



(51) International Patent Classification:

E04B 5/02 (2006.01) E04B 5/06 (2006.01)

(21) International Application Number:

PCT/EP2018/086231

(22) International Filing Date:

20 December 2018 (20.12.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1721561.7 21 December 2017 (21.12.2017) GB

(71) Applicant: **LAING O'ROURKE PLC** [GB/GB]; Bridge Place, Anchor Boulevard, Admirals Park, Crossways, Dartford Kent DA2 6SN (GB).

(72) Inventor: **SCOTT, David**; c/o Laing O'Rourke PLC, Bridge Place, Anchor Boulevard, Admirals Park, Crossways DARTFORD Kent DA2 6SN (GB).

(74) Agent: **COOKSON, Barbara**; Filemot Technology Law Ltd, Popes Head Court Offices, Peter Lane, York YO1 8SU (GB).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: DEMOUNTABLE FLOOR CONSTRUCTION

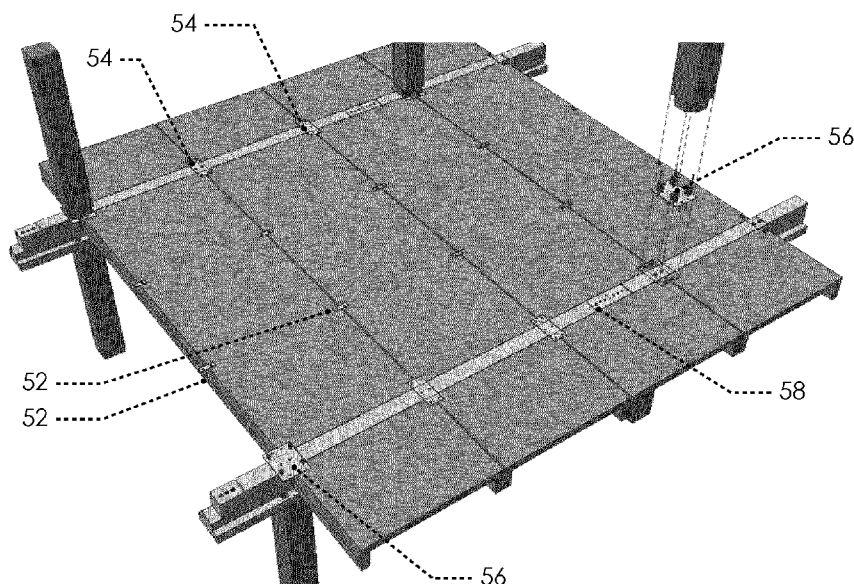


Figure 4

(57) Abstract: Demountable Floor Construction A floor plank (10) for use in a flooring system comprises a reinforced, inverted U-shaped, precast concrete element having an upper surface and depending ribs (14) along its longitudinal edges. The planks are supported on spaced horizontal beams (6) during assembly. The planks are interconnected by means of connector plates (52, 54, 56, 58) and bolts (50) along their edges to create a floor diaphragm and surface appropriate for use.

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Demountable Floor Construction

Technical Field

- [1] The present invention relates to precast concrete floors suitable for use in concrete buildings, for schools, hotels, office, retail and other premises.
- [2] The invention is also applicable to precast concrete floors that connect to conventional steel framed buildings. It is an alternative to building floors that consist of concrete on metal deck spanning onto steel beams, and it can be integrated with this solution or used as a direct replacement.
- [3] The invention is particularly applicable to floors which are required to be demountable in order to change the configuration and/or to have deck openings.

Prior Art

- [4] The challenge with precast concrete buildings is the joints between precast elements. If the joints are exposed, then the joints open and close as the floors are loaded, which damages finishes. A conventional solution would be to either cast an *in situ* topping or an *in situ* joint.
- [5] A steel framed building will typically have an array of vertical columns arranged in a grid structure joined at each floor level by horizontal beams. Various types of floor system for creating a floor or deck supported by the beams have been proposed. Existing steel and metal deck solutions create composite floors with a layer of concrete over a profiled metal deck. These solutions are low-profile and relatively lightweight and set a standard that must be matched by alternative constructions
- [6] A joint between concrete elements has been described in EP2882905 Laing O'Rourke Plc published on 17 June 2015. That joint is formed by overlapping headed bars extending from adjacent faces of the concrete elements with vertical transverse studs between the bars. Such a joint technology has been used successfully to create floors without proppings or toppings from concrete elements in the form of solid precast flat slabs. However, such a strategy requires significant site construction in order to create the joints between adjacent concrete elements. The joints, so made, are also permanent.

Technical problems

- [7] There is therefore a technical problem to create a flooring system from precast and prefabricated elements that does not require a topping or *in situ* joints, that can be assembled easily on site, and that will perform in a way similar to normal steel framed buildings and remain competitive in terms of weight and profile depth with prior art solutions.
- [8] The jointing problems that a solution needs to address include the transfer of diaphragm forces across a floor, as well as making sure that joints do not open up, or suffer excessive cracking when the floor is subject to vertical loads and in-plane loads.
- [9] There is also a technical problem to create a demountable flooring system from precast and prefabricated elements that can be assembled easily on site and remain competitive in terms of weight and profile depth with prior art solutions.

Solution of the Present Invention

- [10] Embodiments of the present invention utilise primary precast floor components made from reinforced concrete or prestressed concrete elements. The secondary components are an inverted U-shaped planks with a depending rib running along each longitudinal edge. These secondary components abut (with a narrow grouted gap) other secondary components along the longitudinal edge to create a ribbed floor. The secondary planks are connected together at regular centres by intermediate connector plates that transfer tensile forces across the grouted joint so that the floor can act as a complete diaphragm.
- [11] The ends of the secondary components are supported on primary beam elements that typically span between columns. The secondary components have a corner connector plate that extends across the grouted joint at the primary beam, to reduce cracking over the primary beam and to provide continuity across that joint, so that the floor can act as a complete diaphragm.
- [12] The primary beams can be an inverted T-shaped profile which enables the secondary components to sit on a support nib. Alternatively, or in addition, primary support

beams can also be rectangular beams below the planks, or steel beams. The secondary planks are continuous over such support beams.

- [13] The primary beams support the secondary planks and sit on columns. A connector plate at the column, connects the secondary planks to the primary beam and to the column above. The column connector plates transfer diaphragm action across the joints and are designed to reduce cracking in the floors and to create a performance similar to a concrete floor on metal deck on steel beams.
- [14] All the connector plates are designed to transfer tensile forces across joints. The plates can be recessed into the floor. Tolerance is achieved by inserting the connector plates into grouted or concreted joints.
- [15] The connector plates are designed to be unbolted and thus the system can be demounted, with concrete/stone splitters used to split the grout joint once the connector plates have been removed.
- [16] The planks are precast with sleeves for bolt holes and recesses so that the various elements of the flooring system can be interconnected with metal plates bolted into the concrete elements. These plates work in combination with grouted joints to create a complete diaphragm. Bolted joints are normally not possible because of the need to allow tolerances.
- [17] The floors are connected together by a series of connector plates and grouted joints that provide a complete diaphragm action and loadable surface.
- [18] The solution of the present invention avoids the use of large *in situ* joints, or welded connections and makes the connections from bolts that can easily be undone. Therefore, the system can be disassembled in order to remove or re-configure the floor allowing at least some components to be reused.
- [19] The elements are stable in their own right and the infill joints are simple.
- [20] Because the floors do not have any propping, nor do they rely on any topping, they can be loaded immediately after erection.
- [21] Because the floors are connected by plates that can be unbolted, the floors can be completely demountable.

[22] The invention is defined in the appended claims.

Description of the Drawings

[23] In order that the invention can be well understood some embodiments thereof will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

[24] Figure 1 shows a perspective view from below of a floor section within a single bay or grid rectangle;

[25] Figure 2 is a perspective view of a primary beam;

[26] Figure 3 is a perspective view of a plank showing how it would be supported for craning into position together with a transparent view showing its internal reinforcement;

[27] Figure 4 is a view of a floor bay from above;

[28] Figure 5 shows a perspective view of two floors;

[29] Figure 6 is a detail showing a primary beam to column connection;

[30] Figure 7 shows an exploded view of a typical column connection;

[31] Figure 8 shows a slab connector plate for use in connecting the edges of two adjoining planks;

[32] Figure 9 shows an exploded perspective view showing a beam connector plate for use in connecting planks on either side of a beam in position;

[33] Figure 10 shows the beam connector plate figure 9;

[34] Figure 11 shows an exploded view of a beam connector plate showing the elements of the bolts;

[35] Figure 12 shows an exploded view of a typical column, beam, and plank connection.

Description of an Embodiment

[36] The modular flooring system described is intended to be installed in a multi-storey building such as a low rise office, retail premises, hotel or school. The building is

defined by means of an array of vertical columns made up of individual floor height column sections 2 arranged in a grid structure, for example a 9m x 9m or 7.5m x 7.5m, or 9m x 12m grid as shown in figure 5. A single bay of the grid is illustrated in the drawings for simplicity. In each bay four vertical column sections 4 are interconnected by a pair of parallel horizontal primary beams 6. The floor between the beams is created by means of a series of adjoining precast concrete planks 10 which serve as the secondary components of the floor.

- [37] Each concrete plank 10 is an elongate inverted U-shaped precast concrete element having ends 12 and ribs 14 depending on the longitudinal side edges. The plank has a substantially flat upper surface that defines the level of the floor. The upper surface has recesses as described later for the purpose of interconnecting the planks. The underside of the plank is the soffit. The concrete planks are precast with internal rebar reinforcement 20 as shown in figure 3. The planks have deeper side edges or ribs where the planks adjoin each other side by side creating a ribbed effect in the underside of the floor and providing sufficient depth of concrete to support connecting bolts. The outer, lower portion of each rib 14 has a slight projection 16 to control the spacing of the planks as they abut each other to form a grout joint zone that when infilled provides a shear key between adjacent planks. The ribs act as beams supporting the flat plank surface.
- [38] A typical inverted U channel plank has a width of 1500 to 3000mm between its side edges and a rib depth of 250 to 550mm at those edges and 120- 150mm in its middle region. The planks may span 6 to 12m between primary beams such that three planks can create a grid bay as illustrated in figures 1 and 4.
- [39] The ends 12 of the longitudinal beams may be square or have an undercut rebate 24 which is sized to cooperate with the adjacent beam and allows the plank to be self-supporting on the beams 6 during construction. The ends of the planks sit on neoprene pads 64 on the beams. The joints between the planks are filled with a grout or concrete mix. Connector plates 54 link the planks across the beams 6 and therefore create a moment connection across the beams in the final condition.
- [40] The longitudinal ribs 14 of the planks may be provided with apertures 44 for services to pass through if required.

- [41] Lifting points 26 are provided on the plank so that it can be hoisted into position as shown in figure 3. Alternative lifting methods are possible such as by lifting it through service penetrations 44 in the ribs.
- [42] Recesses 30 for the connector plates surrounding bolt sleeves 32 are pre-cast in the upper surface of the plank along the longitudinal edges. The bolt sleeves extend from the upper surface into the ribs 14. Recesses 40 surrounding bolt sleeves 42 are also formed at each corner of the end of the plank. These recesses 30, 40 are deep enough, for example 20mm, to accommodate the various connector plates 52, 54, 56, and 58 which are used to join the components of the flooring system together. The use of connector plates 52, 54, 56, 58 and bolts 50 rather than welded or *in situ* joints which require construction work during assembly, allows this flooring system to be demountable.
- [43] The beams 6 are preferably of an inverted T-shaped section as shown in figure 2 with a lower flange 34 and web 36. The lower projecting flange 34 provides support for a base of a rib 14 during assembly, and neoprene pads 64 may be provided on this support surface. The beam 6 can be provided with penetrations or apertures 38 for the passage of services, as required.
- [44] Connector plates 52, 54, 56, 58 are provided in various configurations as shown in figures 7 to 12. The plates are provided with bolts 50 that connect to the plates and are cast into and cooperate with the bolt sleeves 32, 42 precast into the planks. As illustrated in figure 11, each bolt 50 is assembled from a counter sunk head 53 and a threaded stud 55. The head 53 is received in a hole in a connector plate and is connected to the stud 55 by means of a threaded sleeve coupler 51.
- [45] Once the plates and bolts have been assembled, they can be fixed in position by grouting 62 to give moment continuity. The countersunk bolt head 53, can simply be unscrewed to facilitate removal of the connector plates 52, 54, 56, 58. Once the connector plates are removed the panels have no tensile capacity between the precast units, and can be separated by a concrete splitter for later reuse.
- [46] The primary beams 6, are bolted to a column 4 through threaded bars 74 that sleeve through the beam, as shown in figure 12. Where the column is narrower than the

width of the beam, these threaded bars will sleeve through the web 36 of the primary beam 6. The column connector plate 56 connects the primary beam to adjacent planks through bolts 50 cast into sleeves. The column connector plate can be detailed so that it has threaded bars 70 to connect to standard column shoes 72, or can be detailed to connect to steel or concrete columns. Connector plates 52 connect adjacent planks. Connector plates 54 bridge across a primary supporting beam and connector plates 58 can be used to connect other support beams below the planks.

- [47] The flooring system made up of the components as described can be assembled on site without significant construction steps. There is no need for any propping during construction as the planks are self-supporting on the beams.

Claims

1. A flooring system comprising planks (10) each comprising a reinforced, inverted U-shaped, precast concrete element having an upper surface and depending ribs (14) at longitudinal edges; wherein sleeves (32, 42) for receiving removable bolts are preformed into the planks extending from the upper surface into the ribs of the plank; and connector plates (52, 54, 56) carrying removable bolts (50) for connecting adjacent planks to enable a full diaphragm floor to be created.
2. A flooring system as claimed in claim 1, wherein recesses (30, 40) surrounding the bolt sleeves (32, 42) are preformed into the upper surface of the planks to receive the connecting plates.

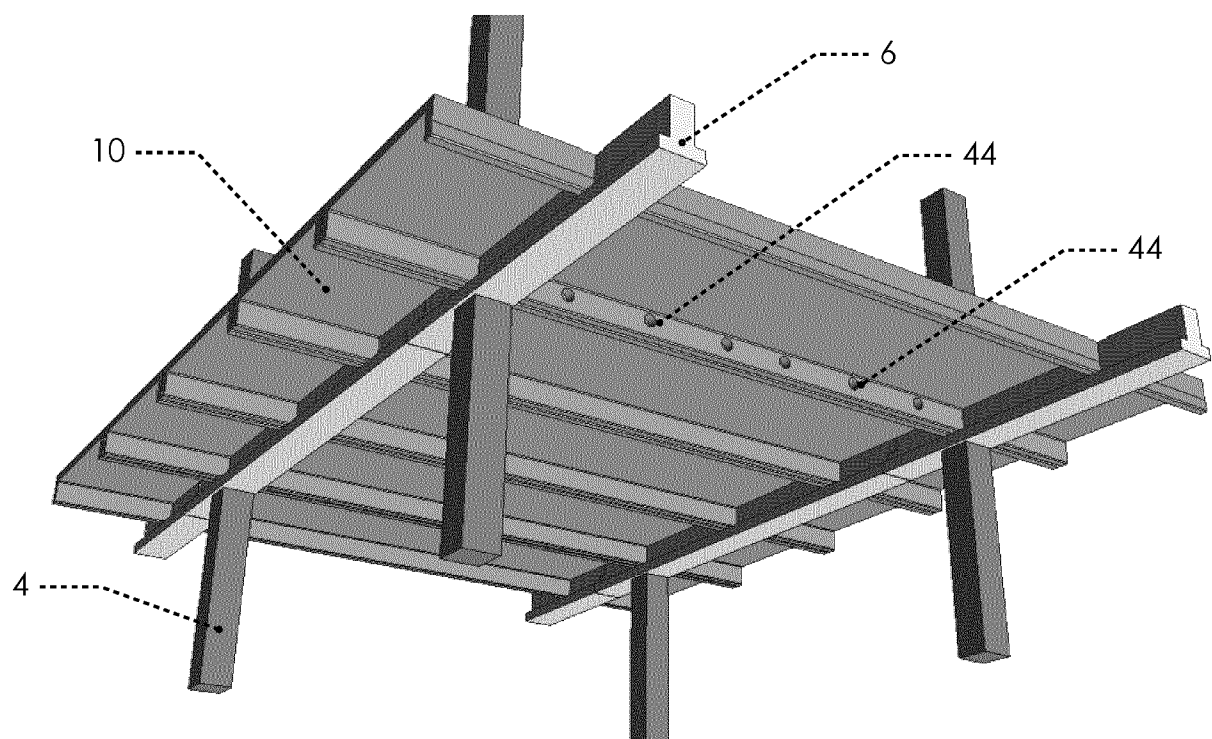


Figure 1

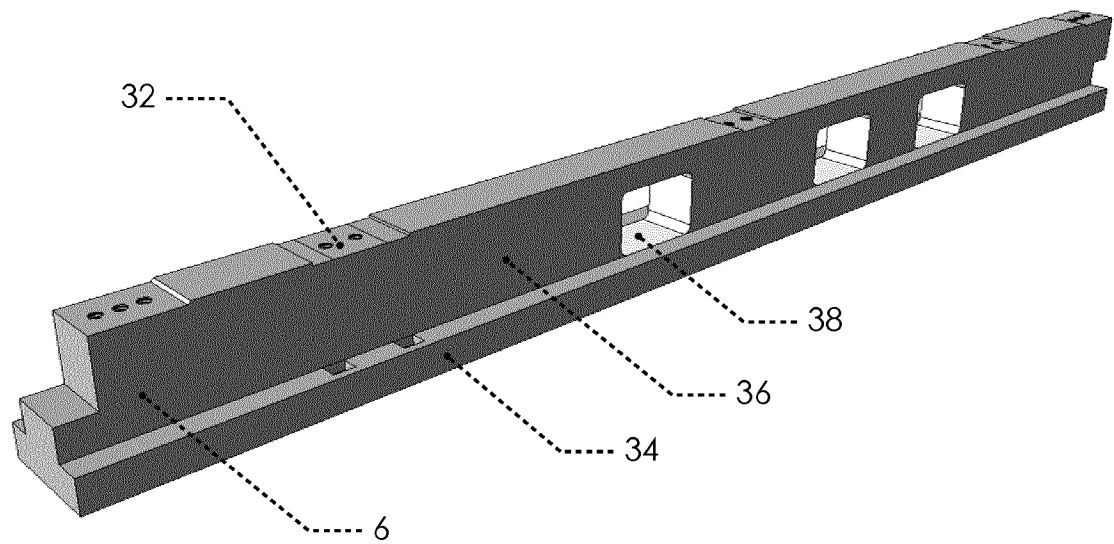


Figure 2

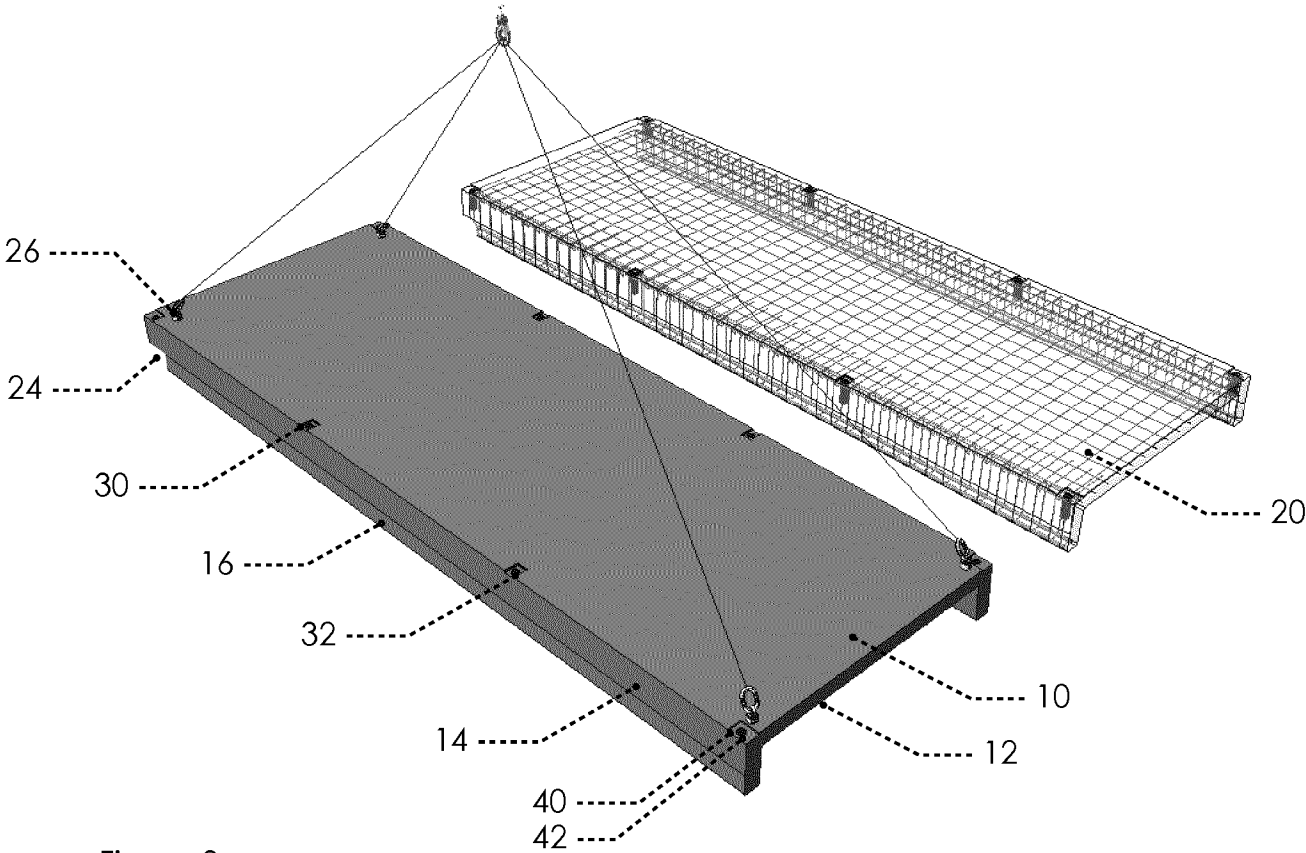


Figure 3

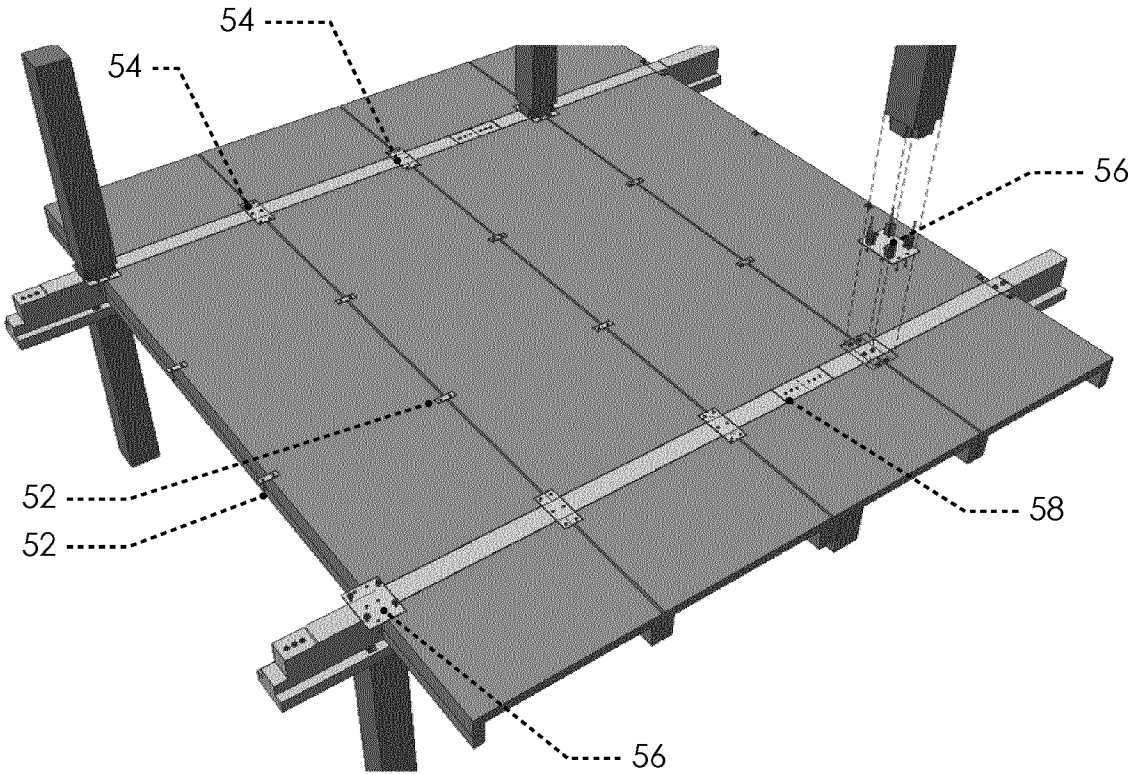


Figure 4

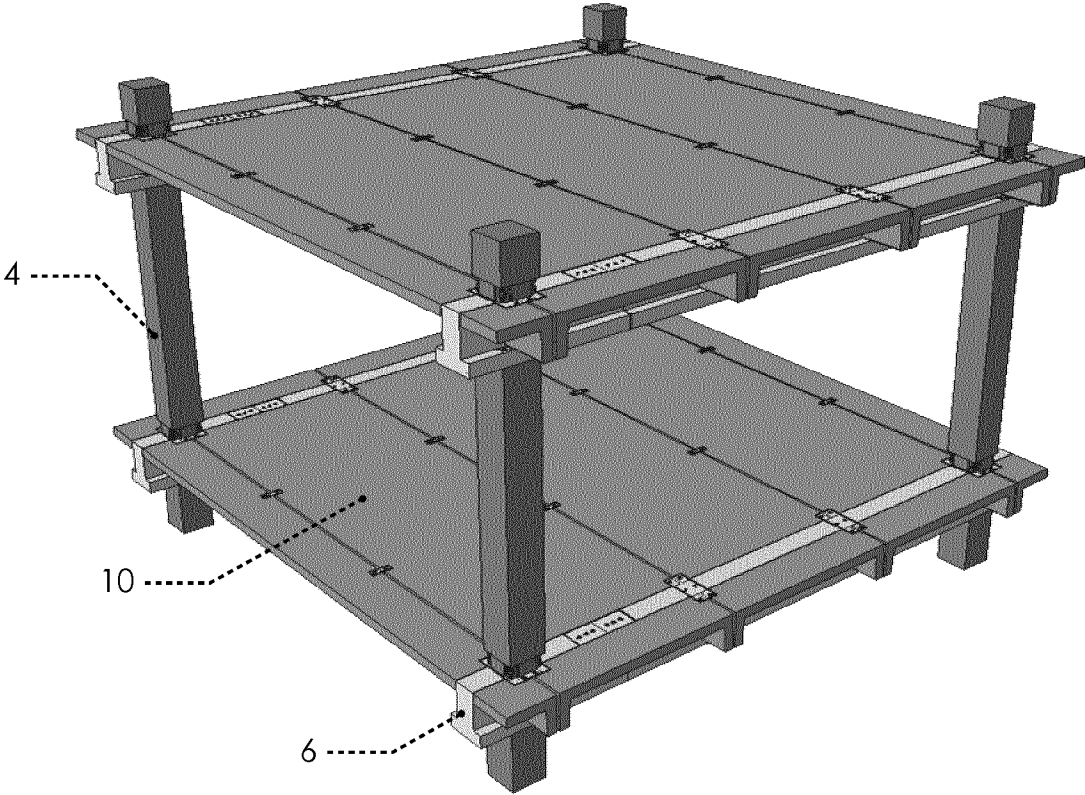


Figure 5

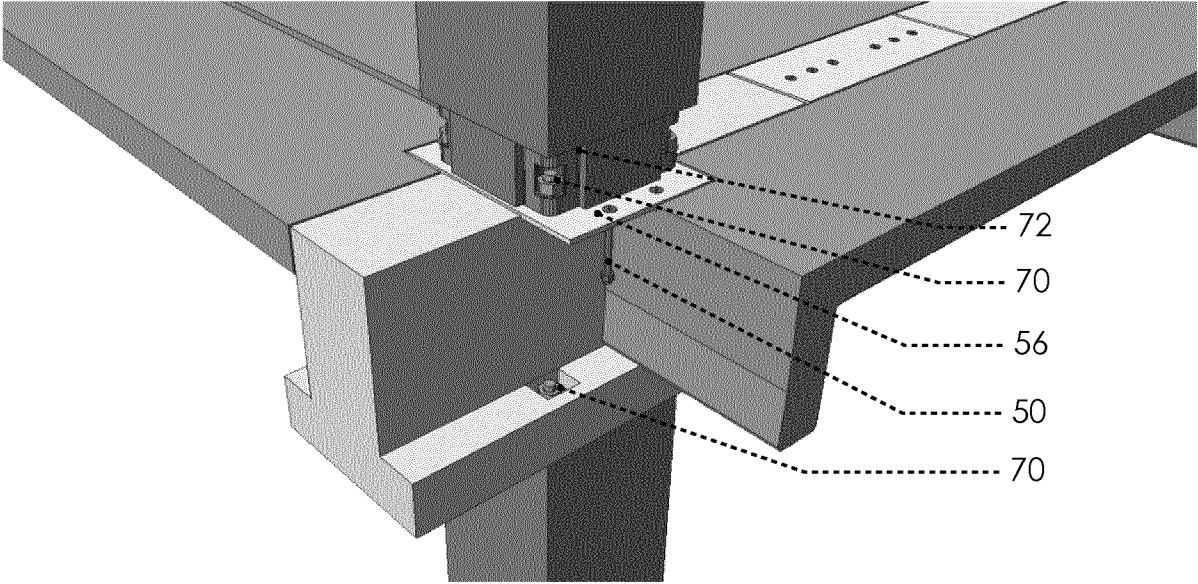


Figure 6

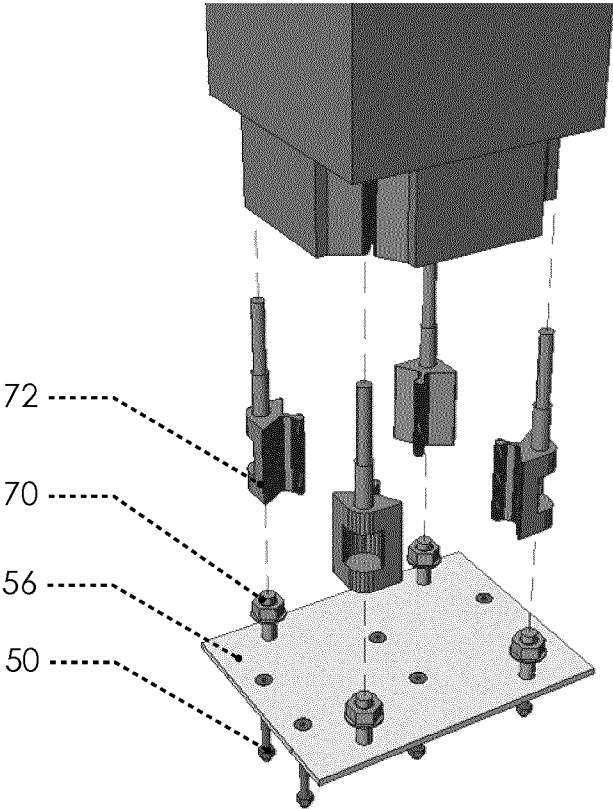


Figure 7

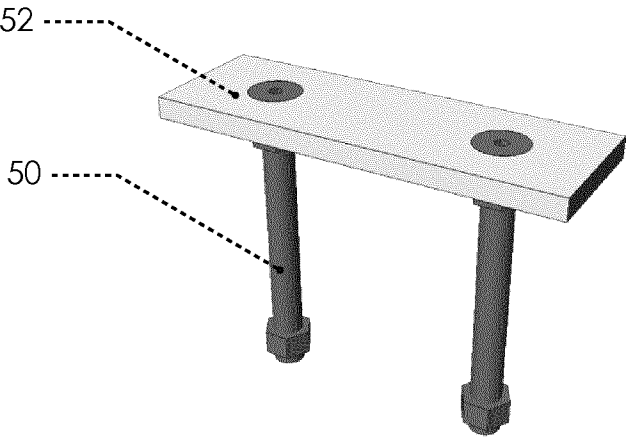


Figure 8

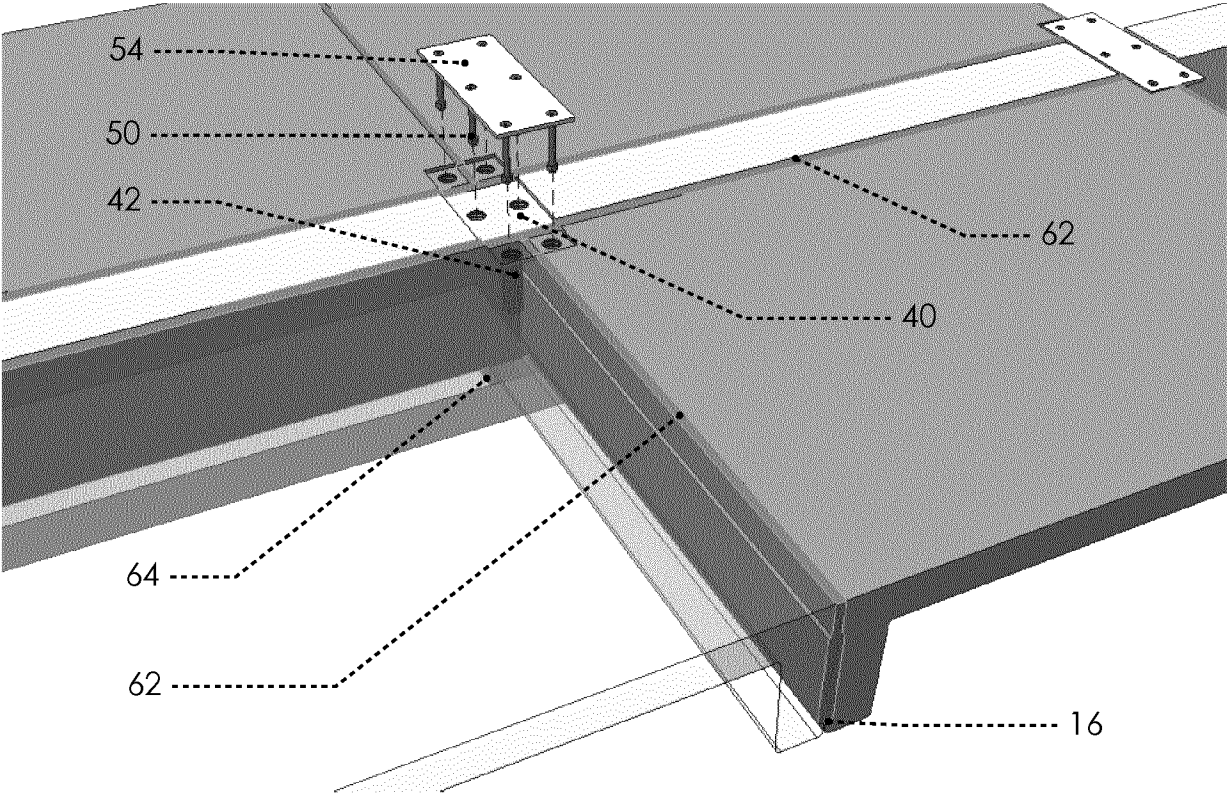


Figure 9

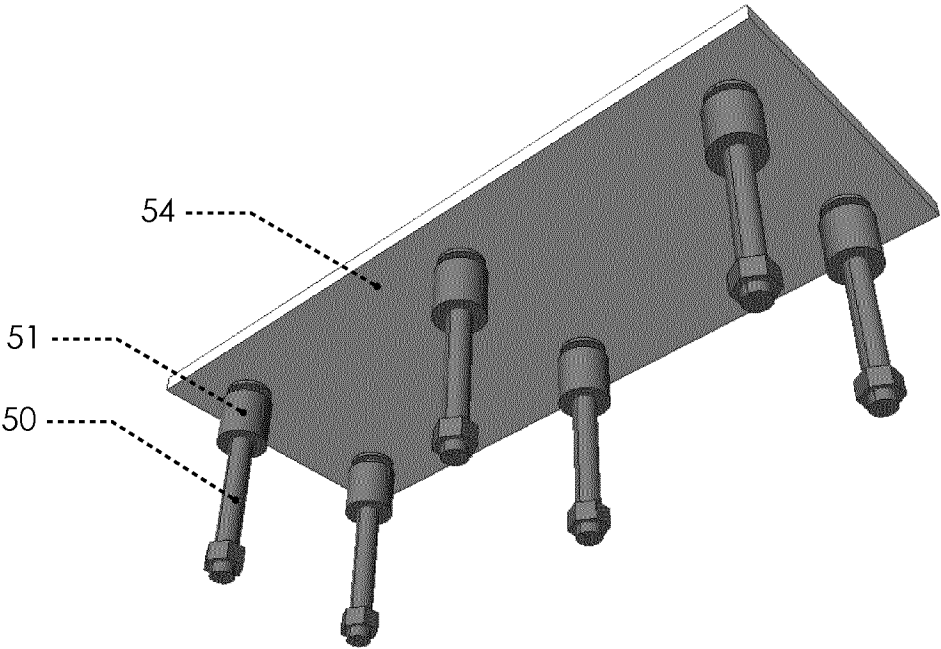


Figure 10

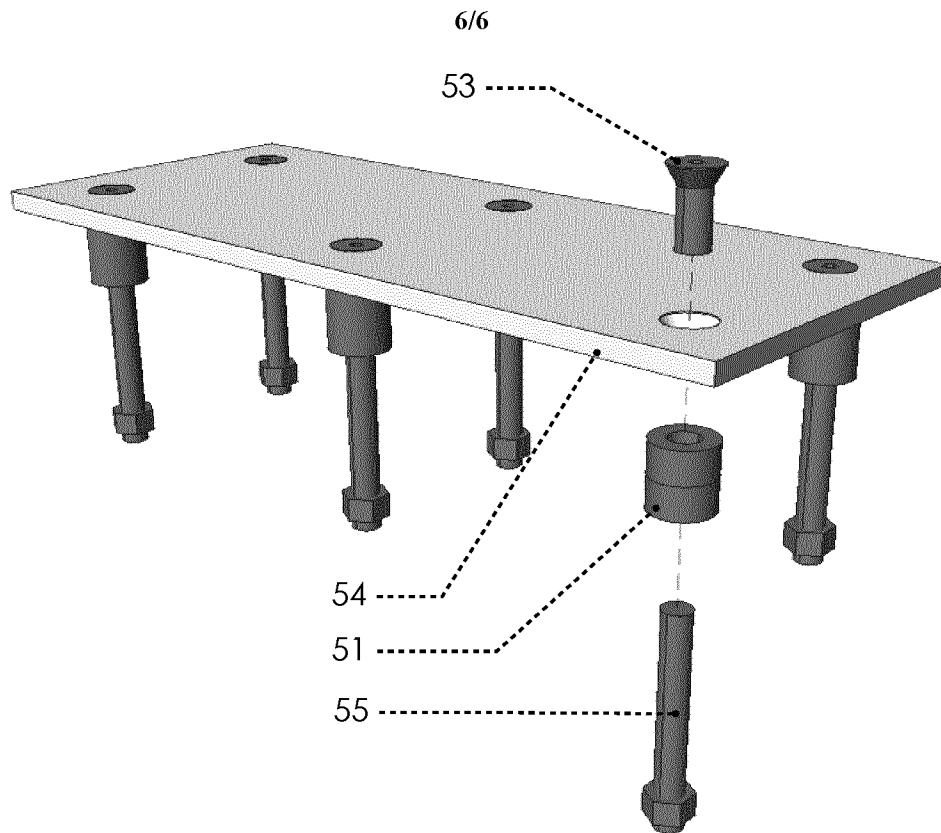


Figure 11

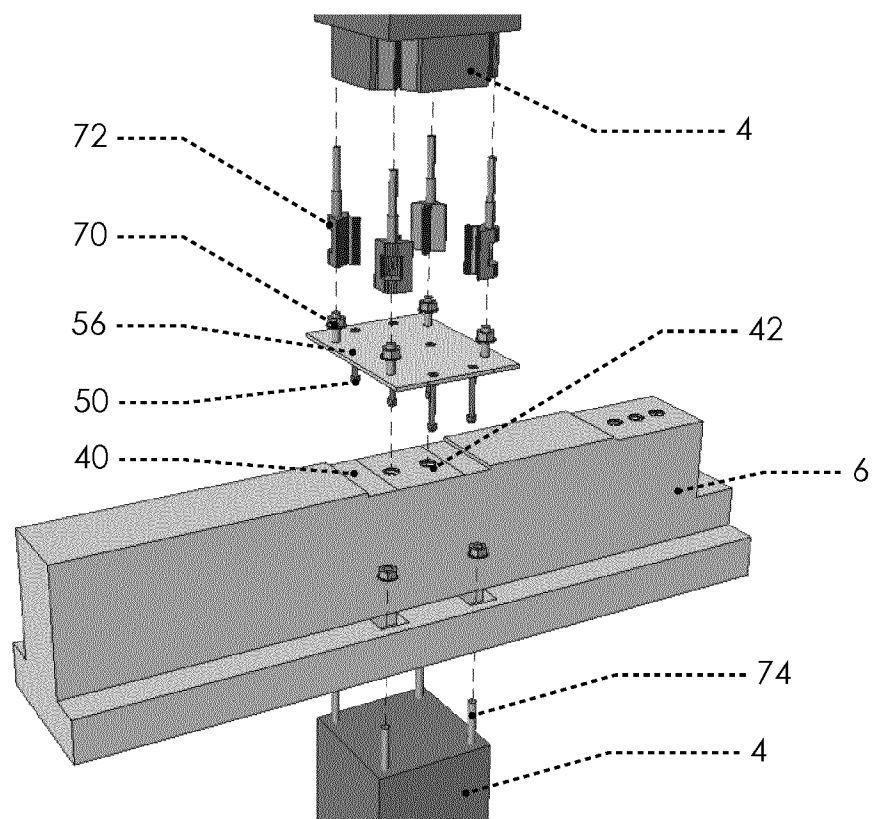


Figure 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/086231

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04B5/02
ADD. E04B5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 422 915 A2 (EREL YIGAL [IL]) 17 April 1991 (1991-04-17) figures 1, 4, 6, 19, 20 -----	1,2
X	FR 2 503 776 A1 (CHARBONNAGES SA STE INDLE CALE [FR]) 15 October 1982 (1982-10-15) figures 1-3 -----	1
Y	WO 94/10389 A1 (DOOLAN TERENCE FOSTER [AU]) 11 May 1994 (1994-05-11) figures 18, 26 -----	1,2
Y	FR 2 697 553 A1 (BOUYGUES SA [FR]) 6 May 1994 (1994-05-06) figure 13 -----	1,2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 March 2019

Date of mailing of the international search report

20/03/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Petrinja, Etjel

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/086231

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0422915	A2	17-04-1991	EP 0422915 A2	17-04-1991
			IL 91978 A	15-12-1991
			JP H03137362 A	11-06-1991
			US 5177913 A	12-01-1993
			US 5305563 A	26-04-1994

FR 2503776	A1	15-10-1982	NONE	

WO 9410389	A1	11-05-1994	AU 5412894 A	24-05-1994
			BR 9307465 A	24-08-1999
			CA 2148697 A1	11-05-1994
			NZ 257488 A	26-04-1996
			WO 9410389 A1	11-05-1994

FR 2697553	A1	06-05-1994	NONE	
