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(54) MULTI-FLOOR BUILIDING STRUCURE

(57) A multi-floor building structure comprising pillars (1), and at least one horizontal structure (5), made of engineered wood, comprising an upper horizontal layer (10) and a lower horizontal layer (20), made of engineered wood segments structurally adhered together providing structural continuity at least in the longitudinal and transversal horizontal directions (LD, TD) across the entire horizontal structure (5), and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical ribs (31, 32); wherein the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers (10, 20) increases, in a gradual or stepped manner, with the proximity to the vertical through holes (3); and/or the thickness, the load-resistance per square centimeter and/or the proximity between successive longitudinal vertical ribs (31) and successive transversal vertical ribs (32) increases, in a gradual or stepped manner, with the proximity to the vertical through holes (3).

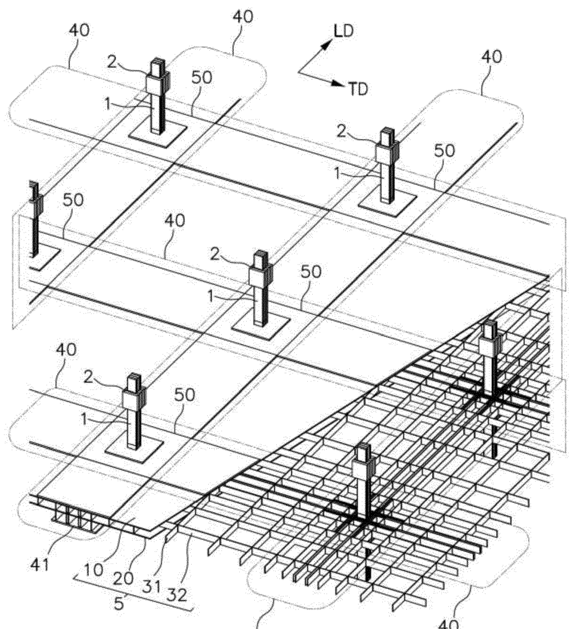

Fig.2

Description

Technical field

[0001] The present invention is directed towards a multi-floor building structure, including an array of pillars and several horizontal structures supported on said array of pillars, wherein at least the horizontal structures are made of engineered wood.

[0002] According to that, the present invention is intended for obtaining a multi-floor building structure where the horizontal structures are mostly or entirely made of engineered wood elements connected together preferably through durable moisture-resistant structural adhesives such as polyurethane or other resins.

State of the Art

[0003] Building construction with concrete or steel structures allows to obtain high buildings of more than ten stories and up to more than one hundred stories with great resistance and durability, achieving diaphanous spaces. However, the construction with concrete or steel is slow and consumes a lot of energy and produces many CO2 emissions.

[0004] Wood construction is also known, and it is advantageous over the concrete and steel construction methods because wood absorbs CO2 while growing, and structures made of wood retain the absorbed CO2 during the entire life span of the building. Also is lighter, easy to manipulate and to transport.

[0005] Despite the above advantages, wood construction methods usually used, known as balloon frame, consisting in the use of wooden struts nailed or screwed together with enclosure panels, only allow the construction of low buildings, such up to four or five stories, given their low resistance compared to concrete or steel construction.

[0006] Prefabricated wood structures are also known, providing cost reductions, quality improvements, reduction in the construction times and material optimizations.

[0007] Those known prefabricated wood structures comprise the prefabrication of structural elements or structure portions in a production facility, its transport to the building site, and the later assembling those elements or portions to obtain the complete structure.

[0008] Despite the above, this system has several limitations. First, size of the prefabricated structural elements or structure portions is limited by the transport thereof, typically limited to a truck size. The second limitation of this prefabricated wood structures is the structural connection between independent structural elements or structure portions in the building site, which is normally obtained by nails, screws or tailor made metallic nodes.

[0009] Because of those two limitations, in those prefabricated wood structures the structural elements and structure portions, once assembled, do not behave as a single rigid structural body, but as different independent structural elements connected to each other.

[0010] A structure of independent interconnected elements is much less efficient than a rigid unitary structure, from the perspective of the mass / resistance relation.

[0011] Prefabricated building structures, typically made of mass timber or similar types of engineered wood, are also known. Those building structures commonly comprise pillars and beams, and sometimes even secondary beams supported on the beams, all covered by a mass timber slabs.

[0012] On those building structures, the connection between beams and pillars commonly comprises metallic connectors, and each beam, secondary beam and mass timber slab are not rigidly connected to each other, but articulated, reducing the overall load-resistance of the structure, and requiring a sub-optimal amount of material and weight to withstand the structural loads.

[0013] In some cases, a concrete layer is poured covering the mass timber slabs to provide structural continuity to the horizontal structure, but greatly increasing the weight.

[0014] It is also known to use i-joist as said beams and secondary beams above described, but also not rigidly connected to each other, obtaining a slab with the same problems described above.

[0015] There are also known the so called structural insulated panels, comprising an upper and lower layers of engineered wood facing each other, separated and rigidly connected to each other through a rigid insulant material placed in between.

[0016] This product can be used as a wall, as a roof, but its use as a building floor requires the addition of beams or secondary beams underneath to increase its structural resistance, with the problems described above. Also, the connection between adjacent panels does not provides a transmission of the structural loads between adjacent panels.

[0017] Document WO2016191510A1 describe a prefabricated wood structure comprising floor segments, each made of upper and lower horizontal boards spaced apart to each other by interposed vertical boards creating a slab segment. Those slab segments include coupling configurations on its sides allowing for coupling adjacent slab segments together.

[0018] Despite the above, this solution does not provide a structural continuity between adjacent upper and lower horizontal boards, preventing the transmission of horizontal loads between adjacent upper horizontal boards or adjacent lower horizontal boards, preventing the horizontal structure to behave structurally as a single continuous and rigid horizontal structure, withstanding bending forces and transmitting such forces to pillars.

[0019] In addition, because WO2016191510A1, and other similar documents, do not describe a structurally unitary slab that channels and accumulates loads around the pillars supporting the slab, there is also no known optimization of the strength of different areas of the slab to support such concentrated loads and to achieve a reduction in weight and cost of the structure.

[0020] The present invention aims to solve the above and other technical problems, providing a building technology with engineered wood.

Brief description of the invention

[0021] The present invention is directed towards a multi-floor building structure, for example a building with at least five stories.

[0022] The proposed building structure comprises, in a manner already known, pillars and one horizontal structure, made of engineered wood, for each building floor of the building supported on said pillars, each horizontal structure including vertical through holes for inserting the pillars therethrough.

[0023] According to that, the pillars are continuous uninterrupted pillars crossing the overlapped horizontal structures through said vertical through holes.

[0024] Each horizontal structure is supported on several pillars, to which it is connected, preferably through first seats integrated in the pillars.

[0025] Each pillar can be, for example, one single vertical strut of engineered wood, preferably with fibers oriented in a vertical direction, or a plurality of parallel vertical struts made of engineered wood, preferably with fibers oriented in a vertical direction, rigidly connected to each other at a horizontal distance.

[0026] Those pillars can also be made of other materials such as steel or concrete.

[0027] It will be understood that the horizontal structure can be also a storey ceiling slab, or a roof slab, and that a horizontal element is an element with its main surfaces being substantially horizontal, and a vertical element is an element with its main surfaces being substantially vertical.

[0028] The engineered wood are derivative wood products which are manufactured by binding or fixing fibers, particles, fibers, veneers or boards of wood, wood chips, wood powder, or other vegetal products such bamboo, together with adhesives to form composite material. This type of wood is also known as mass timber, composite wood, man-made wood, or manufactured board.

[0029] The most common types of engineered wood are the plywood, which is manufactured from sheets of laminated veneer switching directions and bonded under heat and pressure with durable moisture-resistant adhesives, the laminated veneer lumber (LVL), which is similar to plywood but with the veneers all stack in the same direction, the oriented strands board (OSB) manufactured from wood flakes oriented in multiple directions compressed and glued together, the laminated strand lumber (LSL), which is similar to OSB but with the strands all stack in the same direction, and the medium-density fiberboard manufactured from wood fibers or sawdust compressed and glued together. Other types of engineered wood products are commonly known as Glulam, and cross-laminated timber (CLT).

[0030] Preferably, the engineered wood used in the present invention in the main engineered wood components, or at least for the engineered wood components supporting higher loads, such the upper and lower horizontal layers, have a maximal compressive/tensile strength comprised between 10 to 40 N/mm^2 and/or a maximal shear strength up to 8 N/mm^2, and the adhesives used preferably have, once hardened, a maximal compressive strength equal or higher than the compressive strength of the attached engineered wood components and a maximal shear strength equal or higher than the shear strength of the attached engineered wood components.

[0031] Each horizontal structure comprises an upper horizontal layer and a lower horizontal layer of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical ribs of engineered wood elongated in a longitudinal horizontal direction and in a transversal horizontal direction.

[0032] The longitudinal and transversal horizontal directions are two horizontal and intersecting directions, which can be perpendicular to each other, or can define different non-orthogonal angles between them.

[0033] According to that, the horizontal structure is a rigid slab including two overlapped and separated horizontal layers connected to each other through vertical ribs oriented in two intersecting horizontal directions, such the longitudinal and transversal horizontal directions, defining an array of vertical ribs.

[0034] Also, the longitudinal and transversal vertical ribs are structurally attached to both the upper and lower horizontal layers, mainly withstanding shear loads between both upper and lower horizontal layers.

[0035] The present invention further proposes, in a manner not known in the state of the art, the following features:

- the upper and lower horizontal layers are made of engineered wood segments structurally adhered together providing structural continuity at least in the longitudinal and transversal horizontal directions across the entire horizontal structure; and
- the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers increases, in a gradual or stepped manner, with the proximity to the vertical through holes; and/or
- the thickness, the load-resistance per squared centimeter, and/or the proximity between, successive longitudinal and transversal vertical ribs increases, in a gradual or stepped manner, with the proximity to the vertical through holes.

[0036] According to that, each of the upper and lower horizontal layers are structurally continuous both in the longitudinal and transversal horizontal directions, resisting and transmitting tensile and/or compressive structural loads in said at least two different horizontal directions across the entire horizontal structure. This, combined with the array of longitudinal and transversal vertical ribs, provides a bi-directional slab structurally continuous across the entire horizontal structure of one building floor, obtained by individual engineered wood segments structurally adhered together, for example using durable moisture-resistant structural adhesives such as polyurethane or other resins.

[0037] A bi-directional slab can withstand and transmit longitudinal and transversal bending loads between adjacent bays across the entire horizontal structure, reducing the maximum bending loads accumulated on the nodes between the horizontal structure and the pillars.

[0038] The structural continuity of the upper and/or lower horizontal layers can be obtained by a continuous sheet of engineered wood extending in the longitudinal and transversal directions, or by multiple parallel continuous bands of engineered wood extending in the longitudinal direction, providing structural continuity in the longitudinal direction, and multiple parallel continuous bands of engineered wood extending in the transversal direction, providing structural continuity in the transversal direction, said bands of engineered wood being rigidly connected to each other in the intersections, and optionally defining light-weighting apertures between the intersecting bands.

[0039] In order to optimize the structural strength, the weight, and the cost of the horizontal structure, it is proposed to increase the structural strength of the upper and/or lower horizontal layers and/or of the array of longitudinal and transversal vertical ribs in the surroundings of the vertical through holes, where the pillars are inserted and where the loads are concentrated.

[0040] Said structural strengthening is obtained by an increase of the thickness of the upper and/or lower horizontal layers, and/or by an increase of the thickness of the longitudinal and transversal vertical ribs and/or by an increase in the proximity between the longitudinal and transversal vertical ribs in the surroundings of each vertical through hole and/or by an increase of the load-resistance per square centimeter of the engineered wood constitutive of the upper and/or lower horizontal layers, using more resistant engineered wood in the proximity of the through-holes than in other areas.

[0041] Said increase in the thickness of the horizontal layers or of the ribs and/or said increase in the load-resistance per square centimeter and/or said increase in the proximity between ribs can be a gradual increase, providing a gradation of load-resistances, thicknesses and/or separation distances across the building structure, or a stepped increase, providing several sudden increases in the thickness, load-resistance per square centimeter and/or proximity between said elements.

[0042] In this case, the horizontal structure can include preferably at least three, and preferably four, five or more, different thicknesses and/or load-resistances, and/or separation distances between elements, providing the maximal resistance around each vertical through hole, where the thickness and/or proximity between the elements will be the maximal, providing an intermediate resistance in regions comprised between pairs of adjacent vertical through holes of the same longitudinal or transversal aligned succession of vertical through holes, and providing the minimal thickness and/or proximity, and therefore the minimal weight and cost, in central non-reinforced portions of the horizontal structure away from the vertical through holes and from the longitudinal or transversal aligned succession of vertical through holes.

[0043] Optionally, in addition to those three different thicknesses and/or load-resistances and/or proximities, other intermediate thicknesses and/or load-resistances and/or proximities can be provided between said three areas.

[0044] Preferably, the vertical through holes of each horizontal structure comprises several longitudinal successions of vertical through holes aligned in the longitudinal horizontal direction, defined by the direction of the longitudinal vertical ribs, and several transversal successions of vertical through holes aligned in a transversal horizontal direction defined by the transversal vertical ribs, defining an array of vertical through holes. The pillars inserted through said array of vertical through holes will also constitute an array of pillars including several longitudinal aligned successions of pillars and several transversal successions of pillars.

[0045] Alternatively, some or all the through-holes can be misaligned, in correspondence with misaligned pillars.

[0046] Additionally, the present invention further proposes an embodiment according to which the engineered wood segments, constitutive of the upper and lower horizontal layers, mostly comprises fibers oriented in the longitudinal horizontal direction and in the transversal horizontal direction.

[0047] This can be obtained by using engineered wood elements made of wood fibers mostly oriented at least in said longitudinal and transversal horizontal directions, or by combining two types of engineered wood elements, ones with wood fibers mostly oriented in the longitudinal horizontal direction and others with wood fibers mostly oriented in the transversal horizontal direction. This combination can be obtained by overlapping the two types of engineered wood elements, or by placing different segments of those two types of engineered wood elements coplanar to each other, and including additional engineered wood elements in the intersections, producing the overlap of the two types only on the intersections. Other combinations of engineered wood elements with fibers oriented in one or in at least two different horizontal directions are also possible to obtain such result.

[0048] Alternatively or additionally, the longitudinal vertical ribs can be made of engineered wood rib segments mostly comprising fibers oriented in the longitudinal horizontal direction and the transversal vertical ribs can be made of engineered wood rib segments mostly comprising fibers oriented in the transversal horizontal direction.

[0049] As explained above, the engineered wood contains wood fibers glued together. In some kinds of engineered wood said wood fibers are oriented mostly in a particular direction, providing an anisotropic material, the load-resistance per square centimeter of the engineered wood being greater in the direction of the strains than in other directions.

[0050] As the upper and lower horizontal layers are structurally continuous in the longitudinal and transversal directions and are used to transmit and withstand the loads supported by the horizontal structure, the construction of said upper and lower horizontal layers with engineered wood with the fibers oriented at least in said longitudinal and transversal directions increases the overall structural performance of the horizontal structure.

[0051] Equally, the shear forces supported by the longitudinal and transversal vertical ribs, are better withstand by engineered wood with the fibers oriented parallel to the main longitude of the vertical rib.

[0052] Each horizontal structure comprises several elongated reinforced portions, elongated in the longitudinal or transversal direction and comprising one aligned succession of aligned vertical through holes. Said elongated reinforced portions, oriented in the longitudinal and in the transversal horizontal directions, surround central non-reinforced portions of the horizontal structure devoid of vertical through holes.

[0053] According to one embodiment of the present invention, in at least some elongated reinforced portions, the thickness of the upper and/or lower horizontal layers is bigger than the thickness of the upper and/or lower horizontal layers in other portions of the horizontal structure different to the elongated reinforced portions.

[0054] It is to say, that a strip of the upper and/or lower horizontal layers, spanning an aligned succession of vertical through holes where pillars are inserted, is made of a thicker engineered wood than other non-reinforced areas of the horizontal structure, typically said central non-reinforced portions.

[0055] Additionally or alternatively, the thickness of, and/or the proximity between, longitudinal or transversal vertical ribs, parallel to the main longitude of the elongated reinforced portion where they are contained, is bigger than the thickness of, and/or the proximity between, the longitudinal or transversal vertical ribs contained in other portions of the horizontal structure different to the elongated reinforced portions, typically said central non-reinforced portions.

[0056] Also, it is preferred if the longitudinal or transversal vertical ribs, parallel to the main longitude of the elongated reinforced portion where they are contained, fully extends over the entire elongated reinforced portion.

[0057] It is also proposed that, in at least some elongated reinforced portions of each horizontal structure, the load-resistance per square centimeter of the engineered wood constitutive of the upper and/or lower layers in the elongated reinforced portions can be bigger than the load-resistance per square centimeter of the engineered wood constitutive of the upper and/or lower layers in other portions of the horizontal structure different to the elongated reinforced portions.

[0058] Similarly, the load-resistance per square centimeter of the engineered wood constitutive of the longitudinal or transversal vertical ribs, parallel to the main longitude of the elongated reinforced portion where they are contained, can be bigger than the load-resistance per square centimeter of the engineered wood constitutive of the longitudinal or transversal vertical ribs in other portions of the horizontal structure different to the elongated reinforced portions.

[0059] According to that, different types of engineered wood, having different load-resistance characteristics, can be used on different portions of the same elements, obtaining better resistances where it is necessary, and reducing cost and/or weight in other areas.

[0060] The present invention also proposes that, an elongated stiffener, made of engineered wood, can be included in at least some of the elongated reinforced portions.

[0061] Said elongated stiffener will protrude upwards and/or downwards from the horizontal structure extending in the main longitude of the elongated reinforced portion where it is included, the elongated stiffener being rigidly and structurally connected to the horizontal structure, for example though adhesives.

[0062] According to that, said elongated stiffener will be an engineered wood element, preferably a horizontal element, which extends in the longitudinal or transversal direction of the elongated reinforced portion. This elongated stiffener is rigidly and structurally connected, for example through adhesives, to the horizontal structure and, because it protrudes from the horizontal structure upwardly and/or downwardly, it provides a local increase in the height of the horizontal structure, increasing its bending resistance.

[0063] Preferably, said elongated stiffener is made of engineered wood with fibers mostly oriented in a horizontal direction parallel to the main longitude of the elongated stiffener.

[0064] Said elongated stiffener can be interrupted by the vertical through holes or can be continuous along the entire longitude of the elongated reinforced portion, for example being one or two elongated stiffeners tangent to the vertical through holes or an elongated stiffener passing through the pillars or can be a wide elongated stiffener continuous along the entire longitude of the elongated reinforced portion with the vertical through holes passing therethrough.

[0065] Said elongated reinforced portion of the horizontal structure connects successive pillars through a reinforced portion of the horizontal structure which constitutes a virtual beam at least partially embedded in the horizontal structure.

[0066] Also, each horizontal structure comprises one collar reinforced portion surrounding each vertical through hole. Said collar reinforced portions will be coincident with the intersections between two elongated reinforced portions.

[0067] According to an embodiment, in at least some collar reinforced portions of each horizontal structure, the thickness of the upper and/or lower horizontal layers can be bigger than the thickness of the upper and/or lower horizontal layers in other portions of the horizontal structure different to the collar reinforced portions.

[0068] Similarly, the thickness of, and/or the proximity between, longitudinal or transversal vertical ribs can be bigger than the thickness of, and/or the proximity between, the longitudinal and transversal vertical ribs contained in other portions of the horizontal structure different to the collar reinforced portions.

[0069] Said other portions can be the above cited central non-reinforced portions, where a weight reduction is sought, and also regions of the elongated reinforced portions defined between the collar reinforced portions.

[0070] According to another embodiment, in at least some collar reinforced portions, the load-resistance of the engineered wood constitutive of the upper and/or lower layers in the collar reinforced portions is bigger than the load-resistance of the engineered wood constitutive of the upper and/or lower layers in other portions of the horizontal structure different to the collar reinforced portions.

[0071] Similarly, the load-resistance per square centimeter of the engineered wood constitutive of the longitudinal or transversal vertical ribs in the collar reinforced portions can be bigger than the load-resistance per square centimeter of the engineered wood constitutive of the longitudinal or transversal vertical ribs in other portions of the horizontal structure different to the collar reinforced portions.

[0072] As in the previous case, said other portions can be the above cited central non-reinforced portions, where a weight reduction is sought, and also regions of the elongated reinforced portions defined between the collar reinforced portions.

[0073] Additionally or alternatively, in at least some collar reinforced portions an annular stiffener made of engineered wood can be included surrounding the vertical through hole. Said annular stiffener will protrude upwards and/or downwards from the horizontal structure surrounding the vertical through hole, the annular stiffener being rigidly and structurally adhered to the horizontal structure.

[0074] Said annular stiffener will be an engineered wood element, preferably a horizontal element, which encloses the vertical through hole. This annular stiffener is rigidly and structurally adhered to the horizontal structure and, because it protrudes from the horizontal structure upwardly and/or downwardly, it provides a local increase in the height of the horizontal structure, increasing its bending resistance.

[0075] Preferably, said annular stiffener is made of engineered wood with fibers mostly oriented at least in the longitudinal and transversal horizontal directions.

[0076] The collar reinforced portion increases the resistance of the horizontal structure on its intersection with one pillar, creating a virtual capital. Said collar reinforcer portion further conducts and distributes horizontal loads around the vertical through hole, increasing the stiffness of the horizontal structure.

[0077] Said elongated stiffener and/or annular stiffener can be an engineered wood board adhered to the upper and/or lower horizontal layer or can be separated from the horizontal structure at a certain vertical distance and rigidly connected thereto through interposed spacers or through interposed spacers defined by extensions of the longitudinal and/or transversal vertical ribs protruding through openings of the upper and/or lower horizontal layers. Said spacers will greatly increase the structural effect of the stiffener.

[0078] Preferably, each pillar includes at least one first seat for each building floor, and each horizontal structure is supported on said first seats through a second seat facing at least one first seat.

[0079] The first seats are defined as an upward facing surface, preferably a horizontal upwards facing surface.

[0080] Each first seat can protrude from the pillar, for example in the form of a capital or a corbel, and/or can be defined in a housing of the pillar, such a perimeter groove, a step, a carved niche or in an horizontal through hole of the pillar, or can be defined in a hollow interior of the pillar, for example when the pillar is formed by several vertical struts separated in the horizontal direction and rigidly connected to each other through spacers, creating a hollow interior within the pillar.

[0081] Each second seat can be defined on the lower horizontal layer of the horizontal structure or on downwardly exposed portions of the longitudinal and/or transversal vertical ribs.

[0082] Depending on the position of the first seats, said second seats can be adjacent to the vertical through hole, can be defined in a protrusion partially penetrating in said through holes in a horizontal direction or can be defined in bridge portions completely crossing the through hole, in one or two horizontal directions, creating several partial through holes, each housing one of said several vertical struts separated in the horizontal direction and rigidly connected to each other through spacers.

[0083] Those lower horizontal layer and/or longitudinal or transversal vertical ribs constitutive of the second seat are reinforced portions of the horizontal layer and/or longitudinal or transversal vertical ribs, because are on close proximity to one vertical through hole, and therefore are thicker and/or more load-resistant per square centimeter and/or closer to each other than in other regions of the horizontal structure.

[0084] Alternatively, each horizontal structure is supported on said first seats through a second seat defined on the elongated stiffener and/or on the annular stiffener described above.

[0085] According to an alternative embodiment of the present invention, the upper and/or lower layer is, or comprises, a continuous sheet of engineered wood, covering the entire horizontal structure, made of coplanar engineered wood boards, or several overlapped and structurally adhered layers of coplanar engineered wood boards, each engineered wood board constituting one of the engineered wood segments. In this case, when combined with the i-joists, the upper and lower flanges will be adhered to said continuous sheet of engineered wood, which will act as the additional engineered wood element providing structural continuity to the intersections between i-joists.

[0086] The present invention also proposes that each horizontal structure can be made of several independent prefabricated horizontal structure segments laterally connected to each other in a rigid manner through complementary coupling configurations structurally adhered together, each horizontal structure segment comprising:

an upper horizontal layer segment and a lower horizontal layer segment of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical rib segments of engineered wood elongated in the longitudinal and transversal horizontal directions;

the coupling configurations being placed at least in an outer perimeter of each upper and lower horizontal layer segments, providing a partial overlap between adjacent upper and lower horizontal layer segments.

[0087] According to that, each horizontal structural segment is a portion of the horizontal structure and includes coupling configurations on its perimeter. Said coupling configurations are defined in the edges of the upper and lower horizontal layers and are complementary to other coupling configurations of adjacent horizontal structure segments.

[0088] When connected, the coupling configurations of adjacent horizontal structure segments are partially overlapped, increasing the adhesion surface.

[0089] Thanks to this feature, the horizontal structure segments can be prefabricated in advance, transported to the building side, installed in their positions together with the pillars, and adhered to each other through the coupling configurations and structural adhesive applied therein. Once the structural adhesive is hardened, the horizontal structure is complete.

[0090] Preferably, during the hardening of the horizontal structure, the horizontal structure segments will be supported on provisional supports, such provisional props, which can be removed once the hardening is completed. Typically, the hardening time will be between 24-48 h.

[0091] Preferably, at least some of the horizontal structure segments will include at least one vertical through hole.

[0092] Optionally, the horizontal structure segments with vertical through holes can be produced with a prefabricated segment of the pillar inserted and structurally attached thereto.

[0093] The coupling configurations may comprise lap joints, stepped lab joint, double lap joint, strap joints, stepped strap joint, scarf joint, finger joint or a combination thereof.

[0094] In a lap joint, the coupling configurations of both board segments to be connected are overlapped.

[0095] In a stepped lap joint, the coupling configurations of both board segments to be connected are overlapped, each coupling configuration being defined by one or several stepped local thickness reductions of the board segment, for example halving the thickness on each coupling configuration, or by creating two or three stepped thickness reductions on each coupling configuration, so that when both coupling configurations are overlapped, the adjacent board segments are coplanar.

[0096] In a double lap joint one coupling configuration is inserted in a groove defined between two facing portions of the other coupling configuration.

[0097] In a strap joint a connector is simultaneously overlapped and structurally adhered to both adjacent board segments. Said connector can be overlapped to the board segments or can be flush with a surface thereof, inserted in a thickness reduction of both adjacent board segments. A stepped strap joint is similar to the strap joint, but the connector, and both adjacent board segments, having a stepped configuration.

[0098] In a scarf joint, two beveled edges of two adjacent board segments are connected and structurally adhered to each other.

[0099] In a finger joint the coupling configurations are tooth-shaped and interlinked and structurally adhered to each other.

[0100] A particular example of strap joint comprises elongated link elements made of engineered wood tightly inserted and adhered simultaneously in adjacent housings defined on edges of adjacent and coplanar upper and/or lower horizontal board segments.

[0101] The present invention also proposes to define a gap distance between the inner surfaces of each vertical through hole and the pillar inserted therein.

[0102] At least in some of the vertical through holes, the gap distance can be filled with hardened adhesive, providing a rigidly connection between the horizontal structure and the pillar.

[0103] At least in some of the vertical through holes, the gap distance can be an empty air gap, providing an articulated connection between the horizontal structure and the pillar.

[0104] Each pillar can be one single vertical strut of engineered wood made of several successive pillar segments rigidly connected through complementary adhered coupling configurations providing partial overlap between the successive pillar segments.

[0105] Alternatively, each pillar can include a plurality of parallel vertical struts made of engineered wood, rigidly connected to each other at a horizontal distance, the pillar being made of several successive pillar segments rigidly connected through complementary adhered coupling configurations providing partial overlap between the successive pillar segments. The horizontal distance can be a longitudinal horizontal distance and/or a transversal horizontal distance, increasing the inertia of the pillar without increasing its mass, and providing a hollow interior.

[0106] Preferably the first seat of the pillar is housed within said hollow interior and the second seat of the horizontal structure is housed within the vertical through hole of the horizontal structure and penetrates in said hollow interior.

[0107] In at least some portions of the horizontal structure, preferably in the central non-reinforced portions, the horizontal structure can further include a rigid lightweight material, such rigid foam, wood wool, rock wool, honeycomb cardboard or cork panel, preferably with thermal and/or acoustic insulant properties, selected to withstand shear loads between the upper and/or lower horizontal layers and structurally adhered thereto.

[0108] Said rigid lightweight material will constitute a light spacer and will reduce the number of longitudinal and transversal vertical ribs needed, especially in the central non-reinforced regions, reducing the weight of the horizontal structure, and also providing thermal and acoustic insolation between successive stories.

[0109] Also, at least some of the ribs may include light-weighting apertures, reducing the weight and also allowing the passage of mechanical installations.

[0110] The upper and/or lower layer of the horizontal structure may also include light-weighting apertures, preferably defined between the ribs. Those light-weighting apertures, typically placed on the lower layer, reduce the weight, and allows access to the mechanical installations.

[0111] Preferably, the light-weighting apertures decrease, in a gradual or stepped manner, with the proximity to the vertical through holes, it is to say, those light-weighting apertures are smaller and/or more spaced apart to each other the closer they are to the vertical through-holes. Preferably, no light-weighting apertures exist adjacent to the vertical through-holes, for example closer to 50cm from a vertical through-hole.

[0112] The upper and/or lower layer of the horizontal structure may include light-weighting apertures, preferably non-coincident with the longitudinal and transversal vertical ribs, to reduce the weight of the horizontal structure. Typically, those light-weighting apertures will be bigger in the central non-reinforced portion of the horizontal structure.

[0113] According to an embodiment of the present invention, each horizontal structure comprises i-joists made of engineered wood oriented in the longitudinal and in the transversal directions.

[0114] Each i-joist comprises an upper flange, a lower flange and a central web in-between. The central webs constitute said longitudinal and/or transversal vertical ribs of the horizontal structure and the upper and lower flanges will be an integral part of the upper and lower horizontal layers of the horizontal structure.

[0115] According to that, the i-joist are used as spacers between the upper and lower horizontal layers of the horizontal structure, using intersecting i-joist oriented in the longitudinal and transversal horizontal directions.

[0116] In this embodiment, the structural continuity in the longitudinal horizontal direction and in the transversal horizontal direction of the upper and/or lower horizontal layers will be provided by engineered wood segments structurally adhered to the upper and/or flanges of the longitudinal and transversal i-joists on the intersections between the upper and/or lower flanges, oriented in the longitudinal horizontal direction, and upper and/or lower flanges oriented in the transversal horizontal direction.

[0117] The upper and lower flanges of the i-joists can be integrated into the upper and/or lower horizontal layers by being structurally adhered thereto, the structural strength of the upper and/or lower horizontal layers being the result of the combined structural strengths of all the adhered elements, including the upper and lower flanges.

[0118] Alternatively, the upper and/or lower horizontal layers can be integrally constituted by the upper and/or lower flanges, in combination with additional engineered wood elements overlapped and structurally adhered to the intersections between the upper flanges oriented in the longitudinal and transversal horizontal directions and/or to the intersections between the lower flanges oriented in the longitudinal and transversal horizontal directions, providing structural continuity in the longitudinal and transversal directions and rigidity to said intersections through the additional engineered wood elements.

[0119] Typically, on each intersection one i-joist will be continuous and will interrupt an intersecting i-joist, preventing the structural continuity of its upper and lower flanges.

[0120] The additional engineered wood element or segments will be overlapped or embedded through stepped strap joints (recess staggered steps) and adhered to the interrupted upper and/or lower flanges, and also the interrupting upper and/or lower flange placed in between, providing structural continuity to the interrupted upper and/or lower flanges and a rigid linkage between the intersected i-joists, said engineered wood elements acting as link elements. A similar embodiment is proposed when both the longitudinal and transversal i-joists are interrupted in the intersection.

[0121] Preferably, the upper and lower flanges have fibers mainly oriented in the main direction of the upper and lower flange. It is also preferred that the additional engineered wood element has fibers mainly oriented in the main direction of the interrupted upper and/or lower flange adhered thereto.

[0122] The above-described embodiment, according to which the horizontal structure is composed of, or contains, intersecting i-joists, could be implemented irrespective of the essential features of the proposed invention and other optional features, in particular irrespective of whether the horizontal structure includes vertical through-holes, whether is supported on pillars or whether the horizontal structure comprises increasing reinforcements in proximity to the pillars. Therefore, this particular embodiment could be the subject of a divisional patent application.

[0123] Accordingly, said particular embodiment object of a potential divisional patent application would we a building structure comprising lineal horizontal supports, and one horizontal structure, made of engineered wood, for each building floor of the building structure, the horizontal structure being supported on said lineal horizontal supports.

[0124] The lineal horizontal supports can be, for example, walls or beams preferably extending in the longitudinal and/or transversal horizontal directions.

[0125] According to this particular embodiment, each horizontal structure will comprise longitudinal i-joists made of engineered wood oriented in a longitudinal horizontal direction, and transversal i-joists made of engineered wood oriented in a transversal horizontal direction, each longitudinal and transversal i-joist comprising an upper flange, a lower flange vertically separated and rigidly connected through a central web placed in-between, the central web and the upper flanges and/or the lower flanges of the longitudinal and transversal i-joists intersecting each other, interrupting its continuity.

[0126] The horizontal structure will further comprise engineered wood segments structurally adhered to the upper and lower flanges, on all the intersections between longitudinal and transversal i-joists, providing structural continuity to the upper and lower flanges at least in the longitudinal and transversal horizontal directions across the entire horizontal structure, defining a continuous building floor.

[0127] Said engineered wood segments can be overlapped to the upper and/or lower flanges on the intersections or can be partially or completely embedded in recesses of the upper and/or lower flanges of the longitudinal and transversal i-joists.

[0128] Optionally, web connectors, preferably made of engineered wood, can be structurally adhered to the central webs of the longitudinal and transversal i-joists, on at least some of the intersections between longitudinal and transversal i-joists, providing structural continuity to the central webs at least in the longitudinal and transversal horizontal directions.

[0129] The horizontal structure of this particular embodiment will be preferably supported on several lineal horizontal supports, some of said lineal horizontal supports being central lineal horizontal supports supporting non-peripheric regions of the horizontal structure spaced apart from the perimeter thereof. According to that, the horizontal structure is supported on the lineal horizontal supports in non-peripheric regions, the horizontal structure passing uninterrupted above the central lineal horizontal supports.

[0130] The engineered wood segments connecting the intersecting upper and/or lower flanges of this particular embodiment, can be portions of an upper horizontal layer and/or of a lower horizontal layer, the engineered wood portions being structurally adhered together providing structural continuity to the upper horizontal layer and/or to the lower horizontal layer at least in the longitudinal and transversal horizontal directions across the entire horizontal structure.

[0131] Preferably, the upper and/or lower flanges are structurally adhered to the upper and/or lower horizontal layers along its longitude, in which case the upper and/or lower flanges will be an integral part of the upper and lower horizontal layers.

[0132] Optionally, the horizontal structure of the particular embodiment can include at least some elongated reinforced portions, overlapped on one of said lineal horizontal supports and elongated in a direction parallel to said lineal horizontal support. On each elongated reinforced portion:

> the thickness and/or the load-resistance per square centimeter of the upper and/or lower flanges or horizontal layers is bigger than the thickness and/or the load-resistance per square centimeter of the upper and/or lower flanges or horizontal layers in other portions of the horizontal structure different to the elongated reinforced portions; and/or
>
> the thickness and/or the load-resistance per square centimeter, and/or the proximity between central ribs of longitudinal or transversal i-joists, perpendicular to the main longitude of the elongated reinforced portion where they are contained, is bigger than the thickness and/or the load-resistance per square centimeter and/or the proximity between central ribs of longitudinal or transversal i-joists contained in other portions of the horizontal structure different to the elongated reinforced portions.

[0133] The lineal horizontal supports of successive floors of the building structure will be connected to each other, for example through pillars or vertical struts crossing the horizontal structure through vertical through holes.

[0134] The above particular embodiment can be also combined with other features of the present invention.

[0135] It will be understood that references to geometric position, such as parallel, perpendicular, tangent, etc. allow deviations up to $\pm$ 5° from the theoretical position defined by this nomenclature.

[0136] Other features of the invention appear from the following detailed description of an embodiment.

Brief description of the Figures

[0137] The foregoing and other advantages and features will be more fully understood from the following detailed description of an embodiment with reference to the accompanying drawings, to be taken in an illustrative and non-limitative manner, in which:

Fig. 1 shows a schematic perspective view of the building structure, according to a first embodiment of the present invention, where in seek of clarity the upper and lower layers have not been shown;

Fig. 2 shows a schematic perspective view of the building structure according to a second embodiment of the present invention, where a portion of the upper and lower layers has been not shown in seek of clarity;

Fig. 3 shows a schematic perspective view of the building structure according to a third embodiment of the present invention, where a portion of the upper and lower layers has been not shown in seek of clarity;

Fig. 4 shows a schematic perspective exploded view of the building structure according to a fourth embodiment of the present invention in which the horizontal structure is formed by several horizontal structure segments connected through coupling configurations, this figure further includes a zoomed views of two adjacent horizontal structure segments decoupled (left view) and coupled (right view);

Fig. 5A shows a schematic perspective view of the connection between intersecting upper and lower flanges of longitudinal and transversal i-joists according to a fifth embodiment;

Fig. 5B shows a schematic perspective view of the fifth embodiment shown in Fig. 5A, further including an upper horizontal layer attached to the upper flanges;

Fig. 6A shows a schematic perspective view of the connection between intersecting upper and lower flanges of longitudinal and transversal i-joists according to a sixth embodiment;

Fig. 6B shows a schematic perspective view of the sixth embodiment shown in Fig. 6A, further including an upper horizontal layer attached to the upper flanges;

Fig. 7 shows a schematic perspective view of the connection between intersecting central webs of longitudinal and transversal i-joists according to a seventh embodiment.

[0138] In these drawings, the areas where the adhesive is applied are indicated with a hatch.

Detailed description of an embodiment

[0139] The foregoing and other advantages and features will be more fully understood from the following detailed description of an embodiment with reference to the accompanying drawings, to be taken in an illustrative and not limitative way.

[0140] The proposed multi-floor building structure comprises a plurality of vertical pillars 1, and one horizontal structure 5 made of engineered wood for each building floor of the building.

[0141] Each horizontal structure 5 includes a plurality of vertical through holes 3, with one pillar inserted on each vertical through-hole.

[0142] Each pillar 1 includes at least one first seat 2 for each building floor, where one horizontal structure 5 is supported through a second seat included in said horizontal structure 5.

[0143] In Figs. 1, 2 and 4 each pillar is a vertical strut of engineered wood with a protruding capital, defining a perimetral step as a first seat 1, for each building floor.

[0144] In Fig. 3 each pillar is a plurality of vertical struts separated in the horizontal direction and rigidly connected to each other, defining a hollow pillar 1 with the first seat 2 contained therein.

[0145] Each horizontal structure 5 comprises an upper horizontal layer 10 and a lower horizontal layer 20 of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical ribs 31, 32 of engineered wood elongated in longitudinal and transversal horizontal directions LD, TD.

[0146] The upper and lower horizontal layers 10, 20 are made of engineered wood segments structurally adhered together providing structural continuity at least in the longitudinal and transversal horizontal directions across the entire horizontal structure.

[0147] In the example shown in Fig. 2 both upper and lower horizontal layers 10, 20 are continuous layers of engineered wood covering the entire surface of the horizontal structure 5.

[0148] In the example shown in Fig. 3 the upper horizontal layer 10 is a continuous layer of engineered wood covering the entire surface of the horizontal structure 5, but the lower horizontal layer 20 is defined by a grid of intersecting lower longitudinal and transversal flanges of the longitudinal and transversal i-joists, said longitudinal and transversal flanges being connected to each other in the intersections through engineered wood segments adhered thereto overlapping the intersections, the lower horizontal layer 20 including light-weighting apertures between the flanges.

[0149] The horizontal structure is non-uniform, optimizing the resistance and the weight on different regions thereof depending on the requirements, increasing the resistance of the horizontal structure 5 on proximity to the pillars 1, where loads are concentrated, and reducing weight on other regions of the horizontal structure 5.

[0150] Said optimization can be obtained, for example as shown in Figs. 1, 2 and 3, by a gradual or stepped increase, with the proximity to the vertical through holes 3, in the thickness and/or the load-resistance per square centimeter of successive longitudinal vertical ribs 31 and of successive transversal vertical ribs 32.

[0151] The increase in thickness can be obtained, for example, by laterally adhering multiple vertical ribs or by using thicker engineered wood segments in certain areas.

[0152] The increase in the load-resistance per square centimeter is typically obtained by using more resistant engineered wood as engineered wood segments constitutive of the vertical ribs in certain areas, or by laterally adhering additional vertical ribs of a more resistant engineered wood in certain areas, obtaining an increase in thickness and an increase in the load-resistance per square centimeter in said areas.

[0153] As shown in Figs. 1 and 2, the longitudinal and transversal vertical ribs 31, 32, surrounding each vertical through hole and tangent to the pillar 1, are thicker than in other areas, said thickening extending in the longitudinal and transversal directions from the vertical through-hole in a surrounding area close to the vertical through-hole, for example less than 1 meter.

[0154] Additionally, or alternatively, the reinforcement of the vertical ribs can be obtained by a gradual or stepped increase, with the proximity to the vertical through holes 3, in the, the proximity between successive longitudinal vertical ribs 31 and between successive transversal vertical ribs 32.

[0155] In the examples shown in Figs. 1, 2 and 3, the distance between longitudinal vertical ribs 31 is smaller as closer is a particular longitudinal vertical rib 31 to a longitudinal succession of vertical through holes 3 aligned in the longitudinal horizontal direction LD.

[0156] Similarly, the distance between transversal vertical ribs 32 is smaller as closer is a particular transversal vertical rib 32 to a transversal succession of vertical through holes 3 aligned in the transversal horizontal direction TD.

[0157] The optimization in the resistance and weight of the horizontal structure 5 can be also obtained by a gradual or stepped increase, with the proximity to the vertical through holes 3, in the thickness and/or in the load-resistance per square centimeter of the upper and/or lower horizontal layers 10, 20.

[0158] According to one embodiment of the present invention, the horizontal structure 5 is reinforced not only around the vertical through-holes, in an annular reinforced portion 50, but it can include certain reinforcement in at least some elongated reinforced portions 40.

[0159] Each elongated reinforced portion 40 will be elongated in the longitudinal or transversal horizontal directions LD, TD and will comprise one aligned succession of aligned vertical through holes 3.

[0160] To obtain said reinforcement, in said elongated reinforced portion 40, the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers 10, 20 will be bigger than the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers 10, 20 in other portions of the horizontal structure 5 different to the elongated reinforced portions 40.

[0161] Additionally or alternatively, the thickness and/or the load-resistance per square centimeter of the longitudinal or transversal vertical ribs 31, 32, parallel to the main longitude of the elongated reinforced portion 40 where they are contained, is bigger than the thickness and/or the load-resistance per square centimeter of the longitudinal or transversal vertical ribs 31, 32 contained in other portions of the horizontal structure 5 different to the elongated reinforced portions 40, typically the non-reinforced central portions of the horizontal structure 5 surrounded by longitudinal and transversal reinforced portions.

[0162] It is also proposed that the proximity between the longitudinal or transversal vertical ribs 31, 32, parallel to the main longitude of the elongated reinforced portion 40 where they are contained, is bigger than the proximity between the longitudinal or transversal vertical ribs 31, 32 contained in other portions of the horizontal structure 5 different to the elongated reinforced portions 40.

[0163] In this regard, Figs. 1, 2 and 3 show an horizontal structure where the longitudinal vertical ribs 31 extending between vertical through-holes aligned in the longitudinal direction LD, contained in the elongated reinforced portion 40, are closer than the longitudinal vertical ribs 31 not contained in the elongated reinforced portion 40.

[0164] According to the first embodiment shown in Fig. 1, the upper layer 10 has three different thicknesses.

[0165] The thinnest thickness is in the central non-reinforced portions of the horizontal structure 5 distant from all the vertical through holes 3, the thickest thickness is defined in the upper layer 10 comprised in collar reinforced portions 50, around each vertical through-hole, and an intermediate thickness is defined in the upper layer 10 comprised in elongated reinforced portions 40 of the horizontal structure 5.

[0166] Each elongated reinforced portion 40 is elongated in the longitudinal or transversal horizontal direction LD, TD and comprises one aligned succession of aligned vertical through holes 3, and each non-reinforced portion is completely surrounded by elongated reinforced portions 40 and lacks vertical through-holes.

[0167] Said thickness increases can be produced outwards, increasing the overall thickness of the horizontal structure 5, or inwards, maintaining the external surfaces of the horizontal structure 5 flat.

[0168] The same reinforcement described in regard to the upper layer 10 con be implemented in the lower layer 20.

[0169] In this example the intermediate thickness is approximately double than the thinnest thickness, and the thickest thickness is at least triple than the thinnest thickness.

[0170] According to one embodiment, the horizontal structure 5 can include longitudinal and transversal i-joists 60, each comprising an upper flange 61, a lower flange 62 and a central web 63 in between.

[0171] In this case, the central web 63 acts as the longitudinal and transversal vertical ribs 31, 32 of the horizontal structure 5, and the upper and lower flanges 61, 62 are, or are integrated in, the upper and lower layers 10, 20 of the horizontal structure 5.

[0172] According to that, the optimization above described can be obtained, for example as shown in Fig. 3, by reducing the distance between the longitudinal and transversal i-joists 60, with its proximity to a vertical through-hole.

[0173] In the examples shown in Fig. 3, the distance between central webs 63 of longitudinal i-joists 60 is smaller as closer is a particular i-joist 60 to a longitudinal succession of vertical through holes 3 aligned in the longitudinal horizontal direction LD.

[0174] Similarly, the distance between central webs 63 of transversal i-joists 60 is smaller as closer is a particular i-joist 60 to a transversal succession of vertical through holes 3 aligned in the transversal horizontal direction TD.

[0175] The intersection between longitudinal and transversal i-joists 60 produces an interruption of the structural continuity of the upper flanges 61, of the lower flanges 62 and/or of the central webs 63. Those interrupted upper and lower flanges 61, 62 are reconnected by structurally adhering an engineered wood segment or element, acting as a link element, over each intersection, connecting the convergent upper flanges 61 and lower flanges 62 of the longitudinal and transversal i-joists 60.

[0176] In the embodiment shown in Fig. 3, the upper and lower layers 10, 20 covers the entire horizontal structure 5, also covering the intersections between the upper flanges 61 and lower flanges 62. The structural adhesion of the upper and lower layers 10, 20 to the upper and lower flanges 61, 62 restores the structural continuity between the intersected upper and lower flanges 61, 62 in the longitudinal and transversal horizontal directions LD, TD.

[0177] Figs. 5A and 6A sown alternative embodiments of this engineered wood segments adhered to the upper and lower flanges 61, 62. In this case those engineered wood segments are one independent engineered wood segment for each i-joist 60 intersection. Said engineered wood segment can be a linear strip of engineered wood connecting two aligned and interrupted segments of the upper or lower flange 61, 62, or can be a cross-shaped engineered wood segment connecting all the upper or lower flanges 61, 62 converging on the same intersection.

[0178] Said cross-shaped engineered wood segment can be substituted, for example, by a square engineered wood segment where said cross-shape can be inscribed.

[0179] In Fig. 5A the engineered wood segment is overlapped to the upper and lower flanges 61, 62, while in Fig. 6A the upper and lower flanges include a recess where said engineered wood segments are housed, resulting in the engineered wood segment being flush with the upper and lower flange 61, 62.

[0180] In Fig. 5B and 6B an alternative embodiment is shown where, in addition to the engineered wood segment shown in Figs. 5A and 6A, additional engineered wood segments are included, covering the upper flanges 61 with the engineered wood segments adhered to their intersections, and covering the lower flanges 62 and the engineered wood segments adhered to their intersections, creating a continuous upper horizontal layer 10 and a continuous lower horizontal layer 20.

[0181] In the embodiment shown in Fig. 5B the continuous upper and lower horizontal layer includes recesses to house the engineered wood segments adhered on the intersections between upper and lower flanges 61, 62.

[0182] The central webs 63 of the intersecting longitudinal and transversal i-joists 60 can be also connected through link elements, preferably made of engineered wood, adhered to the interrupted central webs and/or to the central webs convergent on an intersection region between longitudinal and transversal i-joists 60, as shown in Fig. 7. Said link element can connect two central web coplanar portions through a strut passing across the interposed central web or can adhere to perpendicular central webs to each other.

[0183] As shown in Fig. 2, the horizontal structure 5 can include an elongated stiffener 41 made of engineered wood. Said elongated stiffener 41 will be contained in one elongated reinforced portion 40 of the horizontal structure 5.

[0184] The elongated reinforced portion 40 will be a region of the horizontal structure 5 elongated in the longitudinal or transversal horizontal direction LD, TD and will comprise one aligned succession of aligned vertical through holes 3.

[0185] The elongated stiffener 41 is made of engineered wood and protrudes upwards and/or downwards from the horizontal structure 5 and extends in the main longitude of the elongated reinforced portion 40. The elongated stiffener 41 is rigidly and structurally connected to the horizontal structure 5, providing an increase in its structural resistance.

[0186] In the example shown in Fig. 2 the elongated reinforce portion 40 extends in the longitudinal horizontal direction LD, and the elongated stiffener 41 also extends in said direction protruding downwardly from the lower layer 20, extending between consecutive vertical through-holes contained in the elongated reinforced portion 40.

[0187] In this example, the elongated stiffener 41 is separated from the horizontal structure 5 at a certain vertical distance and rigidly connected thereto through interposed spacers. In this case, the interposed spacers are defined by extensions of the longitudinal vertical ribs 31 protruding through openings of the lower horizontal layer 20.

[0188] Alternatively, the elongated stiffeners 41 can be one or two symmetric elongated stiffeners 41 tangent to the vertical through-holes and can extend continuously along the elongated reinforced portion 40.

[0189] Optionally, in at least some collar reinforced portions 50 surrounding one vertical through hole, an annular stiffener made of engineered wood can be included. Said annular stiffener will protrude upwards and/or downwards from the horizontal structure 5 surrounding the vertical through hole and will be rigidly and structurally connected to the horizontal structure 5, optionally at a certain vertical distance through interposed spacers such those described in regard to the longitudinal stiffener 41.

[0190] The horizontal structure 5 can be made of several independent prefabricated horizontal structure segments 6 laterally connected to each other in a rigid manner through complementary coupling configurations 70 structurally adhered together, as shown in Fig. 4.

[0191] Each horizontal structure segment 6 comprises an upper horizontal layer segment 11 and a lower horizontal layer segment 21 of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical rib segments 33, 34 of engineered wood elongated in the longitudinal and transversal horizontal directions LD, TD.

[0192] The coupling configurations 70, connecting the horizontal structure segments 6, are placed at least in an outer perimeter of each upper and lower horizontal layer segments 11, 21, providing a partial overlap between adjacent upper and lower horizontal layer segments 11, 21.

[0193] Once all the upper horizontal layer segments 11, 21 have been structurally connected through the coupling configurations 70, they constitute the upper and lower layers 10, 20 and ensure the transmission of longitudinal and transversal horizontal loads though the upper and lower layers 10, 20.

[0194] In this example shown in Fig. 4 the longitudinal and transversal vertical rib segments 33, 34 are central webs of longitudinal and transversal i-joist segments.

[0195] According to the example shown in Fig. 4, the horizontal structure 5 comprises several first horizontal structure segments 6, each with one vertical through hole 3 in a central region thereof, several second horizontal structure segments 6 each comprised between two first horizontal structure segments 6 and supported thereon through the coupling configurations 70, and several third horizontal structure segments 6 surrounded by, and supported between, several second horizontal structure segments 6.

[0196] In this example, the coupling configurations 70 of the first horizontal structure segments 6 comprises a stepped configuration in the perimeter of the lower horizontal layer segment 21, which extends in cantilever from the edge of the first horizontal structure segment 6, providing a support for the second horizontal structure segment 6, and a stepped configuration in the perimeter of the upper horizontal layer segment 11, which is retracted from the edge of the first horizontal structure segment 6. The coupling configuration 70 in the second horizontal structure segments 6 is inverse, with a stepped configuration and with an upper horizontal layer segment 11 extending in cantilever on opposed ends and with a lower horizontal layer segment 21 retracted on opposed ends.

[0197] Also, the coupling configurations 70 between the second and third horizontal structure segments 6 follow the same logic. According to that, the first horizontal structure segments 6 can be placed in place first, then the second horizontal structure segments 6 can be placed in between, by a downward movement, coupling the correspondent coupling configurations 70, which will be attached by structural adhesives, and later the third horizontal structure segments 6 can be placed between the second horizontal structure segments 6 by a downward movement, coupling the correspondent coupling configurations 70 by structural adhesives.

[0198] The coupling configurations 70, as described above, one with upwards facing exposed surfaces and the complementary coupling configuration 70 having downwards facing exposed surfaces, provide temporary support for the assembly between the horizontal structure segments while the structural adhesive hardens.

[0199] The end of the vertical rib segments is preferably placed between the edge of the upper horizontal layer segment 11 and the edge of the lower horizontal layer segment 21.

Claims

1. A multi-floor building structure comprising pillars (1), and one horizontal structure (5), made of engineered wood, for each building floor of the building supported on said pillars (1), each horizontal structure (5) including vertical through holes (3) for inserting the pillars (1) therethrough, wherein

   each horizontal structure (5) comprises an upper horizontal layer (10) and a lower horizontal layer (20) of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical ribs (31, 32) of engineered wood elongated in longitudinal and transversal horizontal directions (LD, TD);

   characterized in that

   the upper and lower horizontal layers (10, 20) are made of engineered wood segments structurally adhered together providing structural continuity at least in the longitudinal and transversal horizontal directions (LD, TD) across the entire horizontal structure (5); and

   the thickness and/or the load-resistance per square centimeter of the upper and/or lower hor-

izontal layers (10, 20) increases, in a gradual or stepped manner, with the proximity to the vertical through holes (3); and/or
the thickness, the load-resistance per square centimeter and/or the proximity between successive longitudinal vertical ribs (31) and successive transversal vertical ribs (32) increases, in a gradual or stepped manner, with the proximity to the vertical through holes (3).

2. The multi-floor building structure according to claim 1 wherein the vertical through holes (3) comprises several longitudinal successions of vertical through holes (3) aligned in the longitudinal horizontal direction (LD), and several transversal successions of vertical through holes (3) aligned in the transversal horizontal direction (TD), defining an array of vertical through holes (3).

3. The multi-floor building structure according to claim 1 or 2 wherein:

the engineered wood segments, constitutive of the upper and lower horizontal layers (10, 20), comprises wood fibers oriented mostly in the longitudinal horizontal direction (LD) and in the transversal horizontal direction (TD); and/or
the longitudinal vertical ribs (31) are made of rib segments of engineered wood comprising wood fibers mostly oriented in the longitudinal horizontal direction (LD) and the transversal vertical ribs are made of rib segments of engineered wood comprising wood fibers mostly oriented in the transversal horizontal direction (TD).

4. The multi-floor building structure according to claim 1, 2 or 3, wherein in at least some elongated reinforced portions (40) of each horizontal structure, elongated in the longitudinal or transversal horizontal direction (LD, TD) and comprising one aligned succession of aligned vertical through holes (3):

the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers (10, 20) is bigger than the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers (10, 20) in other portions of the horizontal structure (5) different to the elongated reinforced portions (40); and/or
the thickness and/or the load-resistance per square centimeter, and/or the proximity between longitudinal or transversal vertical ribs (31, 32), parallel to the main longitude of the elongated reinforced portion (40) where they are contained, is bigger than the thickness and/or the load-resistance per square centimeter and/or the proximity between the longitudinal or transversal vertical ribs (31, 32) contained in other portions of the horizontal structure (5) different to the elongated reinforced portions (40).

5. The multi-floor building structure according to any preceding claim wherein in at least some collar reinforced portions (50) of each horizontal structure (5), each surrounding one vertical through hole:

the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers (10, 20) is bigger than the thickness and/or the load-resistance per square centimeter of the upper and/or lower horizontal layers (10, 20) in other portions of the horizontal structure (5) different to the collar reinforced portions (50); and/or
the thickness and/or the load-resistance per square centimeter and/or the proximity between, longitudinal or transversal vertical ribs (31, 32) is bigger than the thickness and/or the load-resistance per square centimeter and/or the proximity between the longitudinal and transversal vertical ribs (31, 32) contained in other portions of the horizontal structure (5) different to the collar reinforced portions (50).

6. The multi-floor building structure according to any preceding claim wherein

in at least some elongated reinforced portions (40) of each horizontal structure (5), elongated in the longitudinal or transversal horizontal direction (LD, TD) and comprising one aligned succession of aligned vertical through holes (3), an elongated stiffener (41) made of engineered wood protrudes upwards and/or downwards from the horizontal structure (5) extending in the main longitude of the elongated reinforced portion (40), the elongated stiffener (41) being rigidly and structurally connected to the horizontal structure (5); and/or
in at least some collar reinforced portions (50) of each horizontal structure (5), each surrounding one vertical through hole, an annular stiffener made of engineered wood protrudes upwards and/or downwards from the horizontal structure (5) surrounding the vertical through hole, the annular stiffener being rigidly and structurally connected to the horizontal structure (5).

7. The multi-floor building structure according to claim 6 wherein the elongated stiffener (41) and/or the annular stiffener is/are separated from the horizontal structure (5) at a certain vertical distance and rigidly connected thereto through interposed spacers or through interposed spacers defined by extensions of the longitudinal and/or transversal vertical ribs (31,

32) protruding through openings of the upper and/or lower horizontal layers (10, 20).

8. The multi-floor building structure according to any preceding claim wherein each pillar (1) includes at least one first seat (2) for each building floor, and each horizontal structure (5) is supported on said first seats (2) through a second seat facing at least one first seat (2), wherein

each first seat (2) protrudes from the pillar (1) and/or is defined in a housing or in a hollow interior of the pillar (1), and wherein
each second seat is defined on the lower horizontal layer (20) or on a downwardly exposed portions of the longitudinal and/or transversal vertical ribs (31, 32).

9. The multi-floor building structure according to claim 6 or 7 wherein each pillar (5) includes at least one first seat (2) for each building floor, and each horizontal structure (5) is supported on said first seats (2) through a second seat defined on the elongated stiffener (41) and/or on the annular stiffener.

10. The multi-floor building structure according to any preceding claim wherein each horizontal structure (5) comprises i-joists (60) made of engineered wood oriented in the longitudinal and in the transversal horizontal directions (LD, TD), each comprising an upper flange (61), a lower flange (62) and a central web (63) in-between, wherein the central webs (63) constitute said longitudinal and/or transversal vertical ribs (31, 32) and wherein the upper and lower flanges (61, 62) are an integral part of the upper and lower horizontal layers (10, 20), and the structural continuity in the longitudinal horizontal direction (LD) and in the transversal horizontal direction (TD) of the upper and/or lower horizontal layers (10, 20) is provided by engineered wood segments structurally adhered to the upper and/or lower flanges (61, 62), on the intersections between the upper and/or lower flanges (61, 62), oriented in the longitudinal horizontal direction (LD), and the upper and/or lower flanges (61, 62) oriented in the transversal horizontal direction (TD).

11. The multi-floor building structure according to any preceding claim wherein the upper and/or lower layer (10, 20) is, or comprises, a continuous sheet of engineered wood, covering the entire horizontal structure (5), made of coplanar engineered wood boards, or several overlapped and structurally adhered layers of coplanar engineered wood boards, each engineered wood board constituting one of the engineered wood segments.

12. The multi-floor building structure according to any preceding claim wherein each horizontal structure (5) is made of several independent prefabricated horizontal structure segments (6) laterally connected to each other in a rigid manner through complementary coupling configurations (70) structurally adhered together, each horizontal structure segment (6) comprising:

an upper horizontal layer segment (11) and a lower horizontal layer segment (21) of engineered wood facing each other, and vertically separated and rigidly connected through an array of intersected longitudinal and transversal vertical rib segments (33, 34) of engineered wood elongated in the longitudinal and transversal horizontal directions (LD, TD);
the coupling configurations (70) being placed at least in an outer perimeter of each upper and lower horizontal layer segments (11, 21), providing a partial overlap between adjacent upper and lower horizontal layer segments (11, 21).

13. The multi-floor building structure according to any preceding claim wherein each vertical through hole define a gap distance between inner surfaces thereof and the pillar inserted therein, and wherein

at least in some of the vertical through holes (3), the gap distance is filled with hardened adhesive, providing a rigidly connection between the horizontal structure and the pillar; and/or
at least in some of the vertical through holes (3), the gap distance is an empty air gap, providing an articulated connection between the horizontal structure and the pillar.

14. The multi-floor building structure according to any preceding claim wherein each pillar (1) is:

one single vertical strut of engineered wood made of several successive pillar segments rigidly connected through complementary adhered coupling configurations providing partial overlap between the successive pillar segments; or
a plurality of parallel vertical struts made of engineered wood, rigidly connected to each other at a horizontal distance, the pillar being made of several successive pillar segments rigidly connected through complementary adhered coupling configurations providing partial overlap between the successive pillar segments.

15. The multi-floor building structure according to any preceding claim wherein in at least some portions of the horizontal structure (5) the horizontal structure further includes a rigid lightweight material, selected among rigid foam, wood wool, rock wool, honeycomb cardboard or cork panel and selected to withstand shear loads, structurally adhered to the upper and/or lower horizontal layers (10, 20).

16. The multi-floor building structure according to any preceding claim wherein:

at least some of the longitudinal and/or transversal vertical ribs (31, 32) include light-weighting apertures and/or the upper and/or lower horizontal layers (10, 20) of the horizontal structure (5) include light-weighting apertures or light-weighting apertures defined between the longitudinal and transversal vertical ribs (31, 32); or
at least some of the longitudinal and/or transversal vertical ribs (31, 32) include light-weighting apertures and/or the upper and/or lower horizontal layer (10, 20) of the horizontal structure (5) include light-weighting apertures or light-weighting apertures defined between the longitudinal and/or transversal vertical ribs (31, 32), wherein the light-weighting apertures decrease, in a gradual or stepped manner, with the proximity to the vertical through holes (3).

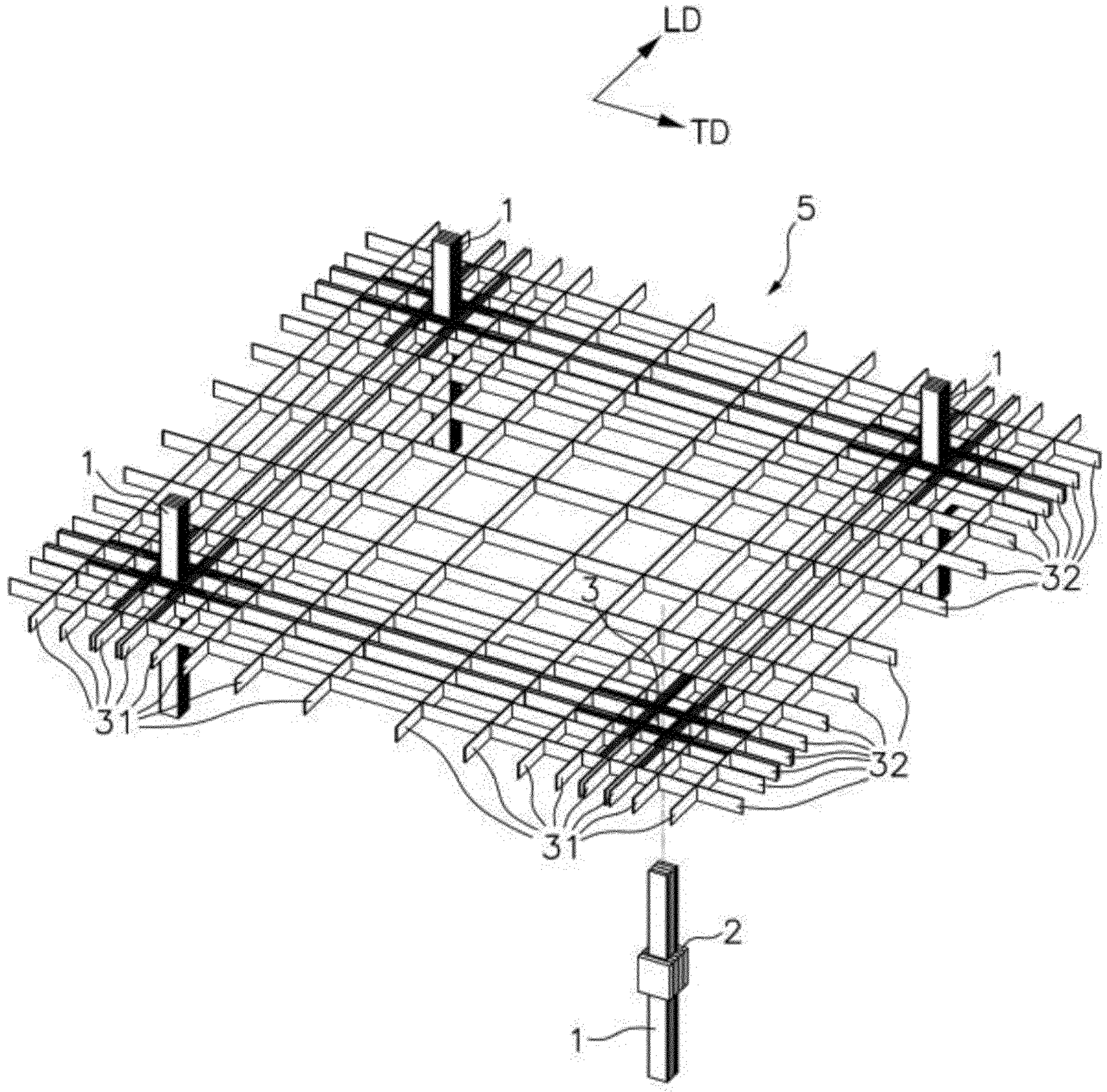

Fig.1

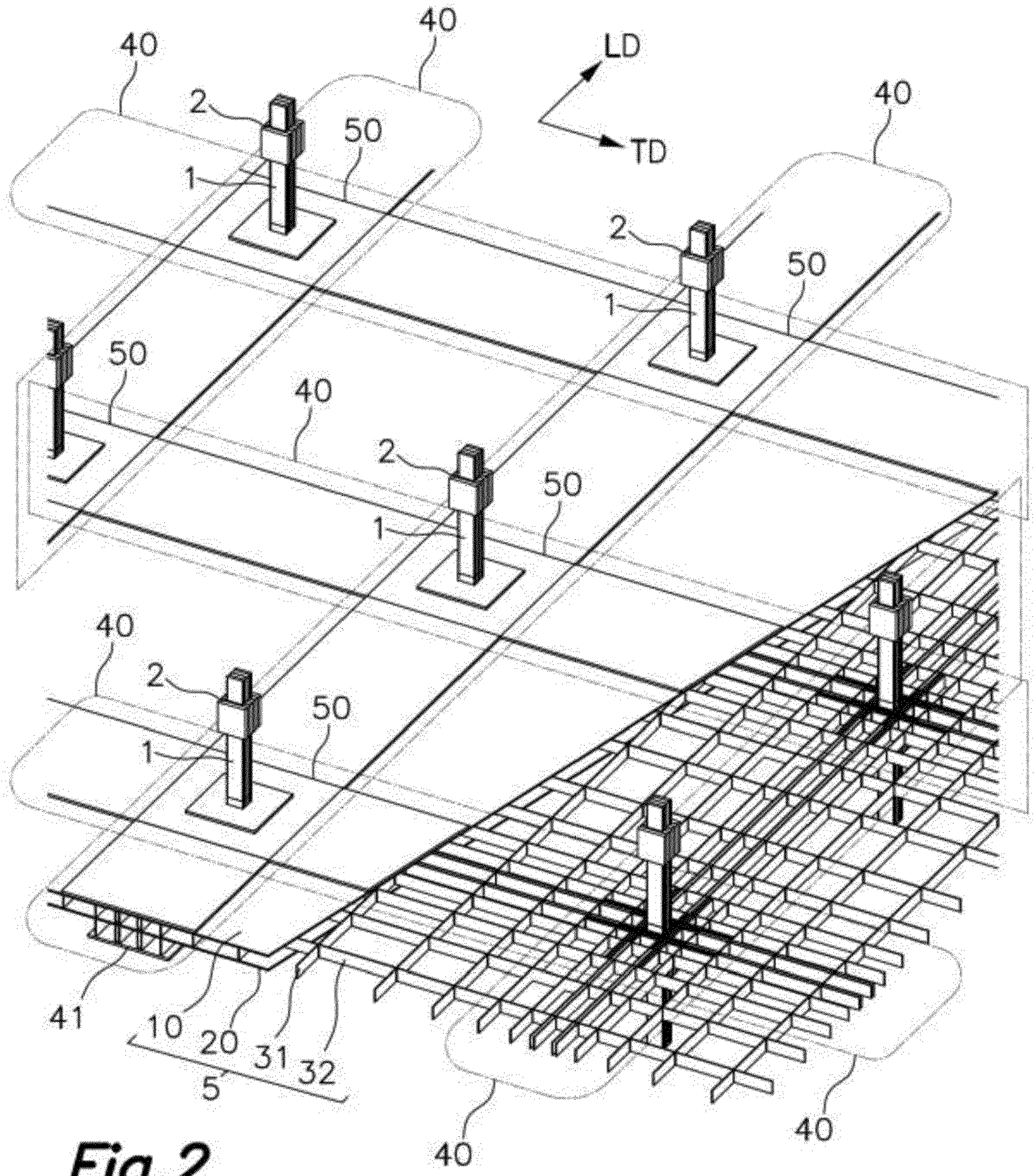
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Fig.2

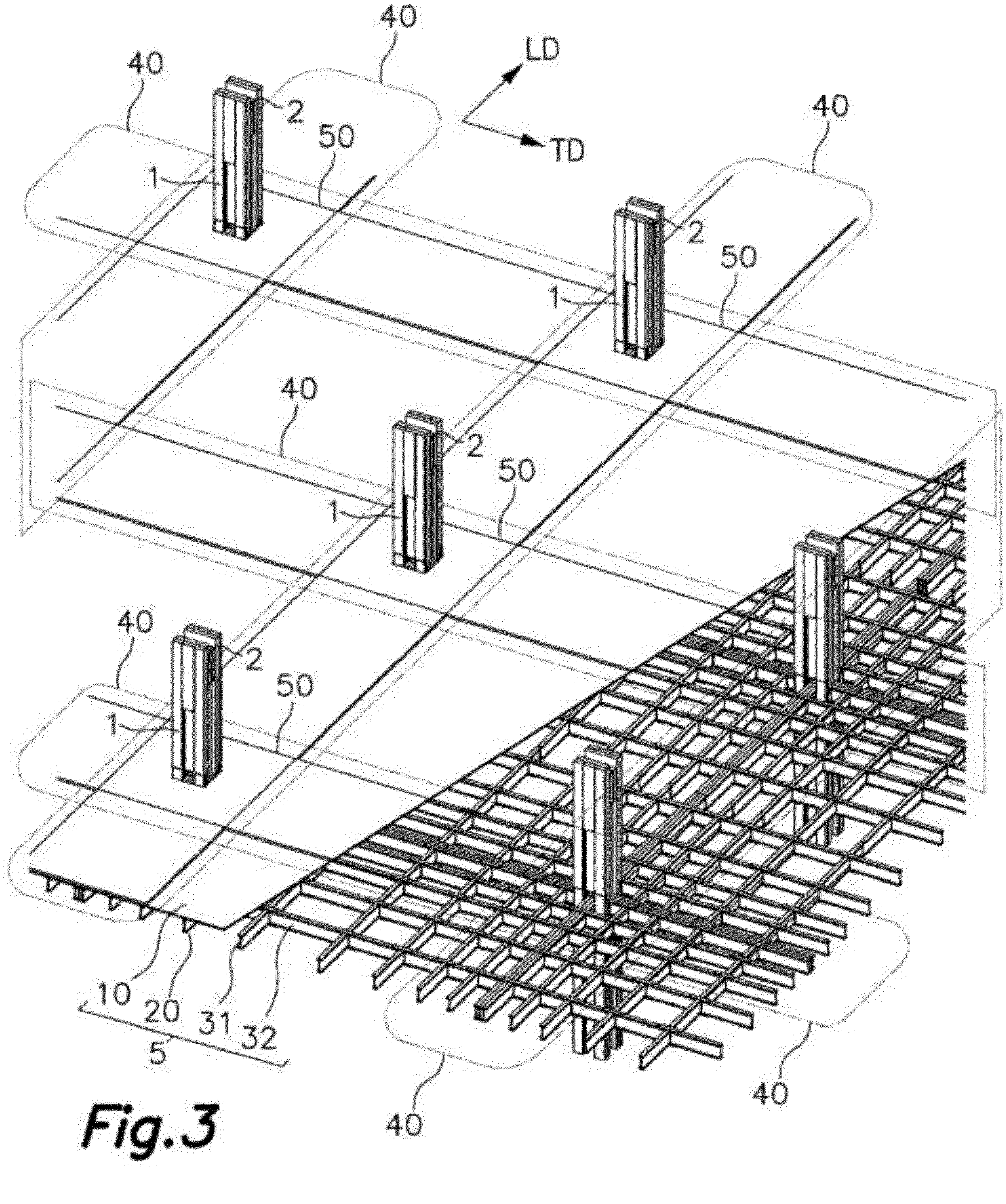

Fig.3

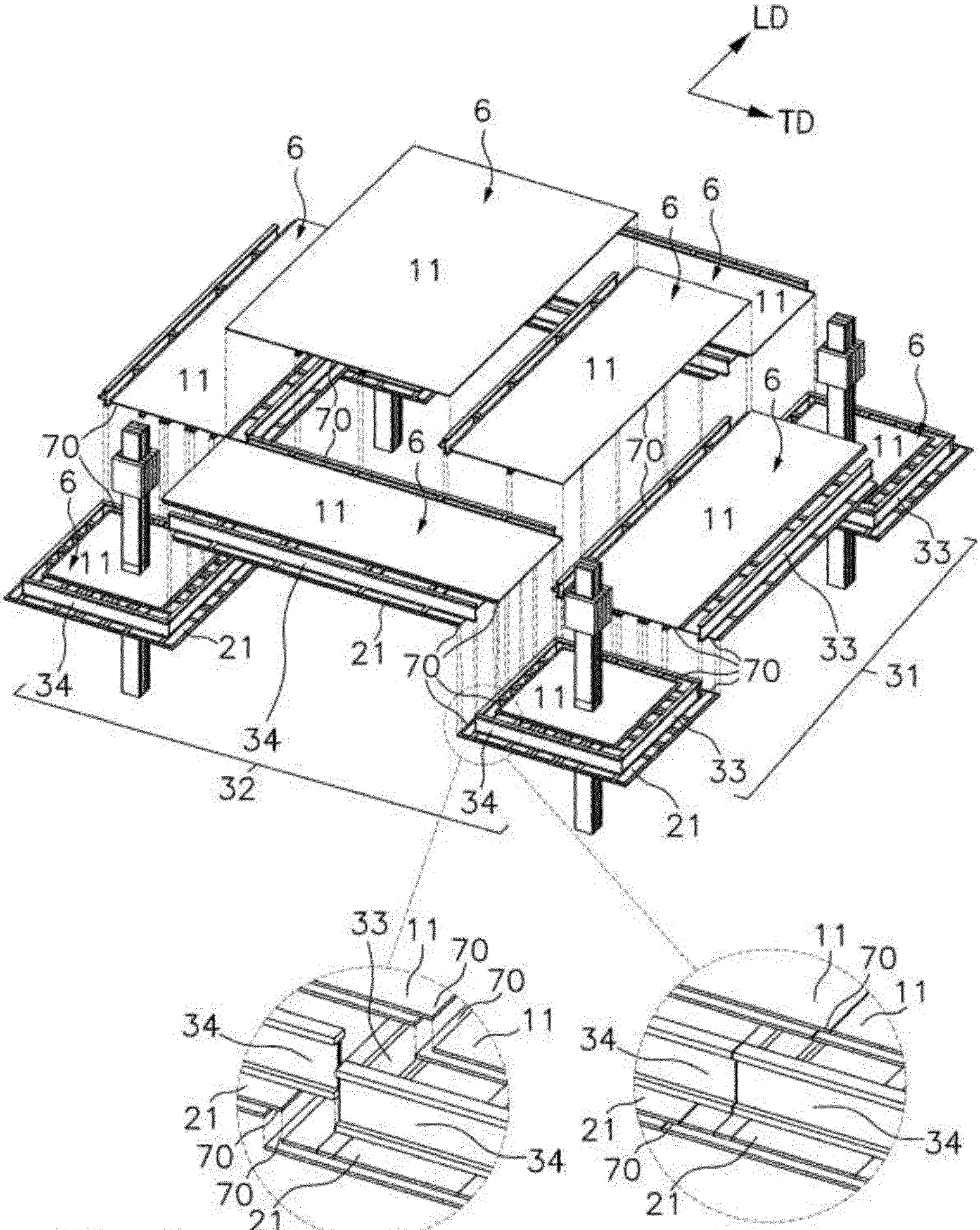
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Fig.4

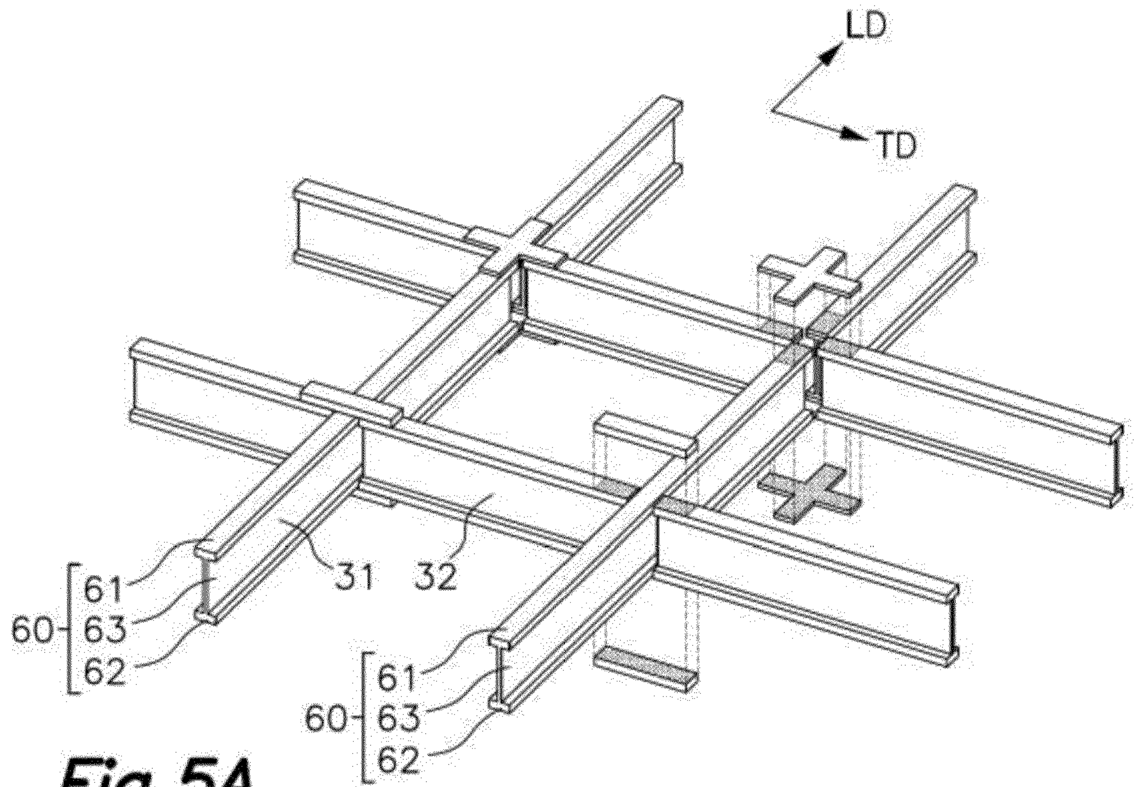

Fig.5A

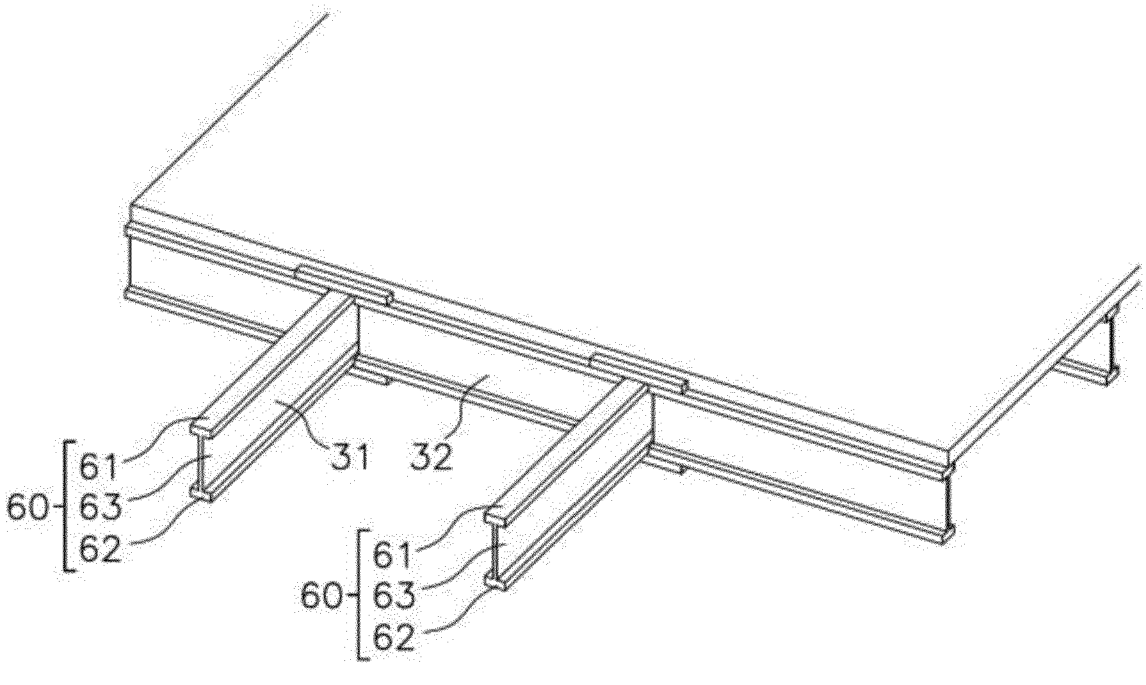

Fig.5B

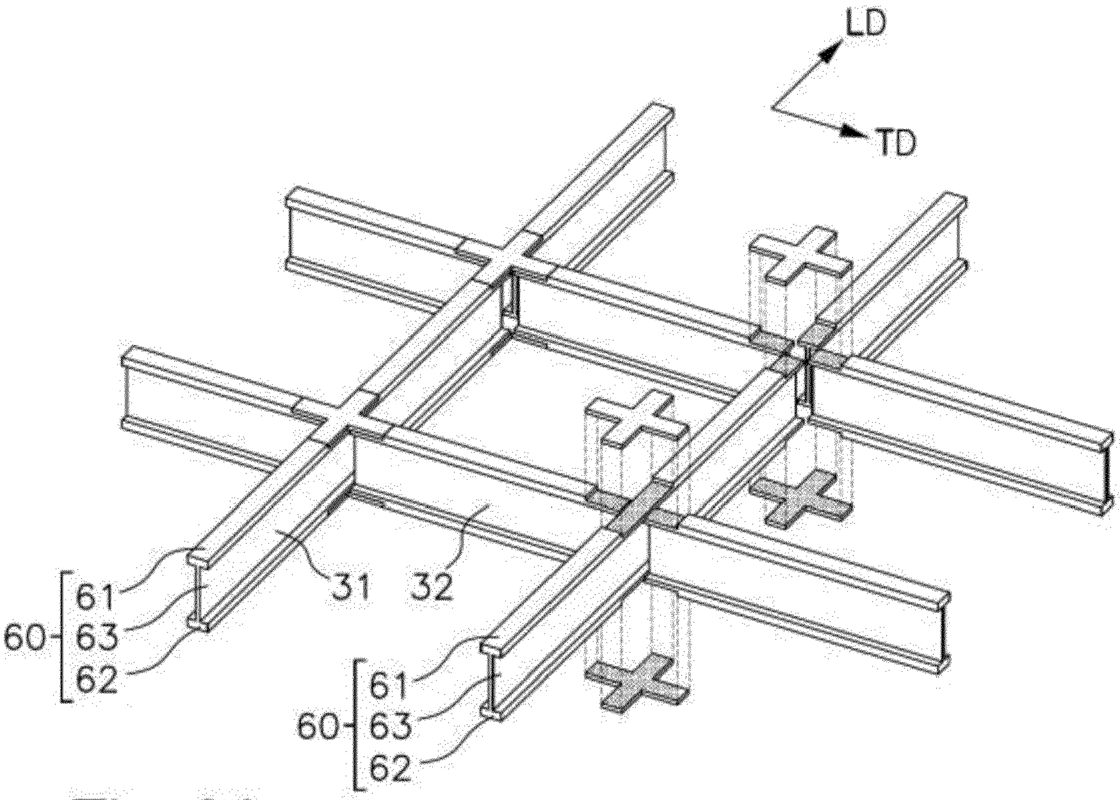

Fig.6A

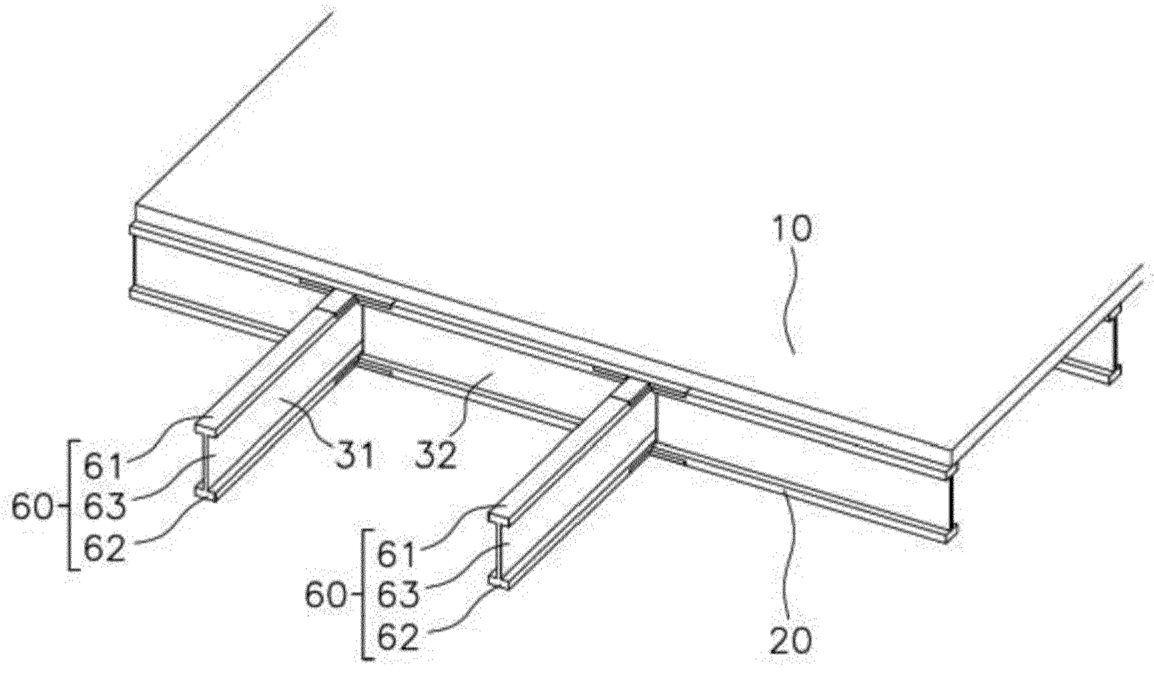

Fig.6B

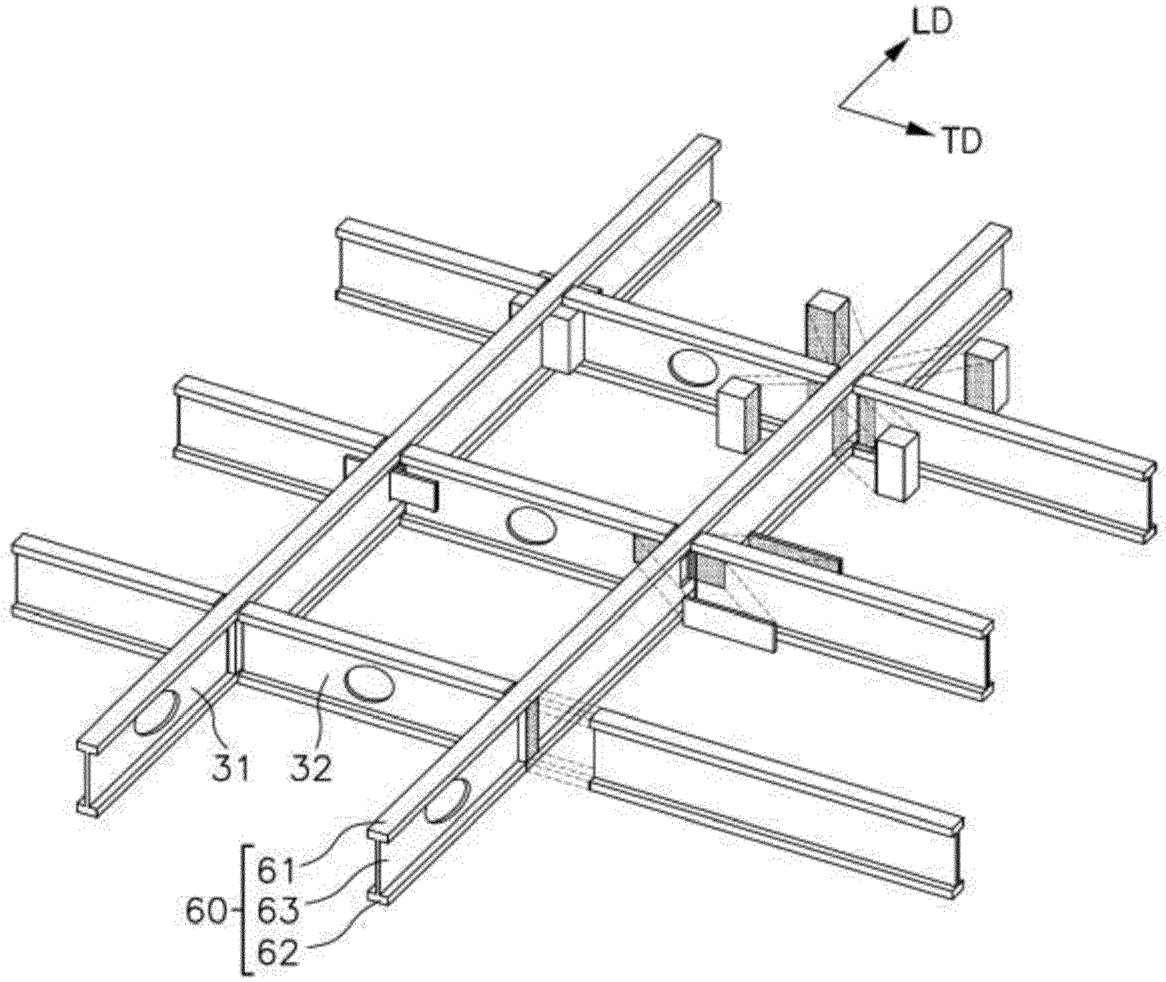

Fig.7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 38 2247

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 919 698 A1 (PHYLEM STRUCTURES SL [ES]) 8 December 2021 (2021-12-08) * figures 1-11 * * paragraph [0030] *	1-16	INV. E04B5/12 E04B5/14 E04B5/43 E04C3/36 E04C3/14 E04C3/16 E04B1/10
A	GB 2 490 304 A (HAAN IAN DE [GB]) 31 October 2012 (2012-10-31) * figures 1-22 *	1-16	
A	WO 2008/070709 A2 (GEORGIA PACIFIC WOOD PRODUCTS [US]; NICHOLS KIRK M [US] ET AL.) 12 June 2008 (2008-06-12) * figures 1-10 *	1-16	
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E04B
E04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 August 2022	Petrinja, Etiel

CATEGORY OF CITED DOCUMENTS

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

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