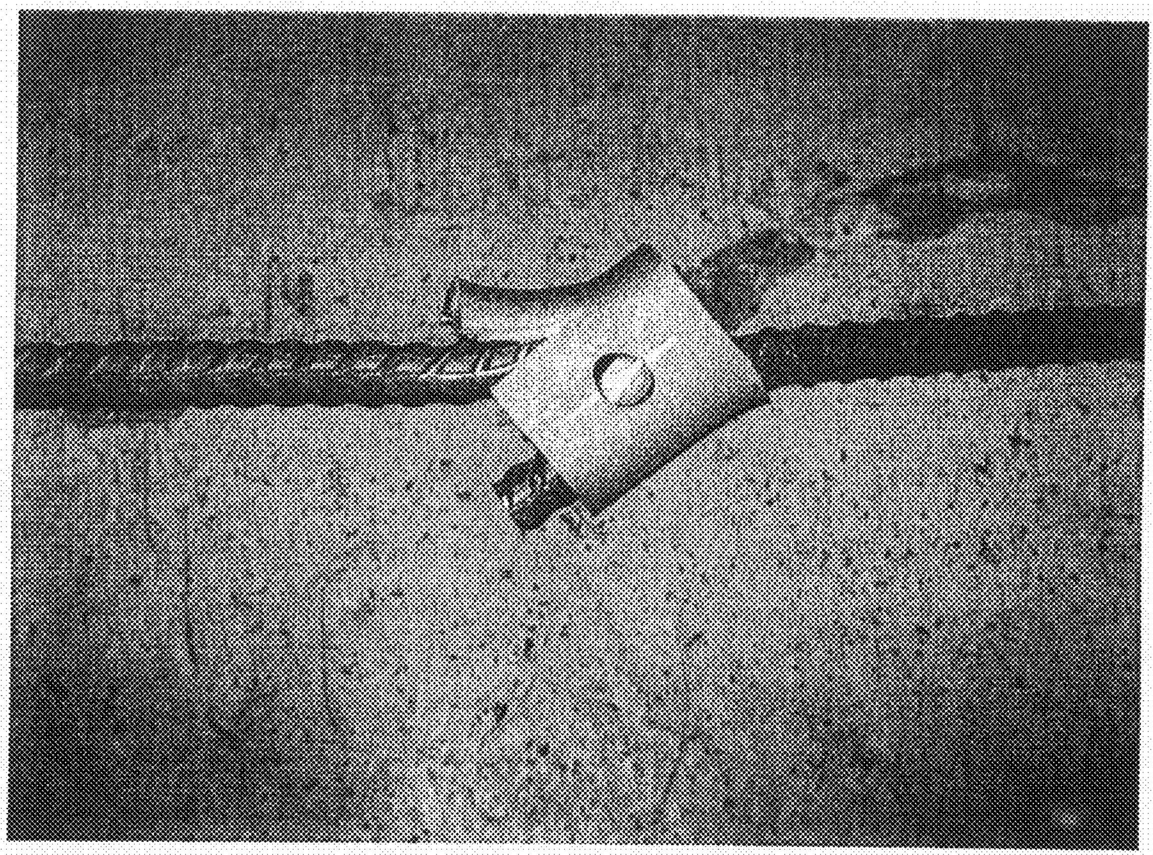
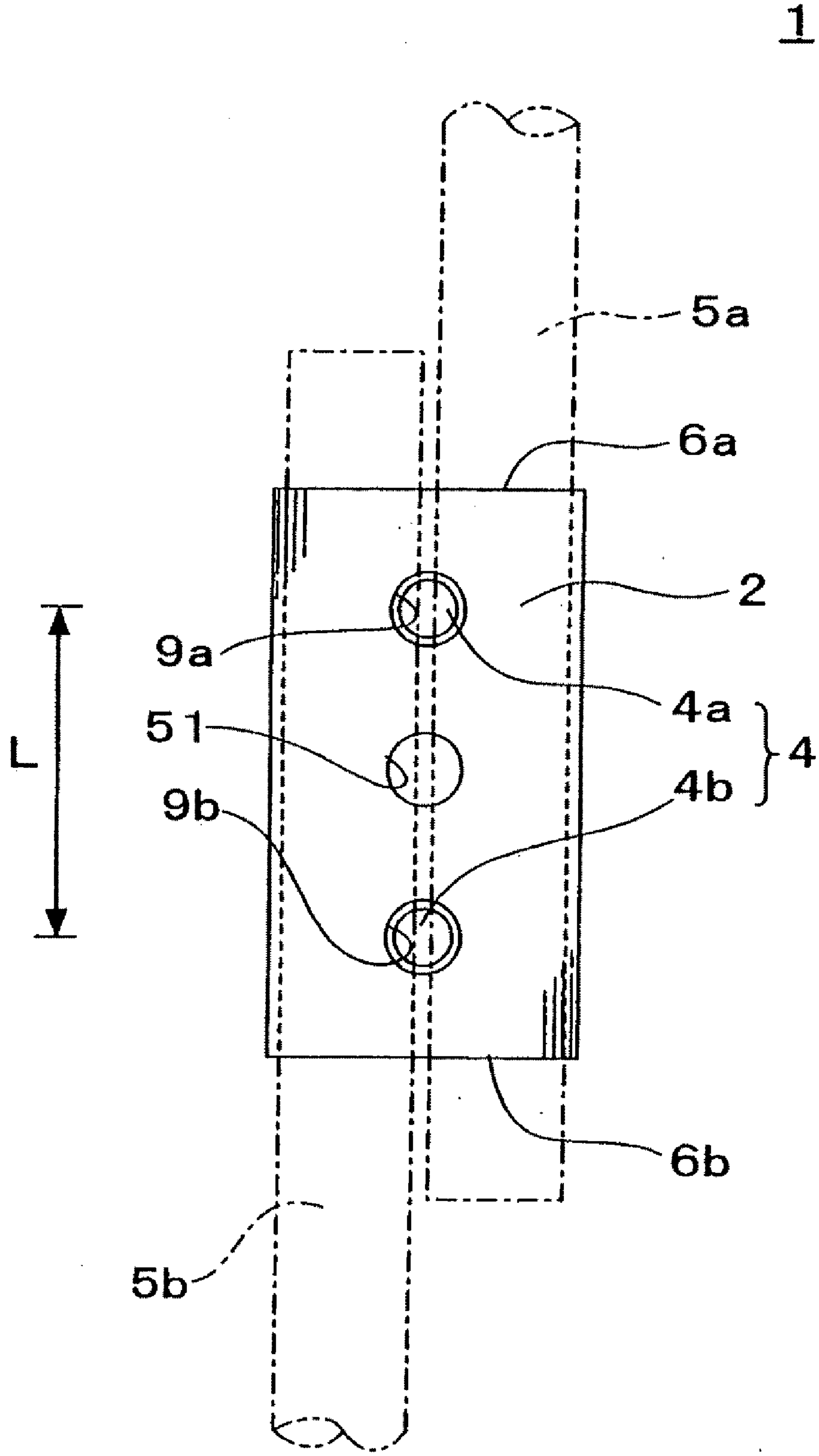


FIG.7



REINFORCING BAR JOINT

TECHNICAL FIELD

[0001] The present invention relates to a reinforcing bar joint to be applied when joining reinforcing bars together.

BACKGROUND ART

[0002] Reinforcing bars are main components of reinforced concrete structures (RC structures) and steel-reinforced concrete structures (SRC structures), and are cut in predetermined lengths so as to be arranged easily during configuration on-site. The operation for joining the reinforcing bars on-site is thus indispensable.

[0003] There are various types of methods for joining reinforcing bars, including a lap joint, a mechanical coupler, and a gas-pressure welding joint. These joints are selected and used as appropriate depending on the quality required of a structure, working conditions, the diameters of the reinforcing bars being used, and the like.

[0004] In this instance, the joining methods mentioned above have respective drawbacks and advantages. For example, a lap joint can join reinforcing bars easily by utilizing the bar's adhesion to concrete. Since two reinforcing bars must be overlapped, it becomes harder to perform various bar arrangements or secure overlapping lengths of such as the bar diameter increases. Furthermore, a mechanical coupler requires management on such details as the insert length of the reinforcing bars being inserted into the coupler and the fastening torque being applied. A gas-pressure welding joint requires the welder to hold a particular qualification for executing of the gas-pressure welding.

[0005] For this reason, bar joining methods that are capable of joining reinforcing bars easily, without requiring a lapping length, have also been developed. Among those methods, one method for joining pairs of mutually parallel reinforcing bars is applicable only to reinforcing bars having fixed spacings, and thus is not sufficiently versatile in terms of bar pitch (see Patent Document 5).

[0006] Under the circumstances, a joint has been developed that is composed of an elliptic-sectioned steel sleeve and a wedge member. According to such a joint, the end portions of two reinforcing bars are inserted into the sleeve from respective opposite directions, and then the wedge member can be driven into the space between the two reinforcing bars through a wedge insertion hole formed in the sleeve to join the reinforcing bars together (see Patent Document 1, Patent Document 2, and Non-Patent Document 1)

[0007] [Patent Document 1] Japanese Utility Model Publication No. Sho 58-32498

[0008] [Patent Document 2] Japanese Utility Model Publication No. Sho 58-53880

[0009] [Patent Document 3] Japanese Utility Model Application Laid-Open No. Hei 04-122111

[0010] [Patent Document 4] Japanese Utility Model Publication No. Sho 60-3858

[0011] [Patent Document 5] Japanese Patent No. 3197079 [Non-Patent Document 1] ERICO International Corporation, [searched on Aug. 2, 2006], the Internet <URL: http://www.erico.com/products/QuickWedge.asp>).

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

[0012] In this configuration, however, the axes of the two reinforcing bars are displaced from each other. Consequently, when the reinforcing bars undergo tensile forces in opposite directions, a bending moment acts on the sleeve, and the sleeve is also rotated such that the lines of action of the respective tensile forces come into alignment on the same line.

[0013] As a result, the reinforcing bars may suffer a bending moment which does not occur when undergoing tensile forces alone. The sleeve rotation can also subject the opening edges of the sleeve to some of the tensile forces acting on the reinforcing bars, thereby causing a split in the sleeve.

[0014] Reaction forces from the sleeve against the forces for acting to widen the opening edges of the sleeve can also act on the reinforcing bars to break them. The rotation of the sleeve may also loosen the engagement between the reinforcing bars and the wedge member, so that the reinforcing bars are sometimes drawn out from the sleeve.

[0015] There has thus been the problem that while the foregoing joint structure can be applied to shear reinforcing bars of a reinforced concrete structure or steel-reinforced concrete structure which are under relatively small tensile loads, it is not suitable for main reinforcing bars under relatively large tensile loads.

[0016] It should be noted that some proposals have been made to notch the opening edges obliquely so as to avoid concentration of stress on the reinforcing bars (Patent Document 3), and to form a wedge of X-shaped section to avoid wedge rotation (Patent Document 4).

[0017] Nevertheless, even if the opening edges of the sleeve would be notched obliquely as in Patent Document 3, the sleeve rotation cannot be prevented under the condition that the reinforcing bars undergo tensile forces. The foregoing sleeve rotation similarly cannot be prevented by the wedge having an X-shaped section as in Patent Document 4.

[0018] Thus, while there have been proposed several joints comprising an elliptic-sectioned steel sleeve and a wedge member, these conventional techniques have not provided a solution to the problem of a decrease in the tensile strength of two reinforcing bars resulting from sleeve rotation when tensile forces act on the reinforcing bars.

[0019] The present invention has been achieved in view of the foregoing circumstances. It is thus an object thereof to provide a reinforcing bar joint applicable to main reinforcing bars of an RC structure or SRC structure, capable of avoiding a decrease in the tensile strength of two reinforcing bars resulting from sleeve rotation when tensile forces act on the reinforcing bars.

[0020] The applicant have conducted research and development on whether or not it is possible to make a sleeve-based reinforcing bar joint applicable to not only shear reinforcing bars but main reinforcing bars as well, by reducing the amount of sleeve rotation, if not eliminating the sleeve rotation completely, when joining reinforcing bars with this reinforcing bar joint. As a result, the applicant has succeeded in reducing the amount of sleeve rotation, and consequently the bending deformation of the reinforcing bars can be suppressed and the pulling out of the reinforcing bars from the sleeve can be prevented, with a new configuration using a plurality of wedge members and pressing the same into place at well-spaced positions.

[0021] That is, according to the present invention, a first wedge member and a second wedge member bite into a first reinforcing bar and a second reinforcing bar under reaction forces from the inner periphery of a sleeve when they are pressed into and between the first and second reinforcing bars. That is, by biting in of the two wedge members and the binding effect of the sleeve, the sleeve becomes to one body with the first and second reinforcing bars, and the first and second wedge members at the area from the vicinity of the press-in position of the first wedge member to the vicinity of the press-in position of the second wedge member. Therefore, the sleeve rotates with the first and second reinforcing bars and the first and second wedge members as a body when the sleeve is rotated by tensile forces acting on the first and second reinforcing bars.

[0022] In other words, when the sleeve rotates due to tensile forces acting on the first and second reinforcing bars, then the first and second reinforcing bars, the first and second wedge members, and the sleeve make an integral rotation in the area between the press-in position of the first wedge member and the press-in position of the second wedge member. The points of action of the tensile forces acting on the respective reinforcing bars are therefore transferred to outside the integral area.

[0023] Consequently, as compared to the conventional configuration with a single wedge member, the distance between the points of action of the tensile forces acting on the reinforcing bars increases significantly, and the amount of sleeve rotation under certain tensile forces on the reinforcing bars accordingly decreases significantly.

[0024] This reduces bending deformation in the reinforcing bars, and also decreases the forces acting to widen the sleeve openings from the reinforcing bars. It is therefore possible to avoid a splitting fracture of the sleeve, and pulling out of the reinforcing bars from the sleeve and a wedge break of the reinforcing bars, which would allow base-material fracture of the reinforcing bars.

[0025] Here, pulling out refers to a shear fracture of a reinforcing bar at a position where a wedge member bites into (an area of chipped section). A sleeve split refers to a splitting fracture of a sleeve edge in contact with a reinforcing bar. A wedge break refers to breakage of a reinforcing bar at a position where a wedge member bites in (an area of chipped section). The term "base-material fracture" refers to fracture of a reinforcing bar at a location other than where the wedge members are driven in.

[0026] It should be noted that the present invention is characterized in that the points of action of tensile forces can be shifted outward by providing of two press-in positions of wedge members so that the increased distance between the points of action reduces the amount of sleeve rotation. The wedge members are therefore not limited to two in number.

[0027] That is, in the case of three wedge members, the distance between the points of action refers to the distance between two outermost wedge insertion holes among three wedge insertion holes. In this case, two of the three wedge members to be driven into the outermost wedge insertion holes correspond to the first and second wedge members according to the present invention.

[0028] The sleeve may have any specific configuration as long as it is configured so that the first reinforcing bar and the second reinforcing bar can be inserted into openings in both ends with a predetermined overlapping length, and the first wedge member and the second wedge member can be driven into two wedge insertion holes therein.

[0029] For example, sleeve specifications such as the sectional shape, length, and hardness of the sleeve may be determined arbitrarily. When the sleeve is given a hardness relatively lower than those of the first and second reinforcing bars, it is possible to avoid a splitting fracture of the sleeve, a pulling out of the reinforcing bars from the sleeve and a wedge break of the reinforcing bars, thereby allowing base-material fracture of the reinforcing bars without fail.

[0030] In order to provide a sleeve hardness relatively lower than the hardness of the first and second reinforcing bars, the sleeve may be annealed during the manufacturing process, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIGS. **1**A and **1**B are diagrams showing a reinforcing bar joint according to one embodiment, FIG. **1**A being a front view, FIG. **1**B being a sectional view taken along line A-A.

[0032] FIGS. **2**A and **2**B are diagrams showing a state where two reinforcing bars are joined with the reinforcing bar joint according to the present embodiment, FIG. **2**A being a front view, FIG. **2**B being a sectional view taken along line B-B.

[0033] FIGS. **3**A and **3**B are diagrams for explaining the operation of the reinforcing bar joint according to the present embodiment.

[0034] FIGS. **4**A and **4**B are diagrams for explaining the same operation of the reinforcing bar joint according to the present embodiment.

[0035] FIG. **5** is a photograph showing the result of a tensile test on a test piece with two wedge members.

[0036] FIG. **6** is a photograph showing the result of a tensile test on a test piece with one wedge member.

[0037] FIG. **7** is a front view of a reinforcing bar joint according to a modification.

DESCRIPTION OF REFERENCE NUMERALS

[0038] **1** reinforcing bar joint
[0039] **2** sleeve
[0040] **4** wedging means
[0041] **4***a* wedge member (first wedge member)
[0042] **4***b* wedge member (second wedge member)
[0043] **5***a* reinforcing bar (first reinforcing bar)
[0044] **5***b* reinforcing bar (second reinforcing bar)
[0045] **6***a*, **6***b* opening
[0046] **9***a*, **9***b* insertion hole

BEST MODE FOR CARRYING OUT THE INVENTION

[0047] Hereinafter, a reinforcing bar joint according to the present invention will be described with reference to the accompanying drawings. It should be noted that components and the like substantially identical to those of conventional technology will be designated by the same reference numerals, and a description thereof will be omitted.

[0048] FIG. **1**A is a front view of the reinforcing bar joint according to the present embodiment. FIG. **1**B is a sectional view taken along the line A-A of FIG. **1**A. As can be seen from the diagrams, the reinforcing bar joint **1** according to the present embodiment comprises a sleeve **2** having an elliptic section, and a wedging means **4**. The sleeve **2** is configured so that the end of a reinforcing bar **5***a*, or a first reinforcing bar, and the end of a reinforcing bar **5***b*, or a second reinforcing bar, can be inserted into openings **6***a*, **6***b* in respective ends with a predetermined length of overlap. The wedging means **4** comprises a wedge member **4***a*, or a first wedge member, and a wedge member **4***b*, or a second wedge member, to be pressed into between the reinforcing bars **5***a*, **5***b*.

[0049] The sleeve **2** is composed of a pair of semicylindrical wall portions **7**, **7** which are arranged with their curved inner surfaces opposite each other, and a pair of flat wall portions **8**, **8** which extend to the corresponding edges of the pair of semicylindrical wall portions. The pair of flat wall portions **8**, **8** are provided with wedge insertion holes **9***a*, **9***a* for the wedge member **4***a* to be inserted through and wedge insertion holes **9***b*, **9***b* for the wedge member **4***b* to be inserted through. The wedge insertion holes **9***a*, **9***a* and the wedge insertion holes **9***b*, **9***b* are spaced from each other by a distance L along the axes of the reinforcing bars **5***a*, **5***b*.

[0050] The sleeve **2** may be formed, for example, by inserting a die into a cylindrical pipe, and applying pressure to the outer periphery at given areas so as to make the flat wall portions.

[0051] The wedge insertion holes **9***a*, **9***a* are formed in the flat wall portions **8**, **8** respectively so as to be disposed face to face with each other near the end of the reinforcing bar **5***b*. The wedge insertion holes **9***b*, **9***b* are formed in the flat wall portions **8**, **8** respectively so as to be disposed face to face with each other near the end of the reinforcing bar **5***a*. The wedge insertion holes **9***a*, **9***a* are desirably positioned to avoid the vicinities of the opening edges of the sleeve **2** where the reinforcing bar **5***a* would be deformed extremely. Similarly, the wedge insertion holes **9***b*, **9***b* are desirably positioned to avoid the vicinities of the opening edges of the sleeve **2** where the reinforcing bar **5***b* would be deformed extremely. More specifically, it is desirable that the wedge insertion holes **9***a*,**9***a* are positioned somewhat away from the edges of the sleeve **2**, for example, a distance equal to or greater than the diameter of the reinforcing bars. The same thing can be said of the wedge insertion holes **9***b*, **9***b*.

[0052] It should be appreciated that the reinforcing bar joint **1** according to the present embodiment is intended to join main reinforcing bars of an RC or SRC structure to each other. The types of steel of the sleeve **2** and the wedge members **4***a*, **4***b* may be determined as appropriate in consideration of the hardness and tensile strength of the reinforcing bars **5***a*, **5***b* to be joined.

[0053] When joining the reinforcing bars **5***a*, **5***b* with the reinforcing bar joint **1** according to the present embodiment, the end of the reinforcing bar **5***a* is initially inserted into one opening **6***a* of the sleeve **2**, and the end of the reinforcing bar **5***b* is inserted into the other opening **6***b* of the sleeve **2**. Here, the reinforcing bars **5***a*, **5***b* are inserted through the sleeve **2** so that their ends overlap each other by a predetermined length.

[0054] Next, the wedge member **4***a* is inserted through and pressed into the wedge insertion holes **9***a*, **9***a*. The wedge member **4***b* is also inserted through and pressed into the wedge insertion holes **9***b*, **9***b*. For press-in, a conventionally known wedge driver may be selected and used as appropriate.

[0055] FIGS. **2**A and **2**B are diagrams showing the state when the wedge driving operation is completed to finish joining the reinforcing bars **5***a*, **5***b*.

[0056] In the reinforcing bar joint **1** according to the present embodiment, the wedge members **4***a*, **4***b* bite into the reinforcing bars **5***a*, **5***b* under reaction forces from the inner periphery of the sleeve **2** when they are pressed into between the reinforcing bars **5***a*, and **5***b*. This biting in of the two wedge members **4***a*, **4***b* and the binding effect of the sleeve **2** for binding the reinforcing bars **5***a*, **5***b* make the reinforcing bars **5***a*, **5***b*, the wedge members **4***a*, **4***b*, and the sleeve **2** generally integral as a whole within the range of an area P from the vicinity of the press-in position of the wedge member **4***a* to the vicinity of the press-in position of the wedge member **4***b* as shown in FIG. **3**A, as far as the rotation of the sleeve **2** ascribable to tensile forces acting on the reinforcing bars **5***a*, **5***b* is concerned.

[0057] In conventional cases with only a single wedge member, on the other hand, the integration is established only within the range of an area P' across the press-in position of a wedge member **31** as shown in FIG. **3**B.

[0058] In other words, the conventional integral area is no more than the area P', while the integral area in the present embodiment is as wide as the area P. The points of action of the tensile forces acting on the reinforcing bars thus shift from points P_1', which fall on the boundaries of the area P', to points P_1, which fall on the boundaries of the area P.

[0059] Consequently, the distance between the points of action increases significantly from M' to M, whereas the distance N between the reinforcing bars remains unchanged. It should be appreciated that the location of the boundaries of the area P for integrating the reinforcing bars **5***a*, **5***b*, the sleeve **2**, and the wedge members **4***a*, **4***b* depends on the length of the sleeve **2**. More specifically, if the sleeve **2** is long, the boundaries of the area P shift toward the ends of the sleeve **2** because of the binding effect. If the sleeve **2** is short, the boundaries of the area P shift toward the center of the sleeve since not much binding effect is expected. The boundaries of the area P also depend on the strength of the sleeve **2**. If the sleeve **2** has a high strength, the boundaries of the area P shift toward the ends of the sleeve **2** due to the binding effect. If the sleeve **2** has a low strength, the boundaries of the area P shift toward the center of the sleeve since not much binding effect is expected.

[0060] FIGS. **4**A and **4**B are diagrams showing how the sleeve rotates when tensile forces act on the reinforcing bars. FIG. **4**A shows a case of the present embodiment where the distance between the points of action is M. FIG. **4**B shows a case of conventional technology where the distance between the points of action is M'.

[0061] As can be seen from these diagrams, according to the conventional technology, the amount of rotation of the sleeve when the reinforcing bars undergo tensile forces is O'(FIG. **4**B). In the present embodiment, the amount of rotation greatly decreases to as low as θ (FIG. **4**A).

[0062] As has been described, according to the reinforcing bar joint **1** of the present embodiment, the wedge insertion holes **9***a*, **9***a* for the wedge member **4***a* to be inserted through and the wedge insertion holes **9***b*, **9***b* for the wedge member **4***b* to be inserted through are spaced apart from each other by a distance L along the axes of the reinforcing bars **5***a*, **5***b*. Since the wedge members **4***a*, **4***b* are pressed into these wedge insertion holes **9***a*, **9***b*, it is possible to reduce the amount of rotation of the sleeve **2** significantly when tensile forces act on the reinforcing bars **5***a*, **5***b*.

[0063] Consequently, bending deformation occurring in the reinforcing bars **5***a*, **5***b* decreases and the forces acting to widen the openings of the sleeve **2** from the reinforcing bars **5***a*, **5***b* decreases as well. This precludes a splitting fracture of the sleeve **2**, pulling out of the reinforcing bars **5***a*, **5***b* from the sleeve **2**, and a wedge break of the reinforcing bars **5***a*, **5***b*, thereby allowing base-material fracture of the reinforcing bars **5***a*, **5***b*.

[0064] Moreover, according to the reinforcing bar joint **1** of the present embodiment, the sleeve **2** is naturally longer since the two wedge members **4**a, **4**b are spaced apart from each other when pressed into between the reinforcing bars **5**a, **5**b.

[0065] This significantly reduces the force components acting on the openings of the sleeve **2** from the reinforcing bars **5**a, **5**b. The rotation of the sleeve **2** can thus also be suppressed in this respect.

[0066] FIGS. **5** and **6** are photographs showing the results of tensile tests. FIG. **5** shows a test piece corresponding to the present embodiment, having two wedge members. The reinforcing bars were US #8 reinforcing bars (GRADE 60; #8 is equivalent to Japanese Industrial Standards (JIS) D25). FIG. **6** shows a test piece corresponding to conventional technology, having one wedge member. The reinforcing bars were US #6 reinforcing bars (GRADE 60; #6 is equivalent to JIS D19).

[0067] Initially, as shown in FIG. **6**, the test piece utilizing conventional technology showed a large rotation of the sleeve due to tensile forces acting on the reinforcing bars. The reinforcing bars also suffered large bending deformation resulting from the rotation. The bending of the reinforcing bars also produced force components acting to widen the sleeve openings, thereby causing a splitting fracture in the sleeve.

[0068] From this test result, it is shown that the test piece of conventional technology causes a splitting fracture of the sleeve before base-material fracture of the reinforcing bars.

[0069] Now, in the test piece corresponding to the present embodiment shown in FIG. **5**, the sleeve showed some rotation due to tensile forces acting on the reinforcing bars, but the amount of rotation was significantly less than in FIG. **6**. Bending deformation of the reinforcing bars ascribable to the rotation was also small. In consequence, no splitting fracture of the sleeve was caused.

[0070] This test result shows that the test piece corresponding to the present embodiment caused a bending tensile fracture of one reinforcing bar near the joint location. The breaking force, however, exceeded the tensile strength (rated value) of the reinforcing bars and reached the same load as the intrinsic tensile strength of that material. This shows that the reinforcing bar joint according to the present embodiment fully satisfies the requirements of a reinforcing bar joint intended for main reinforcing bars.

[0071] While the present embodiment has dealt with the case where the reinforcing bar joint **1** is intended to join main reinforcing bars of an RC or SRC structure to each other, it may be applied to join shear reinforcing bars to each other instead.

[0072] Although not specifically described in the foregoing embodiment, a concrete filling hole **51** may be provided in the sleeve **2** as shown in FIG. **7**.

[0073] According to this configuration, concrete flows into the interior of the sleeve **2** through the concrete filling hole **51** during concrete casting. This can increase the joint strength of the reinforcing bars **5**a, **5**b. It should be appreciated that a plurality of holes may be formed in the sleeve **2** along the axis thereof, so that some of the holes can be used as wedge insertion holes and the rest as concrete filling holes.

Example 1

[0074] Table 1 shows the results of a tensile test. The tensile test used reinforcing bars of steel type SD345 (concrete reinforcing steel rod, Japanese Industrial Standard, specification values of 345 N/mm^2 in yield point and 490 N/mm^2 in tensile strength), having a diameter of D22 (nominal cross-sectional area of 387.1 mm^2). In the cases where two holes were provided, the holes were spaced 50 mm apart. The same holds for the tests to be described hereinafter.

[0075] [Table 1]

TABLE 1

	Sleeve									Test result	
Test piece	Steel type	Yield point $s^{\sigma}y$ (N/mm^2)	Tensile strength $s^{\sigma}u$ (N/mm^2)	Length s^L (mm)	Thick-ness s^t (mm)	Number of holes s^n	Sectional area s^A (mm^2)	Yield strength s^Py (kN)	Maximum strength s^Pu (kN)	Maximum tensile strength (kN)	Final condition
1	STKM	215	370	100	4.0	2	586.1	126.0	216.9	180.0	Split
2	13A			150		1				157.5	Pulling out
3						2				225.0	Base-material fracture
4				100	10.0	2	1599.6	343.9	591.8	224.0	Base-material fracture
5	S45C	325	510	100	5.0	1	719.4	233.8	366.9	175.4	Pulling out
6						2				208.4	Base-material fracture
7				100	4.5	2	654.5	212.7	333.8	176.2	Split Wedge break
										204.6	
8				120		2				216.4	Base-material fracture

[0076] Initially, test pieces 2 and 3 used sleeves of the same steel type and the same configuration. The difference between the test pieces consists in that the test piece 2 had one wedge member (a pair of wedge insertion holes) while the test piece 3 had two wedge members. From a comparison between these test pieces, it can be seen that the reinforcing bars were pulled out in the case of the sleeve with a single wedge member while base-material fracture in the reinforcing bars was caused in the case of the sleeve with two wedge members.

[0077] It is thus shown that even if the sleeves are of the same steel type and the same configuration, the reinforcing bar joint provides a tensile strength higher than the rated value of the tensile strength of the reinforcing bars when two wedge members are provided. This demonstrates the operation and effect of the present invention.

[0078] Next, test pieces 5 and 6 used sleeves made of a different steel type from the test pieces 2 and 3, but identical steel type and configuration to each other. As with the comparison between the test pieces 2 and 3, the test pieces 5 and

6 were intended to compare the case of the sleeve with a single wedge member with the case of the sleeve with two wedge members.

[0079] From a comparison between these test pieces, it can be seen that the reinforcing bars were pulled out in the case of the sleeve with a single wedge member while base-material fracture in the reinforcing bars was caused in the case of the sleeve with two wedge members. As with the comparison between the test pieces 2 and 3, this shows that even if the sleeves are of the same steel type and the same configuration, the reinforcing bar joint provides a tensile strength higher than the rated value of the tensile strength of the reinforcing bars when the number of wedge members is two. This demonstrates the operation and effect of the present invention.

[0080] Test pieces 1 and 4 both had two wedge members, and their sleeves were also identical (with a short sleeve length of 100 mm each) except in thickness. The test piece 1 had a thickness of 4 mm while the test piece 4 had a thickness of 10 mm.

[0083] From a comparison between these test pieces, it can be seen that the sleeve length can be increased to reduce sleeve rotation, thereby avoiding a split of the sleeve ends, and pulling out and a wedge break of the reinforcing bars.

Example 2

[0084] Table 2 shows the results of another tensile test. In the table, pulling out refers to a shear fracture of a reinforcing bar at a position where a wedge member bites into (an area of, chipped section). A split refers to a splitting fracture of a sleeve end in contact with a reinforcing bar. A wedge break refers to a breakage of a reinforcing bar at a position where a wedge member bites into (an area of chipped section).

[0085] The tensile test used reinforcing bars of steel type SD390 (concrete reinforcing steel rod, Japanese Industrial Standard, specification values of 390 N/mm^2 in yield point and 560 N/mm^2 in tensile strength), having a diameter of D22. If a test result included variations, the plurality of results is shown in the "test result" field.

[0086] [Table 2]

TABLE 2

	Sleeve							
Test piece	Steel type	Tensile strength (spec) (N/mm^2)	Tensile strength (material) (N/mm^2)	Length (mm)	Thickness (mm)	Number of holes	Test result	Experimental tensile strength / Material tensile strength
9	S45C	510	679.4	100	4.53	2	Wedge break Base-material fracture	0.93~0.97
10			679.4	110	4.55	2	Wedge break Base-material	0.93~0.98
11					4.60		Base-material	0.97~0.99
12					4.55		Base-material	0.97~0.98
13			679.4	110	5.00		Base-material	0.98~0.99
14					5.00		Wedge break	0.98
15	S45C Annealed	510	589.4	110	4.55	2	Split Base-material fracture	0.97~0.99
16					4.52		Split Base-material	0.99~1.00
17					4.53		Base-material	0.99~1.00
18			589.4	110	4.79		Base-material	0.99~1.00
19					4.80		Base-material	1.00~1.01
20					4.80		Base-material	1.00~1.02

[0081] From a comparison between these test pieces, it can be seen that the sleeve was split at a thickness of 4 mm while base-material fracture in the reinforcing bars was caused at a thickness of 10 mm. In view of this test result alone, it might be considered that the lesser thickness will not allow base-material fracture of the reinforcing bars even with two wedge members. Nevertheless, with consideration also given to the test piece 3 where base-material fracture in the reinforcing bars was caused even with the same thickness, it can be concluded that the operation and effect of the present invention resulting from providing a distance between the press-in positions of the two wedge members was not fully exercised since the short sleeve meant that the distance between the two wedge members was small.

[0082] Next, test pieces 7 and 8 were provided with the same number of wedge members, and their sleeves were of the same steel type and the same thickness. The difference between these sleeves consisted in that the test piece 7 had a sleeve length of 100 mm while the test piece 8 had a sleeve length of 120 mm.

[0087] Initially, a test piece 9 produced variations in the result. In view of this, the sleeve was extended in length from 100 mm to 110 mm to provide test pieces 10 to 12, most of which successfully showed base-material fracture. The reason for this is considered to be as follows: When the sleeve is short, the amount of rotation increases, producing a large bending moment on the reinforcing bars. This greatly affects the areas at which a wedge member bites into the bars (areas of chipped section), causing a wedge break of the reinforcing bars. If the sleeve is made longer, conversely, the amount of rotation decreases to correspondingly reduce the bending moment on the reinforcing bars. This reduces the effect on the areas at which a wedge member bites into the bars, allowing base-material fracture.

[0088] The test pieces 10 to 12 had tensile strength ratios of 0.93 to 0.99, however, showing that there is still room for performance improvement.

[0089] As employed herein, the tensile strength ratio refers to the ratio of a tensile strength obtained by a test to the tensile strength of the reinforcing bars (material). If this value is below 1, it means that the two reinforcing bars are jointed with a decrease in tensile strength.

[0090] Next, in view of the fact that the test pieces 10 to 12 failed to provide adequate tensile strength ratios, the sleeve thickness was increased to 5 mm to provide test pieces 13 and 14. No great improvement was observed, however.

[0091] As can be seen from the results of the test pieces 10 to 14, the sleeve length can be optimized to provide a certain tensile strength ratio but no further improvement even at increased thicknesses. The present inventors considered that the reason for this might be ascribable to excessively high sleeve rigidity, and thus annealed the sleeves used in the test pieces 9 to 14 to provide test pieces 15 to 20.

[0092] More specifically, the sleeves of the test pieces 9 to 14 were made of S45C (carbon steel for machine structural use, Japanese Industrial Standard) non-annealed raw material. Since the S45C raw material has sufficient hardness without quenching, the test pieces 15 to 20 of S45C were annealed into a hardness lower than that of the reinforcing bars. As a result, the test pieces 18 to 20 of approximately 4.8 mm in thickness showed tensile strength ratios of approximately 1, and all allowed base-material fracture of the reinforcing bars. The reason for this is considered to be that the annealing makes the sleeve highly ductile, thereby reducing reaction forces acting from the regions of the sleeve edges on the reinforcing bars and stresses occurring in the reinforcing bars due to those reaction forces. Asperities on the peripheries of the reinforcing bars can also bite into the inner periphery of the sleeve, absorbing asperity variations on the peripheries of the reinforcing bars.

[0093] Table 3 shows the results of the same tensile test where the reinforcing bars were changed from D22 to D25 in diameter. Although the sleeve lengths were changed to 110 to 130 mm in accordance with the increase in bar diameter, the test results were generally the same as with the test pieces 9 to 20. The test pieces 28 to 35 of annealed S45C showed tensile strength ratios of approximately 1. All the test pieces excluding some of the test piece 33 allowed base-material fracture of the reinforcing bars.

[0094] As with D22, the reason for this is considered to be that the annealing makes the sleeve highly ductile, thereby reducing reaction forces acting from the regions of the sleeve ends on the reinforcing bars and stresses occurring in the reinforcing bars due to those reaction forces. Asperities on the peripheries of the reinforcing bars can also bite into the inner periphery of the sleeve, absorbing asperity variations on the peripheries of the reinforcing bars.

[0095] The test piece 35 in which the sleeve length was changed from 120 mm to 130 mm successfully caused base-material fracture without fail, and improved the tensile strength ratio to 1.00 to 1.01. The reason seems to be that the longer sleeve reduced the amount of sleeve rotation.

[0096] It should be appreciated that the sleeve thickness may also be increased for improved sectional properties, ascribing the foregoing splitting fracture of sleeves to a decrease in sleeve strength because of annealing. Even with this method, it seems possible to avoid a splitting fracture of the sleeve and allow base-material fracture of the reinforcing bars without fail.

[0097] [Table 3]

TABLE 3

	Sleeve							
Test piece	Steel type	Tensile strength (spec) (N/mm^2)	Tensile strength (material) (N/mm^2)	Length (mm)	Thickness (mm)	Number of holes	Test result	Experimental tensile strength / Material tensile strength
21	S45C	510	679.4	110	5.13	2	Wedge break	0.94~0.97
22				120	5.06		Wedge break	0.97~0.98
23				130	5.08		Base-material fracture	0.98
24			679.4	120	4.98		Pulling out Wedge break Base-material fracture	0.85~1.01
25					5.03		Pulling out Wedge break Base-material fracture	0.85~0.99
26					4.95		Pulling out Wedge break Base-material fracture	0.84~1.01
27					4.98		Wedge break Base-material fracture	0.91~0.99
28	S45C	510	589.4~585.2	120	5.10	2	Base-material fracture	0.98~1.00
29	Annealed				5.01		Base-material fracture	0.97~0.98
30					5.09		Base-material fracture	0.99
31					4.98		Base-material fracture	0.98~0.99
32					5.14		Base-material fracture	0.99~1.00
33					4.96		Split Base-material fracture	0.99~1.00
34					5.16		Base-material fracture	1.00~1.01
35				130	4.95		Base-material fracture	1.00~1.01

[0098] As above, it is shown that the use of an annealed sleeve can significantly improve the joint performance of the reinforcing bar joint according to the present invention. In the meantime, it is also found that the strength decrease due to the annealing must be compensated for, e.g., by increasing the thickness, or the sleeve might be split at an edge (the test pieces 15, 16, and 33).

[0099] That is, when using an annealed sleeve, it is essential to give due consideration to the sectional properties and the post-annealing strength of the sleeve.

[0100] Instead of compensating for a decrease in strength caused by annealing, the sleeve length may be increased to suppress sleeve rotation so that the load acting on the sleeve decreases. By this method, it is possible to avoid splitting at sleeve edges and allow base-material fracture of the reinforcing bars without fail (see the test pieces 1, 3, 7, and 8).

Table 1, 2, 3	試験体	Test piece
	スリーブ	Sleeve
	鋼種	Steel type
	降伏点	Yield point
	引張強さ	Tensile strength
	全長	Length
	肉厚	Thickness
	孔数	Number of holes
	断面積	Sectional area
	降伏耐力	Yield strength
	最大耐力	Maximum strength
	試験結果	Test result
	最大引張耐力	Maximum tensile strength
	最終状況	Final condition
	抜け	Split
	抜け	Detachment
	母材破断	Base-material fracture
	ウェッジ破断	Wedge break
Table 2, 3	(規格)	(spec)
	(素材)	(material)
	(孔間)	(cross hole)
	実験引張／素材	Experimental tensile/material
	引張	tensile
	焼鈍し	Annealed
FIG. 3	領域	Area

1. A reinforcing bar joint comprising:

a sleeve having an elliptic section and openings in both ends, ends of a first reinforcing bar and a second reinforcing bar being insertable into said openings, respectively, so that the ends of the first and second reinforcing bars overlap each other by a predetermined length, the sleeve including at least a pair of opposed flat wall portions with wedge insertion holes formed therein, respectively; and

a wedging means to be inserted through said wedge insertion holes, and pressed into between said first reinforcing bar and said second reinforcing bar, said wedging means comprising a first wedge member to be inserted through ones of said wedge insertion holes positioned on a side of the end of said second reinforcing bar, and a second wedge member to be inserted through ones of said wedge insertion holes positioned on a side of the end of said first reinforcing bar,

said first reinforcing bar and said second reinforcing bar being main reinforcing bars for use in a reinforced concrete structure or a steel-reinforced concrete structure.

2. A reinforcing bar joint comprising:

a sleeve having an elliptic section and openings in both ends, ends of a first reinforcing bar and a second reinforcing bar being insertable into said openings, respectively, so that the ends of the first and second reinforcing bars overlap each other by a predetermined length, the sleeve including at least a pair of opposed flat wall portions with wedge insertion holes formed therein, respectively; and

a wedging means to be inserted through said wedge insertion holes, and pressed into between said first reinforcing bar and said second reinforcing bar, said wedging means comprising a first wedge member to be inserted through ones of said wedge insertion holes positioned on a side of the end of said second reinforcing bar, and a second wedge member to be inserted through ones of said wedge insertion holes positioned on a side of the end of said first reinforcing bar,

said first reinforcing bar and said second reinforcing bar being shear reinforcing bars for use in a reinforced concrete structure or a steel-reinforced concrete structure.

3. The reinforcing bar joint according to claim **1**, wherein said sleeve has a hardness relatively lower than those of said first reinforcing bar and said second reinforcing bar.

4. The reinforcing bar joint according to claim **3**, wherein said sleeve is annealed in a manufacturing process of the sleeve.

5. The reinforcing bar joint according to claim **2**, wherein said sleeve has a hardness relatively lower than those of said first reinforcing bar and said second reinforcing bar.

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