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(54) MODULAR BUILDING ELEMENTS

(57) A modular building (100) formed by at least a bottom modular building element (30, 32, 33, 34) and a top modular building element (’30, ‘32, ‘33, ‘34), wherein:
- the top building element is positioned above the bottom building element;
- the bottom building element comprises a floor (40), a ceiling (42) with one or more ceiling joists (1) connected to at least one transverse ceiling beam (3, 28), and one or more columns (5) coupling the floor and the ceiling;
- the top building element comprises a floor with one or more floor joists (7, 9) connected to at least one transverse floor beam (6), a ceiling, and one or more columns (5) coupling the floor and the ceiling; and
- the one or more ceiling joists of the bottom building element and the one or more floor joists of the top building element are positioned substantially parallel and at least partially side-by-side.

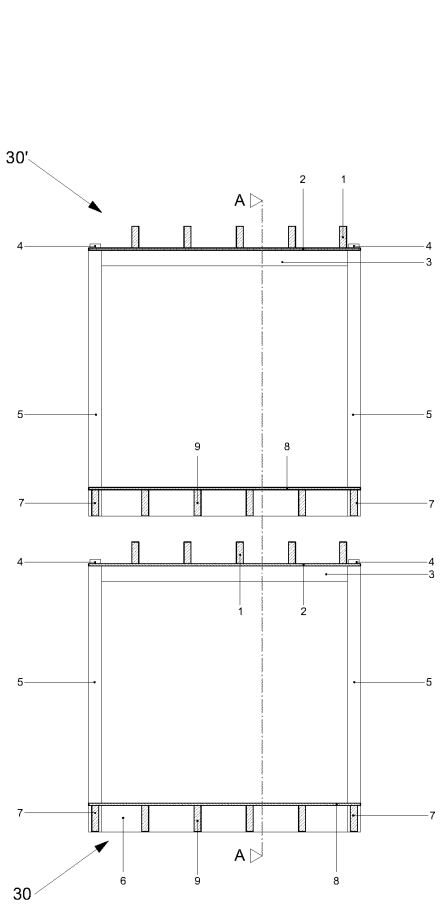

FIG 7

EP 4 461 896 A1

Description

TECHNICAL FIELD

[0001] The technology of the present disclosure relates to the field of modular building elements comprising wood and/or steel.

BACKGROUND

[0002] In traditional building, materials are transported to a construction site and the building is entirely formed at the construction site. For example to improve efficiency of the building process, it has been proposed to use prefabricated modular elements to construct buildings.

[0003] EP2241692A2 discloses a house module, an assembly of a number of house modules for forming a house, a house comprising a number of house modules and to a method for manufacturing a house. In EP2241692A2, it is proposed to form a house from concrete house modules. A number of concrete house modules are manufactured centrally and subsequently transported to a building site.

SUMMARY

[0004] The present disclosure contemplates improving the process of constructing a building formed by multiple modular building elements. Instead of using concrete as in EP2241692A2, the present disclosure contemplates using at least in part different materials, such as but not limited to wood, wood-derived products, plastics, composite materials, metals such as steel or aluminium, or any combination thereof. Although different materials are used, the technology of the present disclosure still provides for an efficient building process.

[0005] Improvements may be found in terms of speed in which the modular building elements can be formed and/or in which the building can be constructed, in reducing weight and/or material use, and/or in reducing an environmental footprint of the building formed from the modular elements.

[0006] The present disclosure contemplates in a first aspect a modular building formed by at least a bottom modular building element and a top modular building element. The top building element is positioned above the bottom building element.

[0007] According to the first aspect, the bottom building element comprises a floor, a ceiling with one or more ceiling joists connected to at least one transverse ceiling beam, and one or more columns coupling the floor and the ceiling, the top building element comprises a floor with one or more floor joists connected to at least one transverse floor beam, a ceiling, and one or more columns coupling the floor and the ceiling, and the one or more ceiling joists of the bottom building element and the one or more floor joists of the top building element are positioned substantially parallel and at least partially side-by-side.

[0008] In particular embodiments of the modular building according to the first aspect, the bottom building element comprises a floor, a ceiling with multiple ceiling joists connected between two transverse ceiling beams, and one or more columns coupling the floor and the ceiling. The top building element comprises a floor with multiple floor joists connected between two transverse floor beams, a ceiling, and one or more columns coupling the floor and the ceiling. The ceiling joists and the floor joists are positioned substantially parallel and at least partially side-by-side, and at least the ceiling joists and the floor joists are formed from wood, wood derived product, or metal.

[0009] By virtue of the ceiling joists and the floor joists being positioned substantially parallel and at least partially side-by-side, a more compact building can be obtained. The ceiling joists and floor joists may thus form a staggered arrangement relative to each other.

[0010] The use of wood, wood derived product, plastic, fibrous material, and/or metal may allow for a lighter and/or more environmentally friendly design - compared to modules comprising concrete, in particular when a majority of the module is formed from concrete, for example reinforced concrete. Examples of wood-derived products are CLT (cross laminated timber), OSB (oriented strand board), plywood, glue-laminated-timber and laminated veneer lumber. Examples of metals are steel and aluminum. A plastic can be any polymer, optionally as a fibre-reinforced composite material. Examples of fibrous materials are paper, cardboard, felt, mineral wool, or any material comprising fibres, for example cellulose fibres.

[0011] In general, one or more columns may be used to couple the floor and the ceiling of a modular building element. To couple here implies that forces can be transferred between the floor and the ceiling via the columns. For any bottom building element, the columns of the bottom building element may supported on a foundation of the modular building. Alternatively, or additionally to using one or more columns, one or more vertical wall elements may be used to couple the floor and the ceiling of any modular building element disclosed herein.

[0012] Preferably, in the modular building, the majority of vertical forces are transferred via columns and/or wall elements. For example, the majority or even all of the weight of the top building element is supported on the column of the bottom building element. The use of columns may prevent or reduce a need of contact between other components of the top building element and the bottom building element. Such contact may otherwise result in undesired transfer of sound between the building elements.

[0013] A column may have any cross-section shape and size. A column may be sized such that it form part of a wall of the building element. As such, a column may span between 0.5% and 99.5% of a width and/or length of a building element. A column may be widened in such a way that one horizontal dimension of a column is larger

than the other, for example at least two times or four times wider, so that it forms a wide column, or a slab. A wide column may be beneficial to stabilize the building element.

[0014] In general, a modular building element can be a bottom modular building element, a top modular building element, or even a bottom and top modular building element at the same time. A modular building element above which another modular building element is positioned is generally regarded a bottom building element. A modular building element below which another modular building element is positioned is generally regarded a top building element. A modular building element above and below which another modular building element is positioned is generally regarded a bottom building element as well as a top modular element.

[0015] A top modular building element which is the top most building element of a modular building may have any ceiling, for example with a ceiling beam arrangement which is similar to a floor, because it does not need to be able to have another element stacked on top of it.

[0016] When the ceiling joists of the bottom building element are shorter in length than the floor joists of the top building element, it may be achieved that at least part of the transverse floor beams of the top building element can be positioned at the same height as the ceiling joists of the bottom building element. This in turn may result in a more compact modular building.

[0017] In general, the terms ceiling joists and floor joists as used herein can refer to a plurality of respectively ceiling joists and floor joists, or to a single respective ceiling joist and floor joist when a building element comprises respective only a single ceiling joist and floor joist.

[0018] When the ceiling joists of the bottom building element are shorter in length than a spacing between the two transverse floor beams of the top building element, at least part of the ceiling joists of the bottom building element can be positioned between the two transverse floor beams of the top building element. This in turn may result in a more compact modular building.

[0019] When the transverse ceiling beams of the bottom building element are vertically structurally spaced apart from the transverse floor beams of the top building element, such that no substantial part of the weight of the top building element is transferred from the transverse floor beams of the top building element to the transverse ceiling beams of the bottom building element, transfer of sound between the bottom building element and the top building element may be reduced.

[0020] Being structurally spaced apart may imply that no rigid or stiff elements, such as a rigid beam, are present between the transverse ceiling beams of the bottom building element and the transverse floor beams of the top building element. Instead, air and/or one or more flexible and/or sound damping elements may be positioned between the transverse ceiling beams of the bottom building element and the transverse floor beams of the top building element.

[0021] In general, a sound damping element is more sound damping compared to non-sound damping elements which may for example comprise concrete, wood, or steel. The sound damping element typically comprises or consists of material or materials with a lower E-modulus than wood and/or steel.

[0022] In any modular building, for any bottom building element and top building element, a column interface element may be positioned between a first column of the bottom building element and a first column of the top building element, and wherein the weight of the top building element of the first column of the top building element is essentially transferred via the column interface element to the first column of the bottom building element.

[0023] In general, any column interface element may be connected to the first column of the bottom building element or to the first column of the top building element during assembly of the modular building. Alternatively, at least part of any column interface element may be formed by the first column of the bottom building element or to the first column of the top building element.

[0024] Preferably, but not necessarily, for any column interface element, the column interface element does not protrude beyond at least one of the first column of the bottom building element and the first column of the top building element in any horizontal direction.

[0025] For any set of a top building element and bottom building element, preferably at least one column interface element is provided per set of columns, each set of columns comprising a column of the bottom building element and a column of the top element positioned above the column of the bottom building element in the respective set of columns.

[0026] For any column interface element, the column interface element may comprise at least two bodies, a first of the bodies comprising a male mating part and a second of the bodies comprising a female mating part which is at least partially shaped complementary to male mating part. Any of the male mating part and the female mating part may be formed by a column interface element, or conceivably also by a column. The complementary shape of the male and female mating part allows for convenient centering of two columns when stacked on top of each other.

[0027] In general, any column interface element may comprise or consist of wood, wood-derived product, metal, and/or plastic. Additionally or alternatively, any column interface element may comprise or consist of material with a low sound transmissivity.

[0028] As a particular option for any modular building, when the length of the ceiling joists of the bottom building element is shorter or at most equal to a spacing between the transverse ceiling beams, mounting brackets may be used to connect the ends of the ceiling joists to the transverse ceiling beams. By virtue of the mounting brackets, are more compact design of the modular building may be achieved.

[0029] Any mounting bracket may additionally or alter-

natively prevent or reduce a chance of lateral torsional buckling of the ceiling joists, for example by limiting a sideways movement and rotation of the ceiling joists with respect to the transverse ceiling beams. In other words, by virtue of one or more mounting brackets, the resistance to lateral torsional buckling of a ceiling joist may be increased.

[0030] Any mounting bracket may be supported on a top surface of one of the transverse ceiling beams. Additionally or alternatively, at least one mounting bracket may be partially positioned along a side surface of one of the transverse ceiling beams.

[0031] For any modular building, part of a top surface of at least one of the transverse ceiling beams of the bottom building element may extend into the building beyond an inner side surface of the transverse floor beam, and at least one of the ceiling joists of the bottom building element may be supported on the part of the top surface.

[0032] For any modular building, at least one of the transverse ceiling beams of the bottom building element may be wider than at least one of the transverse floor beams of the top building element.

[0033] When a ceiling joist of the bottom building element has an at least partially tapered cross-section, a chance of lateral torsional buckling of said ceiling joist may be reduced.

[0034] Additionally or alternatively to being at least partially tapered, any ceiling joist may form a structural element with a hollow cross-section together with part of a ceiling surface of the bottom building element. The ceiling surface may for example be a gypsum plate, or comprise or consist of any other material such as timber, timber based material, fibrous material, mineral material, plastic material, any other suitable material, or any combination thereof. The ceiling joist itself, or the ceiling joist and the part of the ceiling surface preferably form a closed circumference.

[0035] In general, a bottom plane of at least one of the ceiling joists of the bottom modular element may be aligned with a top plane of the transverse ceiling beams.

[0036] In a second aspect, the present disclosure provides an alternative modular building. The modular building comprises a bottom modular building element and a top modular building element, the top building element being positioned above the bottom building element. Features disclosed in conjunction with the building elements in accordance with the building of the first aspect are readily applicable to building elements of the modular building according to the second aspect. These features for example relate to material use, dimensions of any beam, joist, positioning of beams, positioning of joists, options for interface elements, and any other feature disclosed herein.

[0037] It will thus be appreciated that combinations are envisioned wherein at least one ceiling joist of a bottom building element discussed in conjunction with a modular building according to the one of the first or second aspect is positioned substantially parallel and at least partially side-by-side with at least one floor joist of a top building element discussed in conjunction with a modular building according to the other of the first and second aspect.

[0038] The bottom building element in the alternative modular building of the second aspect comprises a floor, and a ceiling with at least one ceiling joist. Preferably, one or more wall elements, columns and/or other vertical supports that couple the floor and the ceiling. Any wall element is generally positioned vertically or approximately vertically, and can as such be referred to as a vertical wall element.

[0039] The top building element in the alternative modular building of the second aspect comprises a floor with at least one floor joist, a ceiling, and one or more wall elements coupling the floor and the ceiling. In the top building element, preferably at least one floor joist is positioned at least partially alongside the at least one wall element.

[0040] In the assembled state of the alternative modular building, similar to the modular building of the first aspect, the ceiling joists and the floor joists are positioned substantially parallel and at least partially side-by-side. As a preference, at least the ceiling joists and the floor joists are formed from wood, wood derived product, plastic, fibrous material, and/or metal.

[0041] Wherein in the first aspect columns are used to couple the floor and ceiling of the building elements, according to the second aspect one or more wall elements are used to couple the floor and the ceiling, at least for the top building element.

[0042] A wall element generally covers an entire side, front, or rear of a building element, whereas when columns are used, typically two or more columns are positioned on one side, front or rear of the building element, with at least a small spacing between adjacent columns.

[0043] In case a building element comprises a wall element, the wall element may be used to substitute the transverse ceiling beam and/or transverse floor beam on one side of the building element. As such, for example, floor joists may extend between two wall elements. Additionally or alternatively, ceiling joists of a bottom modular element may be positioned for at least part of their height between wall elements of the top modular element.

[0044] In general, as an option for any modular element, a bottom surface of a wall element may be essentially aligned with a bottom surface of one or more or all of the floor joists.

[0045] Furthermore in general, as an option for any modular element, a bottom surface of one or more or all of the ceiling joists may be essentially aligned with a top surface of a wall element.

[0046] Generally, a wall element has a generally constant thickness. Any wall elements may have one or more openings therein, for example forming an opening for a window, door, or forming a passageway through the wall element. However, generally speaking, in a wall element with one or more openings, at least two vertical sections

and two horizontal sections can be identified, which sections can overlap each other for example at the corners.

[0047] In any wall element, but in particular any wall element of a building element which forms a top building element, one or more recesses may be formed in an inner side surface of the wall element. In use, when the modular building is formed, an end of a ceiling joist of a bottom building element may be positioned in the recess. Multiple independent recesses may be formed for example according to the number of ceiling joists om the bottom building element.

[0048] The wall elements described herein are generally used to be load-bearing. In a stack of building elements comprising wall elements, vertical loads from the top building elements may be essentially carried by wall elements of bottom building elements.

[0049] It may be preferred to position one or more interface elements between the bottom building element and the top building element, in particular between wall elements of the bottom building element and the top building element. For example, an interface element may be positioned at or near each of the four corners of the bottom building element, on which interface elements the weight of the top building element can be supported. A support on multiple interface elements, instead of a direct support of the wall elements onto each other, may decrease transmission of sounds between the top building element and the bottom building element.

[0050] Between adjacent interface elements, a spacing is present. The spacing is preferably filled with air or sound-dampening material. It is preferably avoided that the space between adjacent interface elements is filled with material through which weight from the top building element is transferred to the bottom building element, for example any wooden or metal materials.

[0051] It will be understood that within the technology of the present disclosure, many embodiments with combinations of optional features are contemplated. For conciseness of the present description, not all embodiments envisioned are explained in full. It will be understood that whenever an optional feature is disclosed as being applicable to any modular building according to any of the first and second aspect, building element, or any part thereof, or such feature is discussed as a general feature, embodiments are envisioned both with and without one or more of these optional features, in any combination thereof. Modular buildings may be formed by combining one or more top elements and bottom elements from the modular buildings of the first and second aspects.

[0052] For any building element disclosed herein, a set of columns and associated transverse floor beam and/or transverse ceiling beam may be substituted by a wall element, and vice versa.

[0053] Features disclosed in conjunction with the modular building according to the first aspect may be readily applied to the modular building according to the second aspect, not only when features and elements are provide with the same or similar name.

[0054] The building elements used to form any modular building, for example according to the first aspect or according to the second aspect, are regarded as separate aspects of the present disclosure. As such, a top building element for use in a modular building and a bottom building element for use in a modular building are envisioned as separate aspects.

BRIEF DESCRIPTION OF THE FIGURES

[0055] In the figures,

Fig. 1 in a schematic isometric view shows a first example of a modular building;
Fig. 2 in a schematic isometric view shows a second example of a modular building;
Fig. 3 in a schematic isometric view shows a third example of a modular building;
Figs. 4A and 4B depict an example of a modular building element;
Fig. 5 shows an exploded view of a modular building;
Fig. 6 shows a schematic exploded section view of the modular building of Fig. 5;
Fig. 7 shows a shows a schematic exploded section view of the modular building of Fig. 5;
Figs. 8A-8C depict three different column interfaces;
Figs. 9A-9D show a detailed section view of part of a modular building;
Fig. 10 shows in an exploded view a modular building;
Fig. 11 shows an exploded view of part of the modular building of Fig. 10;
Fig. 12A shows a detailed view of the modular building of Fig. 10 in assembled state;
Fig. 12B shows a bracket;
Fig. 13A depicts a detailed view of another modular building;
Fig. 13B shows another bracket;
Fig. 14 shows part of another example of a modular building;
Fig. 15 shows in an exploded view another example of a modular building;
Fig. 16 shows yet another example of a modular building;
Fig. 17 shows an alternative modular building element envisioned by the present disclosure;
Figs. 18A-19B show detailed sections view of parts of different embodiments of a modular building comprising the alternative modular element.

[0056] It will be appreciated that the examples and embodiments depicted in the figures are also envisioned with any of the optional features discussed herein, or without any such optional features.

DETAILED DESCRIPTION

[0057] Fig. 1 in a schematic isometric view shows a

first example of a modular building 100 formed with modular building elements 32. Fig. 1 shows that it is envisioned that any modular building 100 may comprise a number of modular building elements in vertical direction, as well as in two orthogonal horizontal directions.

[0058] In Fig. 1, one of the top building elements '32 is shown in an exploded view, lifted away from a bottom building element. During manufacturing of the modular building, typically, building elements will be positioned alongside each other and/or on top of each other. In the example of Fig. 1, the building 100 comprises nine building elements, the building 100 being three elements wide, three elements long, and three elements high. Any building 100 disclosed herein may have a width, length, and height of one or more building elements. When the building elements comprise columns, and weight of top building elements is transferred to columns of bottom building elements, a high number of building elements may be stacked on top of each other.

[0059] Fig. 2 shows a second example of a modular building 100, with as an example twelve modular building elements 33. Compared to the building 100 of Fig. 1, the modular building element are longer relative to the building 100. Furthermore, the building elements 33 have as an example a facade element on each side of the element. The building elements 33 are arranged with their longitudinal direction perpendicular to the facade of the building. the depth of the building 100 is thereby determined by the depth of the building element 33. Each element may have more than four columns, to allow an increase in the longitudinal direction, for example independent of the span of the floor joists and/or ceiling joists The facade elements do not have to be part of the building elements 33 and can also be connected after the building elements have been stacked on top of each other.

[0060] Fig. 3 shows a third example of a modular building 100, shown as an example comprising nine building elements 34. In this example, the longitudinal direction of the elements 34 is parallel to the facade of the building 100. Fig. 3 depicts the general option that the ceiling of the top building elements '34 can be different from the ceiling of the bottom building elements 34. For example, said ceiling can be a roof.

[0061] From the examples of Figs. 1-3, it will be understood that many different configurations of building elements are envisioned to form a modular building 100. A single modular building may comprise building elements which all have the same dimensions, or a single modular building may comprise building elements with different dimensions.

[0062] In general, a single building element may form a separate room, tenable space, office room or dwelling or a number of these spaces. Alternatively, a number of adjacent building elements may form a separate room, tenable space, office room or dwelling. For example, one or more side walls of adjacent building element may be open to allow the adjacent building elements to together form an open space.

[0063] Although in Figs. 1-3 building element comprising columns are depicted, any and all building elements may be substitute by building elements comprising one or more wall elements, as for example discussed in conjunction with Figs. 17-19B.

[0064] Figs. 4A and 4B depict an example of a modular building element 30, which, when used to form part of a modular building together with at least one further building element, can be a top building element and/or bottom building element. For example, multiple modular building elements 30 according to the example of Figs. 4A and 4B may be stacked on top of each other to form at least part of a modular building. The modular building element 30 is respectively depicted in an isometric top view, and an isometric bottom view, in Figs. 4A and 4B.

[0065] The modular building element 30 comprises a floor 40, a ceiling 42, and a plurality of columns 5 coupling the floor 40 and the ceiling 42. Although Figs. 4A and 4B show four columns 5, it will be appreciated that as with any other modular building element disclosed herein, the modular building element 30 may comprise less than four columns, or more than four columns, for example five, six, eight or even more.

[0066] The floor 40 depicted in Figs. 4A and 4B can generally be comprised by any modular building element disclosed herein, also the modular building element 300 of Fig. 17. The floor 40 comprises a plurality of essentially parallel floor joists 9 connected between transverse floor beams 6. In general, any floor may comprise any number of floor joists, including none or only one. The plurality of floor joists comprises two floor edge joists 7 generally disposed on opposite sides of the floor. As best depicted, the floor 40 further comprises a floor surface 8 and a floor finishing 10, both of which are optional for any floor disclosed herein.

[0067] The floor joists 9 are typically formed each by a single beam-shaped element, and can be connected to the transverse floor beams 6 at opposite ends of the floor joists 9, or in case of the floor edge joists 7, the floor joists 7 can be connected to columns 5 at opposite ends of the floor joists 7.

[0068] The ceiling 42 depicted in Figs. 4A and 4B can generally be comprised by any modular building element disclosed herein, in particular by any bottom building element, also the modular building element 300 of Fig. 17. In particular when a building element is only a top element, any other type of ceiling may be used, for example any conventional ceiling or roof element. The roof could in this case also be angled so that it is not parallel to the floors.

[0069] The ceiling 42 comprises a number of ceiling joists 1 which are connected between two transverse ceiling beams 3. Typically, the transverse ceiling beams 3 are at least partially positioned below the ceiling joists 1 of the same building element. Any ceiling beam can comprise or consist of wood, wood-derived product, and/or a metal such as steel. Although the transverse ceiling beams are depicted with a rectangular cross-section, any

transverse ceiling beam can have any other cross-sectional shape, for example a delta shaped, a C-shaped or an I-shaped cross-sectional shape.

[0070] Optionally, the ceiling 42 comprises a number of ceiling battens 11 and a ceiling surface 2 connected to the ceiling battens 11. As a further option, a ceiling surface 2 may be connected directly to the ceiling joists. Merely as an example, any ceiling joist can have a height between 150-400mm and a width between 30-200 mm. As a further example, the ceiling surface 2 can be made from a gypsum based material (sheetrock or gypsum fibre board) or an alternative mineral composite material such as cement based or loam-based materials, timber based materials, fibrous material, plastic material, or any other suitable material, or any combination thereof.

[0071] Typically, at least the ceiling joists and the floor joists, and preferably but necessarily also the columns, transverse ceiling beams, and/or transverse floor beams, are formed from or at least comprise wood, wood derived product, metal, a composite material, a plastic, or any combination thereof. In general, it will thus be appreciated that one, more, or all ceiling joists, floor joists, columns, transverse ceiling beams, transverse floor beams are not formed from concrete, in any combination thereof. This applies for any building element disclosed herein, in any combination of the different options.

[0072] In the example of the modular building element 30 depicted in Figs. 4A and 4B, all four side faces are open. However, as depicted also in other examples of modular building elements in the present disclosure, any one or more of the side faces may be at least partially closed, for example by a facade element, partition wall, party wall, or any other covering member.

[0073] The brackets 23 depicted in Figs. 4A and 4B will be elaborated on further in conjunction with Figs. 10-13B.

[0074] Fig. 5 shows an exploded view of a modular building 100 - or at least part thereof. The modular building 100 comprises a top modular building element ’30 and a bottom modular building element 30.

[0075] Between the columns 5 of the top modular building element ’30 and the bottom modular building element 30, optional column interface elements 4 are depicted. In assembled state, a column interface elements 4 is typically positioned between two columns 5.

[0076] In general, the task of the column interface element is to provide a spacing between the bottom building element and the top building element, preferably to prevent any part of the of the bottom building element and top building - besides the column interface elements - from contacting in such a way that sound can be transmitted between the building elements at noticeable levels to people occupying the building elements.

[0077] In Fig. 5, the column interface elements 4 are depicted as separate elements - separate from the columns 5. This is an option which can apply to any column interface element 4 disclosed herein. Any column interface element 4 may be formed by a single body, or may be formed by multiple separate bodies. When a column interface element 4 is formed by multiple separate bodies, the multiple separate bodies may be connected to multiple columns prior to assembly of the modular building. The same applies to the interface elements 400 discussed in conjunction with Figs. 17-19B. Also any other feature disclosed in conjunction with column interface elements can be readily applied to the interface elements 400 discussed in conjunction with Figs. 17-19B, in any combination.

[0078] In general, it will be appreciated that a column interface element is used to structurally couple two columns which are positioned one above the other. To structurally couple implies that the weight of the top column is transferred to the bottom column via the column interface element.

[0079] As shown for example in Figs. 5 and 6, as a preferred but not essential feature, any column interface element 4 does not protrude beyond their respective column 5 of the bottom building element and column 5 of the top building element in any horizontal direction. In other words, in a top plan view, the column interface element 4 preferably does not extend beyond the footprint of the respective columns 5 of the bottom building element and/or top building element.

[0080] Now referring to Figs. 8A-8C, three different column interfaces are depicted. It will be understood that any of the three column interfaces may be readily applied to any set of columns disclosed herein for any embodiment of the modular building. Other interfaces between a column 5’ of a top building element and a column 5 of a bottom building element may also be used instead of the three particular interfaces depicted in Figs. 8A-8C.

[0081] In the interface depicted in Fig. 8A, the column interface element is formed by two separate bodies 4’ and 4". The first body 4’ is connected to the bottom column 5, or may be formed by the bottom column 5 itself. The second body 4" is connected to the top column 5’, or may be formed by the top column 5’ itself.

[0082] As an option depicted in Fig. 8A, but also applicable whenever the column interface element is formed by two separate bodies 4’ and 4", a first of the bodies comprises a male mating part 74, and a second of the bodies comprises a female mating part 75 which has a shape generally corresponding to at least part of the male mating part 74. In particular when the male mating part 74 has a tapered shape, the bodies 4’ and 4"may be self-centering when the top column 5’ is positioned on top of the bottom column 5. Although in Fig. 8A, the body 4" associated with the top column 5’ comprises the male mating part 74, it will be understood that other embodiments are envisioned wherein the body 4’ associated with the bottom column 5 comprises the male mating part 74.

[0083] In the interface depicted in Figs. 8B and 8C, the interface element 4 is formed as a vertical spacer 4. Furthermore, respectively the top column 5’ and the bottom column 5 are provided with a protrusion 120 arranged to

be at least partially positioned in a pocket 122 in respectively the bottom column 5 and the top column 5'. Preferably, but not necessarily, at least a distal end of the protrusion 120 is tapered towards the end, for example to facilitate inserting the protrusion 120 into the pocket 122. A depth of the pocket 122 may be larger, equal to, or smaller than a length of the protrusion 120, for example whether it is desired that weight is transferred through the protrusion 120 or the protrusion 120 is primarily used as a guiding tool for positioning one column above the other during assembly of the building.

[0084] The column interface element 4 may be readily used as interface element 400 in conjunction with any modular building element, for example as discussed in conjunction with Figs. 17-19B.

[0085] Now referring to Fig. 5, as an option depicted in Fig. 5, a partition wall 18 is positioned in the bottom building element 30. In the example of Fig. 5, the partition wall 18 is oriented perpendicular to the ceiling joists 1, although it is also envisioned that any partition wall 18 can also be oriented parallel to the ceiling joists 1 or at any angle relative to the ceiling joists.

[0086] A further option depicted in Fig. 5 is that one or more sides of any building element disclosed herein may be covered with a facade element 16, with no, one, or more windows 17 of any shape and size in the facade element 16. The facade elements 16 in Fig. 5 are shown in an exploded view relative to the building elements 30 '30. The facade elements can for example either be already mounted to each module at the factory, or attached the modules on-site after the modules have been stacked.

[0087] As a general option for any building element, which as any other option discussed in conjunction with Fig. 5 can also be applied to a building element with one or more wall elements, one or more transverse floor beams 6 of the building element may be positioned between two columns 5. For example, at the ends thereof, any transverse floor beams 6 may be connected to a respective column 5, directly or indirectly through one or more connection elements. Typically, but not necessarily, a top surface of the transverse floor beams is aligned with a top surface of the floor joists 7, 9.

[0088] Additionally or alternatively, as a further general option for any building element, depicted in Fig. 5, floor edge joists 7 may be positioned between two columns 5. For example, at the ends thereof, any floor edge joist 7 may be connected to a respective column 5, directly or indirectly through one or more connection elements. Typically, the floor edge joists 7 are shorter than the other floor joists 9.

[0089] As for example depicted in Fig. 4B, as a preference but not essential for any building element, in particular top building element disclosed herein, a bottom surface 40 of the columns 5 is aligned with, slightly above or below a bottom surface 44 of the transverse floor beams 6 and/or a bottom surface 45 of the floor edge joists 7. Alternatively, the bottom surface 40 of the columns 5 is at least positioned below a top surface of the transverse floor beams 6 and/or a top surface of the floor edge joists 7, in use.

[0090] Fig. 6 shows a schematic exploded section view of the modular building 100 of Fig. 5, along plane AA indicated in Fig. 7. with the top building element '30 and the bottom building element 30. Fig. 7 shows a shows a schematic exploded section view of the modular building 100 of Fig. 5 cut along plane BB, with the top building element '30 and the bottom building element 30.

[0091] As an example depicted in Figs. 6 and 7, during assembling of the modular building 100, the column interface elements 4 may be connected to the bottom building element 30 first, after which the columns 5 of the top building element '30 can be lowered onto the column interface elements 4.

[0092] As a preference depicted in Fig. 6, the ceiling joists 1 of the bottom element may be shorter than the floor joists 9 of the top module. As such, a space between the transverse floor beams 6 of the top module is sufficient for the ceiling joists 1 of the bottom element to nest between the transverse floor beams 6.

[0093] As an option depicted in Fig. 7, the ceiling joists 1 and the floor joists 6 are positioned alternately. It will be appreciated that for any building 100, multiple, for example two or three, ceiling joists may be positioned between two adjacent floor joists, and/or multiple, for example two or three, floor joists may be positioned between two adjacent ceiling joists.

[0094] Figs. 9A-9D show a detailed section view of part of a modular building 100, in particular showing part of the floor of the top building element '30 and the ceiling of the bottom building element 30. As can be seen in Figs. 9A-9D, many shapes and materials are envisioned for the ceiling joists of the bottom building element 30, which shapes may be readily applied to any floor joist 9 as well.

[0095] As a preferred but not essential option, for example shown in Figs. 9A-9D and indicated in particular in Fig. 9A, a first ceiling joist 1 of the bottom building element 30 is positioned between a first floor joist 7 and a second floor joist 9 of the top building element '30. A spacing s*1* between the first ceiling joist and the first floor joist may be larger than a spacing s2 between the first ceiling joist and the second floor joist. Alternatively, in other examples, the spacing s2 may be larger than spacing *s1*.

[0096] By virtue of the larger spacing s1, for example one or more ducts or other installations may be positioned in the spacing *s1*. These ducts or other installations may be of a larger size compared to a situation wherein spacings *s1* and *s2* would be equal or approximately equal.

[0097] It will be appreciated that it in general, for any building 100 disclosed herein, the spacings s1 and s2 may alternatively be equal. The spacings between adjacent floor joists may be equal for a single modular element, or may vary between different sets of adjacent floor joists. The spacings between adjacent ceiling joists may

be equal for a single modular element, or may vary between different sets of adjacent ceiling joists.

[0098] The space defined by spacing *s1* may as an option be empty between the two transverse floor beams 6, at least during assembly of the modular building - for example prior to one or more ducts or wiring being positioned in the space defined by spacing *s1*.

[0099] Fig. 9B depicts alternatively shaped ceiling joists 20. Whereas in in Fig. 9A, the ceiling joists 1 are depicted as beams with a substantially rectangular cross-section, in Fig. 9B the ceiling joists 20 have a generally tapered cross-section, tapered upwards away from the bottom building element 30. Fig. 9C and 9D depict even further alternatives of ceiling joists 21, 22, which are also tapered upwards away from the bottom building element 30.

[0100] In addition to the sections of Figs. 9A-9D, any section shape can be envisioned. In general, application of a ceiling joist with a hollow section, made of a timber based, metal, plastic or other material may increase the resistance against lateral torsional buckling.

[0101] Any ceiling joist, as for example depicted in 9C and 9D, may be made wood-based material. It will be appreciated that any ceiling joist in any embodiment of any building element disclosed herein may have any of the cross-sectional shapes detailed in Figs. 9A-9D.

[0102] In Fig. 9B, the ceiling joist 20 preferably consist of or comprise metal, such as steel. Additionally, as a further option, the ceiling joist 20 may be thin-walled, to reduce weight, for example with a thickness between 0.5 and 3 mm, in particular between 1.0 and 2.0 mm. By virtue of the trapezoidal shape of the ceiling joist 20, a chance of lateral torsional buckling is reduced, for example compared to a beam with a rectangular cross-section.

[0103] The ceiling joists 21, 22 of respectively Fig. 9C and 9D are also designed to reduce a sensitivity to lateral torsional buckling, for example with respect to a similar joist with a rectangular cross-sectional shape. The ceiling joists 21 depicted in Fig. 9C are formed by thin webs, which are at their distal ends connected to a top flange, in particular a thick top flange, and at their proximal end connected to further bottom flanges, in particular thick bottom flanges, which in turn can be connected to the transverse ceiling beams 3. The relative wordings thin and thick imply that the thin elements have a smaller width than the thick elements. The thin elements for example can be a factor two, three, four or even five or more thinner than the thick elements. For example, the thin elements have a thickness between 5-20 mm, in particular approximately 10 mm. The webs are typically made from oriented strand board or plywood, the flanges are typically made from timber or laminated veneer lumber.

[0104] The ceiling joists 22 depicted in Fig. 9D comprise two beam elements which are slanted towards each other and are joined at their distal ends. The beam elements may for example comprise wood, wood-derived product, metal such as steel, or any other material. For example, the beam elements may have a thickness between 10 - 40 mm, in particular between 20 - 30 mm.

[0105] In each of Figs. 9A-9D, the transverse ceiling beam 3 of the bottom building element 30 is vertically structurally spaced apart from the transverse floor beam 6 of the top building element '30. This optional feature is also depicted for example in Fig. 12A, and can be applied to any embodiment of the modular building. In the spacing s3 between the transverse ceiling beam 3 of the bottom building element 30 and the transverse floor beam 6 of the top building element '30, air and/or one or more flexible and/or sound-absorbing elements may be present.

[0106] Preferably, but not necessarily, for any modular building of the present disclosure, no rigid elements extend between one or more or all of the transverse ceiling beams 3 of the bottom building element 30 and the transverse floor beams 6 of the top building element '30 in a vertical direction.

[0107] In general, the height of the spacing s3 may be at least in part defined by the height of the column interface element 4 positioned between the columns 5 of the top building element '30 and the columns 5 of the bottom building element 30.

[0108] In the examples of the ceiling joists of Figs. 9B-9D, the ceiling joists form a structural element together with part of the ceiling surface 2. In particular, a continuous hollow cross-sectional shape is formed. The ceiling joist may have a hollow cross-sectional shape on its own, for example when the ceiling comprises or consists of a non-structural cladding material. Any ceiling joist may be formed by connecting multiple elements with a hollow cross-sectional shape and/or any ceiling joists may have multiple distinct hollow sections formed therein. For example, any ceiling joist may be formed in an extrusion or pultrusion process.

[0109] Any of the ceiling joists disclosed in conjunction with Figs. 9A-9D, and any options for ceiling joists discussed herein may be readily applied to any building element, for example also any building element comprising one or more wall elements, such as but not limited to the building element 300 of Fig. 17.

[0110] Fig. 10 shows in an exploded view a modular building 100 comprising a top building element '30 and a bottom building element 30. Fig. 11 shows an exploded section of the modular building 100 of Fig. 10, and Fig. 12A shows a detailed view of the modular building 100 of Fig. 10 in assembled state, with a bracket 23 detailed in Fig. 12B. The building 100 of Fig. 10 is also depicted in Figs. 4A and 4B.

[0111] In the modular building 100 of Fig. 10, brackets 23 are positioned at both ends of the ceiling joist 1, and the brackets 23 are used to connect the ceiling joists 1 to the respective transverse ceiling beams 28. The transverse ceiling beams 28, as depicted in Fig. 10, but also as an option applicable to any other building element disclosed herein, may have a smaller width than the width of the columns 5 of the building element. The width of the transverse ceiling beams 28 may for example be half

or less of the width of the columns 5, or even 40% or less, 30% or less, or even 20% or less.

[0112] The brackets 23 are an example of how it can be achieved that the ceiling joists 1 of the bottom building element are shorter in length than at least one of the floor joists 9 of the top building element and/or a spacing between the two transversal ceiling beams 28. The brackets 23 may also allow the ceiling joists 1 of the bottom building element to be shorter in length than a spacing between the two transverse floor beams 6 of the top building element.

[0113] Brackets may also be used even when one or both ends of the ceiling joists are positioned above a top surface of one or both transverse ceiling beams, for example to prevent rotation of the ceiling joists around their elongation axis.

[0114] From Fig. 11, it follows that the construction of the ceiling of the top building element '30 and the construction of the floor of the bottom building element 30 are not relevant to the construction of the floor of the top building element '30 and the ceiling of the bottom building element 30.

[0115] Now referring to Fig. 12B, an example of a bracket 23 is depicted, which may be used in any building element disclosed herein to connect an end of a ceiling joist 1 to a transverse ceiling beam 28. The bracket 23 comprises a joist connection part 76 and a beam connection part 77. The bracket 23 may aid in limiting a rotation of the ceiling joist 1 around its elongation axis.

[0116] The joist connection part 76 is in general used to form the connection between the bracket 23 and the ceiling joist 1. Although depicted with two vertical plates, conceivably the bracket 23 may also comprise a single vertical plate. To this end, for example, a reception space 78 may be formed by the joist connection 76 into which part of the ceiling joist 1 can be positioned. The reception space is the space enclosed by the vertical plates, or in case of a single vertical steel plate, on either side or both sides of that vertical steel plate. For example, pins, bolts and/or screws may be used to hold the joist 1 in the reception space 78. The joist connection part can have inclined sides if the ceiling joist that should be received has a trapezoidal shape. The beam connection part 77 is preferably shaped corresponding to a shape of a top surface of the transversal ceiling beam 28.

[0117] The beam connection part 77 is in general used to form the connection between the bracket 23 and the transverse ceiling beam 28. The beam connection part 77 may for example comprises a plate with one or more through-holes. For example a screw connection may be used to connect the beam connection part 77 to the transverse ceiling beam 28.

[0118] Fig. 13A depicts a detailed view of another modular building 100, in which an alternative bracket 29 is used, which bracket 29 is depicted in Fig. 13B. The bracket 29 comprises a similar joist connection part 76 to the bracket 23 depicted in Fig. 12B.

[0119] Where the beam connection part 77 of the bracket 23 of Fig. 12B will in use be typically supported on a top surface of a transverse ceiling beam 28, the beam connection part 77 of the bracket 29 of Fig. 13B will in use typically be positioned along a side surface of a transverse ceiling beam 28.

[0120] In assembled state of the modular building 100, when using one or more brackets, for example those depicted in Figs. 12B and 13B, part of the transverse floor beams 6 of the top building element '30 can be positioned alongside the bracket. This allows for a compact design of the modular building 100. Typically, the brackets are formed in metal, such as steel.

[0121] In the examples of Fig. 12A and 13A, as an option, the transverse floor beams 6 of the top building element have a width at least approximately corresponding to a width of the transverse ceiling beams 3 of the bottom building element. Fig. 14 shows part of another example of a modular building 100, showing part of a top building element '30 positioned on top of a bottom building element 30.

[0122] The brackets 23, 29 depicted in Figs. 12A-13B are merely examples of mounting brackets, and alternatively any other type of mounting bracket may be used. Although the brackets 23, 29 are in Figs. 12A-13B shown as being connected to a transverse ceiling beam 3,28, any mounting bracket may be used to connect a ceiling joist to a wall element 24, as will be elaborated on in conjunction with Figs. 17-19B.

[0123] In general, and specifically depicted in Fig. 14, it is envisioned that the transverse ceiling beams 3 of the bottom building element 30 can be wider than the transverse floor beams 6 of the top building element '30. Preferably, but not necessarily, the outer side faces of the transverse ceiling beam 3 and the transverse floor beam 6 are approximately aligned in a plane P.

[0124] When the transverse ceiling beams 3 of the bottom building element 30 is wider than the transverse floor beams 6 of the top building element '30, part of the top surface of the transverse ceiling beam 3 extends further into the building than the transverse floor beam 6. As such, this part of the top surface may be used for supporting one or more ceiling joist 1.

[0125] More in general, also when the transverse ceiling beams 3 of the bottom building element 30 is not necessarily wider than the transverse floor beams 6 of the top building element '30, part of the top surface 80 of the transverse ceiling beam 3 can extend into the building beyond the inner side surface 82 of the transverse floor beam 6. The part of the top surface 80 can be used to support an end of ceiling joist 1 onto, without the end of the ceiling joist 1 interfering with the transversal floor beam 6.

[0126] As an option depicted in Fig. 14, but also readily applicable to any other modular building disclosed herein, the ceiling joists 1 are supported on a top surface of the transverse ceiling beams 3. In particular, the ceiling joist 1 extends over part of the width of the transverse ceiling beam 3, for example up to 75% of the width, or

up to 50% of the width, or even up to 25% of the width. In the example of Fig. 14, the ceiling joist 1 is shown extending to half the width of the ceiling beam 3.

[0127] Although the example of Fig. 14 shows the bottom building element 30 comprising the transverse ceiling beam 3, as for any bottom building element disclosed herein, the transverse ceiling beam 3 may be substituted by a wall element 24.

[0128] Fig. 15 shows in an exploded view another example of a modular building 100 comprising a bottom building element 30 and a top building element '30. Fig. 15 indicates that many configurations of the building elements are envisioned, with for example any number of columns. In the example of Fig. 15, both building elements comprise six columns 5.

[0129] In particular when a building element comprises more than four columns, for example six columns 5 as depicted in Fig. 15, multiple distinct lengths of ceiling joists 1 and/or floor joists may be used. In the isometric top view of Fig. 15, it is shown that a first set of ceiling joists 1 is positioned left of the central two columns 5, and a second set of ceiling joists 1 positioned right of the central two columns 5. A central transversal ceiling beam 3 is positioned between the first and second sets of ceiling joists 1. Additionally or alternatively, a central transversal floor beam may be comprised at least by any building element with six or more columns.

[0130] The first and second set of ceiling joists 1 are spaced apart, such that in a spacing between the first and second set of ceiling joists 1, at least part of a central transversal floor beam of a top modular element can be accommodated.

[0131] As further options depicted in Fig. 15, independent of the number of columns 5 comprised per building element, one or more partition walls 18, party walls 19, facade elements 16, and/or windows 17 may be comprised by any building element disclosed herein.

[0132] Any set of columns, in the example of Fig. 15 but also for any building element disclosed herein, may be substituted by a wall element 24. The wall elements are further elaborated on in conjunction with Figs. 17-19B.

[0133] Fig. 16 shows yet another example of a modular building 100 within the scope of the present disclosure, in an exploded view. The modular building 100 comprises a top building element 30' and a bottom building element 30 which is use positioned below the top building element.

[0134] In the example of Fig. 16, but also applicable to any other modular building disclosed herein, a floor opening 15 is provided in the floor of the top building element, aligned with an opening in the ceiling of the bottom building element. To form the floor opening 15, the floor joists of the top building element positioned between the floor edge joists 7 are reduced in length. Correspondingly, the ceiling joists 1 are reduced in length - *i.e.* they do not extend between the outermost transversal ceiling beams 3. The floor opening and opening in the ceiling may for example be used as a staircase.

[0135] As depicted in Fig. 16, one or more intermediate columns 12 may be comprised by the bottom building element 30, with an intermediate transversal ceiling beam 14 on which the ceiling joists 1 are supported. Intermediate struts 13 may span between the intermediate transversal ceiling beams 14 and the transversal ceiling beam 3, or - as depicted in Fig. 16 - between the intermediate columns 12 and the outer columns 5. In general, an intermediate column 12 may be supported on the floor surface 8, or on the floor edge joist 7. No vertical coupling is typically required between the intermediate columns 12 and the top building element '30, and as such no interface element 4 is depicted in Fig. 16 above the intermediate columns 12. Any intermediate column may be formed from wood, wood-derived product, or a metal such as steel.

[0136] In general, in conjunction with Figs. 17-19B, another type of modular building element 300 is elaborated. It will be appreciated that the features disclosed in conjunction with the types of modular building element disclosed in conjunction with Figs. 1-16 are readily applicable to the modular building elements of Figs. 17-19B, for example in terms of material use, shapes, dimensions, and relative dimensions of the ceiling joists and the floor joists, the use of mounting brackets, the presence of facades, partition wall, intermediate columns, and any other feature, in any combination.

[0137] As depicted in Fig. 17, a modular building element 300 is envisioned within the context of the present disclosure. The modular building element 300 comprises a floor 40, a ceiling 42, and two wall elements 24 between the floor and the ceiling. The floor 40 comprises floor joists 7,9 spanning between the wall elements 24, and the ceiling 42 comprises ceiling joists 1 spanning between the wall elements 24. When the modular building element 300 is used as a top building element, the ceiling may be substituted by any type of ceiling or roof. When the modular building 300 is used as a bottom building element, the floor may be substituted by any type of floor or foundation.

[0138] The outside floor joists 7 may have the same length as the inner floor joists 9. As shown in Fig. 17, the floor joists are positioned at least partially alongside the wall elements 24. As such, at least part of the floor joist is at the same height of at least of the wall elements.

[0139] Two examples of how two modular building elements with wall elements can be stacked on top of each other, with the ceiling joists of the bottom element and the floor joists of the top element positioned substantially parallel and at least partially side-by-side, are depicted in Figs. 18A and 19A, and Figs. 18B and 19B respectively.

[0140] Figs. 18A and 18B depict in detail part of a modular building 1000 comprising a top building element '300 positioned above a bottom building element 300, in a section view. Figs. 19A and 19B also depict in detail part of the modular building 1000, in a different section view

in a plane perpendicular to the section plane used for Figs. 18A and 18B.

[0141] In any of the examples of Figs. 17-19B, it is preferred that at least four interface elements 400 are positioned between the top building element and the bottom building element. The four interface elements 400 may be positioned at or near corners of the building elements. The interface elements 400 may be similar to the column interface elements, and may thus have any one or more features discussed in conjunction with the column interface elements 4.

[0142] When essentially all the weight of the top building element is transferred to the wall elements 24 of the bottom building element through the interface elements 400, transmission of sound between the top building element and bottom building element may be reduced - compared for example to a situation wherein the wall elements 24 of the building elements would be stacked directly on top of each other, or a solid element, for example a wooden element, would be positioned between the wall elements 24 over the entire width of the wall elements. Preferably, four or more interface elements are provided and/or the interface elements are positioned at or near corners of the top building element.

[0143] In any modular building with wall elements 24, a vertical spacing may be present between a wall element 24 of the top building element relative to a wall element 24 of the bottom building element positioned directly below the respective wall element of the top building element. In the vertical spacing, it is preferred that the interface elements 24 are the only weight-transferring elements. In-between the interface elements 24, for example, air and/or sound dampening material may be present.

[0144] In the example of Figs. 18A and 19A, mounting brackets 23 are comprised by the bottom building element. The brackets may be shaped similar, and function similar, to the brackets described in conjunction with Figs. 12B and 13B.

[0145] In the example of Figs. 18B and 19B, recesses 25 are formed in the wall elements 24 of the top building element 300. The recesses 25 are designed to in use accommodate ends of the ceiling joists 1 of the bottom building element 30. This allows the ceiling joists 1 of the bottom building element to be supported on a top surface of the wall elements 24 of the bottom building element. Furthermore, the recesses allow the ceiling joists 1 of the bottom building element to be longer than at least one of the floor joists 7, 9 of the top building element and/or longer than a spacing between wall elements 24 of the top building element and/or longer than a spacing between wall elements 24 of the bottom element.

[0146] Preferably, but not necessarily, a spacing between the wall elements 24 of the top building element is essentially equal to a spacing between the wall elements 24 of the bottom building element. Additionally, or alternatively, a wall thickness of the wall elements 24 of the top building element is essentially equal to a wall thickness of the wall elements 24 of the bottom building element. Any wall element 24 is preferably provided as a single body.

[0147] As for example visible in Fig. 18B, the shape of the recesses 25 may resemble the shape of the ceiling joists 22, even when the ceiling joists 22 for example have a tapered shape.

[0148] It will be appreciated that building elements are envisioned with on one end a set of columns 5, as explained generally in conjunction with Figs. 1-16, and on an opposite end a wall element 24, as explained generally in conjunction with Figs. 17-19B. Any building element with no, one or more wall elements may be a bottom and/or top building element relative to another building with no, one or more wall elements, in any combination thereof.

[0149] Examples of how at least one ceiling joist of a bottom building element and at least one floor joist of a top building element can be positioned substantially parallel and at least partially side-by-side are for example depicted, in a non-limitative manner, in Figs. 6-7, 9A-9D, 10, 12A, 13A, 14, 18A-18B, 19A and 19B.

LIST OF REFERENCE NUMBERS

[0150]

1 Ceiling joist
2 Ceiling surface
3 Transverse ceiling beam
4 Column interface element
5 Column
6 Transverse floor beam
7 Floor edge joist
8 Floor surface
9 Regular floor joist
10 Floor finishing
11 Ceiling batten
12 intermediate column
13 Intermediate struts
14 Intermediate transverse ceiling joist
15 Floor opening
16 Facade element
17 Window
18 Partition wall
19 Party wall
20 Steel delta shaped ceiling joist
21 Wood delta shaped ceiling joist
22 Wood delta shaped ceiling joist
23 Mounting bracket
24 Wall element
25 Recess
28 Transverse ceiling beam
29 Mounting bracket
30 Modular building element
32 Modular building element
33 Modular building element
34 Modular building element

40 Floor
42 Ceiling
43 Bottom surface of a column
44 Bottom surface of a transverse floor beam
45 Bottom surface of a floor edge joist
74 Male mating part
75 Female mating part
76 Joist connection part
77 Beam connection part
78 Joist reception space
80 Part of the top surface of the transverse ceiling beam
82 Inner side surface of the transverse floor beam
120 Protrusion
122 Pocket
300 Building element
400 Interface element
1000 Modular building

Claims

1. A modular building (100) formed by at least a bottom modular building element (30, 32, 33, 34) and a top modular building element (’30, ‘32, ‘33, ‘34), wherein:

- the top building element is positioned above the bottom building element;
- the bottom building element comprises a floor (40), a ceiling (42) with one or more ceiling joists (1) connected to at least one transverse ceiling beam (3, 28), and one or more, for example at least four or at least six, columns (5) coupling the floor and the ceiling;
- the top building element comprises a floor with one or more floor joists (7, 9) connected to at least one transverse floor beam (6), a ceiling, and one or more, for example at least four or at least six, columns (5) coupling the floor and the ceiling; and
- the one or more ceiling joists of the bottom building element and the one or more floor joists of the top building element are positioned substantially parallel and at least partially side-by-side.

2. Modular building according to claim 1, wherein the one or more ceiling joists of the bottom building element are connected between and/or on top of two transverse ceiling beams, in particular wherein the length of the one or more ceiling joists of the bottom building element is shorter or at most equal to a spacing between the transverse ceiling beams of the bottom building element, and one or more mounting brackets (23, 29) are used to connect the ends of the one or more ceiling joists to the transverse ceiling beams,
or wherein the length of the one or more ceiling joists of the bottom building element is shorter or at most equal to a spacing between the transverse ceiling beam of the bottom building element and a vertical wall element (24) of the bottom building element, and one or more mounting brackets (23, 29) are used to connect the ends of the one or more ceiling joists to the transverse ceiling beam and the wall element.

3. Modular building according to claim 1 or 2, wherein the one or more floor joists of the top building element are connected between two transverse floor beams, in particular wherein at least one ceiling joist of the bottom building element is shorter in length than a spacing between the two transverse floor beams of the top building element.

4. Modular building according to any of the preceding claims, wherein at least the one or more ceiling joists and the one or more floor joists are formed from wood, wood derived product, plastic, fibrous material, and/or metal and/or wherein the columns comprise or consists of wood, wood-derived product, or steel.

5. Modular building according to any of the preceding claims, wherein the transverse ceiling beam or beams of the bottom building element are vertically structurally spaced apart from the transverse floor beam or beams of the top building element, and essentially the entire weight of the top building element is transferred to the columns of the bottom building element or to columns and one or more vertical wall elements (24) of the bottom building element; and/or wherein a vertical space is formed between the transverse ceiling beam or beams and the transverse floor beam or beams, which space is empty or at least partially filled with one or more flexible and/or sound damping elements; and/or wherein the transverse ceiling beam or beams of the bottom building element are positioned below the one or more ceiling joists, and the transverse ceiling beam or beams of the bottom building element are positioned below the floor of the top building element.

6. Modular building according to any of the preceding claims, wherein at least one ceiling joist of the bottom building element is shorter in length than at least one floor joist of the top building element.

7. Modular building according to any of the preceding claims, wherein at least one mounting bracket (23) connected to an end of one of the ceiling joists of the bottom building element is supported on a top surface of at least one of the transverse ceiling beams of the bottom building element and/or wherein at least one mounting bracket (29) connected to an end of one of the ceiling joists of the bottom building element is partially positioned along a side surface of

one of the transverse ceiling beams of the bottom building element.

8. Modular building according to any of the preceding claims, wherein a column interface element is positioned between a first column of the bottom building element and a first column of the top building element, and wherein the weight of the first column of the top building element is essentially transferred via the column interface element to the first column of the bottom building element, in particular wherein the column interface element does not protrude beyond at least one of the first column of the bottom building element and the first column of the top building element in any horizontal direction; and/or

wherein at least one column interface element is provided per set of columns, each set of columns comprising a column of the bottom building element and a column of the top building element positioned above the column of the bottom building element in the respective set of columns and/or wherein at least one column interface elements comprises at least two bodies (4', 4"), a first of the bodies comprising a male mating part (74) and a second of the bodies comprising a female mating part (75) which is at least partially shaped complementary to the male mating part;
preferably wherein at least one column interface element comprises or consists of wood, wood-derived product, metal, fibrous material, and/or plastic.

9. Modular building according to any of the preceding claims, wherein part of a top surface (80) of at least one of the transverse ceiling beams (3) of the bottom building element extends into the building beyond an inner side surface (82) of the transverse floor beam, and at least one of the ceiling joists of the bottom building element is supported on the part of the top surface (80); and/or wherein at least one of the transverse ceiling beams (3) of the bottom building element is wider than at least one of the transverse floor beams of the top building element.

10. Modular building according to any of the preceding claims, wherein at least one of the ceiling joists of the bottom building element has an at least partially tapered cross-section and/or wherein at least one of the ceiling joists of the bottom building element has a hollow cross-sectional shape and/or wherein at least one of the ceiling joists of the bottom building element forms a structural element with a hollow cross-section together with part of a ceiling surface (2) of the bottom building element,
in particular wherein a first ceiling joist of the bottom building element is positioned between a first and a second floor joist (7, 9) of the top building element, and a spacing (s1) between the first ceiling joist and the first floor joist is larger than a spacing (s2) between the first ceiling joist and the second floor joist.

11. Modular building according to any of the preceding claims, wherein a bottom plane of at least one of the ceiling joists of the bottom building element is aligned with a top plane of the transverse ceiling beam or beams of the bottom building element.

12. A modular building (1000) formed by at least a bottom modular building element (300) and a top modular building element ('300), wherein:

- the top building element is positioned above the bottom building element;
- the bottom building element comprises a floor (40) and a ceiling (42) with at least one ceiling joist (1);
- the top building element comprises a floor with at least one floor joist (7, 9), a ceiling, and at least one wall element (24) coupling the floor and the ceiling;
- the at least one ceiling joist and at least one floor joist are positioned substantially parallel and at least partially side-by-side; and
- in the top building element, at least one floor joist is positioned at least partially alongside the at least one wall element,

in particular wherein the top building element comprises two wall elements (24) coupling the floor and the ceiling, wherein at least one floor joist is positioned between the two wall elements, in particular wherein at least one ceiling joist of the bottom building element is shorter in length than a spacing between the wall elements of the top building element and/or wherein at least one ceiling joist of the bottom building element is shorter in length than at least one floor joist of the top building element.

13. Modular building according to claim 12, wherein at least the ceiling joists and/or the floor joists are formed from wood, wood derived product, plastic, fibrous material, and/or metal.

14. Modular building according to any of the claims 12-13, wherein the floor and the ceiling of the bottom building element are coupled through wall elements (24) comprised by the bottom building element, and a length of at least one ceiling joist of the bottom building element is shorter or at most equal to a spacing between the wall elements of the bottom building element, in particular wherein one or more mounting brackets (23, 29) are used to connect one or more ends of the one or more ceiling joists of the bottom building element to a top surface and/or an inner side

surface of at least one wall element of the bottom building element and/or wherein at least one ceiling joist of the bottom building element is at least partially positioned between two wall elements of the top building element, in particular wherein:

at least one of the wall elements (24) of the top building element comprises at least one recess (25) into which an end of one of the ceiling joists (1) of the bottom building element is positioned, in particular wherein a width of the recess (25) is at most 150% of a width of the end of the ceiling joist positioned in the recess; and/or
the modular building further comprises a plurality of interface elements (400) positioned below at least one wall element (24), a further wall element and/or
one or more columns (5) of the top building element, and wherein the weight of the top building element is essentially transferred to the bottom building element through the interface elements, in particular wherein four or more interface elements (400) are provided and/or wherein the interface elements are positioned at or near corners of the top building element.

15. Top building element or bottom building element, for use in a modular building according to any of the preceding claims.

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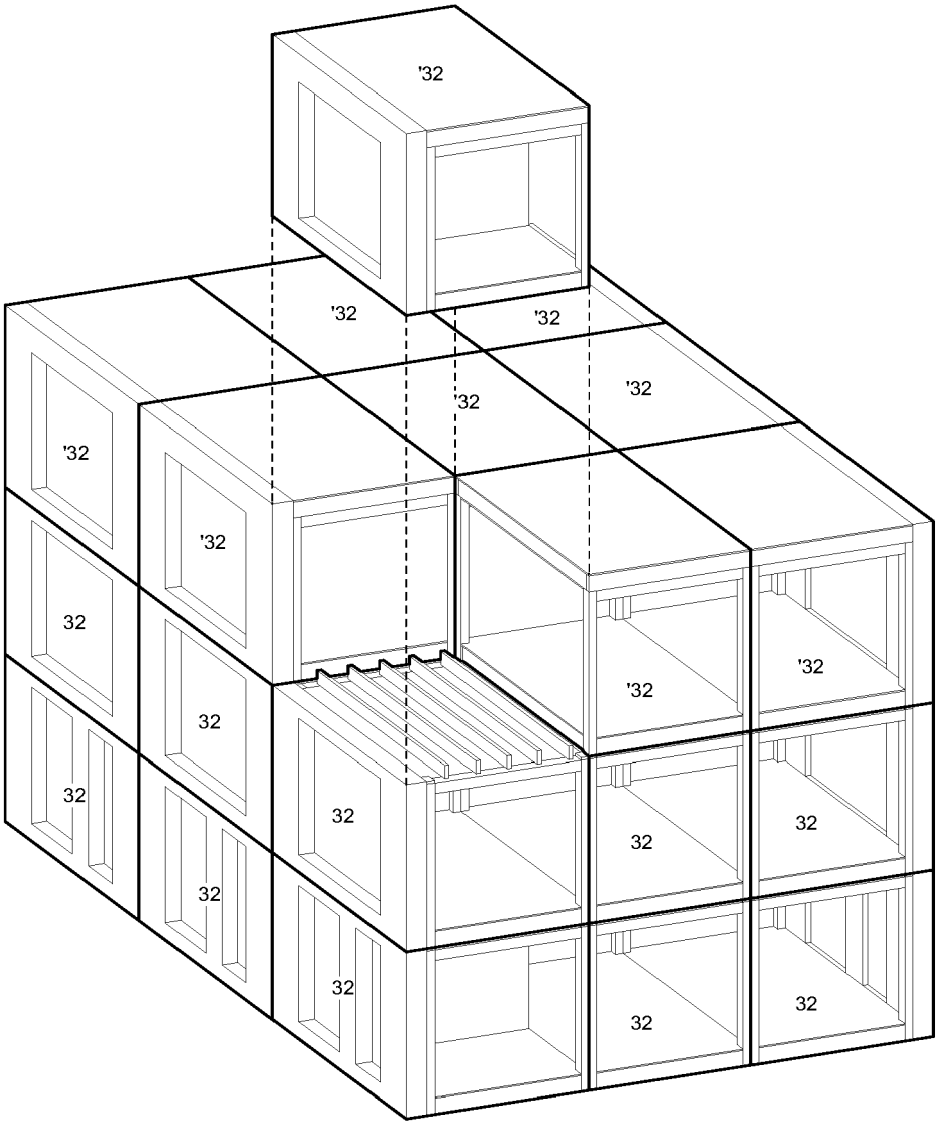

FIG 1

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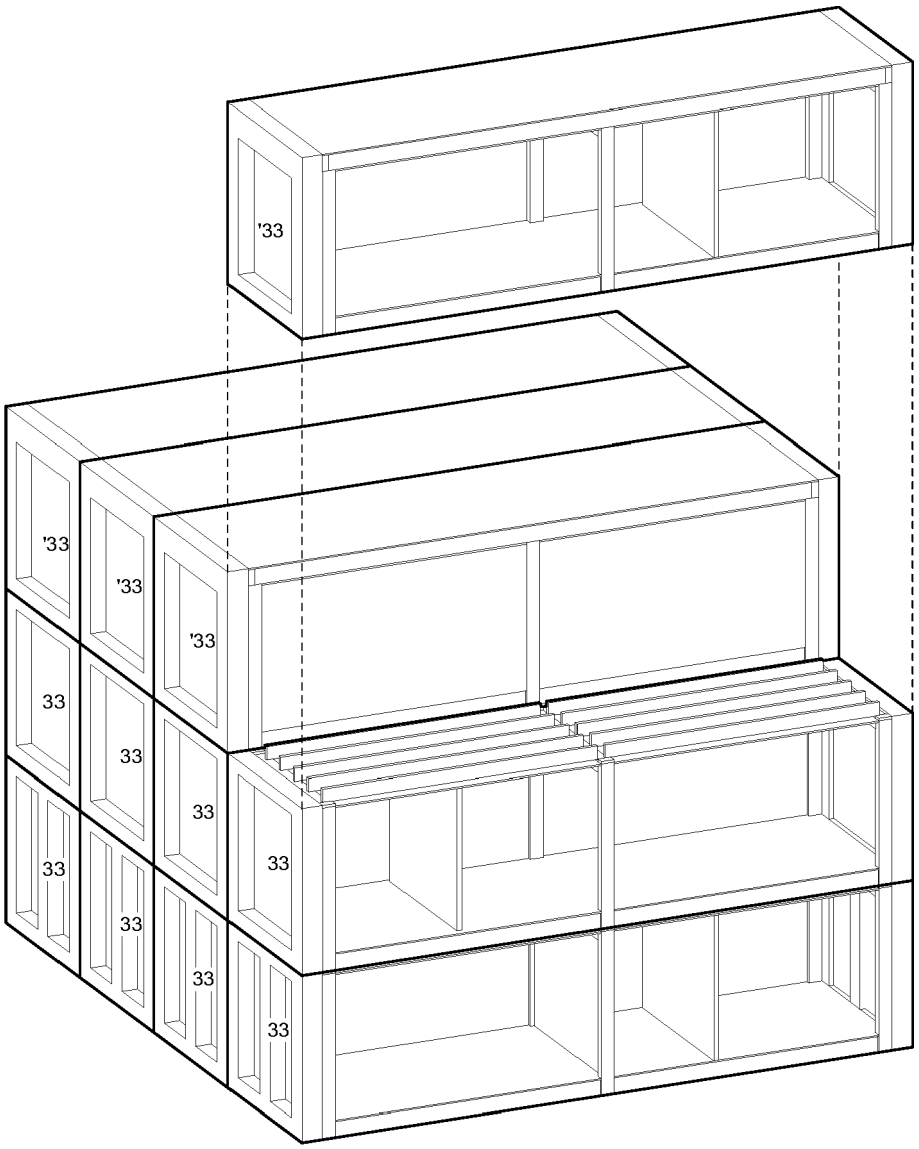

FIG 2

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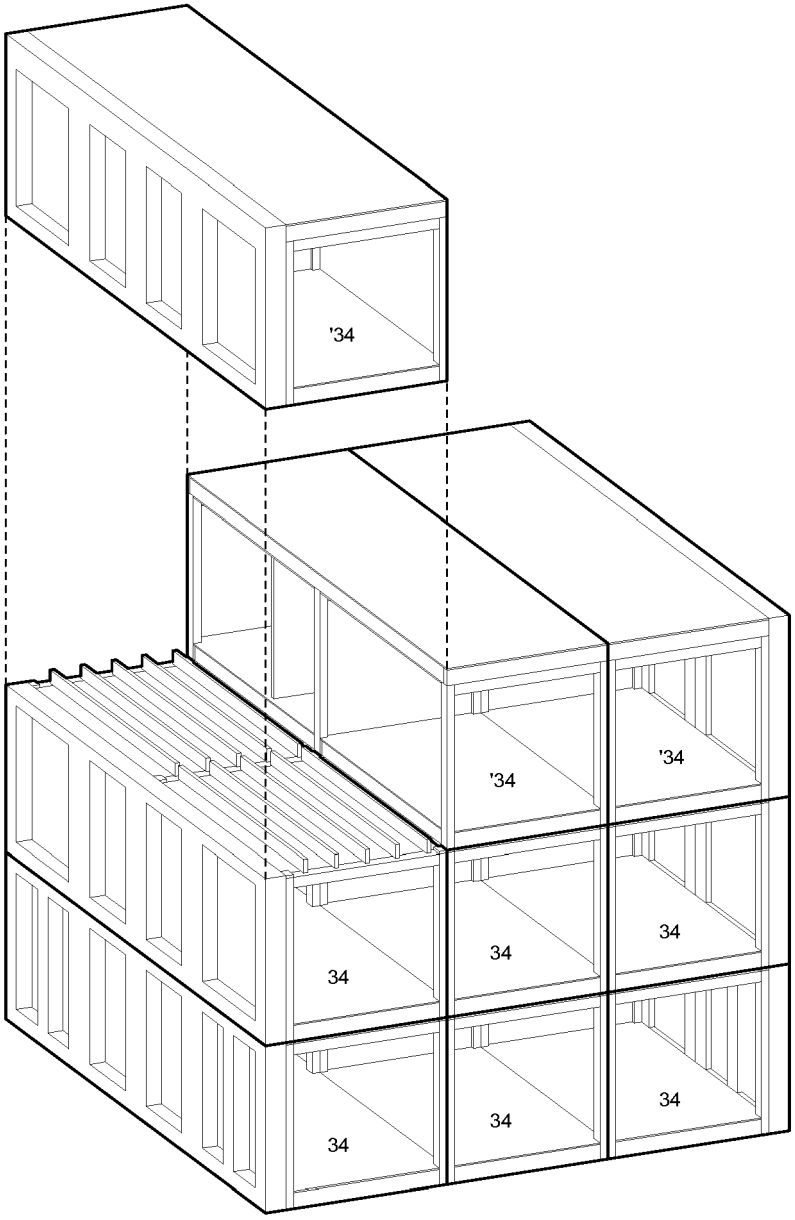

FIG 3

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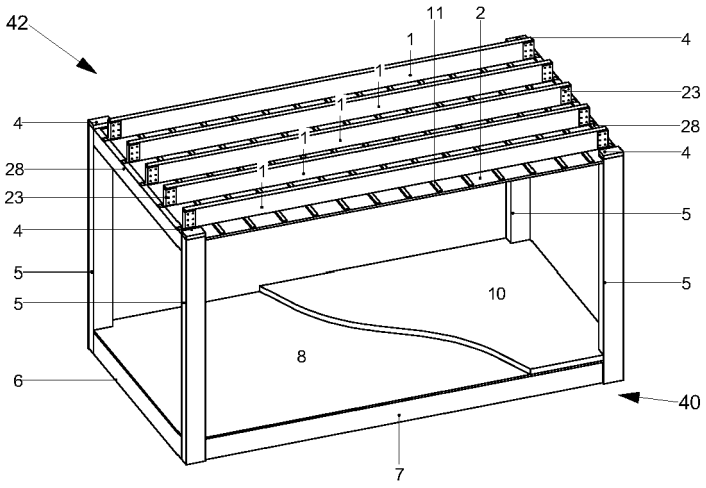

FIG 4A

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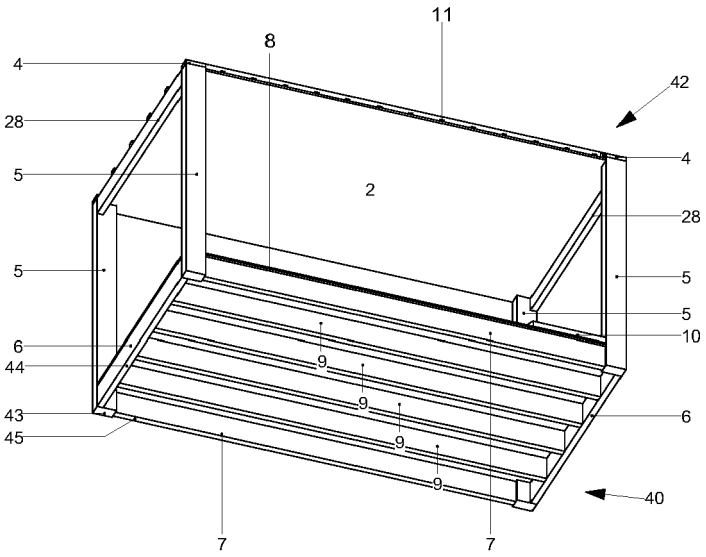

FIG 4B

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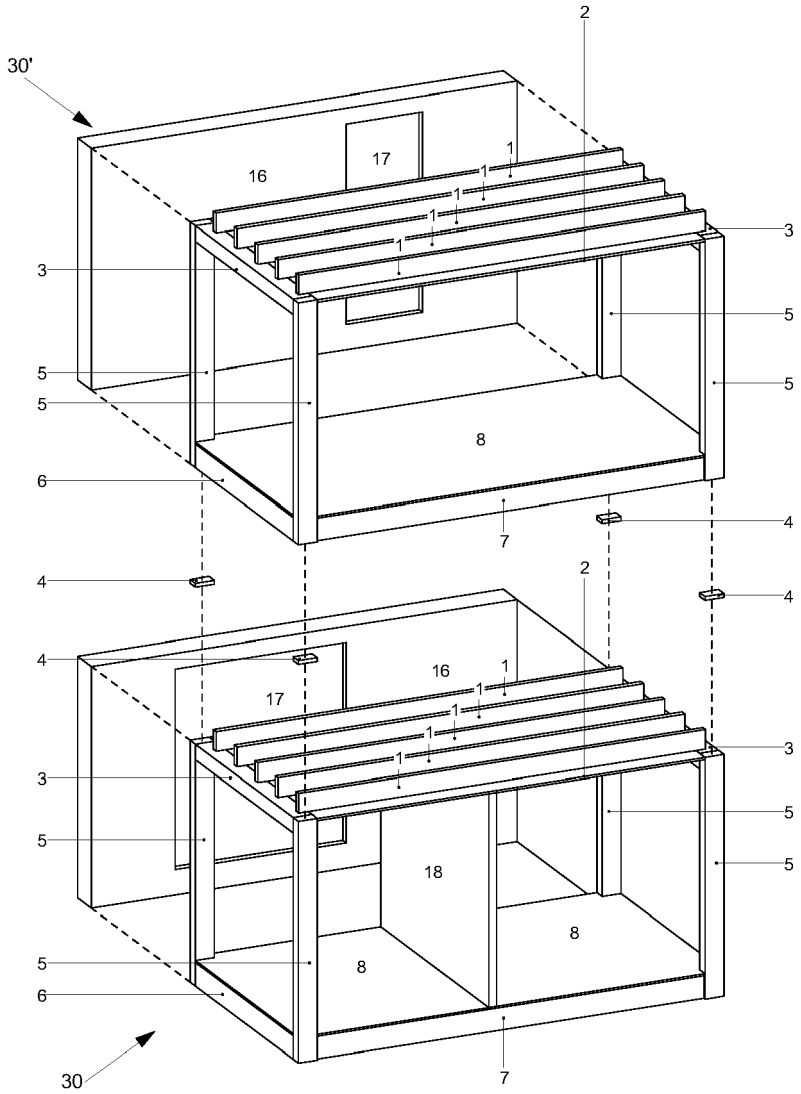

FIG 5

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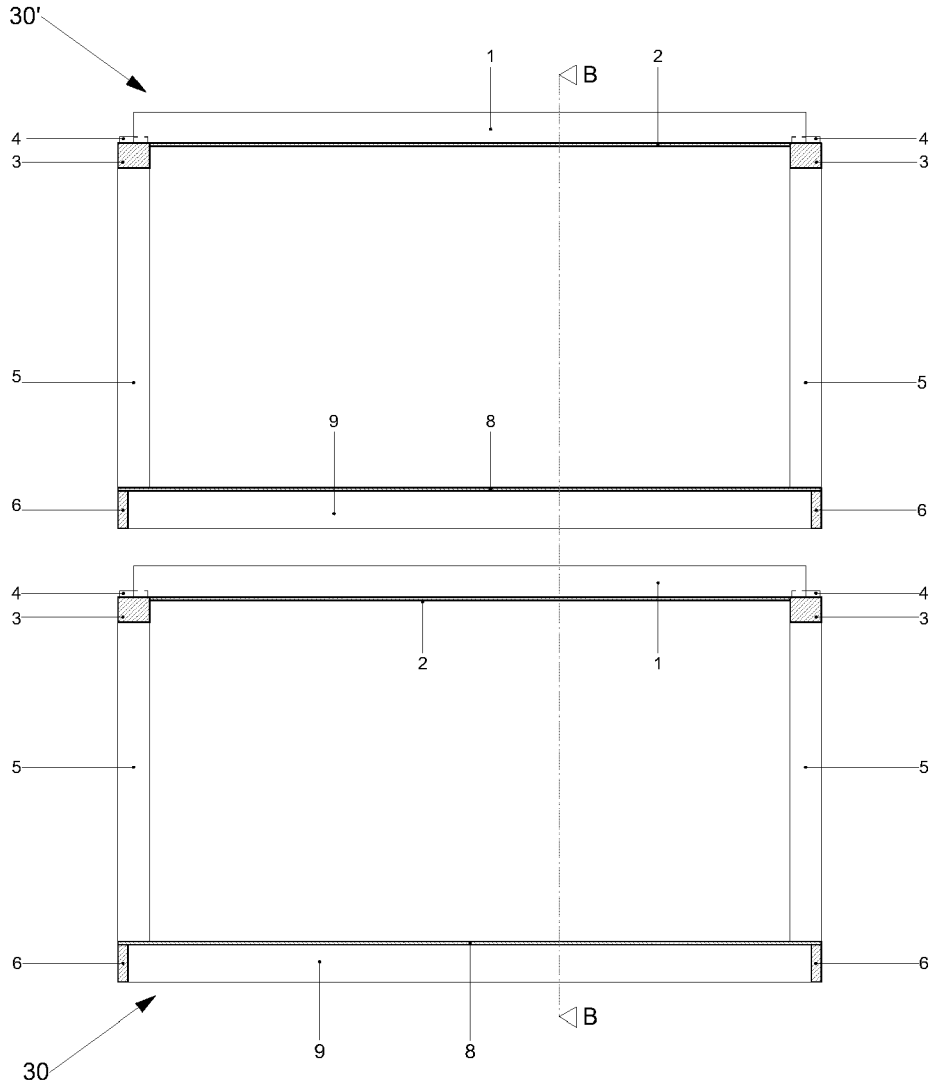

FIG 6

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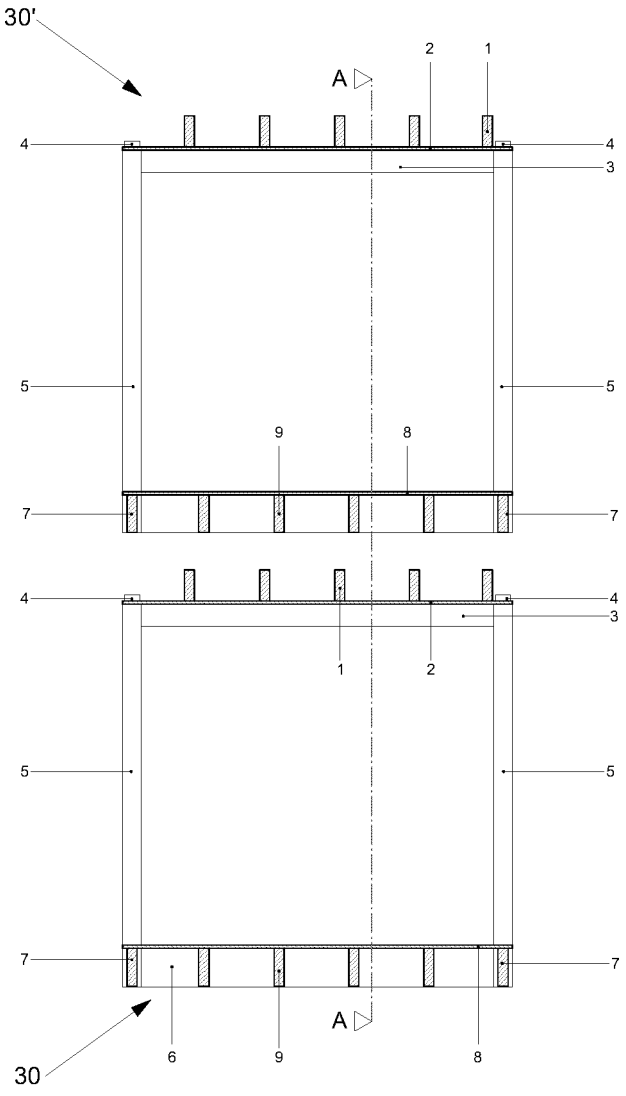

FIG 7

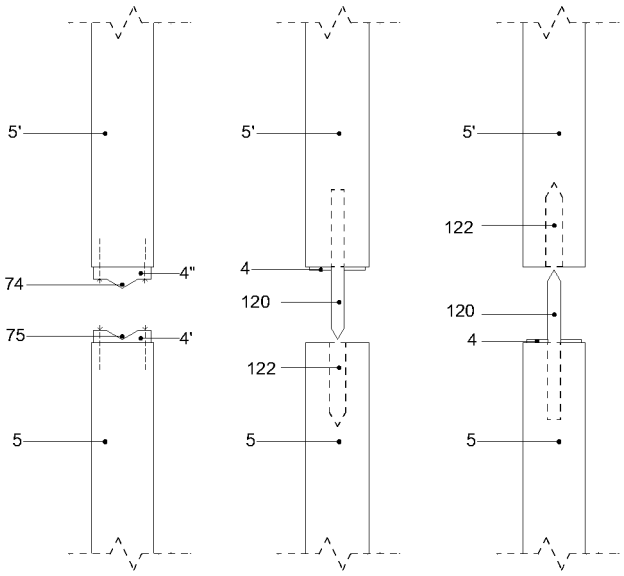

FIG 8A FIG 8B FIG 8C

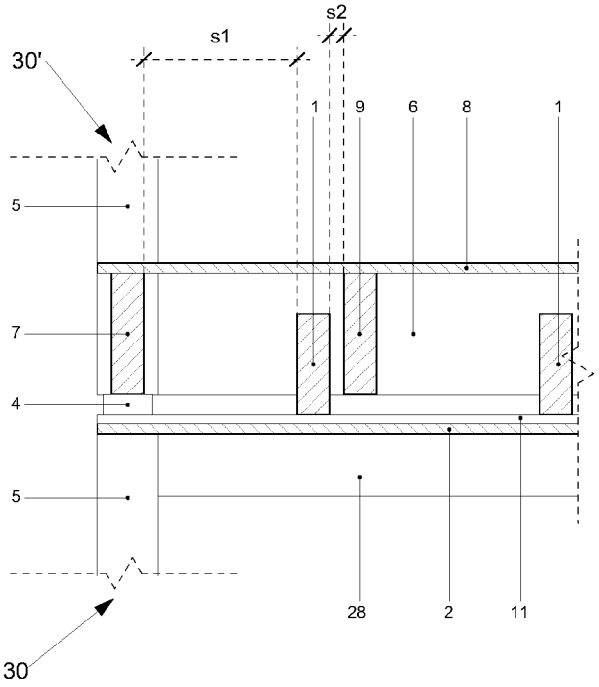

FIG 9A

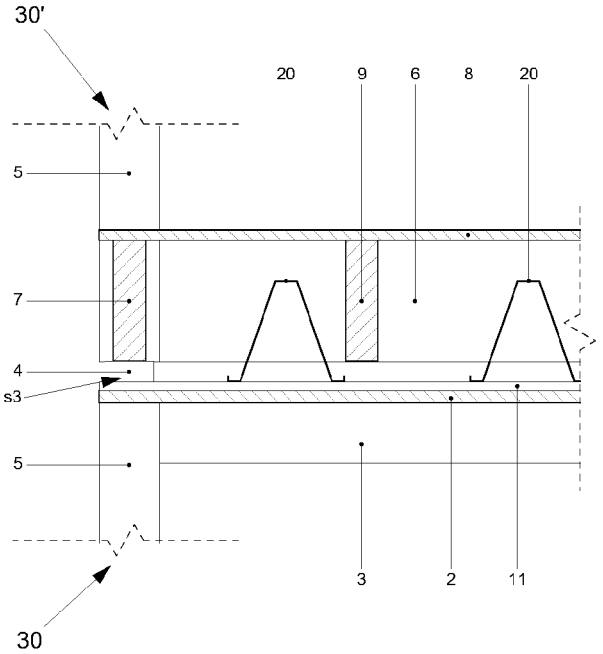

FIG 9B

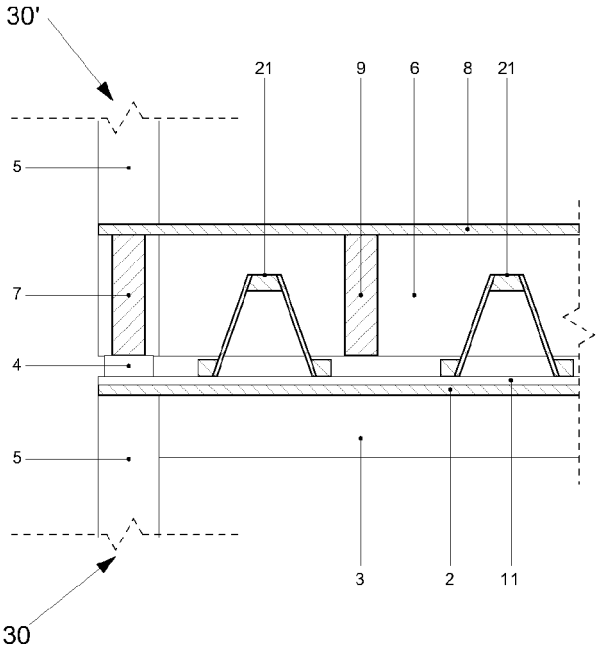

FIG 9C

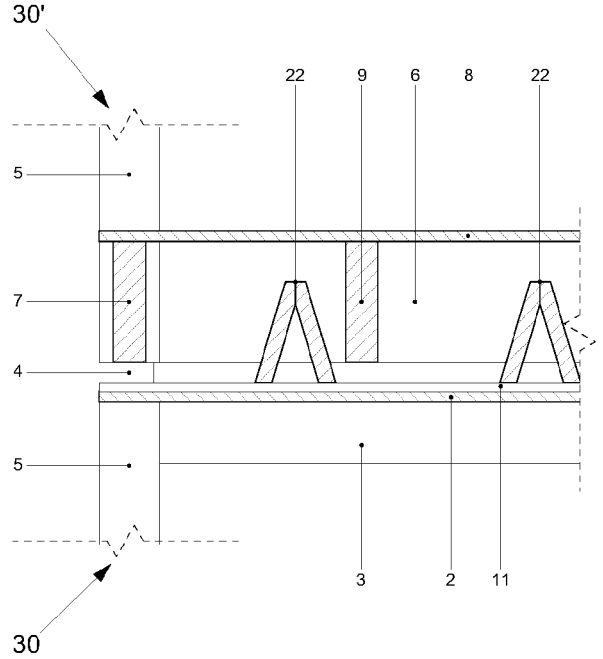

FIG 9D

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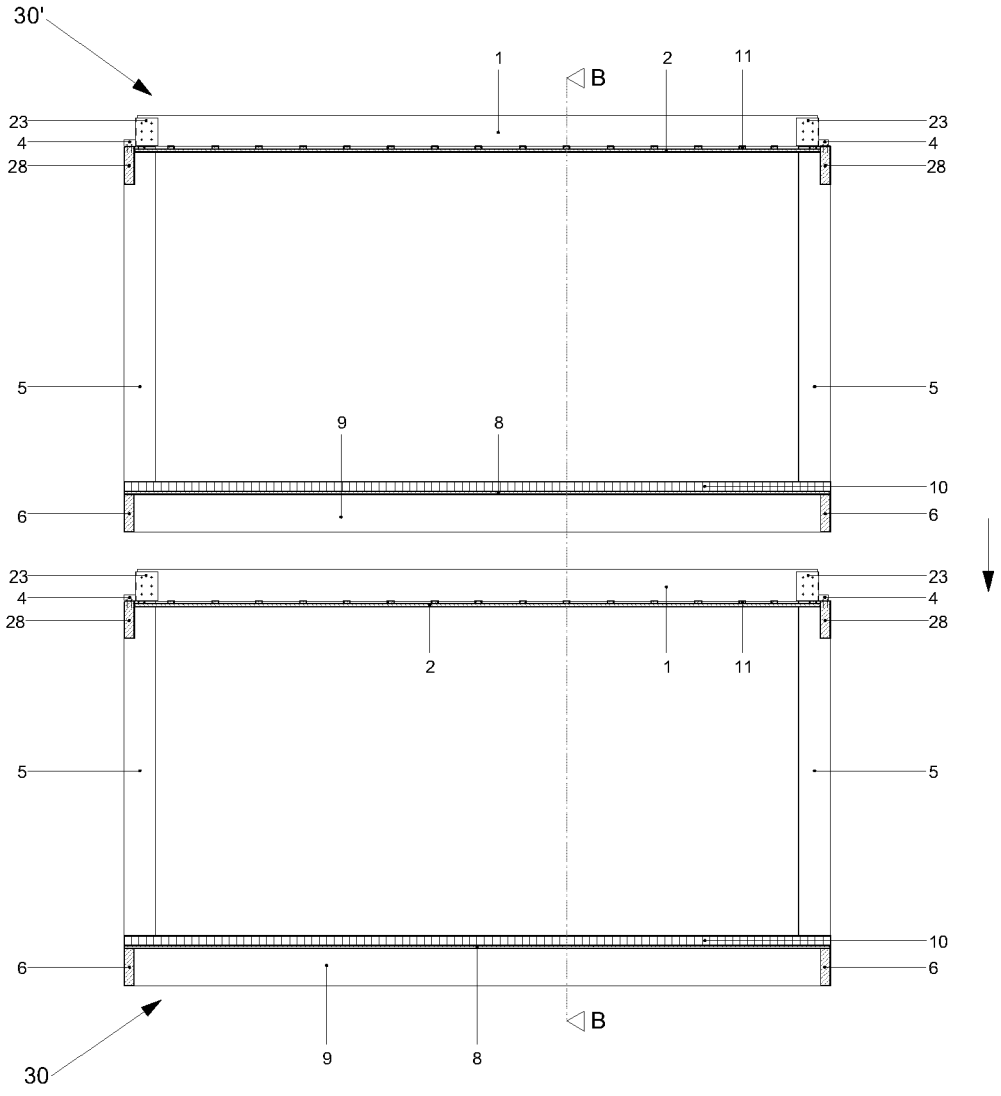

FIG 10

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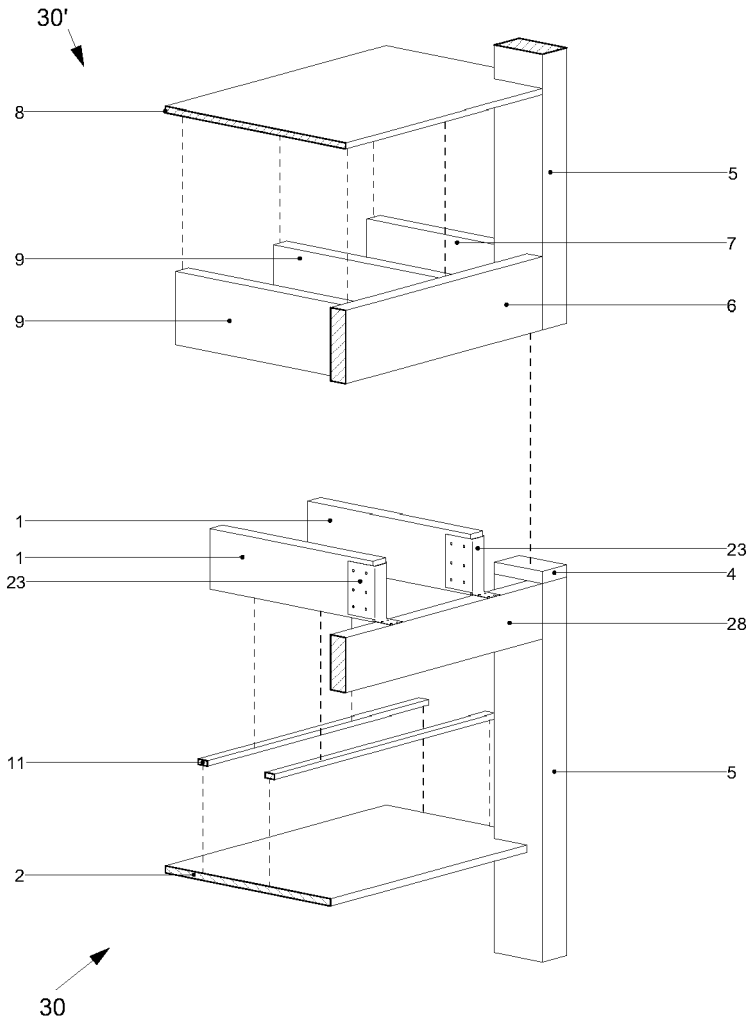

FIG 11

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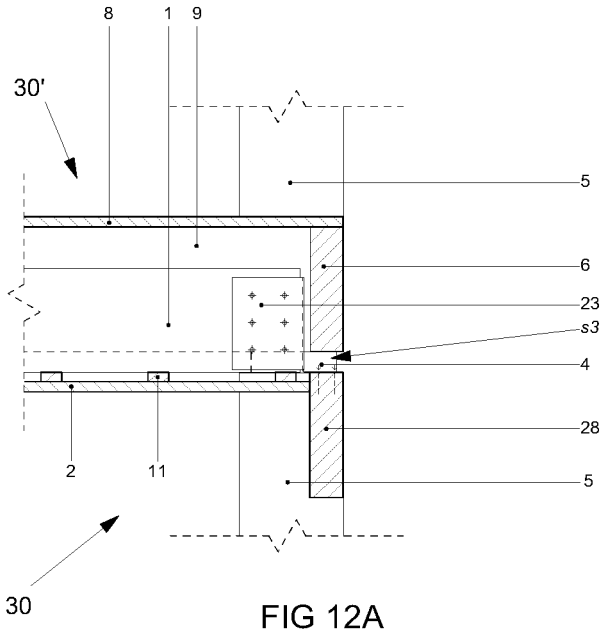

FIG 12A

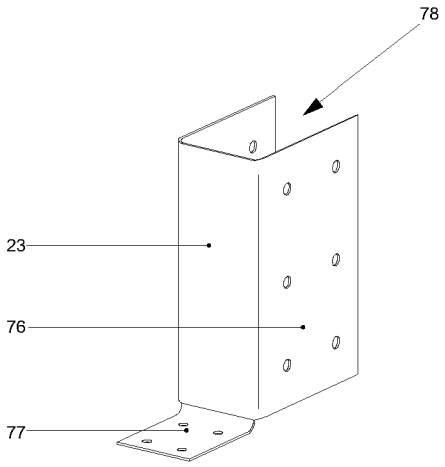

FIG 12B

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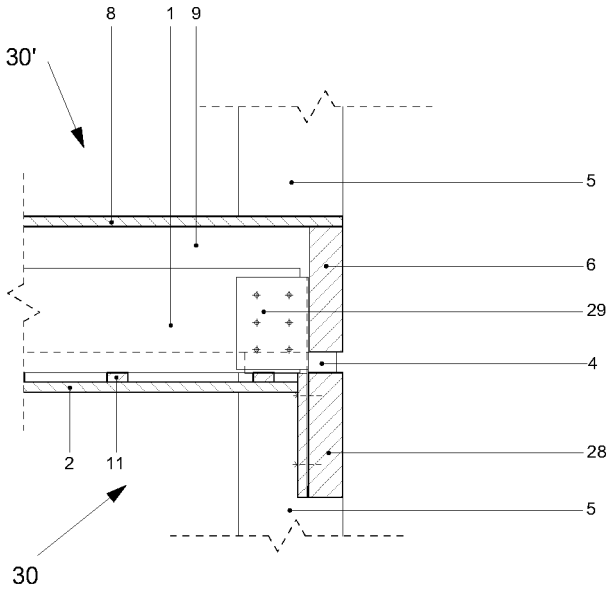

FIG 13A

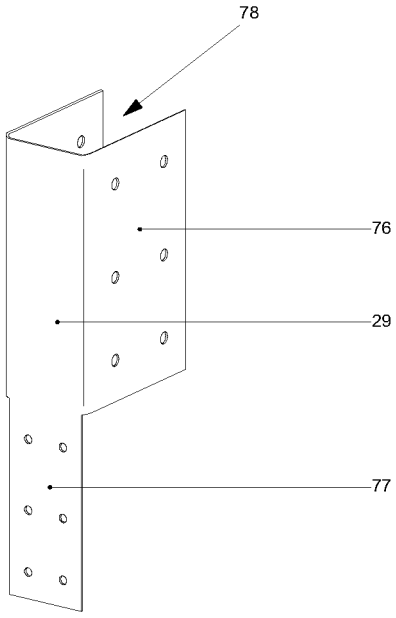

FIG 13B

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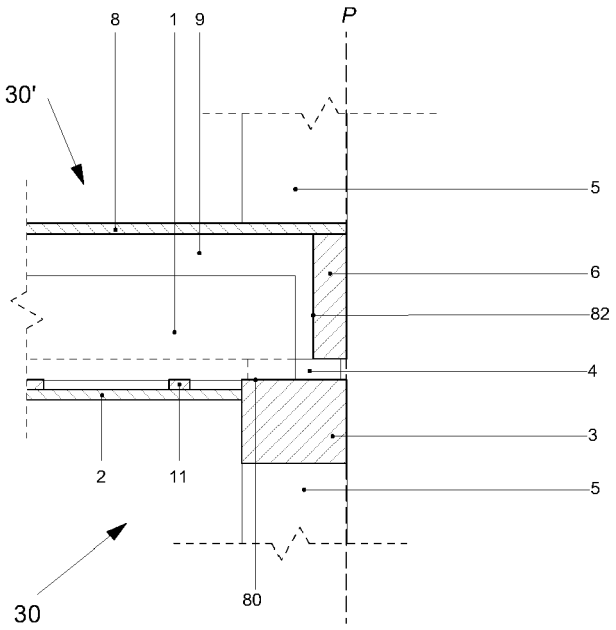

FIG 14

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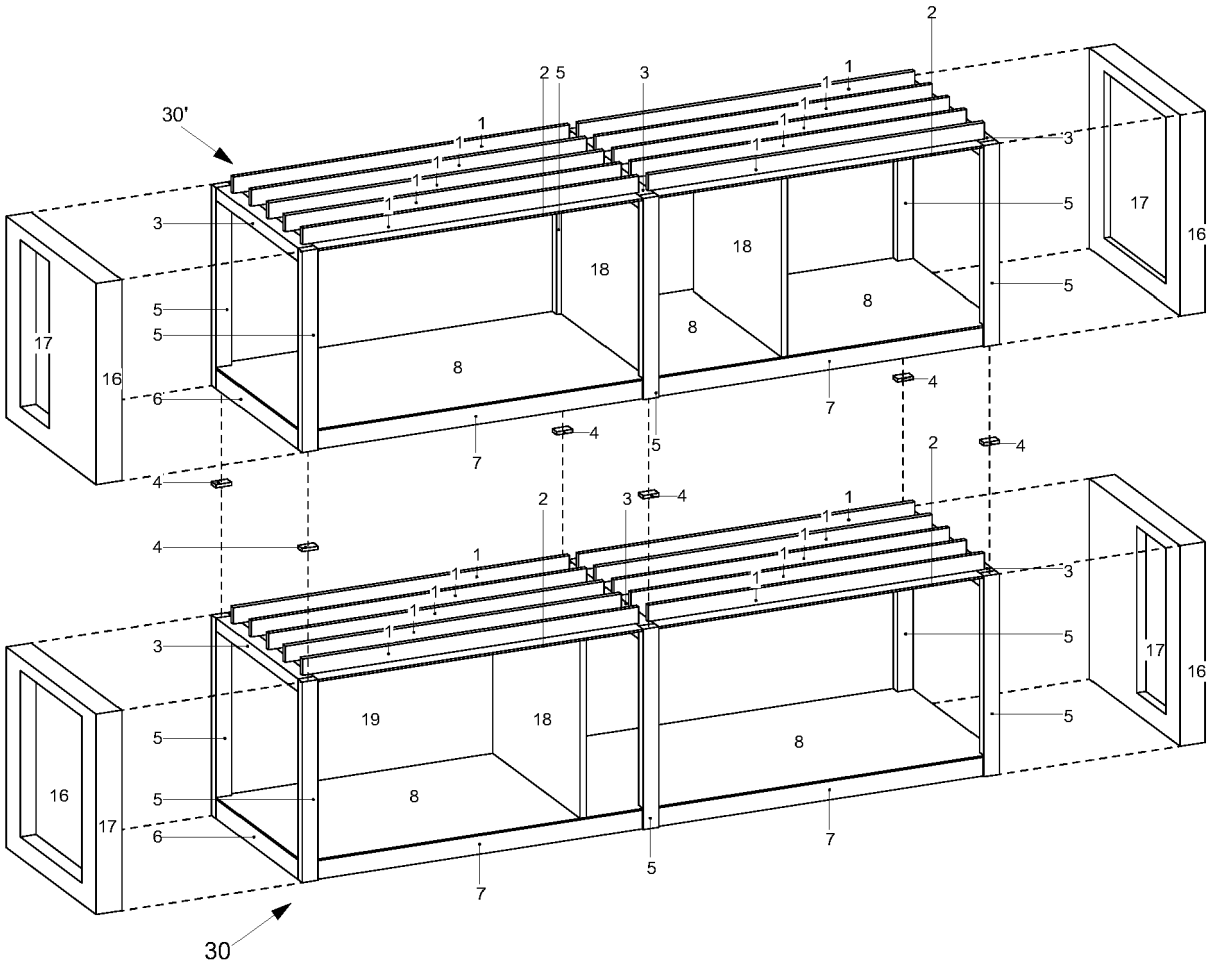

FIG 15

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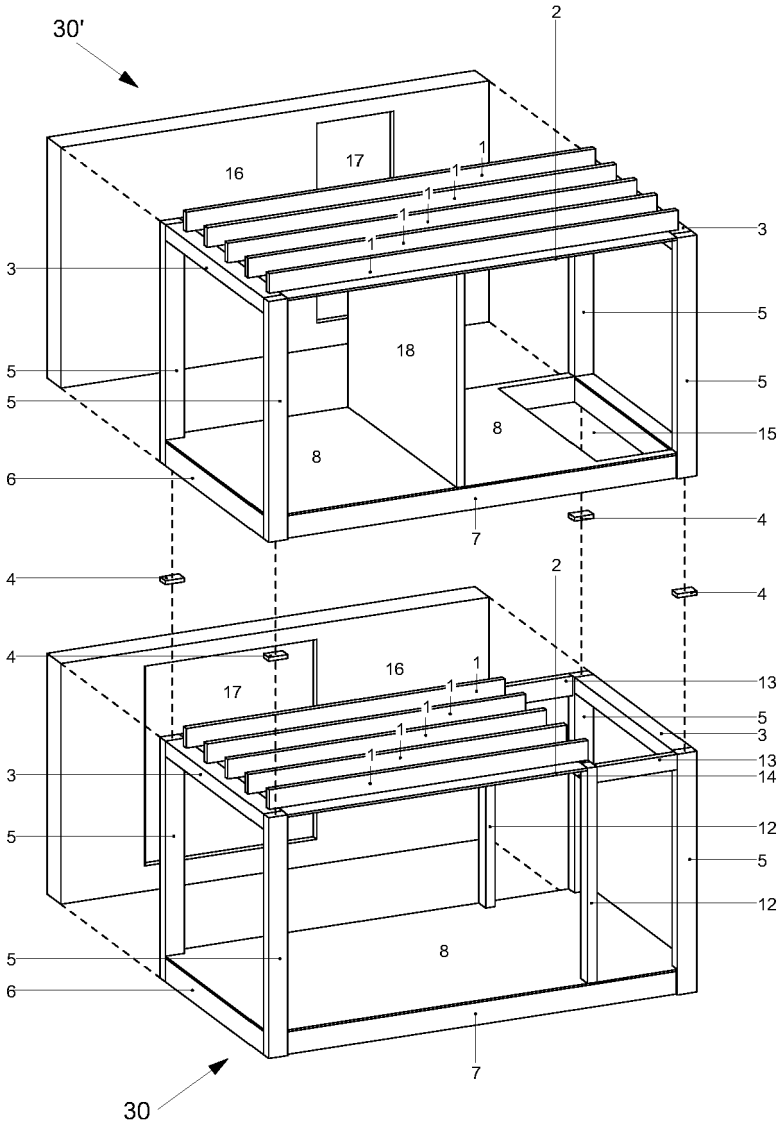

FIG 16

300

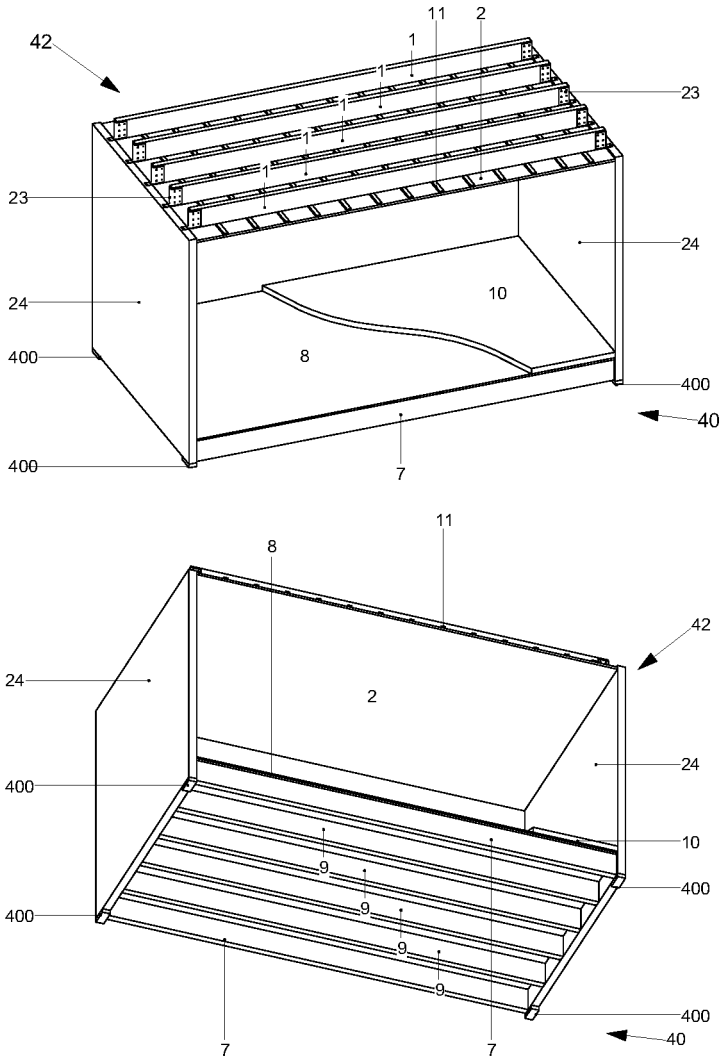

FIG 17

1000

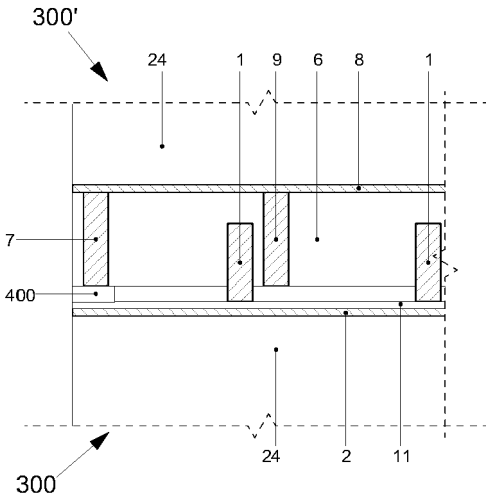

FIG 18A

1000

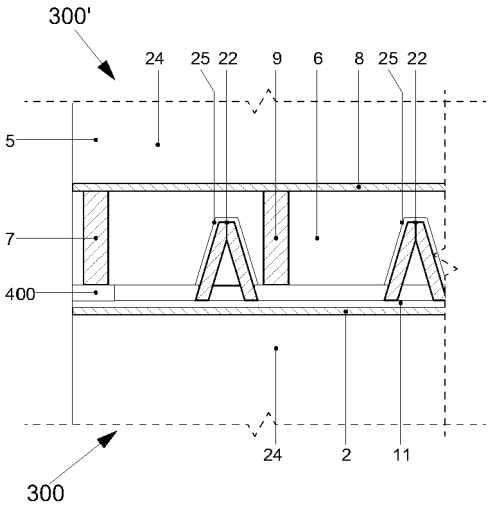

FIG 18B

1000

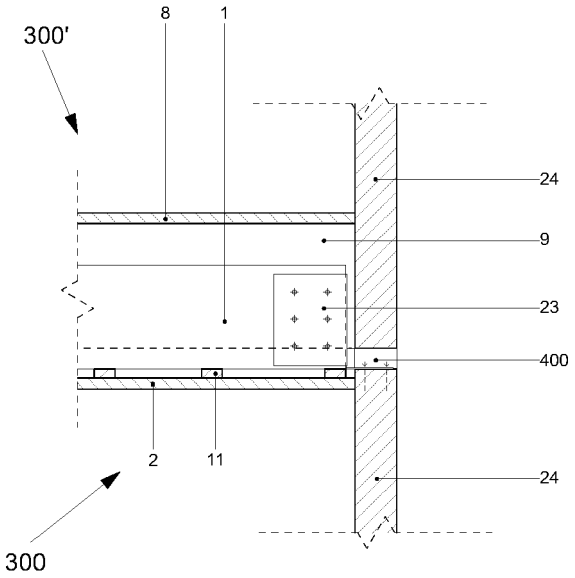

FIG 19A

1000

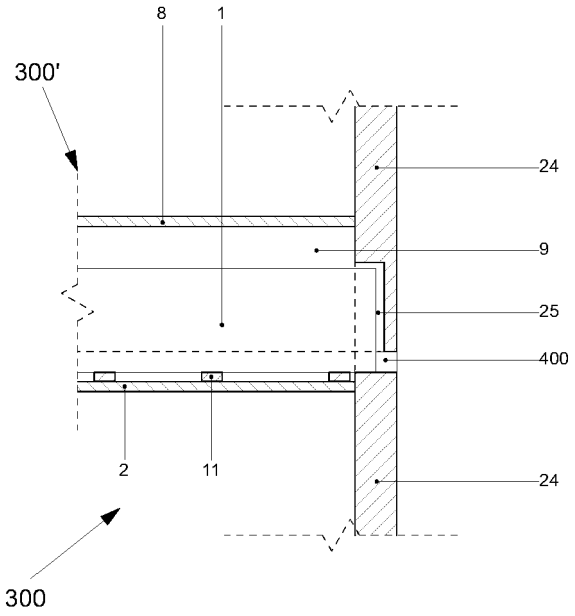

FIG 19B

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 4701

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	EP 3 081 713 A1 (KEYSTONE LINTELS LTD [GB]) 19 October 2016 (2016-10-19) * paragraphs [0054] - [0063]; claim 15; figures 1-5 * -----	1-15	INV. E04B1/348 ADD. E04B1/26 E04B1/82
A,D	EP 2 241 692 A2 (BALLAST NEDAM BOUW EN ONTWIKKE [NL]) 20 October 2010 (2010-10-20) * the whole document * -----	1,12,15	

TECHNICAL FIELDS SEARCHED (IPC)

E04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19 September 2024	Galanti, Flavio

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 17 4701

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19-09-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3081713 A1	19-10-2016	NONE	
EP 2241692 A2	20-10-2010	AT E529575 T1	15-11-2011
		DK 2241692 T3	13-02-2012
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		PL 2241692 T3	30-03-2012

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2241692 A2 **[0003] [0004]**