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(54) METHOD AND ARRANGEMENT FOR STRENGTHENING A CONCRETE STRUCTURE, AND REINFORCED CONCRETE STRUCTURE

(57) The invention concerns a method and an arrangement for strengthening a concrete structure: The invention also concerns a concrete structure (10) comprising a supported element (12) arranged on supporting elements (14), wherein said concrete structure (10) further comprises a strengthening arrangement including at least one pre-bended beam (20) placed under said supported element (12), in contact with said supported element (12), and a connection system (30) mounted on each of two supporting elements (14), forming thereby a pair of connection systems (30) which retain the two extremities of said pre-bended beam (20) when the pre-bended beam (20) is placed under the supported element (12).

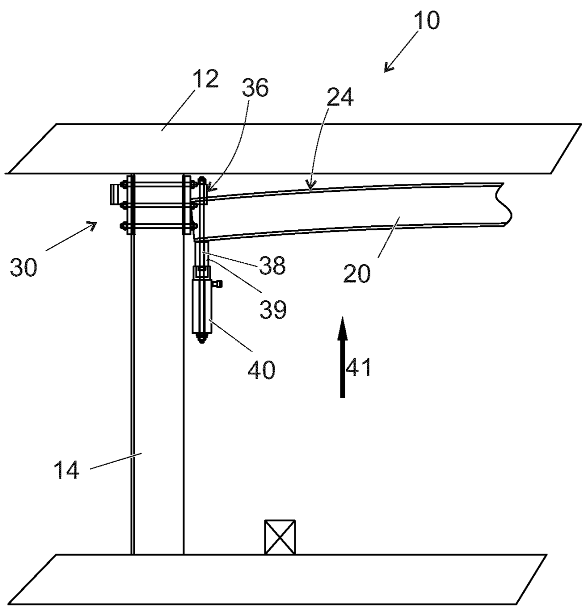

Fig.4B

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Description

Field of the invention

[0001] The present invention concerns a method and an arrangement for strengthening a concrete supporting structure. More precisely, the present invention concerns the reinforcement for the repair, the refurbishment or the strengthening of a pre-existing concrete supporting structure comprising a supported element arranged on supporting elements.

[0002] In some situation, existing buildings and other civil engineering structures need a post-installed mechanical reinforcement. Such a reinforcement can in some case become necessary because the load applied to the supporting or load-bearing structure has increased and/or has changed because of a change in use of the civil engineering structure. In another cases the original design may have been un-sufficient or some change in the design code require a strengthening of the structure.

[0003] In some other situations, because there exist some damage, or some deficiencies during design or construction or because of ageing of the civil engineering structure, a strengthening operation is required in order to guarantee the safe further use of the civil engineering structure.

[0004] There indeed exist multiple reason that create a need to extend the service life of the concrete supporting structure through reinforcement.

[0005] This concrete supporting structure can be, in a non-limiting way, a suspended floor, roof or ceiling, a bridge deck, or other high-rise buildings including a supported element extending in at least two directions arranged on supporting elements. This supported element forms a two dimensional or a three dimensional supported element, such as a slab, a floor, a roof, which can be already reinforced by strengthening elements such as beams.

Description of related art

[0006] Some widely used techniques are based on the reinforcement of the concrete structure by adding reinforcement elements within holes drilled in the structure. In WO2014195504, a fibre bundle runs in a bore filled with an adhesive, this fibre bundle extending from one face into an inner region of the supporting structure, and this fibre bundle also projects along said face, in a groove filled with an adhesive. In EP1033455, a reinforcement panel is glued onto the concrete surface and an anchor plate is fixed to the concrete by means of steel rods forming connectors engaged in holes drilled in the concrete. Drilling holes in the concrete load-bearing structure has to be implemented with care and needs specific expertise and equipment, without any risk of creating cracks into the concrete.

[0007] Also, there is a cladding technique that could be combined with the above mentioned technique. In that cladding technique, retrofitting with additional parts are used in the same than strapping in medical treatment by adhesive plaster for binding injured parts of the body. These additional parts can be formed by plates, rods, profiles, fabrics or elements of other shape made for instance from CFRP for Carbon Fiber Reinforced Polymer. As an example, in US6219991 is presented a method for externally strengthening concrete columns with flexible strap of reinforcing material. Such technique bring reinforcement limited to the area on which the additional parts are brought and is limited to local shear reinforcement or to bending at the middle of a slab. Such reinforcement has generally very limited impact as it is applied after the structure has been constructed or even loaded by service load and therefore the reinforcement will only act on the extra load applied after the repair is done or the structure must be discharged during the repair is made so that the repair will take this load discharged after it is set. The typical repair presented up to there are considered as passive as they do not change the previous load distribution.

[0008] WO2016005941 concerns a strengthening system implementing reinforcement both with internal reinforcement elements (inside anchoring) and the external reinforcement elements (cladding technique). Therefore, the use if this system requires direct interventions on the slab, including drilling holes in the concrete structure.

[0009] In a lot of existing techniques, a punching shear reinforcement is proposed as the main or even only purpose of the strengthening. In civil engineering structures with a slab, the bending or flexion of the slab elements occurs more or less, but in all cases. This phenomena which is due to the static and/or dynamic load acting on the slab results in a deformation as an applied amplitude of a curve in the slab.

[0010] This is therefore an aim of the present invention to address the bending deformation of the slab.

[0011] The present invention also aims to provide a solution which implementation does not interfere with the integrity of the slab, namely which avoids making holes or any other cavity. In addition to bring potential cracks in the structure, drilling operation in concrete also requires time and specific technologies and resources. No drilling operations on the slab would therefore reduce the costs and the damage risks. The present invention has also the ability to provide actively a discharge of the existing structure creating a new distribution of the load allowing to keep the exploitation of the building during the operation and to restore the full service of the structure or even extended capabilities.

Brief summary of the invention

[0012] According to the invention, these aims are achieved by means of a method for strengthening a concrete structure comprising a supported element, such as a slab, arranged on supporting elements, wherein said method comprises the following steps:

- providing at least one pre-bended beam able to be connected between two supporting elements, while being placed under the supported element at least partially in contact with said supported element,
- providing a connection system able to be mounted on each of said two supporting elements and able to receive one extremity of said pre-bended beam,
- fixing said connection system on each of said two supporting elements,
- lifting said pre-bended beam between said two supporting elements and under said supported element, with the extremities of said pre-bended beam facing the side of said supporting elements fitted with said connection system, and
- mounting the two extremities of said pre-bended beam to the corresponding connection system, whereby the two extremities of said pre-bended beam are retained by the connection system.

[0013] These aims are also achieved by means of an arrangement for strengthening a concrete structure comprising a supported element arranged on supporting elements, wherein said arrangement comprises:

- at least one pre-bended beam able to be connected between two supporting elements, while being placed under said supported element,
- a connection system able to be mounted on each of said two supporting elements and able to receive one extremity of said pre-bended beam, forming thereby a pair of connection systems able to retain the to extremities of said pre-bended beam when the pre-bended beam is placed under the supported element, r in contact with said supported element.

[0014] The present also concerns a concrete structure comprising a supported element arranged on supporting elements, wherein said concrete structure further comprises a strengthening arrangement including:

- at least one pre-bended beam placed under said supported element, in contact with said supported element,
- a connection system mounted on each of two supporting elements, , forming thereby a pair of connection systems which retain the two extremities of said pre-bended beam when the pre-bended beam is placed under the supported element.

[0015] Generally, there is also a fire protection system made of intumescent paint or made of material dedicated to the isolation of the concrete structure, including the protection of the strengthening arrangement, against high temperature.

[0016] This solution allows to takes partially or totally the load of the slab through the pre-bended beam acting as a cantilever beam, resulting into the reduction of the bending in the slab or any other supported element of the concrete structure. Also, this solution can be implemented easily and safely on existing concrete structures, without direct intervention on the slab. Therefore, there is no risks to add further deficiencies in the slab. Moreover, this solution being brought from the underside of the slab or supported element, it can be used while the concrete structure is in service. Moreover, due to the very limited equipment required to put this solution into practice, this can be done for low headroom configuration of the concrete structure.

[0017] According to a preferred embodiment, after mounting of said pre-bended beam to said connection system, the upper face of said pre-bended beam is in contact with said supported element so as to transfer actively some load to the supported element, compensating for the bending of the supported element. This way, the load of the supported element is taken through the pre-bended beam as from the installation of the pre-bended beam.

[0018] According to a preferred provision, said pre-bended beam forms, before mounting to said connection system, a curved beam with a convex face, and wherein, after mounting of said pre-bended beam to said connection system, said convex face is close to or preferably in contact with said supported element so as to be able to compensate for the load provided by and through the of the supported element. The pre-bended beam is manufactured with a curvature which takes into consideration the mechanical properties and load behavior of the material of the beam, whereas the maximal load value and repartition map of the load of the supported element.

[0019] The pre-bended beam is preferably a metallic beam, notably a steel beam or double web steel beam. Other material can be used for the manufacturing of the beam, including composites such as fiber reinforced polymers, notably CFRP (for Carbon Fiber Reinforced Polymers), prestressed beam with Ultra High Performance concrete (UHPC)

[0020] According to the invention, the use of a pre-bended beam, i.e. a pre-loaded beam when mounted into the connection system, brings an active solution to absorb the shear and bending efforts of a slab or any other supported element. With such an arrangement, the connection system can also absorb shear stresses present in the supported element, which is taken by the beam and transmitted to the connection system through the extremities of the pre-bended beam. This provision allows the solution according to the invention to cope both with bending deformation and shear (especially punching shear) in the supported element, which is a great advantage for a very simple solution.

[0021] Also, in an embodiment, said connection system comprises tensioned elements able to extend in passages formed through said supporting elements, while being under tension. With such an arrangement, since the connection system comprises tensioned elements (especially tensioned bars or pre-stressed cable made of a multiple wire cable with steel or polymeric material wires), the connection system transfers directly the load to the supporting element through the friction existing between the supporting element and the connection system without any need to transfer load to the structure below by additional column or support. The tensioned elements providing additional friction and extra load carrying capacities.

[0022] In a possible embodiment, said connection system comprises a bracket arrangement attached on the supporting element and receiving the extremity of said pre-bend beam. This is a simple way to provide a connection system that can be attached to the respective supporting element and also lodge and retain the respective extremity of the beam.

[0023] As a possible implementation, said bracket arrangement comprises at least a plate fixed against the supporting elements, said plate having holes for the passage of said bars. In that situation, such a plate can form an enlarged contact surface with the external face of the corresponding supporting element, resulting thereby in a good transfer of load from the slab to the supporting element. Also, such a plate offers a large area for the mounting of other parts of the connection system for the attachment of the pre-bended beams. When the connection system is provided with bars as defined above, the use of such a plate offers a large area for the attachments of a possible large number of such bars.

Brief Description of the Drawings

[0024] The invention will be better understood with the aid of the description of an embodiment given by way of example and illustrated by the figures, in which:

Fig. 1A and Fig.1B show lateral views, respectively from a first lateral side and from a second lateral side, of a portion of a concrete structure during a first step of the strengthening method according to the invention;

Fig. 2A and Fig.2B are views similar to that of Fig. 1A and Fig.1B, during a second step of the strengthening method according to the invention;

Fig. 3A and Fig.3B are views similar to that of Fig. 1A and Fig.1B, during a third step of the strengthening method according to the invention, and Fig. 3C is a perspective detail of the upper part of a column during the third step;

Fig. 4A and Fig.4B are views similar to that of Fig. 1A and Fig.1B, during a fourth step of the strengthening method according to the invention, Fig. 4C is a partial perspective detail of the upper part of a column during the third step, Fig. 4D and 4E are other perspective views of the upper part of a column during the third step;

Fig. 5A and Fig.5B are views similar to that of Fig. 1A and Fig.1B, during a fifth step of the strengthening method according to the invention;

Fig. 6A and Fig.6B are views similar to that of Fig. 1A and Fig.1B, during a sixth step of the strengthening method according to the invention; and

Fig. 7A and Fig.7B are views similar to that of Fig. 1A and Fig.1B, after implementation of the strengthening method according to the invention after installation of further adjacent beams, Fig. 7C is a corresponding perspective detail of the upper part of the column and Fig. 7D is a corresponding lateral detail in perspective of the upper part of the column.

Detailed Description of possible embodiments of the Invention

[0025] In the example now described referenced is made to a concrete structure 10 comprising a slab 12 mounted on the top of columns 14. This concrete structure 10 has to be reinforced against exposure to punching shear also with bending moment acting as agent for potential lower performance of the concrete structure 10, notably creating some damage in the slab 12.

[0026] The method according to the invention for strengthening the concrete structure 10 is explained with reference to the figures also illustrating a possible arrangement according to the invention used for strengthening the concrete structure 10.

[0027] In Figures 1 to 3, the installation of the first part of the connection system 30 is implemented. First, as shown in Figures 1A and 1B, the top of the column 14 (column head) is prepared by drilling horizontal through holes 31 that will form passages for elongated tensioned elements. In the shown example three parallel horizontal rows of three passages 31 are formed but the number and position of the passages 31 will depend on the geometry of the whole system.

[0028] As a second step, visible in Figures 2A and 2B, two brackets 34 are attached to the two opposite previously drilled faces of two adjacent columns 14 (only one of these pairs of column 14 is shown on the figures). To that end the previously drilled passages 31 are first filled in with an adhesive such as a hardening material 33 which is also spread as a layer on the column bearing area of the two opposite previously drilled faces of the column 14 (see Fig 2B). Each bracket 34 comprises a plate 34a forming the basis of the bracket of the connection system 30.This plate 34a is pierced with holes with the same arrangement as the passages 31, and three lugs 35, 36 protruding from the plate 34a and being equipped each with a vertical through hole: as can be seen in Figure 3C, two lugs 36 are protruding orthogonally from the plate 34a on the two lateral sides of the plate whereas the third lug 35 forms a lateral extension of the plane of the plate 34a. For attachment, the holes of the plate 34a are aligned with the passages 31 of the column 14. Then horizontal threaded bars 32 longer than the passages 31 are individually placed in all the passages 31 while their two extremities extend out of the passages 31. Then nuts 37 are mounted on the two extremities of each bar 32 and are tightened with a torque wrench 40 so as to put the bars 32 into tension. After hardening of the hardening material 33, the pre-tensioned bars 32 are anchored within the column 14. In a preferred embodiment, this hardening material 33 is epoxy resin.

[0029] Then Figures 3A to 3C show the preparation of the beam installation. Two vertical threaded bars 38 are respectively placed within the vertical through hole of the two lugs 36. Upper nuts 18a are mounted and tightened on the upper portion of the vertical threaded bars 38 to maintain the bars 38 into their respective hole. Also a beam 20 is placed under the slab 12, between two adjacent columns 14 equipped with the previously described brackets 34. As can be seen from Figure 3B, the beam 20 has a curved profile before being attached to the connection system 30. More precisely the beam 20 has been bended during its manufacture so that at rest, it has a curved profile and when placed in a straight or quite straight shape, reaction forces tending to put the beam back in its rest position are exerted by the beam.

[0030] This beam 20 is manufactured with a pre-bending geometry so that it is not straight (as can be seen from the figures 3B and 4B): it has indeed, in the unstressed condition, a curvature with an upper surface defining the convex side of the curved profile and a bottom surface defining the concave side of the curved profile. The curvature is mathematically defined as to be able to absorb and counterbalance the bending moment and the shear of the portion of the slab 12 that this beam 20 will face as will be explained in the following text. Preferably, the pre-tensed or pre-bended beam 20 is made from steel. Also, preferably, the pre-bended beam 20 is a profile having a H section with a double wall for the transverse wall of the H (as can be seen from the figures 3A and 4A). In this case, the H is tilted over 90° so that the two lateral walls of the H form the upper and the bottom surfaces of the beam 20 (see figures 3A and 4A). Also this pre-bended beam 20 has a length and cuts at its ends which allow that its two ends perfectly fit the outside face of the bracket 34 while surrounding the two lugs 36 (see figure 4C), when these ends are received in the connection system 30.

[0031] In the next fourth step, shown in Figures 4A, 4B, 4C, 4D and 4E, the beam 20 is lifted between the two adjacent columns 14 (see arrow 41 in figure 4B). Then, a bottom support 39 (formed by a part having the shape of a parallelepiped, notably a rectangular parallelepiped) pierced with two vertical holes is mounted on the bottom part of the two vertical threaded bars 38. Also, two lifting systems such as jacks, notably hydraulic jacks 40, are disposed at the end portion of the two vertical threaded bars 38. In that configuration, each of the two ends of the beam 20 is propped by the bottom support 39 at a height controlled by the jacks 40. The bottom support 39 forms a second part of the connection system 30.

[0032] This position is also shown in perspective in figure 4C without the bottom support 39 and in figures 4D and 4E with the bottom support 39, those figures 4C to 4E showing the simultaneous installation of three beams 20, 20' and 20" on the same column 14. Beams 20 and 20' are aligned and mounted to while pressing onto the two plates 34 mounted on the two opposite sides of the column 14 with the ends of the beamy 20 and 20' surrounding the pair of lugs 36. The beam 20" is placed in an orthogonal position with respect to the beams 20 and 20', on another bottom support 39" mounted on the bottom part of the two vertical threaded bars 38 respectively attached to the lug 35 of each of the two plates 34.

[0033] By controlling the jacks 40, the bottom support 39 is lifted towards the slab 20 (see arrow 42 on Figure 5B for the fifth step) up to the point where the upper face 24 of the beam 20 is flush with the upper face of the column 14, and is in contact with the bottom face of the slab 12 as can be seen in Figures 5A and 5B (see also Figure 7C). In that situation, the extremities 22 of the beam 20 is sandwiched between the slab 12 and the bottom support 39. In this final position of the pre-bended beam 20, the beam 20 is in stressed configuration with a straight shape, or a less curved shape, due to the contact of its upper face (convex face in unstressed position) against the bottom face of the slab. It is to be noted that under load onto the upper face of the slab 12. It might arise that the upper face of the beam has a concave curved shape with a relatively large radius of curvature.

[0034] In the sixth step shown in figures 6A and 6B, the service position of the beam 20 is locked: the jacks 40 are removed, and bottom nuts 18b are mounted and tightened on the bottom portion of the vertical threaded bars 38 so as to strongly press against the bottom support 39 which retain the end of the beam 20 (left end on Figure 6B).

[0035] In this situation, the connection system, namely the bracket arrangement 34 with its bottom support, retains the corresponding end of the beam 20 against the bottom face of the slab 12. This results into the housing and more precisely the pinching of the corresponding end of the beam between the bottom face of the slab 12 and the bottom support 39 which tends to upwardly push the bottom face of the corresponding end of the beam 20 against the bottom face of the slab 12.

[0036] Then as shown in Figures 7A, 7B, 7C and 7D, other beams 20' and 20" can be installed around the column 14 with the same previously described third to sixth steps (if using the same connection system 30 comprising the already installed plates 34 with another bottom support 39" using the vertical threaded bars of the lugs 35) or with the same previously described first to sixth step if using another connection system 30 mounted on another column 14 for the other end of these other beams

20' and 20".

[0037] This arrangement allows the beam 20 to work in shear and tension, without any hole drilled in the slab 12 of the concrete structure. The pre-bending value of the beam 20 is previously computer calculated so that the beam can counterbalance the maximum bending or flexion of the corresponding portion of the slab 12. Also, the tensed horizontal threaded bars 32 in the plates 34 of the connection system can counter balance the punching shear applied locally to the slab during its service life.

[0038] Therefore, this solution is also possible for low headroom situations under the slab 12 for simultaneous strengthening the slab 12 in bending and in punching shear.

[0039] The use of the pre-bended beam 20 attached to the column 14 by the connection system 30, allows the taking of the load applied to the slab 12 on the column: The beam 30 forms a cantilever fixed by friction and shear pins (Horizontal threaded bars 32), hence reducing the shear and bending in the concrete structure 20.

[0040] In this solution, according to the invention, there is advantageously no need for fixing means -glue, or any threaded connection or anything else- between the slab 12 and the pre-bended beam 20. Therefore, the strengthening solution according to the invention does not interfere with the existing slab 12, allowing repair of pre-stressed slabs without intervention either on the upper face nor on the lower face of the slab.

[0041] In the example shown in the figures and described in the preceding text, the reinforcement according to the invention is implemented to a flat slab 12, using beams 20, 20' or 20 " which are straight after mounting into the connection system 30. Without departing from the scope of the present invention, non-flat slabs can be reinforced using beam having a profile that fits the shape of the slab and accommodates the load to be counterbalanced. More generally the reinforcement according to the invention can be implemented to any supported elements extending in at least into two directions, said supported element including a bottom face able to be into contact with said pre-bended beam 20, 20' or 20 ".

[0042] In the example shown in the figures and described in the preceding text, the strengthening according to the invention is implemented to a slab 12 arranged on vertical columns 14. The present invention can be applied to concrete structures with supporting elements other than columns, for instance any supporting element that has a face, preferably a vertical face, for attachment of the connection system. In a non-limiting list, such supporting element can be a post, a concrete block or a wall, such as a cast-in-place concrete foundation wall.

[0043] Also, in the example shown in the figures and described in the preceding text, the connection system used for mounting the ends of the pre-bended beam comprise a bracket but other types of fixing means for mounting the ends of the pre-bended beam onto the top portion of the supporting element could replace this bracket. For instance such fixing means can comprises vertical supports, concrete corbel with or without pre-stressed bar, pre-stressed bar fixed mechanically or with epoxy or similar resin, hooks, clips, which are anchored or simply glued to the top portion of the supporting elements. Notably, this fixing means is able to transmit partially or totally upwardly directed forces exerted on the slab, at location close to the supporting elements, to the supporting element itself via the pre-bended beam.

[0044] In the example shown in the figures and described in the preceding text, bars, especially horizontal threaded bars are used: without departing from the scope of the present invention, other shear absorbing elements can be attached within the supporting element. As previously described, due to the action of the load exerted on the slab, the pre-bended-beam ends react by exerting a vertical load. If the connection system contains some prestressed bar(s), this prestressing load will apply a very high compression on the supporting element allowing the vertical load to be taken by vertically friction between the connection and the supporting element..

List of reference signs used in figures

[0045]

10	Concrete structure
12	Slab
14	Column
20	Pre-bended beam
20'	Pre-bended beam
20"	Pre-bended beam
22	Extremity of the beam
24	Upper face of the beam
30	Connection system
31	Passage
32	Horizontal threaded bar
33	Hardening material
34	Bracket
34a	Plate
35	Lug
36	Lug
37	Nut
38	Vertical threaded bars
38a	Upper bolt
38b	Bottom bolt
39	Bottom support
39'	Bottom support
40	Jack
41	Arrow
42	Arrow

Claims

1. Method for strengthening a concrete structure (10) comprising a supported element (12) extending in at least two directions and arranged on supporting elements (14), wherein said method comprises the fol-

lowing steps:

- providing at least one pre-bended beam (20) able to be connected between two supporting elements (14), while being placed under the supported element (12) at least partially in contact with said supported element,
- providing a connection system (30) able to be mounted on each of said two supporting elements (14) and able to receive one extremity of said pre-bended beam (20),
- fixing said connection system (30) on each of said two supporting elements (14),
- lifting said pre-bended beam (20) between said two supporting elements (14) and under said supported element (12), with the extremities of said pre-bended beam (20) facing the side of said supporting elements (14) fitted with said connection system (30), and
- mounting the two extremities of said pre-bended beam (20) to the corresponding connection system (30), whereby the two extremities of said pre-bended beam (20) are retained by the connection system (30).

2. Method according to claim 1, wherein after mounting of said pre-bended beam (20) to said connection system (30), the upper face of said pre-bended beam (20) is in contact with said supported element (12) so as to be able to compensate for the load provided by and through the supported element (12).

3. Method according to claim 1 or 2, wherein said pre-bended beam (20) forms, before mounting to said connection system (30), a curved beam (20) with a convex face, and wherein, after mounting of said pre-bended beam (20) to said connection system (30), said convex face is close to or in contact with said supported element (12) so as to be able to compensate for the load provided by and through the supported element (12).

4. Method according to any of claims 1 to 3, wherein said connection system (30) comprises tensioned element (32) able to extend in passages formed through said supporting elements (14), while being under tension.

5. Method according to any of claims 1 to 4, wherein said connection system (30) comprises a bracket arrangement (34) attached on the supporting element for receiving the extremity of said pre-bend beam (20).

6. Method according to claims 4/ and 5/, wherein said bracket arrangement (34) comprises at least a plate (34a) fixed against the supporting elements (14), said plate (34a) having holes for the passage of said tensioned elements (32).

7. Method according to any of claims 1 to 6, wherein at least on of said supporting elements (14) is a column.

8. Arrangement for strengthening a concrete structure (10) comprising a supported element (12) arranged on supporting elements (14), wherein said arrangement comprises:

- at least one pre-bended beam (20) able to be connected between two supporting elements (14), while being placed under supported element (12) said supported element (12),
- a connection system (30) able to be mounted on each of said two supporting elements (14) and able to receive one extremity of said pre-bended beam (20), forming thereby a pair of connection systems (30able to retain the two extremities of said pre-bended beam (20) connection system (30) when the pre-bended beam (20) is placed under the supported element (12), partially or totally in in contact with said supported element (12).

9. Arrangement according to claim 8, wherein said pre-bended beam (20) is a curved beam (20) with a convex face.

10. Arrangement according to claim 8 or 9, wherein said connection system (30) comprises tensioned elements (32) able to extend in passages formed through said supporting elements (14), while being under tension.

11. Arrangement according to any of claims 8 to 10, wherein said connection system (30) comprises a bracket arrangement (34) able to be attached on the supporting element for receiving the extremity of said pre-bend beam (20).

12. Arrangement of claims 10 and 11, wherein said bracket arrangement (34) comprises at least a plate (34a) able to be fixed against the supporting elements (14), said plate (34a) having holes for the passage of said tensioned elements (32).

13. Concrete structure (10) comprising a supported element (12) arranged on supporting elements (14), wherein said concrete structure (10) further comprises a strengthening arrangement including:

- at least one pre-bended beam (20) placed under said supported element (12), partially or totally in contact with said supported element (12), and
- a connection system (30) mounted on each of

two supporting elements (14), forming thereby a pair of connection systems (30) which retain the two extremities of said pre-bended beam (20) when the pre-bended beam (20) is placed under the supported element (12).

14. Concrete structure (10) according to claim 13, wherein at least one of said supporting elements (14) is a column.

15. Concrete structure (10) according to any of claims 13 to 14, wherein said supported element (12) is a slab, a floor or a roof.

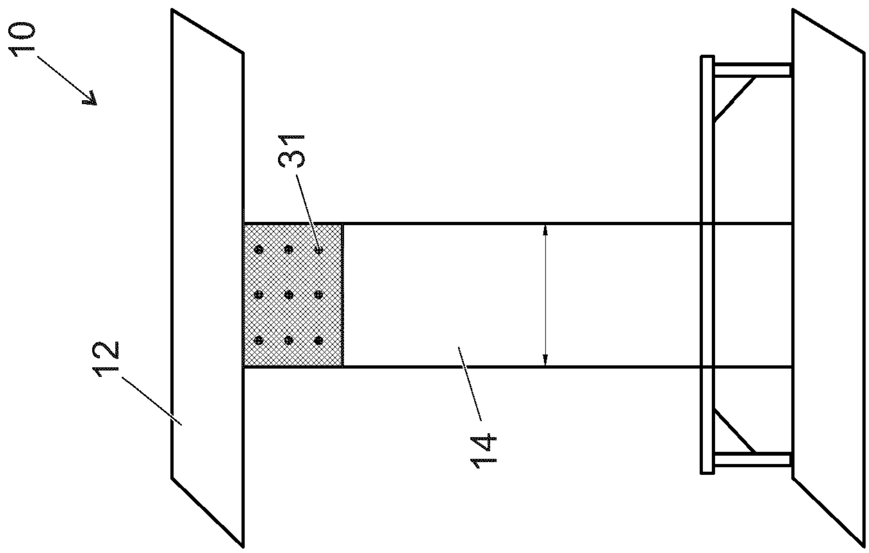

Fig. 1A

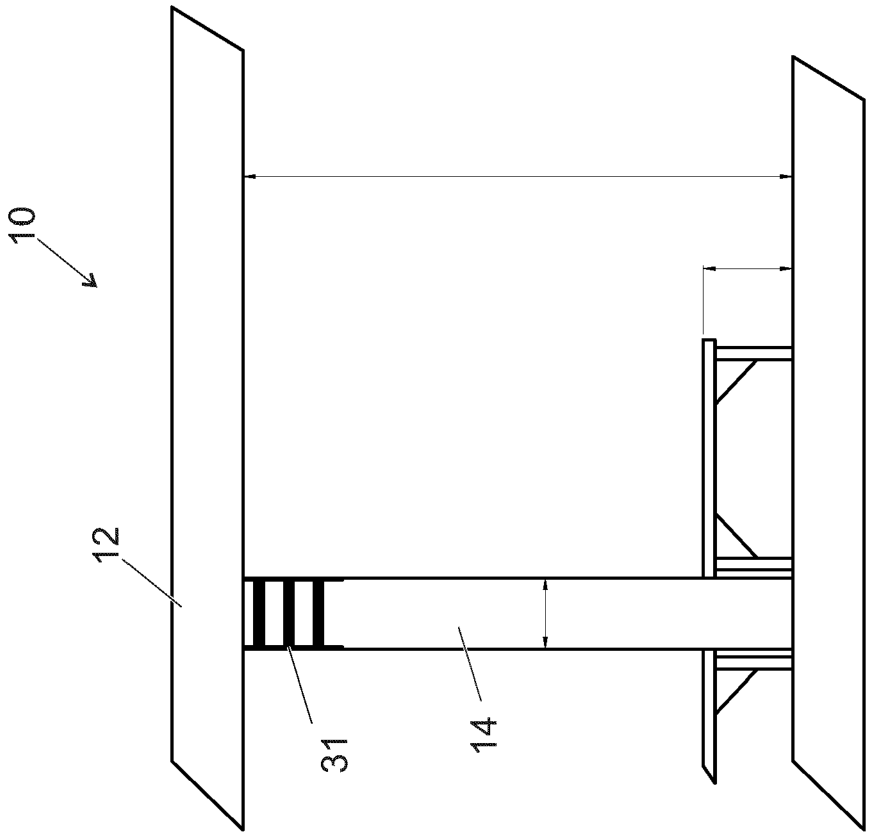

Fig. 1B

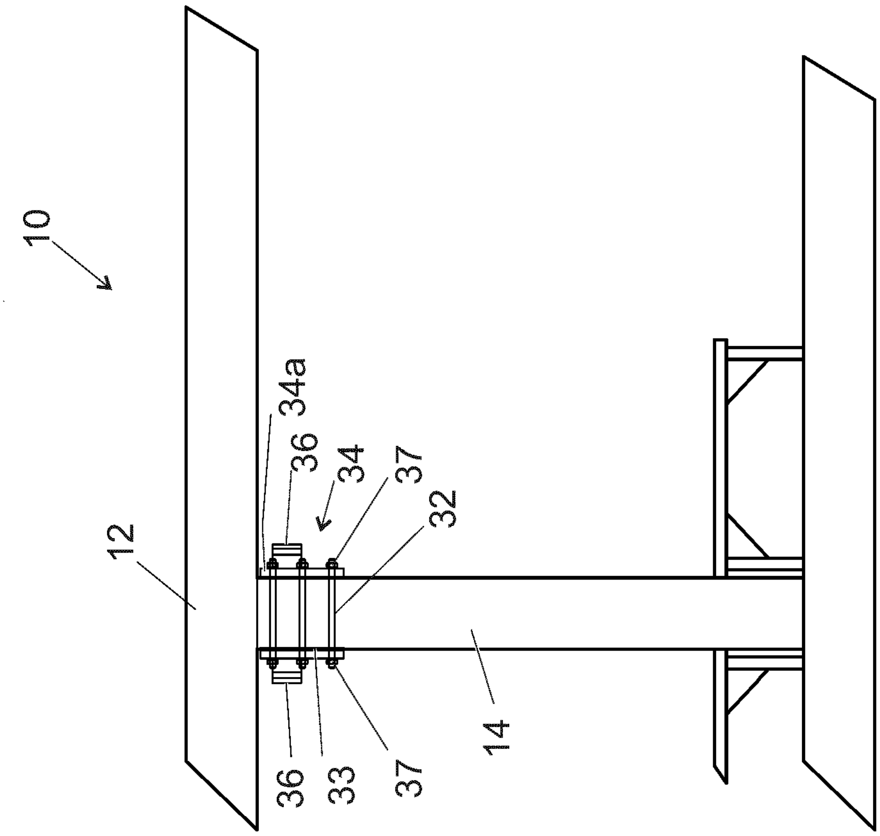

Fig. 2B

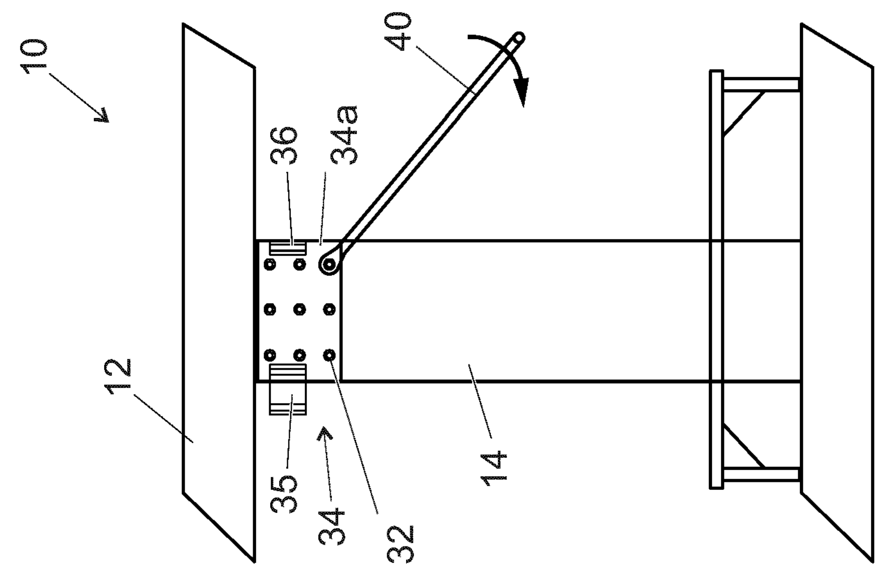

Fig. 2A

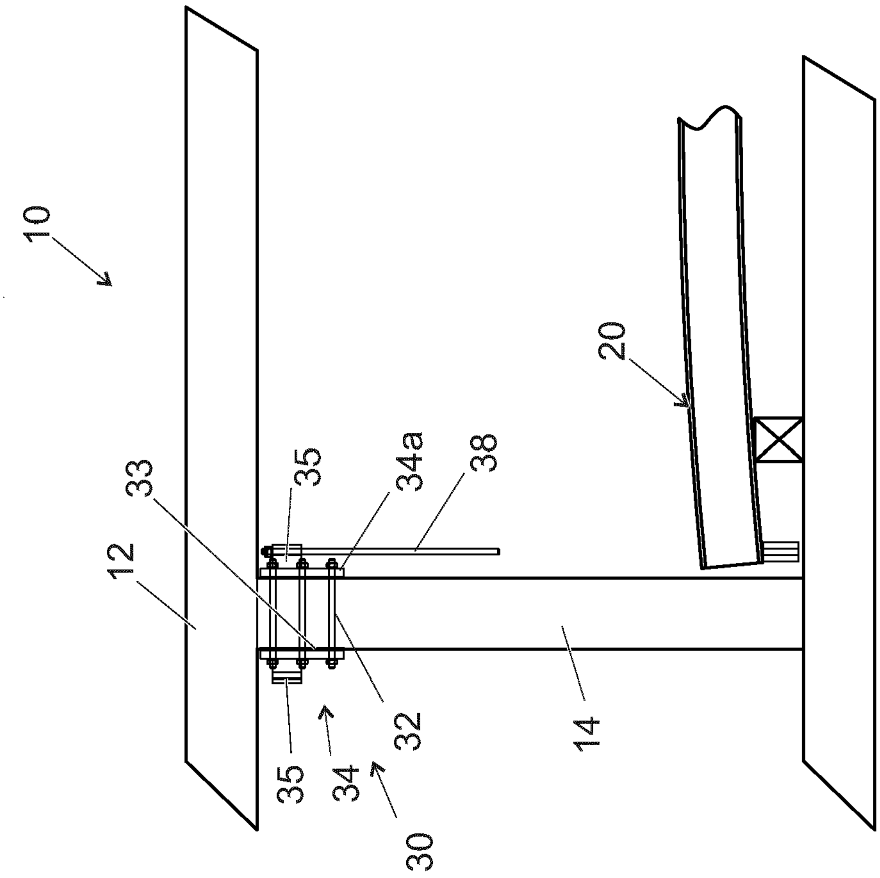

Fig. 3B

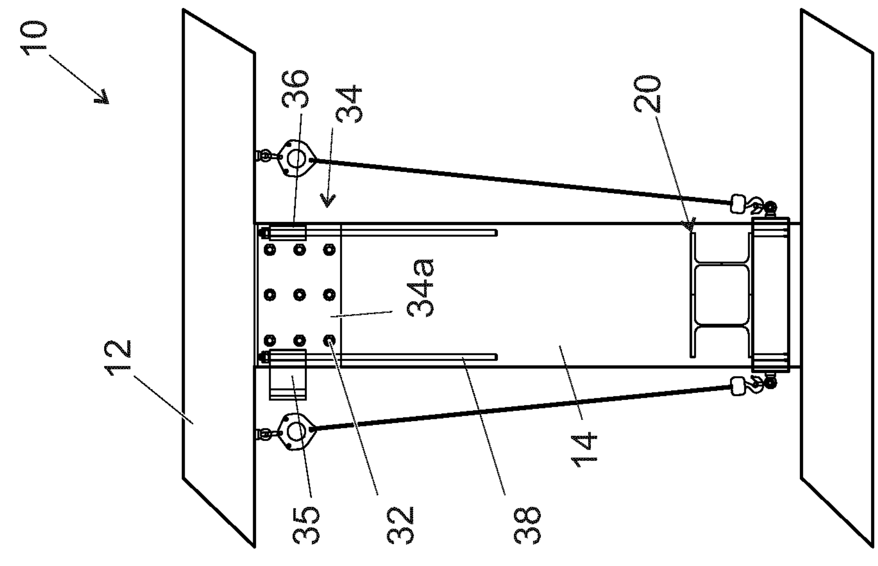

Fig. 3A

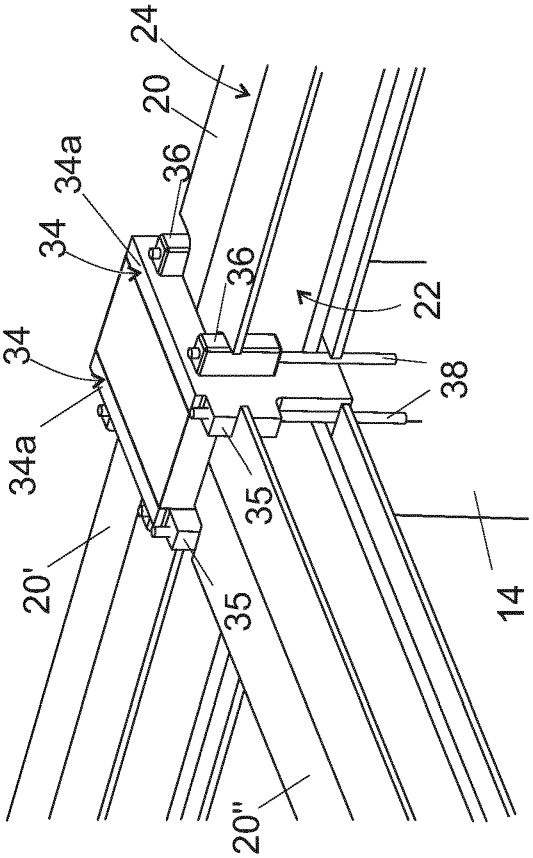
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Fig. 4C

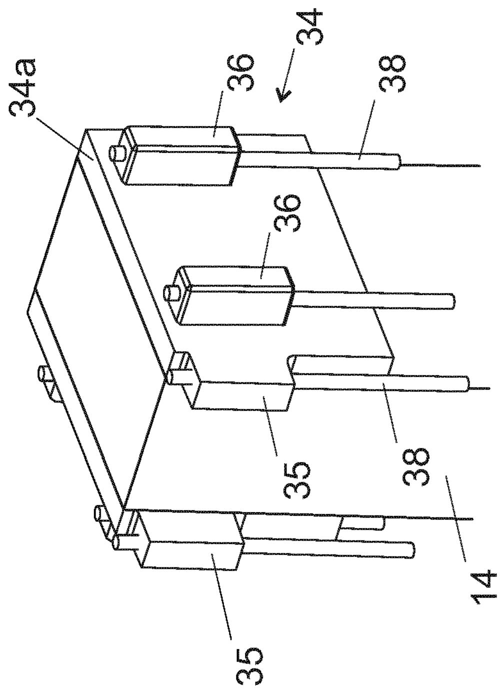
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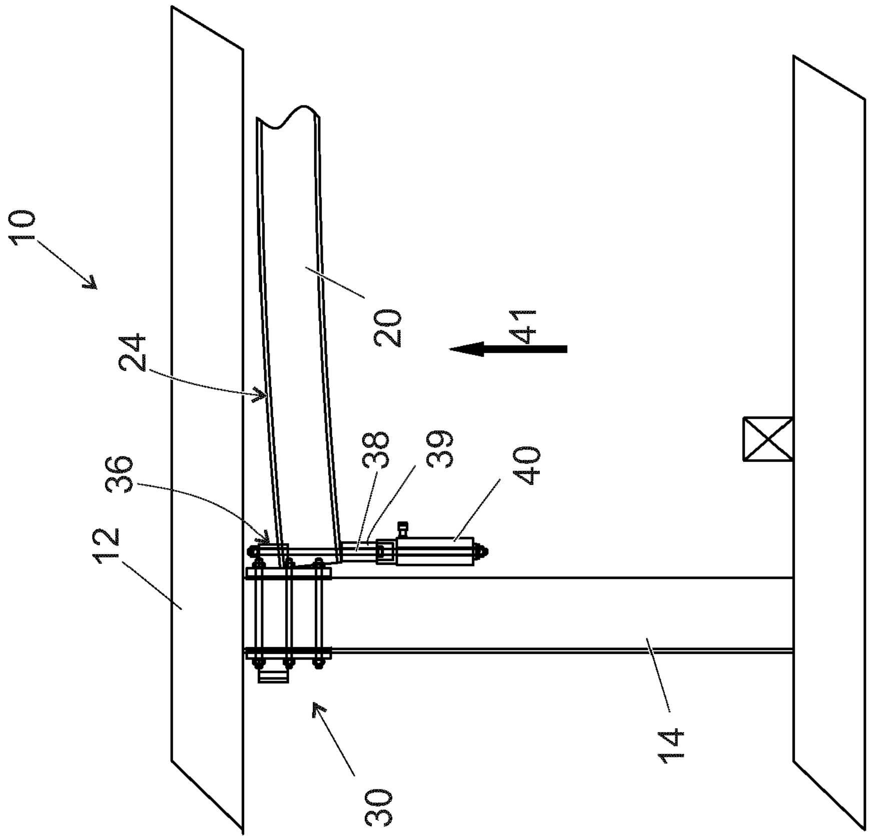
Fig. 3C



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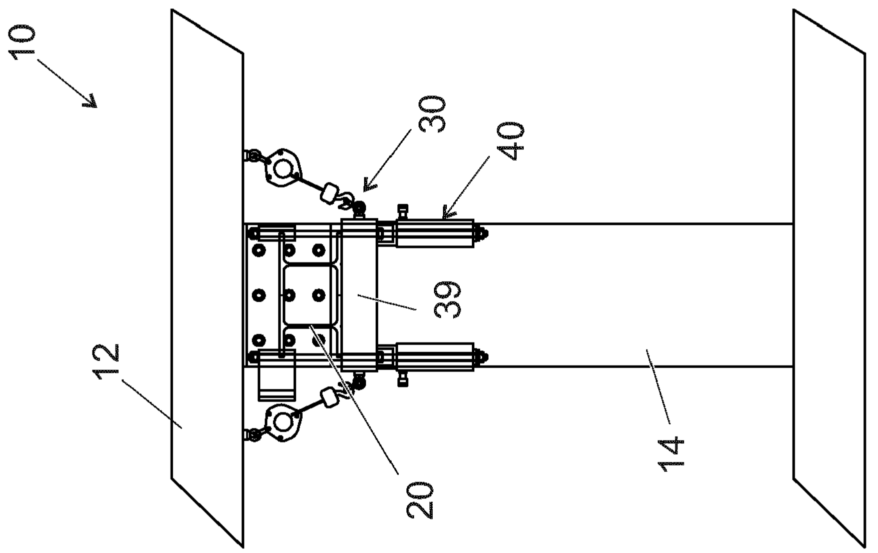

Fig. 4A

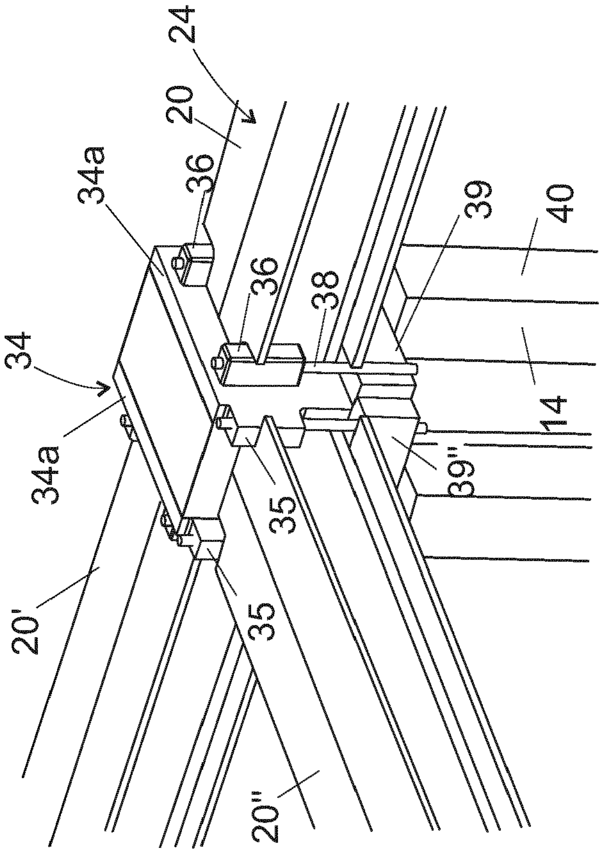
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Fig. 4E

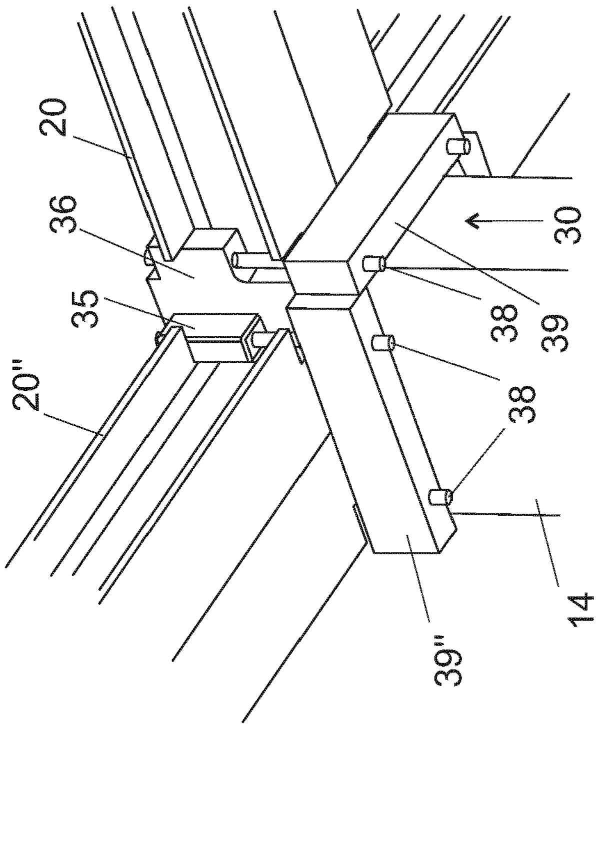
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Fig. 4D

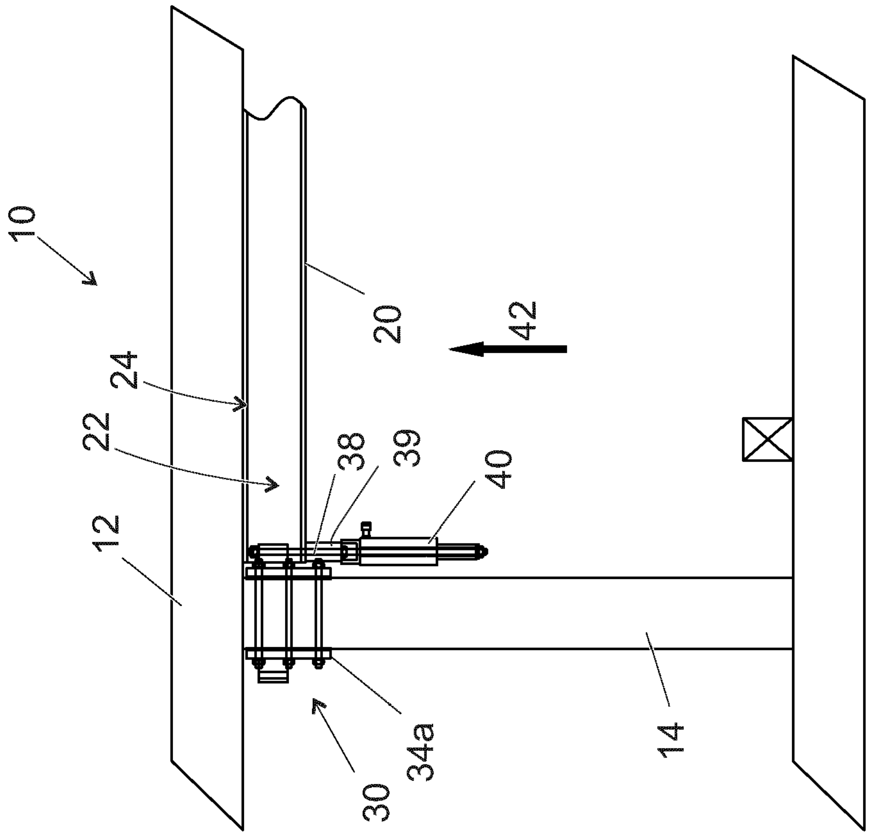

Fig.5B

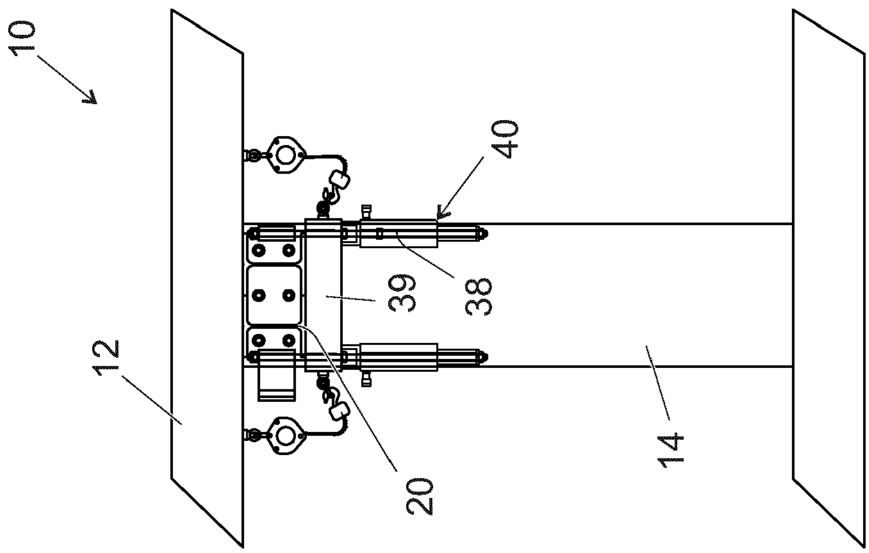

Fig. 5A

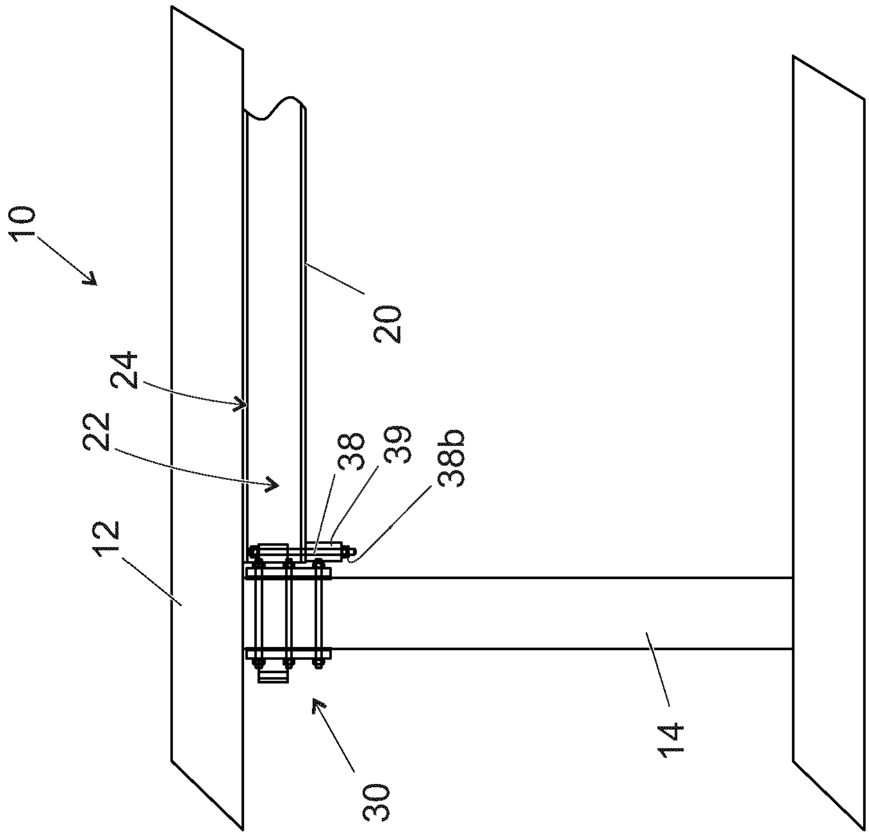

Fig. 6B

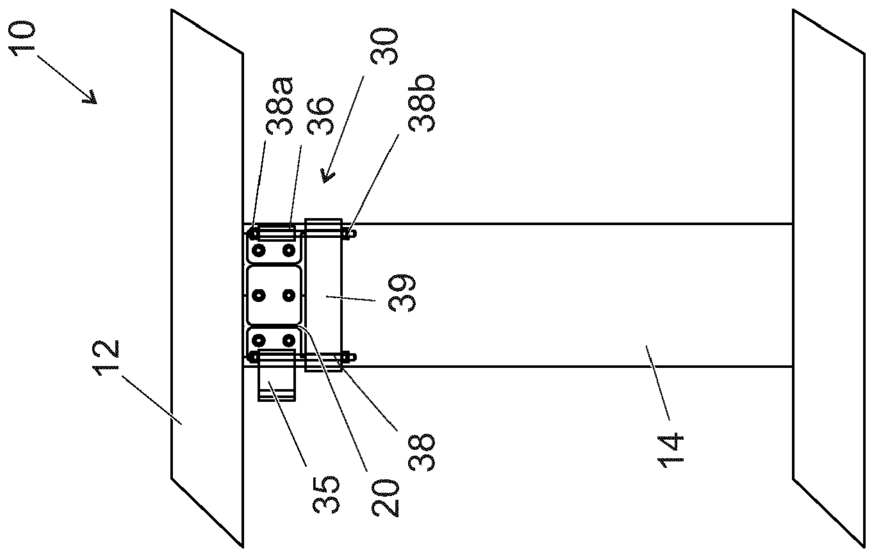

Fig. 6A

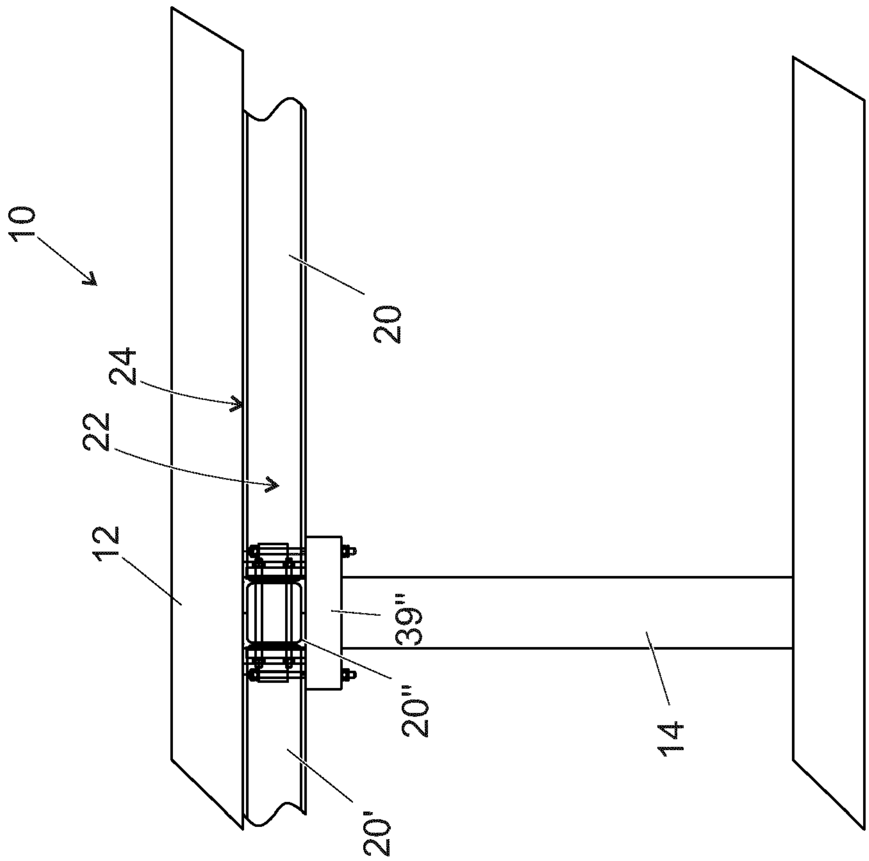

Fig. 7B

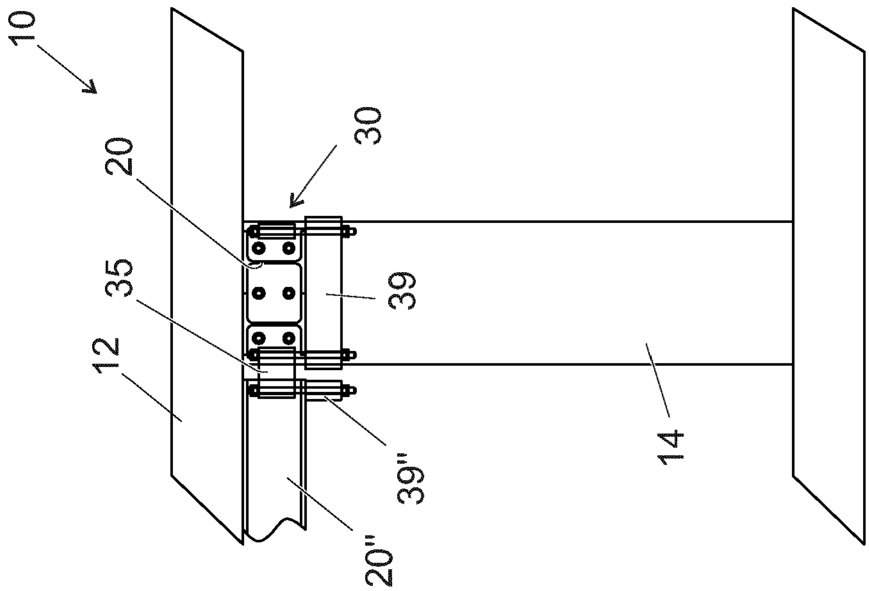

Fig. 7A

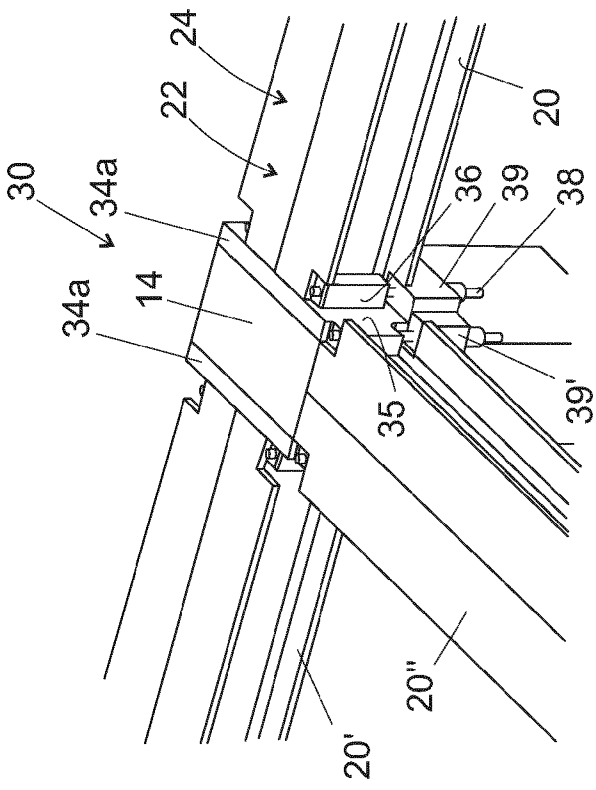
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Fig. 7C

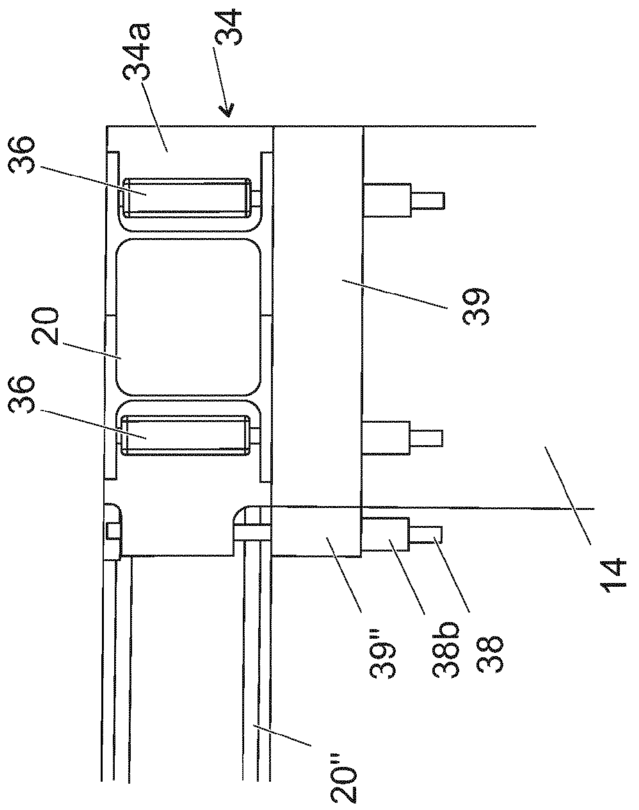
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Fig. 7D

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EUROPEAN SEARCH REPORT

Application Number
EP 17 15 7819

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A	* figures 1,2 * -----	13-15	
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E04G
E04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	12 June 2017	Garmendia Irizar, A

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