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(54) **Interconnection device and method using such a device for connecting a reinforced concrete prefabricated beam to a reinforced concrete prefabricated pillar**

(57) An interconnection device (1) for connecting a prefabricated reinforced concrete beam (3) to a prefabricated reinforced concrete pillar (2) is provided with a first intermediate connecting element (10), which is adapted to be inserted, in part, in at least one seat (24) extending into said pillar (2) and having an upper supporting plate (40) for said beam (3); and a second intermediate connecting element (11) essentially defined by a solidified non-shrink grout casting, which extends between the beam (3) and the pillar (2) and, in part, in a first and second recess (19, 32) made respectively in the pillar (2) and in the beam (3).

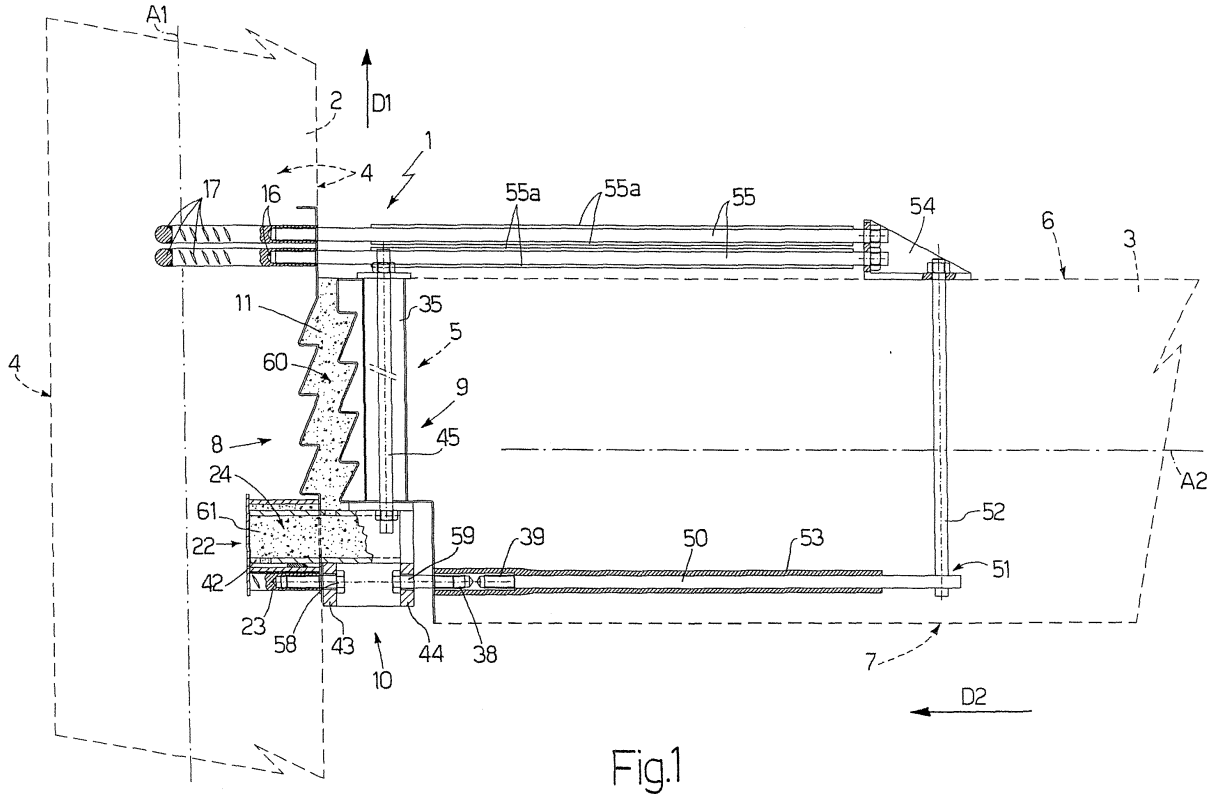


Fig.1

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## Description

**[0001]** The present invention relates to a device for interconnecting a reinforced concrete prefabricated beam to a reinforced concrete prefabricated pillar.

**[0002]** A known type of connection between a prefabricated reinforced concrete pillar and beam envisages the used of shelves, which are prefabricated in reinforced concrete with the pillar so as to form a single structural element. This type of connection between a pillar and a beam requires the making of a high number of formworks to make the pillars with shelves. Indeed, one pillar generally has four side faces and may have from one to four shelves, as many are the side faces. Indeed, one shelf overhangingly protrudes from a corresponding side face, and consequently the formworks must be adapted to make one or more overhanging shelves from the central body of the pillar according to the pillar type of use.

**[0003]** In order to avoid this drawback, an interconnection device for connecting a beam to a pillar which comprises an intermediate connecting element adapted to be inserted, in part, in a cavity extending in the pillar and comprising a supporting shelf for the beam it has established itself on the market. Some interconnection devices of the type described above are the subject matter of patent applications, such as GB 2,027,785; EP 311,653; and EP 1,405,958. In essence, the shelf element is disconnected from the pillar and may be coupled to the pillar if needed. In this way, it is sufficient to create a cavity in the pillar adapted to be coupled to the intermediate connecting element. This type of connection between prefabricated reinforced concrete beams and prefabricated reinforced concrete pillars imposed itself rapidly on the market because making a cavity in a pillar while casting concrete in a formwork is much simpler an operation than the one which envisages forming an overhanging shelf with respect to the central body of the pillar.

**[0004]** However, also this type of interconnection device has the drawback of not being capable of supporting high loads, such as for example the loads transmitted by a beam supporting a slab in a multilevel car park.

**[0005]** It is the object of the present invention to make a device for interconnecting a prefabricated reinforced concrete beam and a prefabricated reinforced concrete pillar which is capable of supporting very high loads simply and cost-effectively and solving the drawbacks of the interconnection devices of the known type.

**[0006]** According to the present invention, an interconnection device for connecting a prefabricated reinforced concrete beam to a prefabricated reinforced concrete pillar is made; the interconnection device comprising a first intermediate connecting element, which is adapted to be inserted, in part, in at least one seat extending into said pillar and comprising an upper supporting plate for said beam; the interconnection device being characterised by comprising a second intermediate connecting element comprising a solidified non-shrink grout casting, which is arranged between the beam and the pillar and, in part, in a first and second recess made respectively in the pillar and in the beam.

**[0007]** In this way, the supporting surface between beam and pillar can be increased by employing two intermediate connecting elements and, at the same time, the drawbacks related to accurate positioning between the first and the second intermediate connecting elements are avoided. Indeed, the second intermediate connecting element may be arranged between the pillar and the beam in liquid state and may, therefore, advantageously adapt itself to the position assumed by the beam following the connection made by the first intermediate connecting element.

**[0008]** The present invention also relates to a method for connecting a reinforced concrete prefabricated beam to a reinforced concrete prefabricated pillar.

**[0009]** According to the present invention, a method is provided according to claim 26.

**[0010]** For a better understanding of the invention, one embodiment will now be described only by way of non-limitative example, and with reference to the accompanying drawings, in which:

- figure 1 is a lateral elevation view, with parts removed for clarity and parts in cross-section, of an interconnection device made according to the present invention;
- figure 2 is a lateral elevation view, on magnified scale and with parts removed for clarity and parts in cross-section, of a component of the interconnection device in figure 1;
- figure 3 is a frontal elevation view of the component in figure 2;
- figure 4 is a lateral elevation view, on magnified scale and with parts removed for clarity and parts in cross-section, of a second component of the interconnection device in figure 1;
- figure 5 is a frontal elevation view of the component in figure 4;
- figure 6 is a lateral elevation view, on magnified scale and with parts removed for clarity and parts in cross-section, of a third component of the interconnection device in figure 1;
- figure 7 is a plan view of the component in figure 6.

**[0011]** With reference to figure 1, number 1 indicates as a whole an interconnection device between a prefabricated reinforced concrete pillar 2 and a prefabricated reinforced concrete beam 3. Pillar 2 extends along a vertical axis A1 in a direction D1 and presents four side faces 4, only one of which in figure 1 is connected to beam 2 by means of device 1, while it is understood that a device 1 identical to that shown may be applied to each of the other side faces 4.

**[0012]** Beam 3 extends along an axis A2 in an essentially horizontal direction D2 and comprises an end 5 facing side face 4 of pillar 2 connected to beam 3, an extrados or upper face 6 and an intrados or lower face 7.

**[0013]** Connecting device 1 comprises a connecting element 8 integral with pillar 2; a connecting element 9 integral with beam 3; an intermediate connecting element 10 adapted to form a overhanging shelf with respect to pillar 2; and an intermediate connecting element 11 essentially formed by a solidified grout casting setting with connecting elements 8 and 9.

**[0014]** Connecting element 8 is an integral part of pillar 2, which is made by casting concrete into a formwork (not shown) in which a grid of metallic deformed bars (not shown in figure 1) are arranged to which connecting element 8 is fixed. In practice, element 8 does not present overhanging parts with respect to a side face 4 along which it is arranged. Similarly, connecting element 9 is fixed to end 5 of beam 3 and forms an integral part of beam 3 itself through the connection with a metallic grid (not shown) of beam 3.

**[0015]** With reference to figures 2 and 3, connecting element 8 comprises a metal sheet 12, which presents in sequence from the top to the bottom a flat portion 13 levelled with side face 4, a toothed portion 14 and a flat portion 15 levelled with side face 4. Connecting element 8 comprises four bushings 16, which are internally threaded, arranged at the flat portion 13 and connected in two-by-two by deformed bars 17. Bushings 16 and bars 17 extend within pillar 2 (figure 1) in direction D2 perpendicular to flat portion 13, which presents holes 18 at bushings 16 for allowing access to the bushings 16 themselves.

**[0016]** Toothed portion 14 comprises a series of recesses 19 in pillar 2. Each recess 19 comprises a metal plate supporting wall 20 perpendicular to direction D1 and a metal plate wall 22 slanted with respect to direction D1. The external face of wall 20 faces upwards. In practice, each recess 19 defines a series of supporting walls 20 which each has a depth of approximately 40 mm and a width of approximately 400 mm.

**[0017]** Two pockets 22 which, in used, stretch into pillar 2 (figure 1) and two internally threading bushing 23, which are parallel in direction D2 and arranged underneath pockets 22 within pillar 2 (figure 1) are arranged along flat portion 15. The metal plate flat portion 15 presents openings 25 at pockets 22 so as to allow access to respective seats 24 defined by pockets 22 themselves and two holes 26 to allow access to bushings 23.

**[0018]** With reference to figures 4 and 5, connecting element 9 comprises a shaped metal sheet 27, which presents in sequence from the top down a portion of plate 28 perpendicular to direction D1 and levelled with extrados 6; a toothed portion of plate 29 extending essentially perpendicularly to direction D2; a portion of plate 30 perpendicular to direction D1; and a portion of plate 31 perpendicular to direction D2. In essence, portions 30 and 31 are reciprocally perpendicular and form a marked recess at the lower part of end 5 of beam 3 (figure 1). Toothed portion 29 comprises a series of recesses 19 in pillar 3. Each recess 2 is formed by a supporting wall 33 perpendicular to direction D1 and a slanted wall 34 with respect to direction D1. The free face of wall 33 faces downwards in sense of direction D1. In practice, recesses 32 define along toothed portion 29 an essentially complementary profile along portion 14.

**[0019]** Connecting element 9 comprises two tubes 35, which are parallel to direction D1, have rectangular section and are destined to be entirely incorporated in beam 3 (figure 1). The upper end of tubes 35 is fixed to the edge of plate portion 28, while the lower end is fixed to portion 30, which presents openings 36 for allowing access to tubes 35. Two holes 37 which allow access to two internally threaded bushings 38 extending in direction D1 are arranged along portion 31. Each bushing 38 is integral to an internally threaded bushing 39, which is coaxial to bushing 38 and counterpoised to bushing 38 in that bushing 39 is accessible from the opposite band of bushing 38. In essence, the two bushings are integral.

**[0020]** With reference to figures 6 and 7, intermediate connecting element 10 comprises an upper plate 40 perpendicular to direction D1 rigidly squared to a frontal plate 41 which extends downwards with respect to the upper plate 40 perpendicularly to direction D2. Two hollow profiles 42 are rigidly fixed to the upper plate 40 and to the frontal plate 41, which extend in direction D2 and are adapted to be inserted, in part, in seats 24 of pockets 21 to make a prismatic coupling. Profiles 42 are in turn connected to a rear plate 43, which is parallel and faces the frontal plate 41. Each profile 42 presents a rectangular section, four side walls, a hole 42a arranged along the upper side wall at upper plate 40 and a hole 42b arranged along the lower side wall at the free end of profile 42 itself. Upper plate 40 presents two holes 44 for fastening threaded bars 45 parallel to direction D1, while the frontal plate 41 and the rear plate 43 present respective slots 46 and 47 and are connected together by two side stiffening corner plates 48 and 49.

**[0021]** Interconnection device 1 comprises a fastening and tensioning system of connecting elements 8 and 9 and of intermediate connecting element 10. The fastening and tensioning system comprises two bars 50, each of which is embedded in beam 3, has a threaded end engaging one of the bushings 39 and the opposite end provided with an eyebolt 51; two bars 52, each of which is parallel to direction D1, is embedded in beam 3 and has an end inserted in eyebolt 51 and an threaded end which protrudes from the extrados 6 of beam 3. Bars 50 are arranged along with bushings 38 and 39 within respective protective sheaths 53. The fastening and tensioning system comprises a square bracket 54 arranged on extrados 6 of beam 3 and fixed to the treaded ends of bars 52 and four tie-rods 55, which of which extends parallelly to direction D2, has one threaded end engaging one of bushings 16 and the other end fixed to bracket 54 and is arranged, at least in part, within a sheath 55a. The fastening and tensioning system also comprises two washers 56 and two bolts 57, which respectively mesh with bars 45 and close tubes 35, two bolts 58 engaging slots 47 and bushings 23, and two bolts 59 engaging

slots 46 and bushings 38.

**[0022]** Intermediate connecting element 11 is defined by a solidified grout casting arranged in a cavity 60 essentially comprised between toothed portion 14 and toothed portion 29. The minimum cavity depth 60 is slightly deeper than the depth of supporting walls 20 and 33 measured in direction D2. The applicant experimented with MAPEFILL™ non-shrink grout marketed by MAPEI for making intermediate connecting element 11 and found the product to provide excellent structural hold. However, we cannot exclude that other brands of non-shrink grout are equally adapted to the purpose. The non-shrink grout is cast in liquid state and penetrates in the free cavities. In particular, figure 1 shows a portion of grout which defines a stiffening element 61 arranged within profile 42.

**[0023]** In use, the connection sequence of beam 3 to pillar 2 envisages inserting profiles 42 in seats 24 of pockets 22 and arranging the rear plate 43 against portion 15 so as to connect intermediate connecting element 10 to connecting element 9 and to pillar 2. Upper plate 40 of intermediate connecting element 10 forms the supporting shelf of beam 3, which is lowered from the top by means of a crane resting on the upper plate 40 and the bars 45 are inserted in tubes 35. Later, bolts 58 and 59, washers 56 and nuts 57 and tie-rods 55 are inserted and fastened. However, bolts 58, 59, and tie-rods 55 which allow to tension beam 3 and pillar 2 in direction D2 are loosely fastened. Grout is cast in cavity 60 before tightening the fastening and tensioning system components.

**[0024]** The grout casting in addition to flowing in cavity 60 penetrates in each profile 42 through hole 42a to form the stiffening element 61 and occupies all the free space determined by the plays between profile 42 and pocket 22.

**[0025]** Once the grout has set, bolts 58 and 59 and tie-rods 55 are tightened to secure intermediate connecting element 11 between beam 3 and pillar 2.

**[0026]** Later, a slab (not shown in the accompanying figures) is made over beam 3 to incorporate tie-rods 55 and bracket 54 into the slab itself. Actually, bars 50 and tie-rods 55 are capable of sliding within the respective sheaths 53 and 55a also when sheaths 53 and 55a are incorporated in the concrete. Consequently, the tensioning system acts as an anti-seismic joint thanks to the sheaths 53 and 55a.

**[0027]** In general, thanks to interconnection device 1 the loads transmitted by beam 3 to pillar 2 are distributed on a very wide surface without the need to make very deep cavities inside pillar 2, which would weaken pillar 2 itself. In essence, intermediate element 11 forms shores between supporting walls 20 and 33 while stiffening element 61 stiffens the hollow profiles 42 when installed.

## Claims

1. An interconnection device for connecting a prefabricated reinforced concrete beam (3) to a prefabricated reinforced concrete pillar (2); the interconnection device (1) comprising a first intermediate connecting element (10), which is adapted to be inserted, in part, in at least one seat (24) extending into said pillar (2) and comprises an upper supporting plate (40) for said beam (3); the interconnection device (1) being **characterised by** comprising a second intermediate connecting element (11) comprising a solidified non-shrink grout casting, which is arranged between the beam (3) and the pillar (2) and, in part, in a first and second recess (19, 32) made respectively in the pillar (2) and in the beam (3).

2. A device according to claim 1, **characterised in that** said second intermediate connecting element (11) is arranged over the first intermediate connecting element (10).

3. A device according to claim 1 or 2, **characterised in that** said first recess (19) is delimited by a first essentially horizontal supporting wall (20) whose first free face faces upwards and said second recess (32) is delimited by a second supporting wall (33) essentially horizontal whose free face faces downwards.

4. A device according to claim 3, **characterised in that** said first recess (19) is further delimited by a first slanted wall (21) with respect to the first supporting wall (20) and said second recess (32) is further delimited by a second slanted wall (34) with respect to said second supporting wall (33).

5. A device according to claim 3 or 4, **characterised in that** said first or second supporting walls (20, 33) are made of metal plate.

6. A device according to any one of the claims from 1 to 5, **characterised by** comprising one series of first recesses (19) in said pillar (2) and a series of second recesses (32) in said beam (3), each of said first and second recesses (19, 32) being adapted to be occupied by said second intermediate connecting element (11).

7. A device according to claim 6, **characterised in that** said first recesses (19) are delimited by a first toothed portion (14) of plate comprising the first essentially horizontal supporting walls (20) and whose free faces face upwards; said second recesses (32) being delimited by a second toothed portion (29) of metal plate comprising second supporting walls (33) essentially horizontal and whose free faces face downwards.

**8.** A device according to claim 7, **characterised by** comprising a first connecting element (8), which is integrally made with said pillar (2) and comprises said first toothed plate portion (14).

**9.** A device according to claim 8, **characterised in that** said pillar (2) extends along an axis (A1) in a vertical direction (D1).

**10.** A device according to claim 8 or 9, **characterised in that** said first connecting element (8) extends along a side face (4) of said pillar (2).

**11.** A device according to any of the claims from 8 to 10, **characterised in that** said first connecting element (8) comprises a pocket (22) defining said seat (24); the pocket (22) and the first toothed portion (14) of plate forming an integral body.

**12.** A device according to claim 11, **characterised in that** said first connecting element (8) comprises two pockets (22) arranged side by side defining two respective seats (24).

**13.** A device according to claim 11 or 12, **characterised in that** said pocket (22) is arranged underneath said pocket (22) is arranged underneath the first toothed portion of plate (14).

**14.** A device according to any one of the claims from 7 to 13, **characterised by** comprising a second connecting element (9), which is made integrally with said beam (3) and comprises said second toothed portion (29) of plate.

**15.** A device according to claim 14, **characterised in that** said beam (3) extends along an axis (A2) in an essentially horizontal direction (D2).

**16.** A device according to claim 14 or 15, **characterised in that** said second connecting element (9) extends along an end of the beam (3) and faces pillar (2) at the first connecting element (8).

**17.** A device according to claims from 14 to 16, **characterised in that** said second connecting element (9) comprises a flat supporting portion (30) on said upper plate (40).

**18.** A device according to any one of the claims from 7 to 17, **characterised in that** the first and the second toothed portion (14, 29) essentially face each other and are parallel and arranged at a distance one from the other such to form a cavity (60) adapted to be occupied by said second intermediate connecting element (11).

**19.** A device according to claim 18, **characterised in that** the minimum distance between the first and the second toothed portion (14, 29) is slightly higher than the depth of each of the first and second recesses (19, 32).

**20.** A device according to any one of the claims from 1 to 19, **characterised by** comprising a fastening system comprising tensioning means (55, 58, 59) to secure the second intermediate connecting element (11) between the beam (3) and the pillar (2).

**21.** A device according to claim 20, **characterised in that** said tensioning means (55, 58, 59) comprise tie-rods (55) which directly connect beam (3) to pillar (2).

**22.** A device according to claim 20 or 21, **characterised in that** said tensioning means (55, 58, 59) comprise bolts (58, 59) for connecting the first intermediate element (10) to the pillar (2) and to the beam (3).

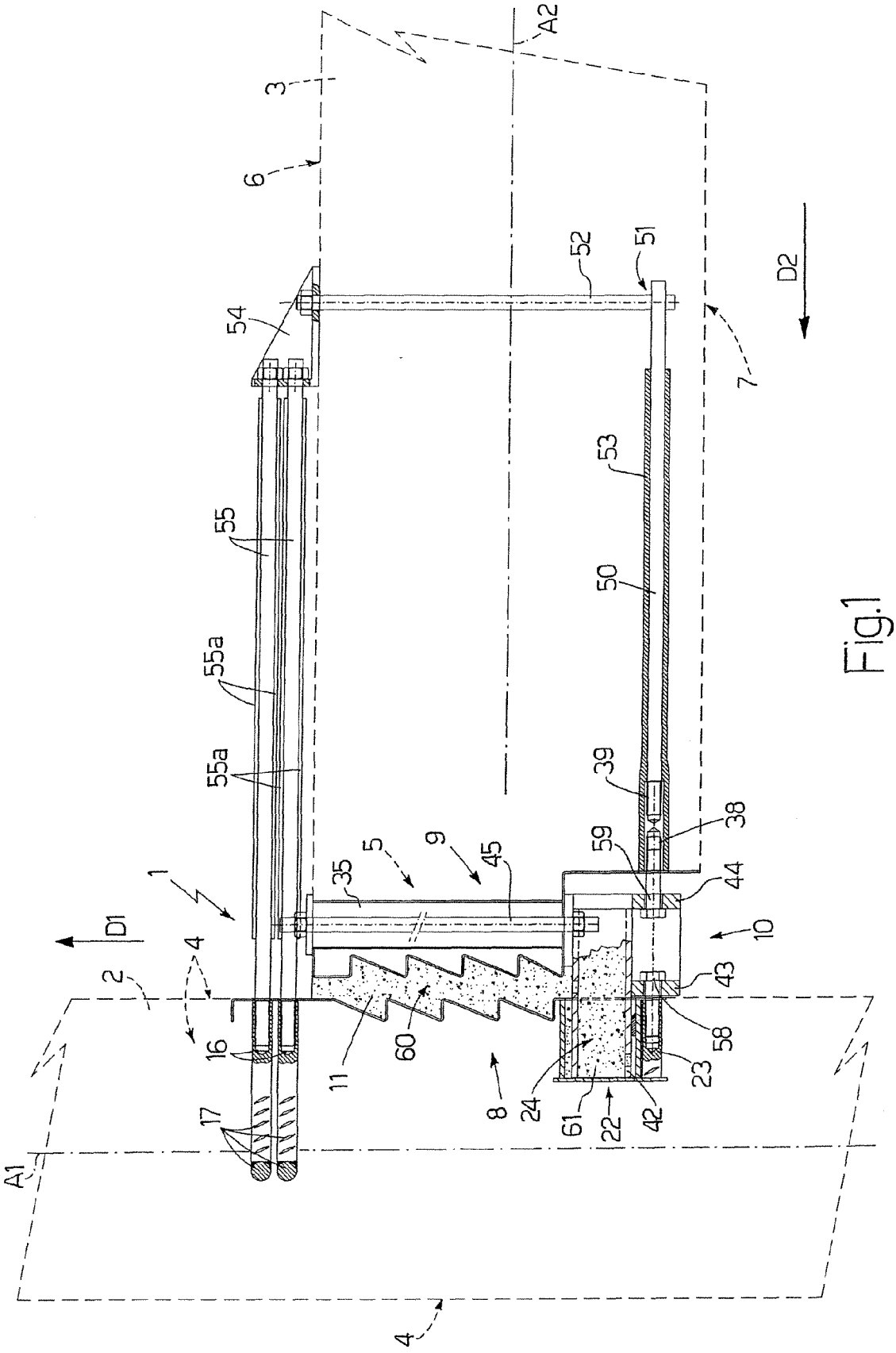
**23.** A device according to any of the claims from 20 to 22, **characterised in that** said tensioning means (55, 58, 59) are arranged over the second intermediate connecting element (11) and underneath the second intermediate connecting element (10).

**24.** A device according to any one of the claims from 20 to 23, **characterised in that** said tensioning means comprise tie-rods (55) and bars (53) extending in the longitudinal direction of extension (D2) of the beam (3); the tie-rods (55) and the bars (53) being arranged inside sheaths (55a, 53) which allow the tie-rods (55) and the bars (53) to slide also when they are incorporated in concrete.

**25.** A device according to any one of the preceding claims, **characterised in that** said first intermediate connecting element (10) comprises at least one hollow profile (42) which is adapted to be inserted in said seat (24) and is provided with an opening (42a) along one of its side wall so as to allow to be filled with said non-shrink grout so that the hardened non-shrink grout forms a stiffening element (61) within said hollow profile (42).

**26.** A method for connecting a prefabricated reinforced concrete beam (3) to a prefabricated reinforced concrete pillar (2) by means of an interconnection device (1) described in any of the preceding claims, **characterised in that** it comprises the steps of connecting the beam (3) by means of the first intermediate connecting element (10) and connecting the beam (3) to the pillar (2) by means of tensioning means (55, 58, 59); of making a non-shrink grout casting to form said second intermediate connecting element (11); of letting the grout set; and of tightening said second intermediate connecting element (11) by

means of said tensioning means (55, 58, 59).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D2
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D1
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Fig.1

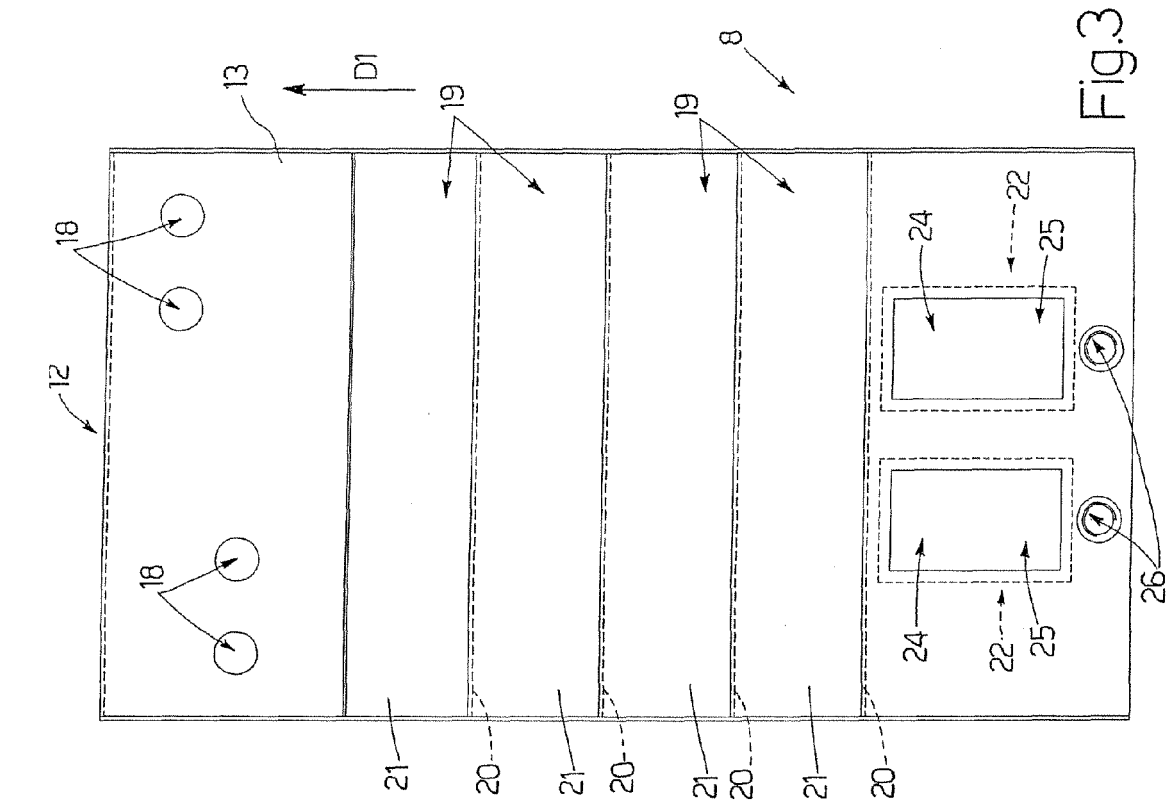
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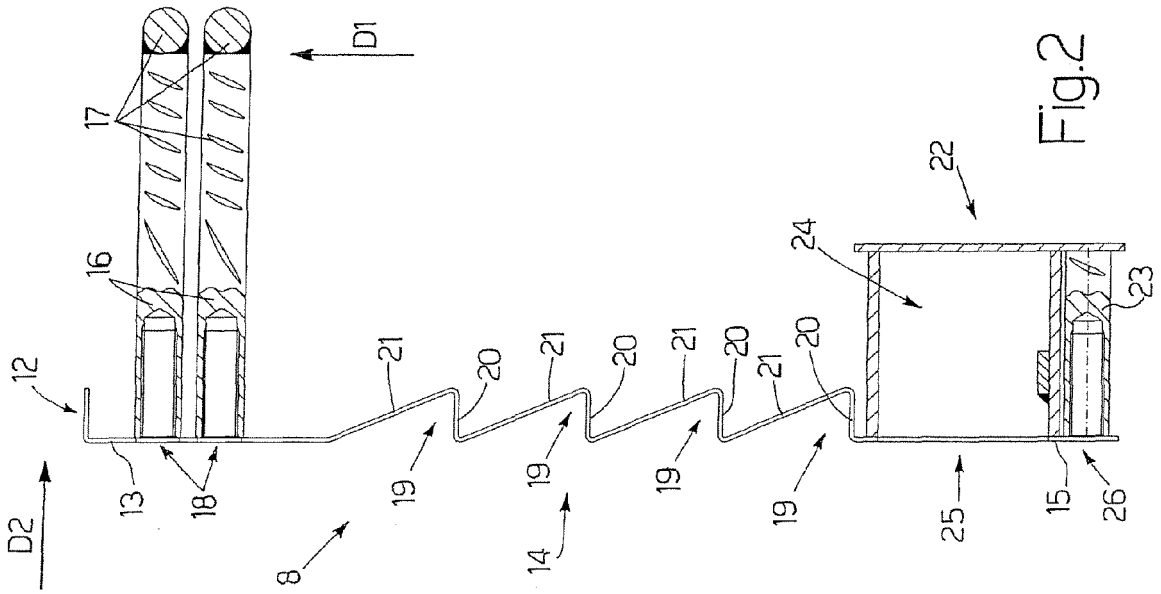
Fig.3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15
26

Fig.2

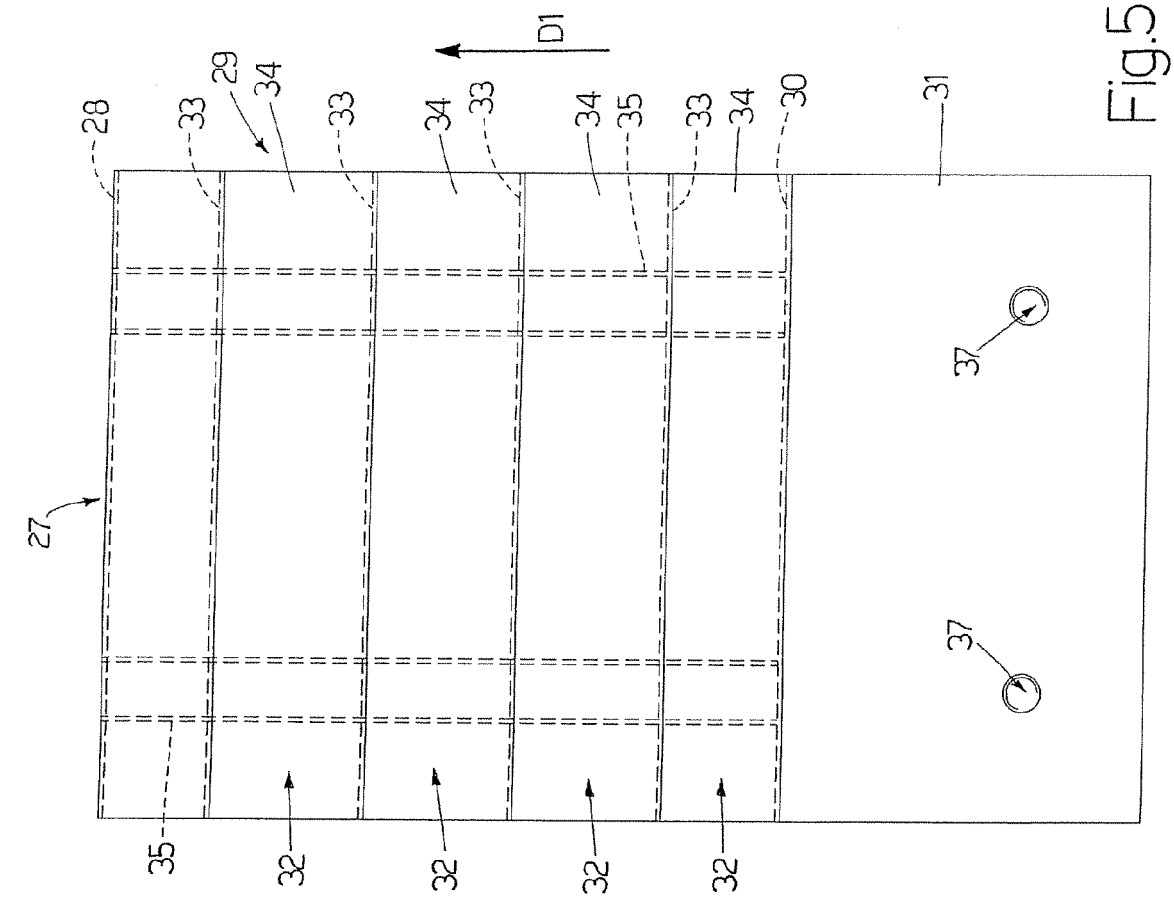
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Fig.5

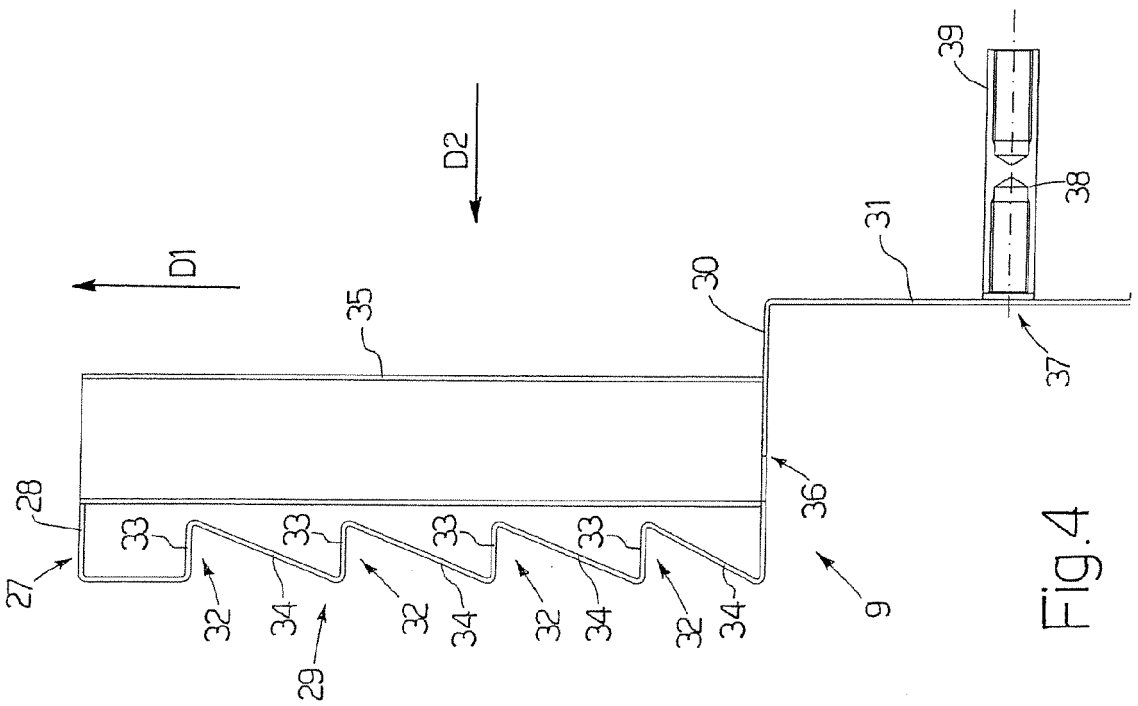
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Fig.4

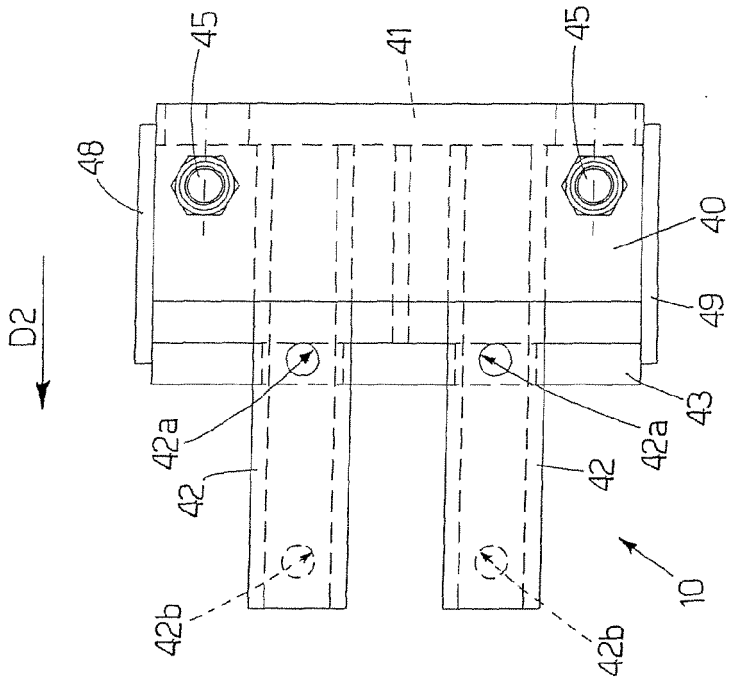
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Fig.7

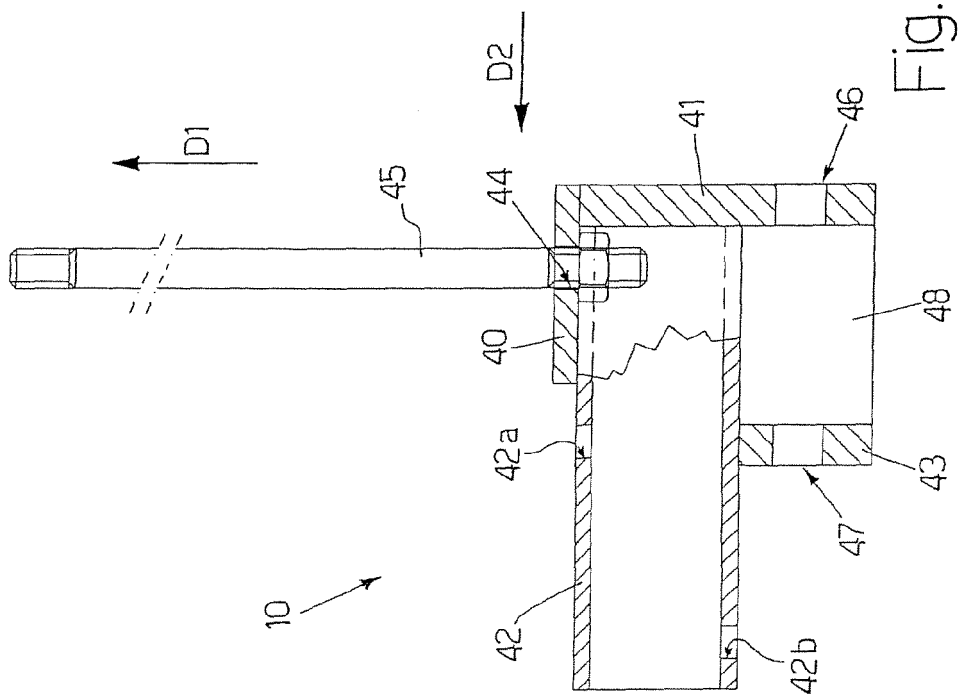
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Fig.6

## REFERENCES CITED IN THE DESCRIPTION

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