



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.06.2011 Bulletin 2011/25

(51) Int Cl.:
E04G 23/02 (2006.01)

(21) Application number: **09386037.7**

(22) Date of filing: **14.12.2009**

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

(71) Applicants:
• **Aristotle University of Thessaloniki**
54124 Thessaloniki (GR)
• **Manos, Giorgios**
54006 Thessaloniki (GR)
• **Katakalos, Konstantinos**
54006 Thessaloniki (GR)

• **Kourtidis, Vladimiros**
54006 Thessaloniki (GR)

(72) Inventors:
• **Manos, Giorgios**
54006 Thessaloniki (GR)
• **Katakalos, Konstantinos**
54006 Thessaloniki (GR)
• **Kourtidis, Vladimiros**
54006 Thessaloniki (GR)

(74) Representative: **Petsis, Christos**
4-6, Kyparissias
542 49 Thessaloniki (GR)

(54) **Construction system for strengthening an existing structure with tension sheets and a respective anchoring device and method therefore**

(57) Construction system (5+6) for strengthening an existing structure (5) with tension sheets (3) made of FRP

provided in the direction of extension of said existing structure (5) and a respective anchoring device (4).

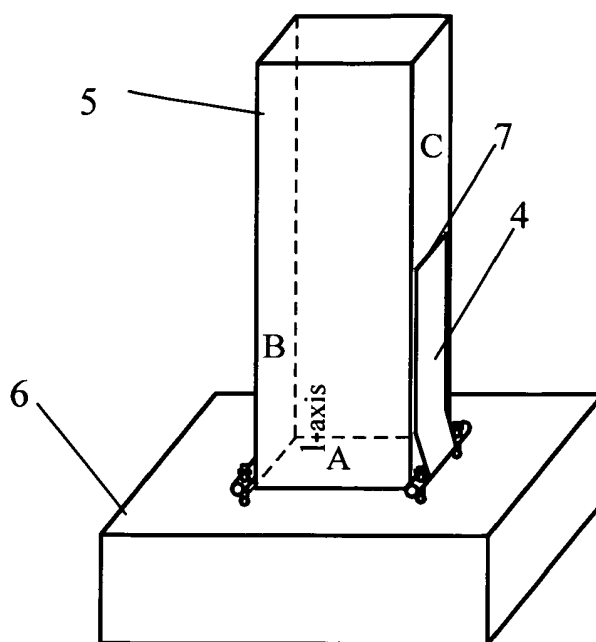


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a construction structure or system with strengthening anchoring device in a construction for strengthening same, actually in the industry of strengthening existent structures.

BACKGROUND OF THE INVENTION

[0002] At first, existing old structures, like bridges, buildings, silos, need strengthening in order to sustain the increasing demand loads or new design codes. In addition, some of the existing structures are deteriorated due to their age or environmental conditions resulting in that they need strengthening as well.

[0003] Many so-called R/C Reinforced Concrete structures need strengthening because they were built according to old seismic codes, thereby not meeting the requirements of new codes. The reason may also be that they are damaged after a strong earthquake sequence. One of the basic parameters of strengthening using so-called FRP -fiber reinforced polymer- layers externally, is the efficient anchorage of these polymer sheets to the concrete parts for the desired transfer of the tensile forces that develop on these layers. Thus the satisfactory behaviour of the anchorage scheme becomes very important since said FRP layers can withstand by themselves a high level of tensile forces. An effective anchorage of the FRP layers can be used to exploit the strengthening potential of such FRP layers and to prevent the neutralization of the FRP layers strengthening contribution that would result from the premature failure of their anchoring.

[0004] Besides, structural members such as walls, beams or columns, in buildings or bridges, or other structural systems are often required to resist uplifting tensile forces and bending moments resulting from overturning actions caused by loads imposed on the structure due to its occupancy or external environmental actions, especially from the lateral loads of strong wind and earthquakes. There is a large inventory of old infrastructures that require repair or strengthening, rehabilitation or retrofit to restore or enhance their load carrying capacities to a required performance level, in order to ensure their safe use and operation.

[0005] A practical and promising means to increase the tensile load or bending moment capacity of a structural member consists in adding external surfaced bonded reinforcing materials thereto. Thin steel plates or sheets were used for this purpose in the past. More recently since the 1990s, FRP sheets have been proved to be an attractive alternative to steel plates. The FRP alternatives are typically of the types of carbon (CFRP), glass (GFRP) or aramid (AFRP) fiber reinforced polymers. Even more recently, steel reinforced polymers (SRP) have been introduced as a further alternative material type. All material types above have the advantages

of high strength, light weight and excellent corrosion resistance compared to conventional reinforcing steel.

[0006] The strengthening of a structure by means of a FRP reinforcing device may consist in bonding FRP sheets to the surface of the structural member by applying epoxy or other adhesives. (=ET?!). At the boundaries of the structural member to its supporting member or foundation, the load carried by the FRP sheets must be transferred safely to said supporting member or foundation. Consequently, an anchoring device is incorporated in order to transfer this load suitably for insuring the effectiveness of the strengthening system.

[0007] It is generally referred hereinafter to ACI Committee 440 (2001) "Guide for the design and construction of concrete reinforced with FRP bars" ACI 440.1 R-01, American Concrete Institute, Farmington Hills.

PRIOR ART

[0008] In the past, anchoring devices were yet introduced for the aforementioned purpose. A well known anchoring device consists of an L-shaped angle anchor, wherein the first leg is parallel to the FRP reinforced structural member and the other leg is parallel to the surface of the supporting element. The FRP sheet is wrapped around the outer surfaces of both legs. Reference is made here to Hall et al. III "Ductile Anchorage for Connecting FRP Strengthening of Under-Reinforced Masonry Buildings" in Journal of Composites of Construction, ASCE, February 2002, 3-10. The main disadvantage of this anchoring device is focused on the eccentricity between the loading direction and the hold down of the L-shaped angle. Indeed, it generates a large out-of-plane distortion of the FRP sheet from its loading plane, which finally leads to a reduced load carrying capacity of the strengthening scheme, especially under cyclic load loadings.

[0009] Another drawback of retrofitting using FRP is the problem caused by debonding of the FRP sheet from said supporting member or foundation. First reference is made to Nanni et al. "Anchorage of Surface Mounted FRP Reinforcement" in Concrete International: Design and Construction, Vol. 21, No. 10, October 1999, pp. 49 54 with his attempt to employ a U-shaped anchor in order to prevent such debonding in beams reinforced with FRP sheets. The desired achievement is to develop anchoring force in the U-anchor by embedment of the FRP sheet. For this purpose, viscous paste is used to fill the groove. However the viscous paste may not be strong enough to hold the FRP sheet.

[0010] Finally, a technique was developed to improve the debonding of the FRP sheet from the concrete surface. This technique called Near Surface Mounted (NSM) uses small metallic or non metallic bolts. Reference is made to Ekenel M et al "Flexural Fatigue Behavior of Reinforced Concrete Beams Strengthened with FRP Fabric and Precured Laminate Systems" in Journal of Composites of Construction, ASCE, September/October

2006, 433-442, respectively Eshwar et al. "Performance of Two Anchor Systems of Externally Bonded Fiber-Reinforced Polymer Laminates" in ACI Materials Journal, Volume 105, No. 1, January-February 2008, 440.2R. The major disadvantage of that technique is that it cannot be used or it does not have a good behavior when it is used to strengthen joints in order to upgrade their flexural capacity.

OBJECT OF THE INVENTION

[0011] There is thus a need for incorporating an improved anchoring device or system providing safety and trust in the load transfer mechanism, which the present invention aims at to provide with.

SUMMARY OF THE INVENTION

[0012] For this purpose, it is proposed according to the present invention a constructive arrangement consisting of a construction structure as defined in main claim 1, thereby comprising at least one structural member, resp. support element connectively cooperating with each other, further comprising at least one anchoring device, wherein said structural member is supported on said support element by its bottom surface, its adjoining lateral surfaces extending therefrom along a longitudinal axis thereof. Said construction structure is remarkable in that it further comprises sheet means for securing said mutual connectively cooperation between said structural member and said support element, which is delimited by a bottom resp. opposite top side and a pair of lateral sides and which has at said top side, and bonding means for bonding said sheet means at its top end onto said active lateral surface of said structural member so that said sheet is connected with said structural element, on the one hand, and wherein said sheet means is connected at its opposite bottom end to said structural element by actively cooperating with, on the other hand, by means of said anchoring device. The latter consists of a holder means extending at least over the whole bottom side of said sheet and of fastening means for anchoring said holder means to said support element, in order to improve its resistance by resisting additional forces.

[0013] In addition, said sheet means is connectively cooperating with said structural support element in order to transfer the additional forces onto said structural support element. Said additional forces are essentially tensile forces that are all directed in one single direction which is oriented longitudinally defined as the length direction of said sheet, wherein said holder means is located substantially in a tangent plane of the sheet bottom edge.

[0014] There is thus provided thanks to the invention an anchoring device, wherein firstly said sheet is bonded onto the structural member of said constructive arrangement in order to improve its resistance by resisting additional forces, and secondly anchored to a structural sup-

port element thereof in order to transfer the additional forces onto said structural support element. The developed forces are transferred from the bonded sheet to the supporting member, such as a foundation, in a safe and easily predictable manner. Remarkably, said shaft means of the anchoring device is extending substantially in a plane of the sheet, which allows improving the resistance of the construction structure which thus gets reinforced thanks to the invention. The anchoring device is thus used for strengthening applications, like transferring new forces due to the strengthening scheme.

[0015] According to an advantageous embodiment of the invention, said anchoring device is arranged in an elastically and plastically deformable bonding assembly with said sheets resulting in that said device has an elastic-plastic behaviour. Thanks to this, the stress distribution in said device and in said sheet in the working situation is significantly better than the stress distribution in said device and in said sheet immediately after its installation on said construction structure. According to this embodiment, the stress is distributed over the whole device and sheet, so that the stress differences are smaller, and thus the maximal values of stress are smaller as well.

[0016] The anchoring device included in a construction system according to the invention thus allows combining the two characteristics to secure anchoring of the strengthening scheme and of its elastic-plastic behaviour, thus defining a so-called Hybrid Anchoring Device abridged hereinafter as "H.A.D."

[0017] According to a particular embodiment of the invention, said holder means of the anchoring device consists of a shaft preferably a cylinder, thus allowing said sheet means to be wrapped around said holder means smoothly and fairly uniformly.

[0018] According to an advantageous embodiment of the invention, said sheet is thus wrapped around said shaft with a solid section or consisting of a tube with a circular outer surface, in particular arranged horizontally, i.e. extending substantially in parallel to said support element, and having its said fastening means provided along the longitudinal axis thereof.

[0019] According to a further particular embodiment of the invention, said fastening means consist in lock-down fixation means provided at each end of said holder means, more particularly a vertical anchor bolt or cylinder rod e.g. of steel, mounted through the centre thereof, which is held securely by said lock-down means which, in turn, is embedded or anchored in the structural support member.

[0020] According to a still further particular embodiment of the invention, said bonding means consist of a bonding strip, in particular extending in parallel to said holder means.

[0021] According to a preferred embodiment of the invention, said sheet means is a reinforcement sheet, in particular made of a fiber reinforced polymer.

[0022] According to a further preferred embodiment of the invention, said fibers are carbon, glass or aramid fib-

ers.

[0023] According to an alternative embodiment of the invention, said fibers are steel fibers.

[0024] According to a still further embodiment of the invention, said sheet is a plate or a shell.

[0025] According to a further alternative embodiment of the invention, said reinforcing sheet is made of steel.

[0026] Said composite or steel or other metallic or non-metallic material, reinforcing sheet, plate or shell is bonded to the surface of the structural member, and optionally, to the supporting member, and it passes underneath the outer circular surface of the tube or shaft by wrapping it or just bonding it.

[0027] According to a specific embodiment of the construction structure according to the invention, its constructive members have an overall block shape, with the top one being elongated and extending substantially upright along said longitudinal axis. The bottom one may have a flattened profile, both in a mutually aligned arrangement.

[0028] According to a further specific embodiment of the invention, it is substantially symmetrical, particularly respective a central plane of symmetry extending substantially upright so as to include said longitudinal axis, thereby defining at least two symmetrical parts, each including one said anchoring device actively connecting elastically said constructive members within each said symmetrical part.

[0029] To summarize, thanks to the anchoring device according to the invention, two features are remarkably combined: the secure anchoring of the strengthening scheme and the elastic-plastic behaviour of the anchoring device, wherein this behaviour could be achieved by the yieldingness of the metallic or non-metallic materials which are the horizontal shaft and basically the lock-down means. Due to this behaviour, the stress distribution on the composite or steel or other metallic or non-metallic material, reinforcing sheet, plate or shell is becoming more distributed, which results in a better use of the composite material. Finally, by using the so-called Hybrid Anchoring Device, an elastic strengthening method is becoming inelastic, more ductile.

[0030] In addition to providing a self-centering anchoring device which eliminates the eccentricity problem, the invention thus allows the composite, metallic or non-metallic materials to fully utilize their high strength without premature failure. As a consequence, the present invention allows solving the problem of anchoring externally bonded composite, steel or other materials, metallic or non metallic, to structural support elements in concrete or steel. It enables the developed forces to be transported on said latter materials, composite or steel or other metallic or non metallic materials, to healthy concrete or steel blocks.

[0031] The present invention thus combines the use of a reinforcement sheet with an anchoring device with an inelastic behaviour due to the yielding either of said holder means or of said fastening means.

[0032] Thanks to the invention, there is thus provided an anchoring device allowing an easy installation, without the need to employ new or advanced technology to manufacture or use.

[0033] A further notable advantage of the invention consists in its fairly universal profile enabling the application of the anchoring mechanism to a wide variety of structures, which may be made of quite different materials and shapes, such as reinforced concrete, steel or masonry structures, structural members with a flat surface, such as straight walls and square columns, and structural members with a curved surface, such as curved walls and circular columns.

[0034] According to a useful embodiment of the invention, said structure is an existing structure, and said sheet a reinforcement sheet.

[0035] The present invention also relates to an anchoring method for a surface bonded sheet for improving the resistance of a structure, wherein said sheet is bonded onto the surface of a structural member of said structure in order to improve its resistance by resisting additional forces, and anchored to a structural element of said structure in order to transfer the additional forces onto said structural element, wherein said additional forces are essentially tensile forces all in one single direction being defined as the length of said sheet. Said method is remarkable in that a rod extending at least over the whole width of said sheet is locked to said structural element by a lock means, and in that the rod is substantially in the plane of the sheet.

[0036] According to a preferred embodiment of the method according to the invention, the rod, the lock means and the sheet once assembled are elastically and plastically deformed in such a way that the stress distribution in said rod, lock means and sheet in the working situation is significantly better than the stress distribution in said rod, lock means and sheet immediately after its installation on said structure.

[0037] Further features and properties of the device and the anchoring method will emerge from the following description in detail of some embodiments of the invention, which are illustrated with the aid of the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038]

FIG. 1 is a perspective view of a construction system with an anchoring device of the invention with a sheet bonded to a vertical structural member thereof.

FIG. 2 is a functional perspective view of a diagrammatic representation 4 of said embodiment of the anchoring device according to the invention with a sheet wrapped around it.

FIG. 3 is a cross sectional view of an embodiment

as shown in the latter FIG. in a connective relationship, taken along a vertical longitudinal plane thereof.

FIG. 4 is a similar side view of said embodiment of the invention as in both previous figures showing sections of the sheet.

FIG. 5 is a further enlarged perspective view of the embodiment as shown in FIG. 2, under a different observation angle.

FIG. 6 is an experimental setup of the overall arrangement according to the invention as shown in FIG. 1.

FIG. 7 shows results as displayed on an experimental graph with 100% capacity increase thereof.

DESCRIPTION OF THE INVENTION

[0039] The present invention generally relates to a construction system comprising an anchoring device for strengthening structures, wherein conventional structural reinforcing materials are used. The surface reinforcing agent is e.g. a surface reinforcing sheet 3. It could be a plate or a shell as well. However, its composition may also be of non-metal or metal. The structural reinforcing material is preferably made of composite materials known as FRP.

[0040] FIG. 1 shows a preferred embodiment of said construction system incorporating said anchoring device 4 wherein the developed load is transferred from the FRP sheet 3 to a supporting member or foundation 6, through the anchoring device 4. The main advantage thereof is that said anchoring device 4 offers a confident prediction and a safe transfer of the forces.

[0041] Said sheet 3 is bonded to the surface of the strengthening structural member 5 shown vertical in FIG. 1 e.g. by epoxy or any other conventional bonding materials. The anchoring device 4 is thus attached to the supporting member 6.

[0042] FIG. 2 shows an enlarged detailed view of said anchoring device 4 for providing structural reinforcement with said composite FRP sheet 3. Said sheet 3 is wrapped around the outer surface of a horizontal holder means 1 consisting of a shaft, preferably circular, thus transferring the load carried by said sheet 3 to the anchoring device 4 and further through its fastening means 2. The latter consist of bolts engaged vertically in corresponding holes 8, e.g. metallic bolts. Said load is thus transferred to the supporting member 6 or foundation. Said holder means 1 may also consist of a tube, e.g. cylindric.

[0043] Typically, the structural member 5 is a concrete or steel structural element, while the supporting member 6 is a foundation, also composed of concrete or steel. Upon applying tensile load to the sheet 3, the resultant action of the applied FRP load and the interface shear

force provided by the epoxy bond 7 of the sheet 3 to the structural member 5 and supporting member 6 is parallel to said horizontal holder 1, resulting in a complete utilization of the sheet's mechanical properties.

[0044] In other words, the sheet 3 is transferring the forces to the horizontal circular holder 1, which in turn is transferring those forces to said fastening means 2 of the anchoring device 4. Said fastening means 2 may also consist of a pair of rods 2 arranged vertically through the shaft 3 and acting as vertical anchors 2 for said device 4, which may be made of non metal as well. Finally, those vertical anchors 2 are transferring those forces to the supporting structural element or foundation 6 as shown in FIG. 1.

[0045] As a consequence, there is a tendency of pull out of the vertical bolts or rod 2 acting as anchors. This tendency is avoided by the safe and proper embedment of said anchors 2 in the concrete or steel blocks 6 as shown in FIG. 3. The appropriate depth, resp. diameter of the receiving holes 8 opened in the top face of the supporting structural element or foundation 6 for anchoring said fastening means 2, is determined by the analysis and the design of the strengthening scheme. The vertical anchors 2 can be either steel or other metallic bolts, or even regular structural reinforcing bars. The anchoring can be established with the use of an epoxy material which is placed between the vertical anchors 2 and the foundation 6. Alternatively, it may also be achieved with mechanical means like welding or screwing and the like.

[0046] Also referring to FIG. 4, the developed forces may thus be considered as acting parallel to said composite sheet 3 as well as to the Hybrid Anchoring Device 4 abridged as HAD, which results in a both safe and easy prediction. Also this arrangement of the forces results in the safe and easy fabrication of the strengthening scheme.

[0047] The anchoring device 4 is illustrated with the following strengthening example of a vertical structural member 5.

[0048] The design load of the anchoring device 4 is the load that the CFRP sheet 3 applies thereto 4 in a vertical structural element 5 loaded at the top by a lateral force. The dimensions of the anchoring device 4 are selected so that the maximum stress therein 4 under the design load does not exceed the yield stress of the material thereof 4.

[0049] The anchoring device 4 also shown under a different observation angle in FIG. 5 is designed by using Mechanics of Material simple laws. As a result, a 40 mm diameter steel horizontal solid shaft 1 is chosen with 18 mm diameter vertical steel bolts 2. The thickness of the CFRP sheet 3 is equal to 0,34 mm. The design of the strengthening scheme is done in a way that the CFRP will fail. In this way, the maximum capacity of the CFRP will be utilized. The diameter of the steel horizontal shaft 1 may vary between 10 mm and 200 mm according to overall capacity which is demanded by the design of the strengthening scheme. This diameter range may be big-

ger or smaller in accordance with the needs as well as for the vertical steel bolts 2 and the CFRP 3.

[0050] The properties of the vertical concrete structural element 5 are not mentioned. It is the mean of testing the behaviour of the anchoring device 4.

[0051] FIG. 6 shows an example of the experimental setup thereof. It consists in a baseplate 6 about 1 m in square and 300 mm thick on which a structural member 5 is fixed, about 1400 mm long, and with a 500 mm square section. Hydraulic pistons 11 are installed on top and on a side face near the top of said structural member 5, in order to allow applying vertical resp. horizontal forces on it. Load cells 12 are installed near the application point of said pistons 11 in order to measure the applied forces. Displacement sensors 13 (LVDT) measure the horizontal displacement of the upper end of the structural member 5, and the vertical uplift of the reinforcement sheet and/or the said member.

[0052] Finally, FIG. 7 shows the use of the present invention as a means of a strengthening system results to an increase of the structural's member capacity equal to 100%. More specifically, the Virgin Pier, which is the Pier without the Hybrid Anchoring Device 4 resulted to a maximum horizontal load equal to 37kN, whereas the 24mm-Pier resulted to a maximum horizontal load equal to 75kN. The 24mm-Pier corresponds to a Pier which was imposed to a maximum horizontal displacement equal to 24 mm with HAD 4 attached on it. The use of the present anchoring device 4 resulted in an increase of the ultimate horizontal displacement as well. It was increased from 15 mm to 29 mm, due to the plasticity of the device. The present anchoring device 4 is qualified as "Hybrid" due to the fact that it combines the secure anchoring of the strengthening scheme, offering at the same time to a structure an increase of the ductility due to its plasticisation.

[0053] It is to be understood that the description above is given only by way of example to illustrate the present invention, without confining the scope thereof.

[0054] Indeed, the application of the anchoring device of the present invention is not limited to anchoring application of bonded FRP sheet. The structural and/or supporting surfaces can be reinforced with bonded or unbonded reinforcing plate or shell made of FRP or steel or other metallic or non-metallic materials.

[0055] Said anchoring device is not limited to retrofitting or repairing of existing structures, such as seismic upgrade of structural and supporting walls. Any new building structures may incorporate the present invention, so as to provide for improved structural reinforcements.

[0056] It is further to be understood that the present invention may be carried out in other specific ways than those that were described here.

Claims

1. A construction structure comprising at least one structural member (5), resp. support element (6) connectively cooperating with each other, further comprising at least one anchoring device (4), wherein said structural member (5) is supported on said support element (6) with its bottom surface (A), its adjoining lateral surfaces extending therefrom (B, C) along a longitudinal axis (ℓ) thereof (A), **characterized in that** it further comprises

- reinforcement surface means (3) for connectively securing said mutual cooperation between said structural member (5) and said support element (6), which is delimited by a bottom (a) resp. opposite top side (b) and which (3) has at said top side (b)

- bonding means (7) for bonding said reinforcement surface means (3) at its top end (b) onto said active lateral surface (B, C) of said structural member (5), on the one hand, and wherein said reinforcement surface means (3) is actively cooperating at its opposite bottom end (a) with said support element (6), on the other hand, by means of said anchoring device (4) consisting of

- a holder means (1) extending continuously and at least over the whole bottom side (a) of said reinforcement surface means (3) for holding same in a remote connective relationship with said support element (6) and of

- fastening means (2) for anchoring said holder means (1) to said support element (6).

2. A construction structure according to the preceding claim, **characterized in that** said anchoring device (4) is arranged as an elastic-plastic device with an elastic-plastic behaviour in an elastically and plastically deformable bonding assembly with said reinforcement surface means (3).

3. A construction structure according to one of the preceding claims, **characterized in that** said holder means (1) is a shaft (1), in particular a cylinder around which said sheet (3) is wrapped at its said bottom side (a) and which extends substantially in parallel to said support element (6), wherein said bonding means consist in particular of a bonding strip (7), more particularly extending in parallel to said holder means (1).

4. A construction structure according to one of the preceding claims, **characterized in that** said reinforcement surface means (3) is a sheet, in particular which is made of a fiber reinforced polymer FRP, more particularly a composite FRP material.

5. A construction structure according to the preceding claim, **characterized in that** said fibers are carbon, glass or aramid fibers, and/or **in that** said fastening means (2) are non metallic.
6. A construction structure according to one of the preceding claims, **characterized in that** its constructive members (5) and/or (6) have an overall block shape, the top one (5) being elongated and extending substantially upright along said longitudinal axis (t), both (5, 6) in a mutually aligned arrangement, and/or in particular wherein it (10) is substantially symmetrical, particularly respective a central plane of symmetry (α) extending substantially upright so as to include said longitudinal axis (ℓ), thereby defining two symmetrical parts, each (11, 12) including one said anchoring device (4) connecting elastically said constructive members (5, 6) within each said symmetrical part (11, 12).
7. An anchoring device (4) for a surface bonded sheet (3) aimed at improving the resistance of a structure (5, 6), wherein said sheet (3) is bonded onto the surface of a structural member (5) of said structure in order to improve its resistance by resisting additional forces, and anchored to a structural element (6) of said structure in order to transfer the additional forces onto said structural element, said additional forces being essentially tensile forces all in one single direction being defined as the length of said sheet, **characterized in that** said anchoring device (4) consists in a rod (1) extending at least over the whole width of said sheet (3) and a lock means (2) aimed to lock said rod to said structural element (6), and **in that** the rod (1) is substantially in the plane of the sheet (3).
8. An anchoring device according to the preceding claim, **characterized in that** the stress distribution in said device (4) and in said sheet (3) in the working situation is *significantly* better than the stress distribution in said device and in said sheet immediately after its installation on said structure (5, 6), thanks to an elastic-plastic behaviour and/or **in that** said structure (5, 6) is an existing structure, and said sheet (3) a reinforcement sheet.
9. An anchoring device according to one of both preceding claims, **characterized in that** said rod (1) has a circular outer surface in order to provide a smooth contact with the reinforcing sheet (3) passing around it, wherein said rod (1) is a cylinder, solid or hollow, in particular wherein said sheet (3) is wrapped around said rod (1) and/or wherein said reinforcing sheet (3) is made of a fiber reinforced polymer.
10. An anchoring device according to one of the claims 7 to 9, **characterized in that** said sheet (3) is a plate or a shell and/or **in that** said fibers are steel fibers or carbon, glass or aramid fibers.
11. An anchoring device according to one of the claims 8 to 10, **characterized in that** said reinforcing sheet (3) is made of metal, in particular steel.
12. An anchoring device according to the preceding claim, **characterized in that** said lock means (2) consist in fixation means provided at each end of said rod (1), in particular wherein said fixation means are bolts or steel cylinder rods.
13. An anchoring method for a surface bonded sheet (3) aimed at improving the resistance of a structure (5, 6), wherein said sheet is bonded onto the surface of a structural member (5) of said structure in order to improve its resistance by resisting additional forces, and anchored to a structural element (6) of said structure in order to transfer the additional forces onto said structural element, said additional forces being essentially tensile forces all in one single direction being defined as the length of said sheet (3), **characterized in that** a rod (1) extending at least over the whole width of said sheet is locked to said structural element (6) by a lock means (2), and **in that** the rod (1) is substantially in the plane of the sheet (3).
14. An anchoring method according to the preceding claim, **characterized in that** the rod (1), the lock means (2) and the sheet (3) once assembled are elastically and plastically deformed in such a way that the stress distribution in said rod (1), lock means (2) and sheet (3) in the working situation is significantly better than the stress distribution in said rod (1), lock means (2) and sheet (3) immediately after its installation on said structure (5, 6).
15. Use of an anchoring device according to one of the claims 7 to 12 in a construction structure according to one of the claims 1 to 6, in particular with a method according to one of both preceding claims, **characterized in that** its (10) structural members are submitted to external loads, wherein said and bonded sheets are adjusted, resp. anchoring device further fastening said sheets so as to improve the resistance of said construction structure (10), while its (5) resistance is improved by resisting additional forces, wherein said additional forces are transferred onto said structural element (6), on the other hand, said additional forces being essentially tensile forces that are all directed in one single direction which is oriented longitudinally respective said sheet (3).

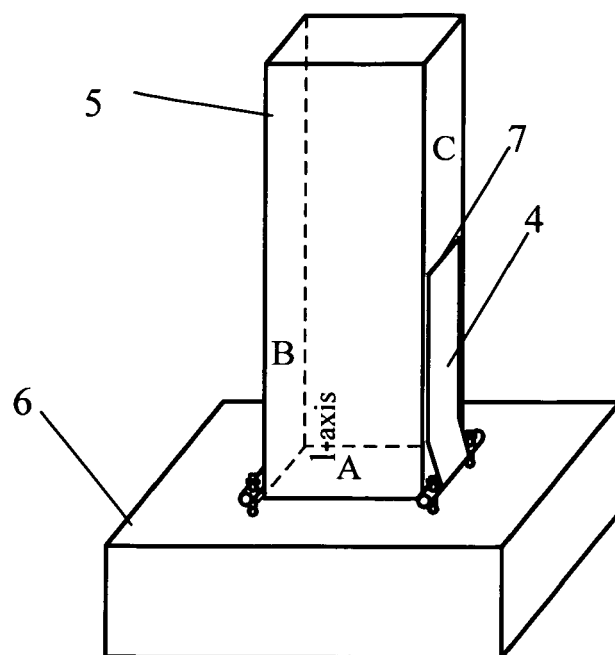


FIG. 1

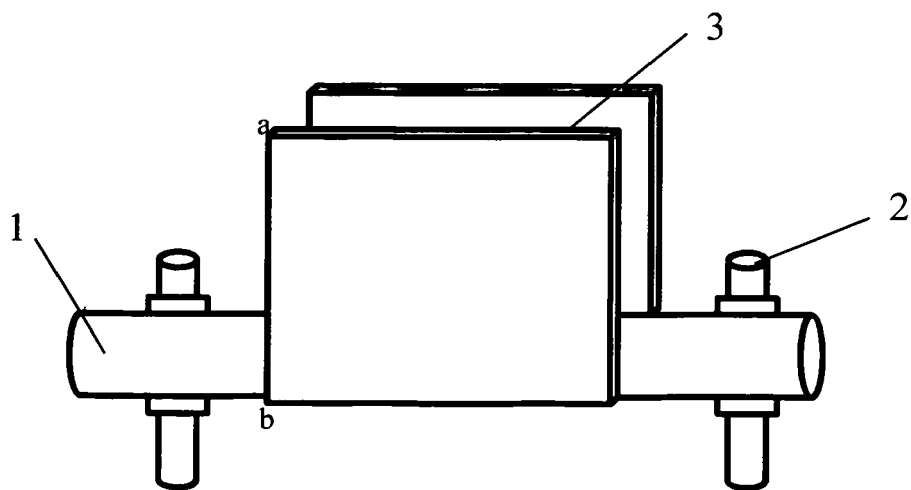


FIG.2

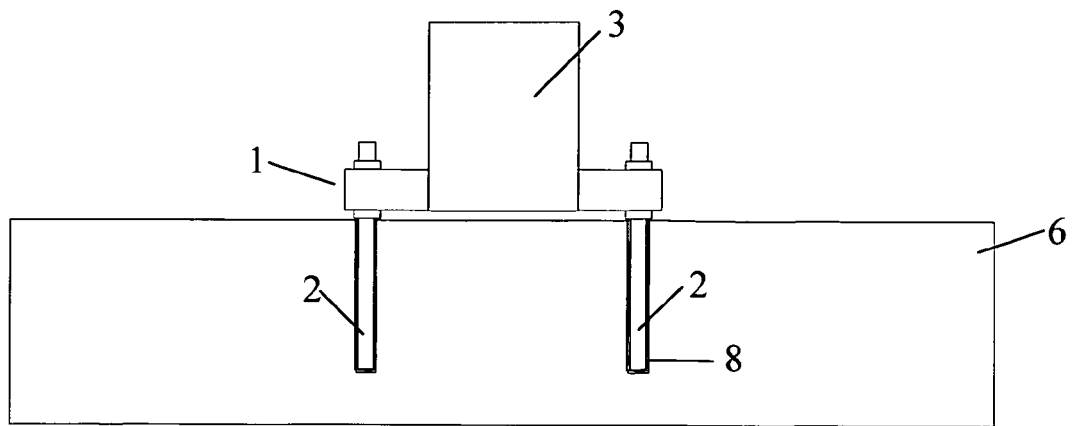


FIG.3

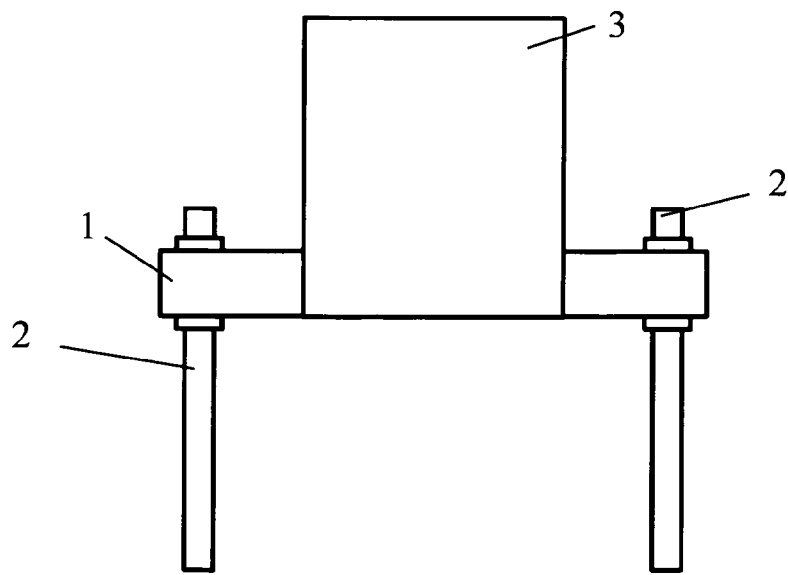


FIG.4

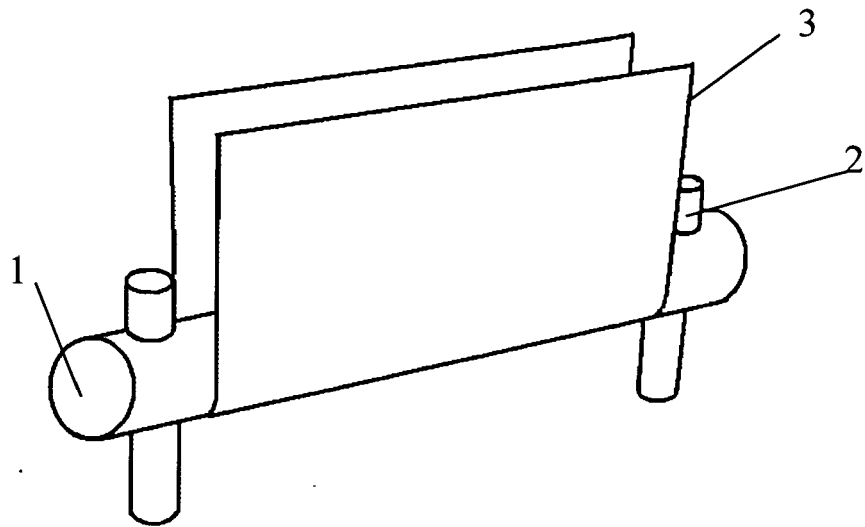


FIG. 5

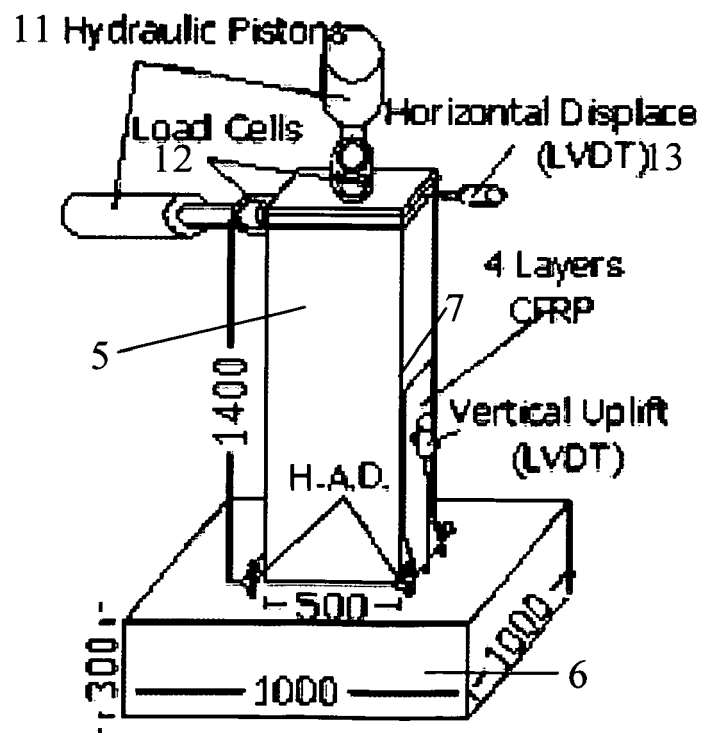


FIG. 6

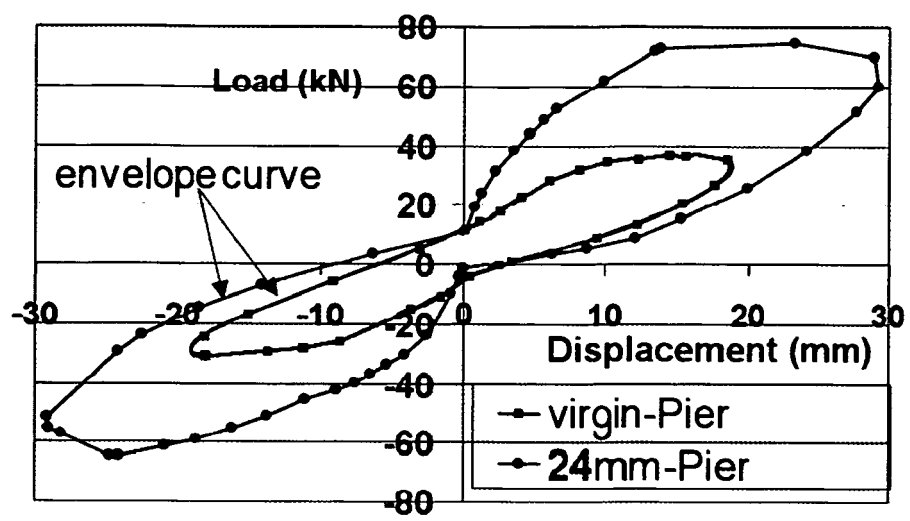


FIG.7



EUROPEAN SEARCH REPORT

Application Number
EP 09 38 6037

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 163 473 A (CEE PAPWORTH LIMITED) 26 February 1986 (1986-02-26)	7,9,12	INV. E04G23/02
A	* page 2, lines 18-64; figures 1-3 * * page 2, lines 126-128 *	1,3-6	
A	DE 299 24 305 U1 (BILFINGER BERGER AG [DE]) 5 September 2002 (2002-09-05) * page 3, line 9 - line 29; figure 1 * * page 5, line 9 - line 17 *	1,3-7,9, 12,13,15	
A	JP 2002 322817 A (KENCHIKU SYST KK J) 8 November 2002 (2002-11-08) * abstract *	1,3-7,9, 12,13,15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) E04G
Place of search Munich		Date of completion of the search 15 June 2010	Examiner Valenta, Ivar
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2
EPO FORM 1503 03/82 (P04C01)

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

EP 09 38 6037

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-06-2010

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2163473	A	26-02-1986	NONE	

DE 29924305	U1	05-09-2002	NONE	

JP 2002322817	A	08-11-2002	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **HALL ET AL. III et al.** Ductile Anchorage for Connecting FRP Strengthening of Under-Reinforced Masonry Buildings. *Journal of Composites of Construction*, ASCE, 03 February 2002 [0008]
- **NANNI et al.** Anchorage of Surface Mounted FRP Reinforcement. *Concrete International: Design and Construction*, October 1999, vol. 21 (10), 49-54 [0009]
- **EKENEL M et al.** Flexural Fatigue Behavior of Reinforced Concrete Beams Strengthened with FRP Fabric and Precured Laminate Systems. *Journal of Composites of Construction*, ASCE, September 2006, 433-442 [0010]
- **ESHWAR et al.** Performance of Two Anchor Systems of Externally Bonded Fiber-Reinforced Polymer Laminates. *ACI Materials Journal*, January 2008, vol. 105 (1), 440 [0010]