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(54) **MODULAR STRUCTURE FOR THE CONSTRUCTION OF BUILDINGS AND CORRESPONDING ASSEMBLY AND DISASSEMBLY METHOD**

(57) Modular structure (10) for the construction of buildings which comprises at least one module (11) formed by four vertical pillars (12) to which there are con-

nected four horizontal beams (13) on which a floor (15) rests, a concrete topping (16) which crowns said floor (15) and said beams (13).

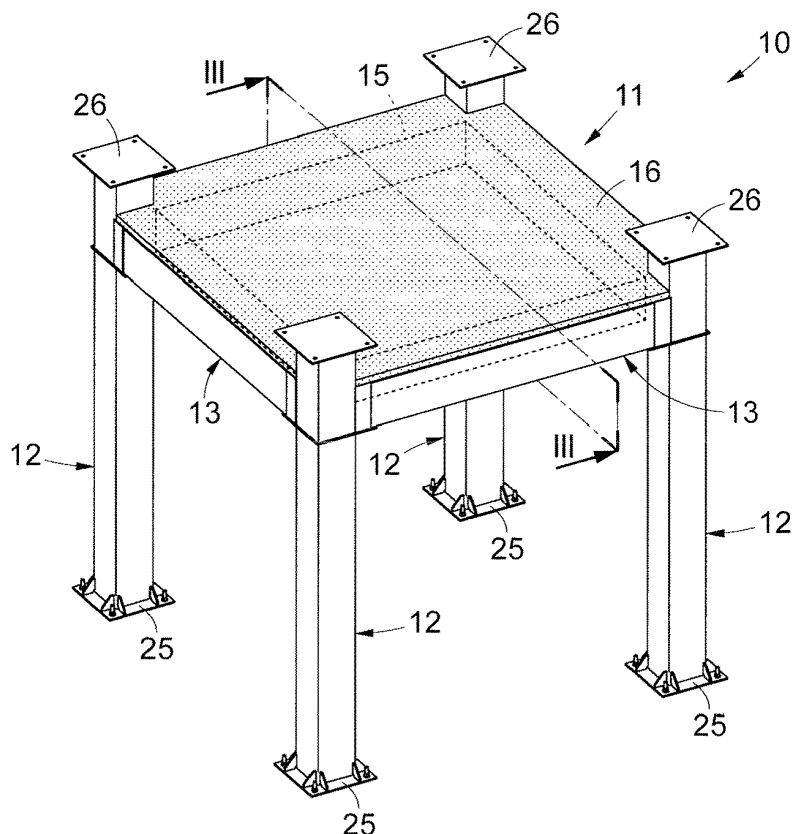


fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention concerns a modular structure for the construction of industrial, civil and tertiary sector buildings, but also accommodation facilities, hospital facilities, infrastructures, renovations, raising structures. The present invention also concerns a method for assembling and disassembling such a modular structure with minimized and localized demolition works.

BACKGROUND OF THE INVENTION

[0002] It is known to build industrial, civil and tertiary sector buildings, but also accommodation facilities, hospital facilities, infrastructures, renovations, raising structures, using prefabricated modular structures formed by vertical pillars with which horizontal beams are associated, defining a support perimeter for a modular floor.

[0003] Typically, in such prefabricated structures the floor is resting on the support perimeter, and it can be attached to the beams by means of reversible connection members. The various modules which the floor is made up of can be connected to each other by means of joints that structurally have hinged behavior. These prefabricated structures are therefore of the type able to be disassembled by acting on the connection members and on the joints.

[0004] There are also prefabricated structures in which, once the floor has been laid, a layer of concrete or other construction material is cast in order to form a so-called concrete topping, so as to make the floor integral and continuous with the beams and obtain, in addition to a hyperstatic structural layout, a continuous and regular surface. In these structures, the beams that form the external perimeter have containing lateral edges to retain the concrete, but they are open on the side facing the floor to allow the installation of continuity reinforcements. In addition, continuity to the beam - pillar node is usually demanded for important improved-adherence reinforcements embedded in the two structural elements.

[0005] One disadvantage of these prefabricated structures is that they are difficult to disassemble, and the structural components, especially the beams, are not reusable or have to undergo expensive demolition and restoration processes.

[0006] These structures, in case of ceased use or obsolescence, must therefore be demolished and the structural components have to be disposed of, with high costs of landfilling and considerable environmental impact. Currently, in fact, the construction sector is responsible for the emission of about 36% of CO₂ and 30% of waste, so the transition to a circular and zero-emission economy is a need that is increasingly felt nowadays.

[0007] There is therefore the need to perfect a modular structure, of the type able to be disassembled, for the construction of buildings and a corresponding assembly

and disassembly method which can overcome at least one of the disadvantages of the state of the art.

[0008] One purpose of the present invention, which corresponds to the technical problem to be solved, is to provide a disassemblable modular structure in which the main structural elements, that is, the pillars, the beams and the floor, are able to be separated easily, even when the structure is completed with structural solutions and a concrete casting that temporarily makes such elements integral.

[0009] Another purpose of the present invention is to provide a disassemblable modular structure, cast in concrete, in which the pillars, the beams and possibly also the modules that constitute the floor can be reused without, or with reduced, waste.

[0010] Another purpose of the present invention is to provide a modular structure for the construction of buildings with low environmental impact and according to a circular economy logic, while still guaranteeing all the standards and requirements set by sector regulations, for example standards on construction in earthquake zones provided both in the NTC 2018 and in the Eurocode 4 and 8.

[0011] Another purpose of the present invention is to develop a method for assembling and disassembling such a modular structure which is fast, simple, reliable and guarantees the structural elements can be reused once disassembled.

[0012] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0013] The present invention is set forth and characterized in the independent claims. The dependent claims describe other characteristics of the present invention or variants to the main inventive idea.

[0014] In accordance with the above purposes and to resolve the technical problem disclosed above in a new and original way, also achieving considerable advantages compared to the state of the prior art, a modular structure for the construction of industrial, civil and tertiary sector buildings, but also accommodation facilities, hospital facilities, infrastructures, renovations and raising structures, comprises at least one module, advantageously having a square or rectangular plan, formed by four vertical pillars disposed in corner positions, four horizontal beams, each one connected in a removable manner to two respective consecutive pillars, a floor resting on the beams and a concrete topping which drowns the floor and the beams, making them integral.

[0015] In accordance with one aspect of the present invention, each beam has a lattice body integral with a bottom and enclosed in a casing with two lateral edges, of which one, by being interposed between the lattice body and the floor, makes the beams separable from the

floor.

[0016] Advantageously, the presence of the lateral edges on both sides of the lattice body allows to define a physical separation between the components which, although drowned in the concrete topping, will be more easily separable if the structure is disassembled.

[0017] In accordance with another aspect of the present invention, the beams have two flanged ends connected to respective "cantilevered" type support members of each pillar by means of connection means positioned in a containing compartment, substantially isolated from the concrete topping, by means of a removable covering element. The aforementioned element can be made of wood, plastic or sheet metal, and it can have the function of protecting the bolted connection from deterioration and degradation phenomena, on par with a plain concrete cover.

[0018] In accordance with another aspect of the present invention, the support member comprises a bracket element present on at least two lateral walls of the pillar, to which there is reversibly bolted a corresponding flanged end of one of the beams. The bracket element and the flanged end define a saddle joint, sized so as to guarantee structural continuity.

[0019] In accordance with another aspect of the present invention, the bracket element is laterally surrounded by two wings distanced from each other and having a U-shaped profile which partly circumscribe the containing compartment. The containing compartment is open at the top in order to receive the covering element, and transversely in order to receive the flanged end.

[0020] In accordance with another aspect of the present invention, between one of the lateral edges, in particular the one closest to the floor, and the floor there is defined a longitudinal interspace drowned by the concrete topping. This interspace can advantageously be used as a separation section during the works of disassembling the structure.

[0021] In this way, it would be possible to carry out treatments on the internal lateral edge, understood as the one closest to the floor, such as the application of paint, adhesive rubber or releasing agents, in order to facilitate the subsequent separation during disassembly. Moreover, this measure would allow to not have to cut the entire section of the structure, but only the cover (concrete topping), significantly saving on the equipment needed on site and on time.

[0022] In accordance with another aspect of the present invention, the lattice body is completely contained within the overall dimensions of the lateral edges.

[0023] In accordance with another aspect of the present invention, the lateral edges have own free ends which are located at a same height of an upper surface of the floor measured from the bottom.

[0024] In accordance with another aspect of the present invention, each bottom is provided with at least one longitudinal flat edge, protruding with respect to the assembly consisting of the lattice body and the casing,

on which the floor is able to rest advantageously by means of the interposition of a compensation element.

[0025] In accordance with another aspect of the present invention, the support member comprises a plate which surrounds one or more lateral walls of the pillar, defining a continuity with the at least one flat edge.

[0026] In accordance with another aspect of the present invention, the structure can be single-story or multi-story.

[0027] Some embodiments of the present invention also concern a method for assembling a structure which comprises the installation of at least one module according to the following assembly steps:

- laying four vertical pillars in a corner position according to a square or rectangular layout, wherein the pillars are provided with cantilevered support members;
- connecting four horizontal beams, each one to respective support members of two consecutive pillars, by means of removable connection means positioned in a containing compartment, wherein each beam has a lattice body integral with a bottom and enclosed in a casing with two lateral edges;
- positioning corresponding removable covering elements to protect the connection means;
- disposing a floor on the beams, one of the lateral edges being interposed between the lattice body and the floor to make the beams separable from the floor;
- casting a concrete topping to drown the floor and the beams making them integral, the containing compartment remaining substantially isolated with respect to the concrete topping. The laying of the concrete topping also comprises filling the sections of the beams.

[0028] A corresponding method for disassembling the modular structure comprises the following disassembly steps:

- making a series of longitudinal cuts on the concrete topping, in a section comprised between one or both the lateral edges and the floor, in order to make the floor separable and removable, wherein the longitudinal cuts are parallel to the length of the beam;
- removing the floor;
- removing the covering elements and unblocking the connection means;
- disconnecting the beams from the pillars.

DESCRIPTION OF THE DRAWINGS

[0029] These and other aspects, characteristics and advantages of the present invention will become apparent from the following description of an embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a three-dimensional view of a modular structure for the construction of buildings, according to the present invention;
- fig. 2 is a partly sectioned detail view of the structure of fig. 1;
- fig. 3 is a section view along the plane III-III of fig. 1;
- fig. 4 is a top view of the beam-pillar connection of fig. 2;
- fig. 5 is a separated components view showing the beam-pillar connection;
- fig. 6 is a possible embodiment of the modular structure for the construction of buildings, according to the present invention.

[0030] We must clarify that the phraseology and terminology used in the present description, as well as the figures in the attached drawings also in relation as to how described, have the sole function of better illustrating and explaining the present invention, their purpose being to provide a non-limiting example of the invention itself, since the scope of protection is defined by the claims.

[0031] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can be conveniently combined or incorporated into other embodiments without further clarifications.

DESCRIPTION OF AN EMBODIMENT OF THE PRESENT INVENTION

[0032] With reference to fig. 1, a disassemblable modular structure 10 according to the present invention for the construction of buildings comprises at least one module 11 having a square or rectangular plan, formed by four vertical support elements, or pillars, 12 disposed in a corner position, and four horizontal support elements, or beams, 13 each removably connected to two respective consecutive pillars 12.

[0033] The beams 13 define a self-supporting rest frame 14, partly visible in fig. 2, for a floor 15 that is part of the module 11.

[0034] The floor 15 can be formed by a single panel or by several panels that can be of the honeycomb or slab type.

[0035] By the term floor 15 we mean a flat two-dimensional structure with orthogonal structural load that contributes to static safety, distributing the loads on the beams 13.

[0036] The module 11 is completed by a concrete topping 16 (figs. 1-4 and 6), typically consisting of a layer of concrete that acts as a completion casting on top of the floor 15 and the beams 13, thus drowning them and making them integral with each other.

[0037] The concrete topping 16 fills both the interspaces G present between the floor 15 and the beams 13 (figs. 3-4), and also the beams 13 (figs. 2 and 3), and it also incorporates the pillars 12.

[0038] Once hardened, the concrete topping 16 becomes a uniform plate that has the function of stiffening the structure, of compensating the heights - making the surface of the floor 15 perfectly horizontal, and of distributing the loads along the entire surface.

[0039] With reference to figs. 2-5, each beam 13 has a bottom or base 17, a lattice body 18 integral with the bottom 17 enclosed by a casing 19 defined by two opposite lateral edges 20, 21 and longitudinally contained by two opposite terminal walls 36 of the beam 13 (figs. 2, 4 and 5). The lateral edges 20, 21 develop along the entire length of the beam 13, are connected to the terminal walls 36 and have a height greater than the height of the lattice body 18. These heights being measured with respect to the bottom 17, see for example fig. 3.

[0040] The casing 19 is attached to the bottom 17, or drowned therein, so that the lateral edges 20, 21 are essentially orthogonal to the flat surface of the bottom 17. In other words, the lateral edges 20, 21 develop vertically from the bottom 17.

[0041] The space thus defined in which the lattice body 18 is present is filled by the concrete.

[0042] The beams 13 can be made entirely of steel, for example S355J steel, or they can have a mixed structure with the bottom 17 made of concrete, for example C28/35 concrete.

[0043] The beam 13 is open at the upper part to allow the material of the concrete topping 16 to fill the lattice body 18, drowning it completely, filling the space comprised between the two lateral edges 20, 21, the terminal walls 36 and the bottom 17.

[0044] The bottom 17 has a flat edge 17a protruding with respect to the assembly consisting of the lattice body 18 and the casing 19, on which the floor 15 is able to rest.

[0045] The bottom 17, in addition to being an integral part of the bearing structure, is therefore also a self-supporting rest for the floor 15 and formwork for the concrete completion casting.

[0046] The bottom 17 can have two flat edges 17a on both longitudinal sides of the assembly consisting of the lattice body 18 and the casing 19. This occurs in the event that the beam 13 is shared by two adjacent modules 11 (fig. 6).

[0047] The flat edges 17a of the beams 13 that form the module 11 define overall the rest frame 14 for the floor 15, fig. 2.

[0048] The upper surface of the floor 15 is substantially at the same height as the upper ends of the lateral edges 20, 21, fig. 3.

[0049] The upper ends of the lateral edges 20, 21 can be turned toward each other with segments parallel to the surface of the bottom 17, figs. 2-5.

[0050] On the flat edge 17a there can be disposed a compensation element 35, on which the floor 15 is able to rest, fig. 3, which can consist of one or more flat bearings made of rubberized material, for example neoprene. The compensation element 35 can extend for the entire length of the flat edge 17a or only in part, or it can be

formed by several parts spaced apart over the length of the flat edge 17a.

[0051] When the concrete topping 16 is laid, the presence of the two lateral edges 20, 21, in particular the one facing the floor 15, allows to physically separate the beams 13 from the floor 15 through the interposition of the innermost lateral edge 21 (figs. 1-5), or of both lateral edges 20, 21 in the event that the beam 13 is shared by two adjacent modules 11 (fig. 6).

[0052] The interspace G between the beams 13 and the floor 15, which is also filled with the material of the concrete topping 16, can act as a separation section during the disassembly works of the structure 10. In this case, in fact, it is provided to carry out a series of longitudinal cuts (represented with a dash-dot line in figs. 3 and 4), that is, in the direction of the length of the beam 13, in a section comprised between the lateral edges 20, 21 and the floor 15, in order to make the floor 15 removable and subsequently remove it. These longitudinal cuts break, in a localized manner, the continuity of the concrete topping 16, allowing the complete disassembly of the structure 10. Advantageously, demolition works are practically absent and the structure 10 is completely disassemblable and reusable.

[0053] Each beam 13 is also provided with two flanged ends 22 for the removable connection with the pillars 12, figs. 4 and 5. The flanged ends 22 are each provided in correspondence with a respective terminal wall 36 of the beam 13.

[0054] The flanged end 22 is formed by a plate 23 on which one or more female type anchoring elements 24 are made, for example through holes, slots, apertures, grooves.

[0055] Each pillar 12 has a lower base 25 and an opposing upper base 26, figs. 1 and 2. In an intermediate position between the lower base 25 and the upper base 26, or in another position along the height of the pillar 12, there is created, cantilevered with respect to lateral walls defining the body of the pillar 12, a support member 27 configured to define a stable rest for a respective flanged end 22 of the beam 13, fig. 5.

[0056] The support member 27 comprises a plate 28, which surrounds one or more lateral walls of the pillar 12. The plate 28 is substantially orthogonal to the lateral walls of the pillar 12.

[0057] The support member 27 also comprises a bracket element 29, favorably present on at least two walls of the pillar 12, to which a flanged end 22 of one of the beams 13 is able to be reversibly anchored.

[0058] A bracket element 29 is provided on each side of the pillar 12 to which a beam 13 is to be connected.

[0059] The connection between the bracket element 29 and the flanged end 22 is of the so-called "Gerber saddle" type.

[0060] The bracket element 29 is provided with male type anchoring elements 30 such as screws, pins, pivots or other similar or comparable elements facing the upper base 26 of the pillar 12, fig. 5.

[0061] The female type anchoring elements 24 and the male type anchoring elements 30 form beam-pillar connection means 32, visible in a coupled condition in fig. 4.

[0062] In one embodiment, the connection means 32 are formed by bolts, possibly securable through local welding, figs. 4 and 5.

[0063] The bracket element 29 is attached cantilevered on a respective lateral wall of the pillar 12 and is disposed distanced from the corresponding plate 28, so as to create an interspace. According to one variant, the bracket element 29 can be disposed in contact with the corresponding plate 28.

[0064] With reference to figs. 4 and 5, the bracket element 29 is surrounded laterally by two wings 33 that have a development parallel to the length of the pillar 12 and at least partly circumscribe the zone where the male type anchoring elements 30 are located, defining a sort of containing compartment 31. The containing compartment 31 can be closed, on the side of the beams 13, by the terminal walls 36 of the beams themselves.

[0065] The wings 33 have a U-shaped profile and face each other defining a containing compartment 31 in the shape of a parallelepiped.

[0066] A removable covering element 34 can be associated between the two wings 33, which has the function of protecting the connection means 32, preventing them from being covered by the material of the concrete topping 16, figs. 2 and 5.

[0067] The covering element 34 can have a flat portion 34a able to close the section of the containing compartment 31, and one or more caps 34b which, during use, surround the connection means 32, isolating them, fig. 5.

[0068] The covering element 34 can be made of wood, plastic or sheet metal, and it has the function of protecting the bolted connection from deterioration and degradation phenomena, on par with a plain concrete cover.

[0069] The module 11 just described can be repeated to form a more complex structure 10 which can be single-story or multi-story. An example of a multi-story structure 10 is shown in fig. 6.

[0070] In the case of a multi-story structure 10, the upper base 26 of the pillars 12 which form a lower first floor serves as a support for the pillars 12 forming an upper second floor.

[0071] When the structure comprises more than one module 11, the front of a first module 11, formed by two pillars 12 and one beam 13, is shared with an adjacent module 11, and so on.

[0072] It is clear that modifications and/or additions of parts may be made to the structure 10 and to the assembly and disassembly method as described heretofore, without departing from the field and scope of the present invention, as defined by the claims.

[0073] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art will be able to achieve other equivalent forms of a modular structure for the construction of buildings and corresponding assembly and

disassembly method, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

[0074] In the following claims, the sole purpose of the references in brackets is to facilitate their reading and they must not be considered as restrictive factors with regard to the field of protection defined by the claims.

Claims

1. Modular structure (10) for the construction of buildings which comprises at least one module (11) formed by four vertical pillars (12) to which there are connected four horizontal beams (13) on which a floor (15) rests, a concrete topping (16) which drowns said floor (15) and said beams (13), **characterized in that** each beam (13) has a lattice body (18) integral with a bottom (17) and enclosed in a casing (19) with two lateral edges (20, 21) of which one, by being interposed between said lattice body (18) and said floor (15), makes said beams (13) separable from said floor (15).
2. Structure (10) as in claim 1, **characterized in that** said beams (13) have two flanged ends (22) connected to respective cantilevered support members (27) of each pillar (12) by means of connection means (32) positioned in a containing compartment (31) with a removable covering element (34).
3. Structure (10) as in claim 1 or 2, **characterized in that** said support member (27) comprises a bracket element (29) present on at least two lateral walls of said pillar (12), to which there is reversibly bolted a corresponding flanged end (22) of one of said beams (13), wherein said bracket element (29) and said flanged end (22) define a saddle joint.
4. Structure (10) as in claim 3, **characterized in that** said bracket element (29) is laterally surrounded by two wings (33) distanced from each other and having a U-shaped profile which partly circumscribe said containing compartment (31), which is open at the top in order to receive said covering element (34) and transversely in order to receive said flanged end (22).
5. Structure (10) as in any claim hereinbefore, **characterized in that** between one of said lateral edges (20, 21) and said floor (15) there is defined a longitudinal interspace (G) drowned by said concrete topping (16).
6. Structure (10) as in any claim hereinbefore, **characterized in that** said lattice body (18) is completely contained within the overall dimensions of said lateral edges (20, 21).
7. Structure (10) as in any claim hereinbefore, **characterized in that** said lateral edges (20, 21) have own free ends which are located at a same height of an upper surface of said floor (15) measured from said bottom (17).
8. Structure (10) as in any claim hereinbefore, **characterized in that** each bottom (17) is provided with at least one longitudinal flat edge (17a), protruding with respect to the assembly consisting of said lattice body (18) and said casing (19), on which said floor (15) is able to rest by means of the interposition of a compensation element (35).
9. Method for assembling a modular structure (10) for the construction of buildings which comprises the installation of at least one module (11) according to the following assembly steps:
 - laying four vertical pillars (12) in a corner position according to a square or rectangular layout, wherein said pillars (12) are provided with cantilevered support members (27);
 - connecting four horizontal beams (13), each one to respective support members (27) of two consecutive pillars (12) by means of removable connection means (32) positioned in a containing compartment (31), wherein each beam (13) has a lattice body (18) integral with a bottom (17) and enclosed in a casing (19) with two lateral edges (20, 21);
 - positioning corresponding removable covering elements (34) to protect said connection means (32);
 - disposing a floor (15) on said beams (13), one of said lateral edges (20, 21) being interposed between said lattice body (18) and said floor (15) to make said beams (13) separable from said floor (15);
 - casting a concrete topping (16) to drown said floor (15) and said beams (13) making them integral, said containing compartment (31) remaining isolated with respect to said concrete topping (16).
10. Method for disassembling a modular structure (10) assembled according to the method of claim 9, comprising the following disassembly steps:
 - making a series of longitudinal cuts on said concrete topping (16), in a section comprised between said lateral edges (20, 21) and said floor (15), in order to make said floor (15) removable;
 - removing said floor (15);
 - removing the covering elements (34) and unblocking said connection means (32);
 - disconnecting said beams (13) from said pillars

(12).

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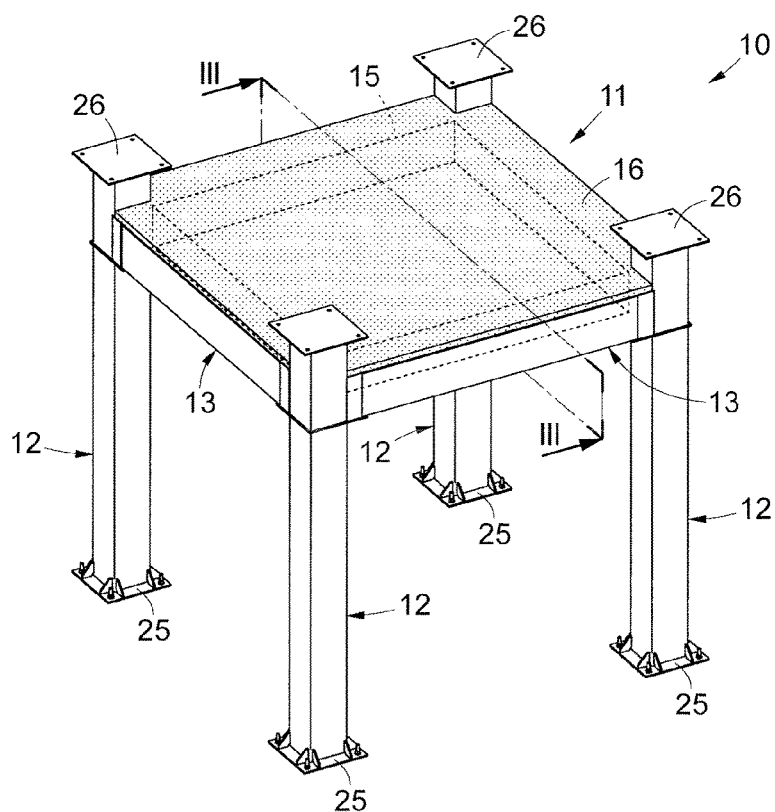


fig. 1

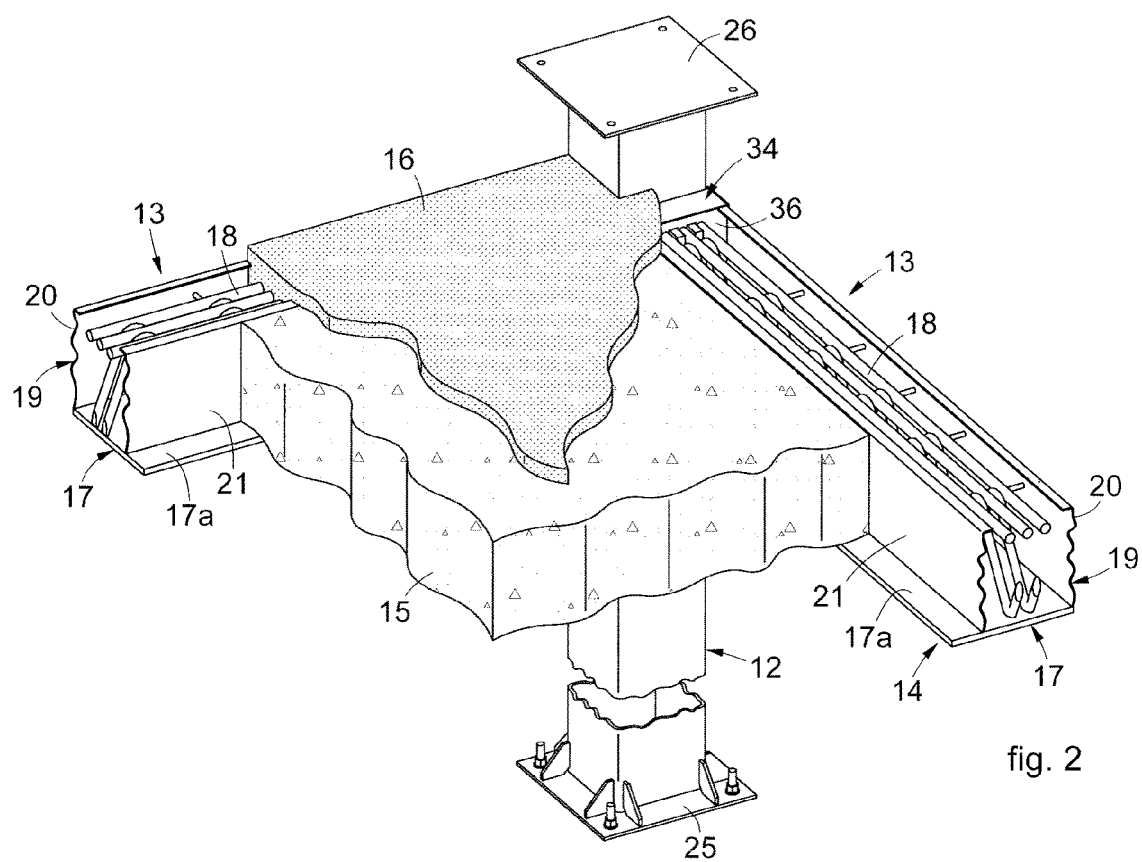


fig. 2

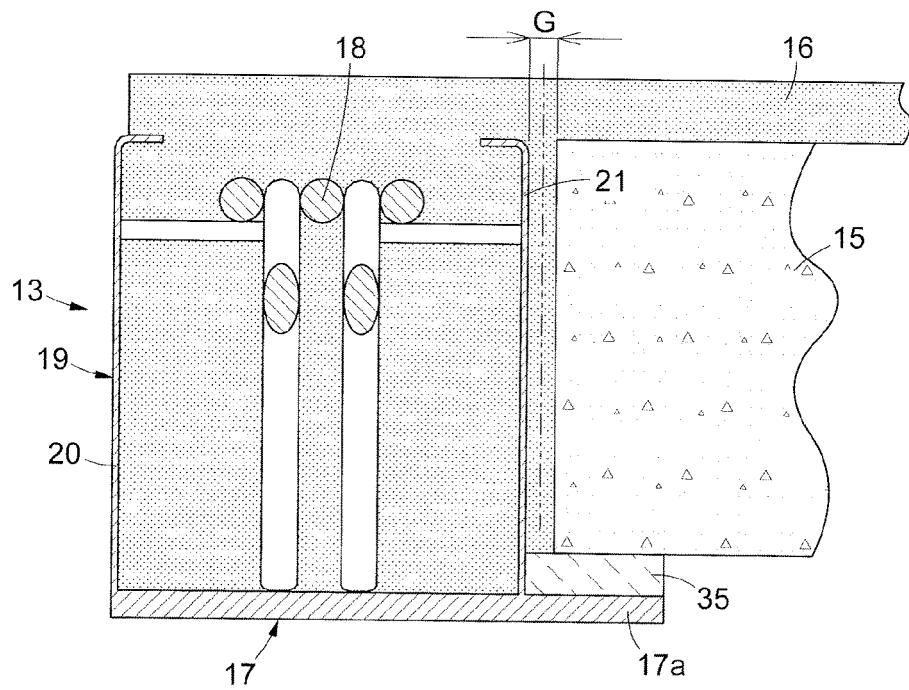


fig. 3

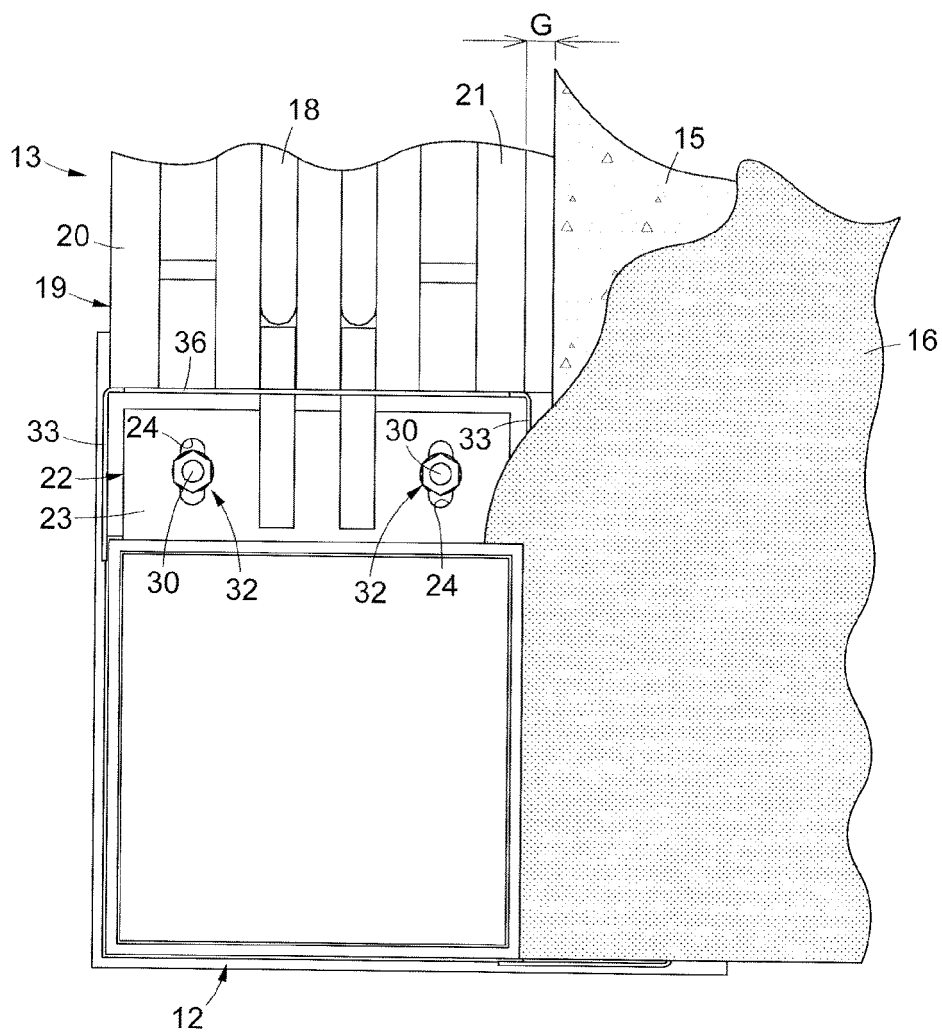
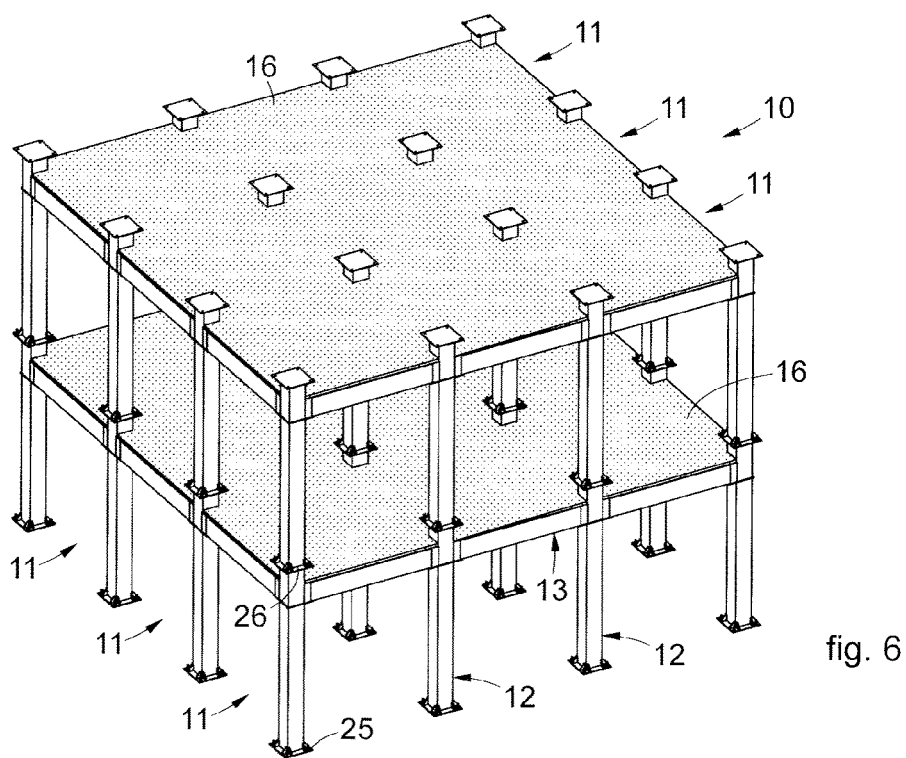
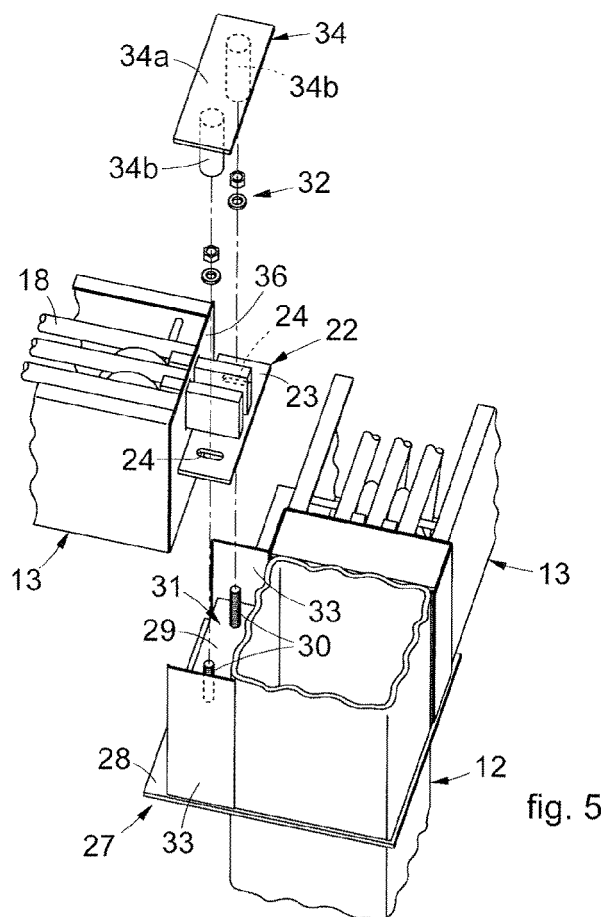


fig. 4





EUROPEAN SEARCH REPORT

Application Number

EP 24 15 9381

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EPO FORM 1503 03.82 (P04C01)

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	US 5 050 358 A (VLADISLAVIC NEVEN I [CL]) 24 September 1991 (1991-09-24) * column 8, line 53 - column 9, line 63; figures 1A, 1B, 10-12 * -----	1-10	INV. E04B1/16 E04B1/21 E04B1/30 E04B1/343 E04C3/294
X	US 2018/355600 A1 (YANG DONGZUO [CN]) 13 December 2018 (2018-12-13) * paragraph [0176] - paragraph [0180]; figure 19 * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04B E04C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 March 2024	Examiner Melhem, Charbel
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	

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

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