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(54) **Building element for a timber wall and a ceiling constructions and a producing method thereof**

(57) A building element for timber wall and ceiling structures and the producing method thereof solve a problem of an easily producible building element that is based on a cross laminated massive timber plate (18) assembled from a layer of outer lamellas (2) and (4) and of an optional number of inner lamellas (3, 4, 5) with vertical ribs (1) or (1, 1') placed at certain spacing between the outer lamellas (2) in an optional sequence. In the compartments between the ribs (1) or (1, 1') insulation infill (19) can be placed and the whole setup can be closed with a cover plate (20). For the pre-stressed structures

of building elements, the vertical ribs (1) and/or (1') are curved in the tangential direction of the longitudinal axis by an optional distance of (X).

The last layer of the outer lamellas (2) with the intermediate vertical ribs (1) and (1') is glued and laid to the former layer of inner lamellas (3) preferentially simultaneously and fully and within the given sequence also as pressed in the press together with the other layers of lamellas (3, 4, 5) of the cross laminated massive plate (18).

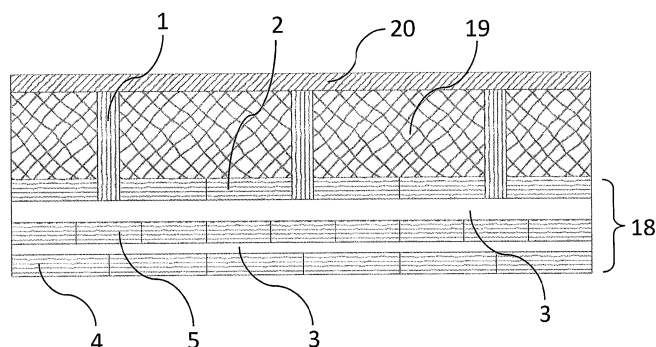


Fig. 1

Description

The subject of the invention

[0001] The subject of the invention is a building element for timber wall and ceiling constructions and the method thereof, or to be more specific, a massive cross laminated timber plate with transversely inserted ordinary or pre-stressed ribs and the method for its production. Building elements according to the invention can be used for building timber walls and/or ceilings in new buildings and for renovating existing buildings, including their seismic strengthening.

[0002] According to the international patent classification the invention belongs to E04C 2/38 and to E04C 2/34 and, additionally, to E04C 2/296.

Technical problem

[0003] The technical problem solved by this invention is how to conceive an isolated building element for timber ceiling and wall constructions that will be made in a uniform continuous phase of a technological process and preferentially from the same type of wooden boards, that will be based on a cross laminated massive timber plate and that if combined with inserted ordinary or pre-stressed and curved ribs, respectively, it will be useful for a prefabricated construction of timber floors, or if combined with inserted ordinary and straight ribs, respectively, it will be useful for a prefabricated construction of timber walls, where during construction the massive cross laminated timber plate could be located on either the outer or inner side of the wall or the ceiling, the process of prefabrication and assembly of the construction element will be simple, fast and affordable.

Current state of the art

[0004] According to document EP 2 360 327 a construction element for wall and ceiling systems is known. Strengthening timber ribs are fitted into a massive timber plate from one side or with one longer edge and with the opposite edge into a groove of a strengthening purlin with insulation infill built in between. The webs of the ribs can be made continuous or discontinuous with the strengthenings at the ends of the ribs always being continuous. The grooves in the massive timber panel are profiled and of the same width as the timber ribs the edges of which are also profiled. The cross section of the grooves is mirrored compared to the cross section of the profiles, however, both of them are preferentially milled. The massive panel and the strengthening ribs are made separately and independently of one another followed by the connecting of ribs with the plate. The connection between the massive timber panel and the strengthening timber ribs is made via the aforementioned milled grooves and edges. The shape of the profiled grooves and edges is such that it allows connecting of strengthening ribs to the

massive plate by preventing them from being pulled out. The document does not specify if the ribs are also glued into the grooves. This can present a weakness and deficiency that can lead to the joint between the ribs and the plate slipping, hence preventing a full interaction. Furthermore, weakness and deficiency is in the fact that the use of laminated timber plates glued in one direction is foreseen, hence only allowing for loading of the panels along their main longitudinal direction, depending on their orientation. Furthermore, weakness and deficiency is in the fact that each of the components is made from a different timber product with different characteristics. Furthermore, weakness and deficiency is in the fact that its production takes place in several sequential and non-continuous technological phases. First, the profiled grooves are milled into the massive timber plate and then the profiled edges on the strengthening ribs as well as the grooves in the strengthening purlins. In the last phase, all these components are assembled together in a certain order. Furthermore, weakness and deficiency is in the fact that the design of the strengthening ribs is such that it does not allow for the use of the structural element with the massive plate on the bottom side and the ribs on the top side in the case of structural and/or fire requirements.

[0005] According to document GB 2 450 359 a construction of a multi-layer insulation plate made as a combination of timber load bearing layers and insulation layers, such as thermal, sound and fire layers is known. The plates are combined in a relatively optional manner, the shear connection between the softer insulation layers is made with transverse timber ribs that are fitted into the upper and lower plate through pre-milled adapted grooves. The grooves are of optional depth, of the same shape and width as the longitudinal edges of the ribs inserted and glued into them. As a rule, the load bearing timber connections are on both end sides or faces of the multilayered plate. Weakness and deficiency of this solution is in the fact that the assembly takes place in several sequential and non-continuous technological phases, expressed particularly in the fact that individual layers, purlins, and transverse ribs are made individually, independently of one another and connected together in a certain order in the last phase of assembly. Furthermore, weakness and deficiency is in the fact that it does not allow for an open structure with visible ribs on one side. As a consequence, a subsequent choice of the type and thickness of the insulation on the building sight is not possible. Since the multi-layer plate is conceived so that its outer layers are always load bearing the use of softer, non-load bearing layers allowing for a higher vapour transparency is not possible in those positions. Hence, there is a possibility of water vapour condensation in the plates with a closed in insulation in the core and due to insufficient evaporation a risk of timber decay. Therefore, this known solution is not the most suitable for the building's outer walls or roof plates.

[0006] According to document US 4,329,827 a roof element which is a combination of plywood, timber T pro-

files, steel sheet and the intermediate insulation is known. It is intended for covering roofs though not meant for walls and floors of building. Weakness and deficiency of this solution is in the fact that the production takes place in several sequential and non-continuous technological phases since all the components are made independently of one another. It is followed by their assembly where the timber beams are connected together with plywood on the top compressions side, namely with gluing or with a combination of glue and nails. The insulation is inserted in between and a thin layer of steel sheeting is placed at the bottom though the latter does not contribute to the load bearing capacity. The element's use is explicitly restricted to the use for roof constructions where the bottom steel layer does offer a non-combustible surface, however, not also the necessary insulation in the case of a fire. It basically leads to a fast combustion of the inner timber ribs. Furthermore, weakness and deficiency is in the fact that due to the slenderness of the construction elements and the non-load bearing role of the steel sheeting it is not suitable for the construction of wall and ceiling elements.

[0007] The common characteristics of described known solutions of wall and ceiling elements is are that they do not foresee the use of cross laminated timber plates, that they are made of different types of timber products, that they do not allow the installation of elements or plates with the open ribs on the upper side, that, due to the closed in insulation, vapour condensation is possible and hence wood decay and that their assembly is based on several sequential and independent production phases that do not allow for a continuous technological process.

[0008] Due to the formerly mentioned weaknesses and deficiencies of known timber wall and ceiling building elements there is a need for more suitable building elements the production of which will take place within a single continuous technological construction process phase and from one type of timber and that will be usable as building elements for timber walls and ceilings including for seismic strengthening of existing buildings.

The technical problem solution

[0009] According to the invention, the technical problem is resolved with a building element for timber wall and ceiling constructions along with the producing method thereof whose main feature is that it is conceived as a massive cross laminated timber plate with perpendicularly transverse strengthening ribs and can be made within one single continuous technological production phase of the production process. Based on the intended use the strengthening ribs can also be pre-stressed. The building element according to the invention is made from one type of timber without any necessary additional machining of individual parts. The design of the ribs allows the building element to be turned upside down in the case of floor structures, hence the bottom side of the plate can

be massive and the ribs are turned upwards and vice versa. The building element is preferentially conceived as an open structure with its massive cross laminated timber plate allowing various loads in the longitudinal or transverse direction, based on its main orientation.

[0010] The invention will be more precisely described in relation to the feasibility examples and figures, which show as follows:

- 10 Fig. 1 the building element according to the invention from a 5-layer cross laminated timber plate with ribs with intermediate thermal and sound insulation and a cover plate in an orthogonal projection;
- 15 Fig. 2 a 3-layer cross laminated plate in an axonometric projection, the first feasibility example;
- Fig. 3 a 3-layer cross laminated plate with somewhat wider ribs, the second feasibility example;
- Fig. 4 a 5-layer cross laminated plate, the third feasibility example;
- 20 Fig. 5 a 5-layer cross laminated plate with two-part ribs, the fourth feasibility example;
- Fig. 6 a 5-layer cross laminated plate, the fifth feasibility example;
- 25 Fig. 7 a 5-layer cross laminated plate, the sixth feasibility example;
- Fig. 8 a 3-layer cross laminated plate with pre-stressed ribs in an axonometric projection, the seventh feasibility example and
- 30 Fig. 9 a schematic display of the continuous production procedure of a cross laminated massive plate with ribs

[0011] The building element according to the invention is preferentially made of at least 3 or more layers, with its cross laminated massive timber plate 18 made from timber outer lamellas 2 and 4 and inner lamellas 3 and 5, where between and perpendicularly to the outer lamellas 2 the ribs 1 are placed, which are spaced to each other for the width of the intermediate outer lamellas 2 so that they form the intermediate compartments into which the insulation infill 19 can be placed and the whole assembly can be closed by a cover plate 20 on the side of the ribs 1. The building element according to the invention can also be made without a cover plate 20 and/or insulation infill 19. As said, the lamellas 2, 3, 4 and 5 form a cross laminated massive timber plate 18, the number of layers can be optional.

[0012] The stratification of cross laminated massive timber plates 18 can be optional as layers from timber lamellas 2, 4 and 5, which are normally orientated in the same direction as timber ribs 1, and the layers of timber lamellas 3, which are normally orientated perpendicularly to the longitudinal axis of the ribs 1, follow each other alternatively. The total number of layers, by taking into account the aforementioned alternating row of lamellas 2, 3, 4 and 5, depends on the desired thickness of the cross laminated massive plate 18. However, it applies

that the layers of outer lamellas 2 and 4, which run in the direction of ribs 1, can be doubled. Below the outermost layers of lamellas 2 on the side of the ribs 1 and the outer lamellas 4 on the opposite side, a layer of lamellas 5 can be placed, which also runs in the direction of the ribs 1. The ribs 1 are preferentially shaped as a longer and somewhat thinner block, however, they can be of various dimensions and also of different shapes and the height of the ribs 1 has to be larger than their width.

[0013] For cross laminated timber massive plates 18 that are used for wall elements the spacing and cross section of ribs 1 are adjusted to the type of the insulation infill 19, which can be placed in between the ribs 1 either in plates or can be blown in.

[0014] Also the number and width of the outer lamellas 2 placed flat in the first outer layer on the side of the ribs 1 are adjusted.

[0015] The ribs 1, all the layers of the outer lamellas 2 and 4 and the inner lamellas 3 and 5 can be of massive timber, of the shape of a single lamella with a limited length, or of cross laminated timber, glued laminated timber or LVL.

[0016] The ribs 1 can be made from one piece of timber, of an optional thickness, or can be made from several thinner elongated timber elements 1, 1.1, 1.n as shown in Fig. 5.

The lamellas 2, 3, 4 and 5 can be of optional widths and thicknesses.

[0017] For all, hereinafter described feasibility examples of the cross laminated massive timber plates 18 with ribs 1 according to the invention it applies that the ribs 1 and lamellas 2, 3, 4 and 5 are made of timber, preferentially of the same type, however, in certain specific cases, they can be made of different types of timber.

[0018] Where the cross laminated timber plates 18 are used for floor structures, the ribs 1 normally run along their longer direction, namely along the building, however, with the lower wall elements the ribs 1 run transversely or along the height of the wall. Where the cross laminated massive plates 18 are used for walls, the ribs 1 are preferentially straight, not pre-stressed, however, for their use as floor or ceiling elements, the cross laminated massive plates 18 have ribs 1 pre-stressed as shown in Fig. 8. In some other feasibility example, not shown here, the building elements can be made from a combination of pre-stressed and non-pre-stressed ribs 1 if the stresses and loads demand so.

[0019] The composition of the cross laminated massive plate 18 made from lamellas 2, 3, 4, 5 and ribs 1 is made within one uninterrupted phase of the technological procedure, hence in a continuous production process, described hereinafter.

[0020] In Fig. 1, a building element according to the invention is shown that is made from a 5-layer cross laminated massive timber plate 18 with vertical ribs 1, the insulation infill 19 and a wooden cover plate 20. The cross laminated massive timber plate 18 is made of two layers of the outer lamellas 2 and 4 in between which, there are

located two layers of inner lamellas 3 that surround the layer of inner lamellas 5. The ribs 1 are positioned between the neighbouring outer lamellas 2, and within the same cross laminated massive timber plate 18, they are preferentially of the same height, width and length. The ribs 1 run parallel in the same direction and are spaced to each other for the width of one or more outer lamellas 2 so that they form intermediate hollow compartments that are later filled with an appropriate insulation infill 19. The outer lamellas 2 and 4 and inner lamellas 5 run in the direction of ribs 1 and perpendicularly to them run inner lamellas 3 in both layers. On the side of the ribs 1, the cross laminated massive timber plate 18 can be covered with a cover plate 20. As said, the cross laminated massive timber plate 18 with ribs 1 is made in a one-time continuous process of stacking, gluing and pressing. The insulation infill 19 and the cover plate 20 are built in subsequently.

[0021] In terms of the load resistance of the cross laminated massive timber plate 18 with ribs 1 the gluing contact surfaces are of high importance. Hence when gluing the layers of lamellas 2, 3, 4 and 5 of the building element according to the invention the most important are the load bearing, as a rule, larger contact surfaces 7, 13, 14, 15 and 17 that must be glued together. Namely those are the contact surfaces 7 between the outer lamellas 2 and inner lamellas 3 and surfaces 12 between the ribs 1 in the case of their two- or more-layered structure, further for surfaces 13 between the inner lamellas 3 and 5 and surfaces 14 between the inner lamellas 3 and outer lamellas 4, for surfaces 15 between the outer lamellas 4 and inner lamellas 5, for surfaces 16 between the ribs 1 and inner lamellas 5 and for surfaces 17 between the outer lamellas 2 and inner lamellas 5. The main contact surface of the ribs 1 with the other layers of lamellas 2, 3, 4 and 5 is over the narrower contact surface 6 that is in contact with the previous layer of inner lamellas 3. The ribs 1 can also be glued to the first layer of outer flat-laid lamellas 2 over the side contact surface 8, however, this contact does not act as a primary load transfer of the shear forces into the core of the cross laminated massive plate 18. The narrower contact surfaces 9, 10, 11 and 16 can also be glued, however, they do not matter from the construction point of view as they are not load bearing which also applies for side contact surfaces 8 between the outer lamellas 2 and ribs 1. The described is shown in a series of figures, namely from Fig. 2 to including Fig. 7. The type of glue can be optional, however, the characteristics of the glue must fit the intended use of the building element.

[0022] The feasibility example of a 3-layered cross laminated massive timber plate 18 with ribs 1 in Fig. 2 is characterised by the fact that the outer lamellas 2 and the outer lamellas 4 that run in the direction of the ribs 1 are of the same thickness on both sides of the cross laminated massive plate 18 and are somewhat thicker than the inner lamellas 3 that run perpendicularly to the ribs 1. The described is only valid for this feasibility ex-

ample and is not a general rule for the other feasibility examples of the building element.

[0023] The feasibility example of a 3-layered cross laminated massive plate 18 with ribs 1 in Fig. 3 is characterised by the fact that the thickness of the ribs 1 is much larger than the thickness of the outer lamellas 2 and 4 and of the inner lamellas 3 that form the cross laminated timber plate 18.

[0024] Fig. 4 shows a 5-layer cross laminated timber plate 18 with ribs 1 the characteristic of which is the numerical sequence of the outer lamellas 2 and the intermediate ribs 1 that is in a 2:1 ratio in the presented feasibility example. Hence the sequence is formed by two juxtaposed lamellas 2, one rib 1 and again two juxtaposed lamellas 2 that is cyclically repeated over the whole width of the cross laminated massive plate 18, in which the outer lamellas 4 and inner lamellas 5 are located that run in the direction of the ribs 1 and are of different widths. The inner lamellas 3 in both layers and that run perpendicularly to the direction of the ribs 1 can also be of different dimensions. In the presented feasibility example the thicknesses are different.

[0025] The next feasibility example in Fig. 5 shows a 5-layer cross laminated massive timber plate 18 with ribs 1, 1', which is characterised by the numerical sequence of the outer lamellas 2 and the intermediate ribs 1 that is in a 1:2 ratio in the presented feasibility example. The sequence is formed by a single lamella 2, juxtaposed ribs 1 and 1' of a two-layer structure and again by a single lamella 2. The sequence is cyclically repeated over the whole width of the cross laminated massive plate 18 where the outer lamellas 4 and 2 and inner lamellas 5 run in the direction of the ribs 1 and 1', whereas the inner lamellas 3 in both layers run perpendicularly to the aforementioned composition.

[0026] Fig. 6 shows a feasibility example of a 5-layer cross laminated massive plate 18 with ribs 1, which is characterised by the fact that orientation or position of the two marginal layers of the outer lamellas 4, inner lamellas 5 and outer lamellas 2 that all run in the direction of the ribs 1 is the same. Perpendicularly to the ribs 1 are only the inner lamellas 3 in the layer between the outer lamellas 2 and the inner lamellas 5 where the lamellas 2 and lamellas 5 in the appurtenant layers are somewhat shifted hence the contact surfaces 9 and 11 between individual lamellas 2 and 5 do not coincide along the vertical.

[0027] The next feasibility example of a 5-layer cross laminated massive plate 18 with ribs 1 is shown in Fig. 7. It is characterised by the fact that the orientation of the juxtaposed connections of the outer lamellas 2 and the inner lamellas 5 on the side of the ribs 1 is the same. Perpendicularly to the ribs 1 run only the inner lamellas 3 in the layer between the outer lamellas 4 and the inner lamellas 5, where the lamellas 4 and lamellas 5, that run parallel with the ribs 1 along with the outer lamellas 2, are somewhat shifted, hence the contact surfaces 9 and 11 between individual lamellas 4 and 5 do not coincide

along the vertical.

[0028] A 3-layered feasibility example of a cross laminated massive plate 18 with ribs 1, shown in Fig. 8, is characterised by the fact that the ribs 1 are of a pre-stressed structure. In this method, the ribs 1 in their neutral form are somewhat pre-curved in the tangential direction of the longitudinal axis, namely by a distance X. The height of the curve X over the tangent depends on the demanded characteristics of an individual composition of a cross laminated massive timber plate 18, its expected loading and on the dimensions and spacing of ribs 1. The pre-stressed rib 1 structure is, as a rule, usable for floor building elements as its use for wall elements would not make sense. The ribs 1, if made from one thinner piece of timber, can be bent before the procedure of assembling and pressing and the procedure of their pre-stressing can be done within this procedure. If the ribs 1 are made from a glued laminated timber, they are bent within their gluing procedure and if they are made from massive timber, they can be milled to shape. With vertical pressing, the prior bent ribs 1 in a neutral stress state are completely straightened to a horizontal shape where the height X of the curve completely diminishes. At the same time, the free outer longitudinal edge of the ribs 1 enters a compressive state. In the final state when such a building element is built into a floor construction that same edge enters a tension state. Due to such pre-stressed ribs 1 we consequently achieve a more uniformly exploited cross section of this building element at bending of the floor structure. By experience, it goes that the distance X for the cases of pre-stressed ribs 1 can be from a few millimetres to a few centimetres measured from the tangent of a straight axis. For larger spans of cross laminated massive plates 18, it can be up to 5 cm or more. In doing so, it is essential that the ribs 1 reach a target stress state that will, in combination with a cross laminated massive plate 18, give the optimal balance of stresses. Therefore, it follows that the ribs 1 should be bent for a larger distance X for larger spans and somewhat less for shorter spans to achieve about the same stress state. It applies that the distance X depends on the static demand of individual spans of ribs 1 in cross laminated massive plates 18. Its upper value is theoretically limited with a formula $X_{\max} = (5 \times L^2 \times f_m) / (24 \times E \times h)$, which defines the largest displacement at bending of the ribs 1 before rupture occurs. In the equation, L defines the span of the cross laminated massive plate 18, f_m the bending strength of the timber used for ribs 1, E the modulus of elasticity of timber and h the height of ribs 1. Based on this mathematical form the distance X is not dependant of the rib 1 width. The largest displacement or the largest maximum distance $X_{\max}$ for 10 cm wide and 14 to 20 cm high ribs 1 and for spans of 4 m to 8 m is between 22 and 126 mm with the average value of 63 mm. The size of bending and hence the pre-stressing of ribs 1 is also influenced by the thickness of the cross laminated massive plate 18.

[0029] All the aforementioned feasibility examples of

the building elements according to the invention that include a cross laminated massive plate 18 with ribs 1 are characterised by the fact that the lamellas 2, 4 and 5 run in the direction of the ribs 1, the lamellas 3 run perpendicularly to them and that the number of layers of lamellas 2, 3, 4 and 5 within a cross laminated massive plate 18 can be optional as can their location and relative position. It is also a fact that the ribs 1 run in the longer direction of the production format of the building element or the cross laminated massive plate 18 when it is used for floor elements and in the shorter direction for the production of wall elements.

[0030] The continuous procedure of the building element's production according to the invention is characterised by the fact that all the necessary working operations are done within one uninterrupted phase of a technological process or procedure without additional prior and/or intermediate machining of grooves for ribs 1. In the procedure, a press is used for pressing massive timber plates of all sorts of implementations, however, it is not specifically presented. It has to enable the production of cross laminated massive plates 18 with ribs 1 that can have the shape of a somewhat larger cube or a somewhat longer block of an optional thickness and width. In our case, it is a cross laminated massive plate 18 in the shape of a block, glued together from several layers of lamellas 2, 3, 4 and 5 where the timber ribs 1 are perpendicularly placed between and to the outer lamellas 2. For all feasibility examples it applies that a cross laminated massive plate 18 is made from a layer of outer lamellas 4 and a layer of outer lamellas 2 and between them can be located an optional number of layers of inner lamellas 3 and/or 5 that run perpendicularly and/or parallel with ribs 1. For the stacking and gluing of individual layers of lamellas appropriate devices can be used such as a lamella sorter and a glue spreader that are not shown here.

[0031] For a clearer description of the method of construction and assembly of the building elements Fig. 9 is used where a 3-layer cross laminated massive plate 18 made of layers of outer lamellas 2 to 2.n and 4 to 4.n and inner layers of lamellas 3 to 3.n and ribs 1 to 1.n is shown. By analogy the procedure is the same for four, five and more layered cross laminated massive plates with ribs 1 and/or 1.1.

[0032] First, the sorter places the first layer of the outer lamellas 4, 4.1, 4.2, 4.3, 4.4 to 4.n, the fibres of which run in the same direction as the ribs 1, which will be added later, on an appropriate movable base. Glue can be applied to their contact surfaces 9 prior to that, however, that is not necessary even though it improves the airtightness between lamellas 4 and increases the shear stiffness of layers at in-plane loading of the cross laminated massive plate 18, i.e. at earthquake loads on walls.

[0033] A layer of glue is then applied over the first layer of lamellas 4 to 4.n followed by the application of the second layer of inner lamellas 3, 3.1, 3.2, 3.3 to 3.n and both layers are glued together over the larger contact surfaces 14. The lamellas 3 to 3.n can run perpendicularly

to lamellas 4 to 4.n or parallel to them. For the gluing of the narrow contact surfaces 10 between lamellas 3 to 3.n the same applies as for the aforementioned narrow contact surfaces 9. The application of the glue on the second layer is followed by the procedure of assembling the third, final upper layer that is made from outer lamellas 2, 2.1, 2.2 and 2.n and the intermediate ribs 1 and/or 1.1 perpendicular to them. All the constructions of 3-layered cross laminated massive plates are characterised by the fact that the orientation of lamellas 2 to 2.n is always perpendicular to the lower second layer regardless of the direction in which the lamellas 3 to 3.n were previously placed. It also applies for every feasibility example that the uppermost outer lamellas 2 to 2.n are orientated in the same direction as the lowermost outer lamellas 4 to 4.n regardless of the number of layers of the cross laminated massive plate 18.

[0034] The claimed invention is above all characterised by the procedure and the sequence of the assembly and gluing of the uppermost layer of outer lamellas 2 to 2.n and the intermediate perpendicular ribs 1 and/or 1.1 without any machine or manual treatment of the necessary grooves, as shown in Fig. 9. The upper layer of lamellas 2 to 2.n and the intermediate ribs 1 to 1.n are placed on the second-to-last layer preferentially simultaneously, whereby they are placed in the chosen order by the sorter. For the feasibility example shown in Fig. 9, it applies that they are placed by the sorter on the previously glue-coated layer of lamellas 3 to 3.n in the following order: horizontal lamella 2, next to it a vertical rib 1, followed by the horizontal lamella 2.1, followed by the rib 1.1., followed by the horizontal lamella 2.2 and at the end of the series a vertical rib 1.n and a horizontal lamella 2.n. The described sequence consists of an alternating string of one lamella 2 and one rib 1, which is cyclically repeated until the final dimension of the cross laminated massive plate 18 is achieved. In some other procedure, the assembly or the stacking of outer lamellas 2 and vertical ribs 1 can also be done individually in the given sequence if the sorter does not allow simultaneous stacking.

[0035] The joining of the vertical rib 1 between lamellas 2 and 2.1 and lamellas 3 to 3.n is marked by the side contact surfaces 8 and the base contact surface 6 that forms an optical slot 21 in the cross section.

[0036] In some other feasibility example, not shown here, the sorter can sort the final layer in different alternating strings formed by, for example one rib 1 and one lamella 2 or two lamellas 2 and one rib 1 or two ribs and 1' and one lamella 2, etc.

[0037] In the case of 4-layer cross laminated massive plates production 18 glue is applied on the surface of the 3rd layer and the 4th layer of lamellas 3 is laid down, the orientation of which is perpendicular to lamellas 5 and parallel to ribs 1 and lamellas 2.

[0038] In the case of a 5-layer cross laminated massive plates 18 glue is applied on the surface of the 4th layer and the 5th layer of lamellas 3 is laid down, the orientation

of which is the same as in the aforementioned feasibility example of a 4-layer assembly. Hence, the 4th and 5th layer can both be parallel or perpendicular based on the orientation of the 1st and 2nd layer.

[0039] For the ribs 1 it applies that they can be of an optional cross-section and of an optional type of timber. They can be made from several pieces that are assembled together in the process of pressing. For each feasibility example of the building element according to the invention it applies that the vertical ribs 1 to 1.n are glued to the second-to-last layer of the cross laminated massive plate, in the presented example on the inner lamellas 3 to 3.n. Here the main load bearing contact surfaces 6 are located, over which the shear flow is transferred along the ribs 1 into the core of the cross laminated plate 18. The side contact surfaces 8 between the ribs 1 and the lamellas 2 are not load bearing as they are not primarily meant to transfer stresses.

[0040] When the assembly of the building element according to the invention from the cross laminated massive plate 18 and ribs 1 is finished, it is placed into the press where all the assembled elements are pressed together in the vertical and if necessary also in the horizontal direction. Especially important is the pressing in the vertical direction that assures that the glue between the main contact surfaces 7, 13, 14, 15 and 17 of individual layers reaches its appropriate or desired strength. The pressing in the horizontal direction is necessary in the case of the simultaneous gluing of the narrower contact surfaces 6, 9, 10, 11, 12 and 16.

If the vertical ribs 1 are tangentially curved in the longitudinal direction, they are straightened in a horizontal shape in the press during pressing and are straight in the final form.

[0041] The insulation infill 19 and the cover plate 20 are preferentially built after the final pressing procedure, before or after the installation of the building elements into walls or floors.

[0042] The global orientation of the cross laminated massive plates 18 with ribs 1 can be optional. For the floor structures of buildings they can be turned with the ribs 1 either up or down. On the upper side, various installations can be placed between the ribs 1 or the space can be filled with an insulation infill 19 or similar. If the cross laminated massive plates 18 are turned with ribs downwards, the smooth surface of the flat upper plate can be used and the installations are led between the ribs 1 on the bottom side. If the cross laminated massive plates 18 are meant for wall elements, then the ribs 1 are placed on the outer side, hence providing a secondary structure on which the façade panels are hung. In this case, the intermediate space between the ribs 1 is filled with either an insulation infill 19 in panels or it is blown into the compartments. As the construction of the cross laminated massive plates 18 with ribs 1 is not closed, the insulation infill can be closed from the outer side with a vapour-defusing cover plate 20.

Claims

1. The building element for timber wall and ceiling structures consisting of a glued cross laminated massive plate, into the outer layer of which at certain distances vertical ribs are inserted with intermediate compartments with built in insulation infill **is characterised by the fact that** it is constructed of a cross laminated massive plate (18) with an optional layer setup and from vertical ribs (1) being placed perpendicularly into the first upper layer between the outer lamellas (2) so that they lie with their smaller contact surface (6) on the layer of inner lamellas (3), where in this area the ribs (1) and lamellas (2) and (3) together form an optical slot (21), the spacing between the ribs (1) depends on the number and width of the intermediate outer lamellas (2); that the cross laminated massive plate (18) is on one side limited by a layer of spaced outer lamellas (2) and on the other side a layer of outer lamellas (4), whereby the outer lamellas (2, 4) in all feasibility examples run in the longitudinal direction of the ribs (1), and whereby the orientation of the outer lamellas (2) is in all feasibility examples perpendicular to the layer of inner lamellas (3) beneath them; that in the cross laminated massive plate (18) the larger glued contact surfaces (7, 13, 14, 15, 17) are load bearing and the lamellas (3, 4, 5) within the same layer can be additionally face glued together over the smaller face contact surfaces (9, 10, 11) and that the ribs (1) are glued to the lower layer of inner lamellas (3) or (5) over the main contact surfaces (6) or (16) as well as over the side contact surfaces (8) with the neighbouring outer lamellas (2) and that the more-layered ribs (1, 1') can be glued together over the contact surfaces (12).
2. The building element according to Claim 1 **is characterised by the fact that** the ribs (1) can be made of thinner one-layered timber, from glued laminated timber or from massive timber and are pre-curved in the tangential direction of the longitudinal axis by an optional distance (X), the upper limit of which is determined with the form $X_{\max} = (5 \times L^2 \times f_m) / (24 \times E \times h)$ in the case of a pre-stressed structure.
3. The building element according to Claim 1 **is characterised by the fact that** the ribs (1) can be of an optional cross section and geometry depending on the static demands of the wall or floor construction.
4. The building element according to Claim 1 **is characterised by the fact that** in the cross laminated massive plates (18) with vertical ribs (1) for floor structures, the ribs (1), as a rule, run along the longer side of the plates (18) and in the wall elements, the ribs (1) run in the shorter transverse direction or along the height of the wall.

5. The building element according to Claim 1 **is characterised by the fact that** the cross laminated massive plates (18) in the walls of a building are preferentially turned with the ribs (1) to the outside and in the floor elements with the ribs (1) either up or down. 5
6. The producing method of the building element **is characterised by the fact that** the upper layer of outer lamellas (2) with intermediate ribs (1) on the cross laminated massive plate (18) is placed in the given sequence on the complete surface of the lower layer of the inner lamellas (3) completely and in a single stroke with the help of an appropriate sorter or manually in individual consecutive elements in an equal given string, hence eliminating the need of pre-curse machining of slots or grooves for the installation of ribs (1) in the upper layer of the building element. 10 15
7. The producing method according to Claim 6 **is characterised by the fact that** the one-layer vertical ribs (1) for the pre-stressed structure of the cross laminated massive plate (18) are tangentially curved along the longitudinal axis by a distance (X) before the installation in the upper layer of lamellas (2) and with the more-layered rib (1, 1') structure they are already pre-glued along the contact surface (12) and already curved. 20 25

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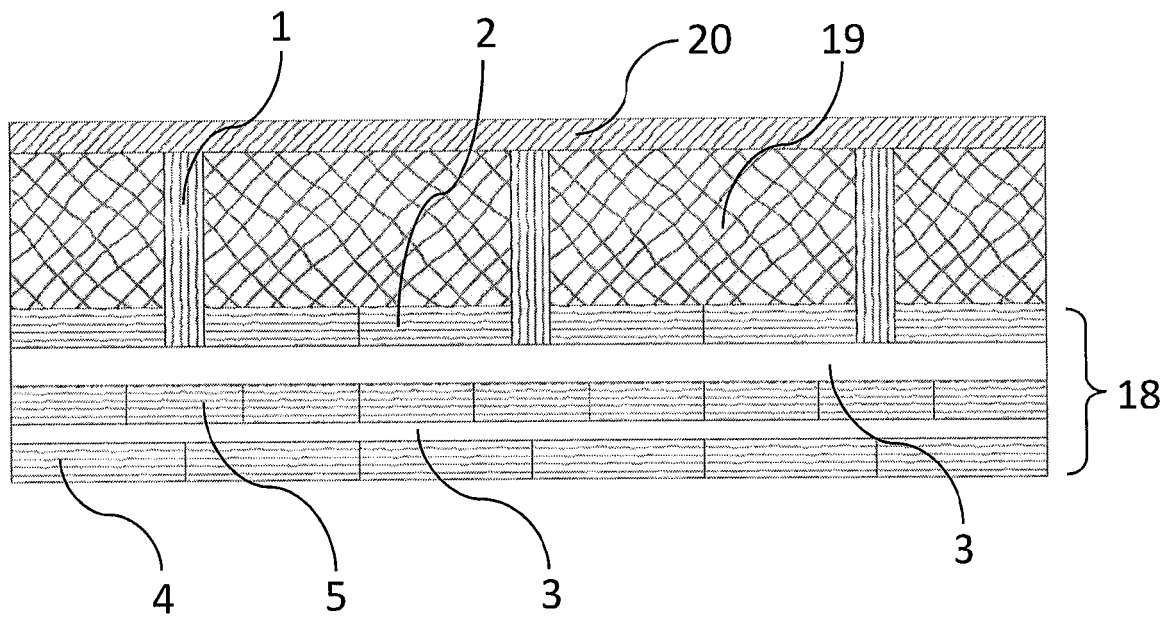


Fig. 1

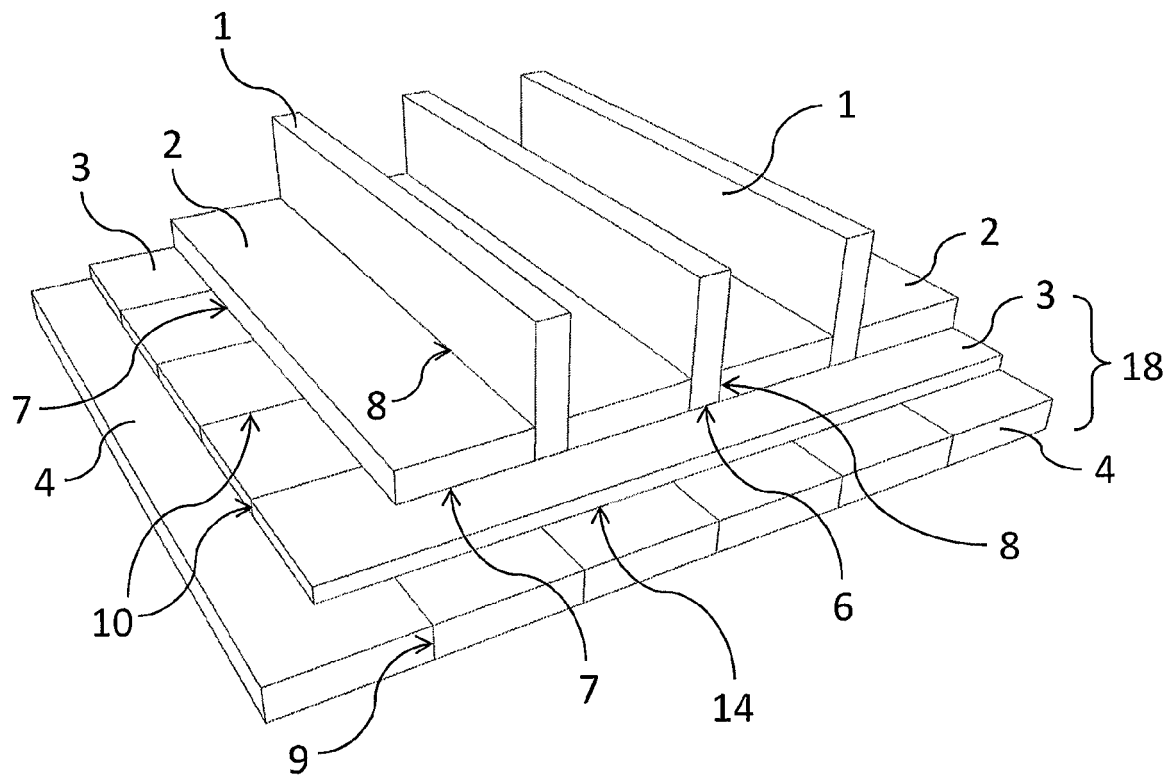


Fig. 2

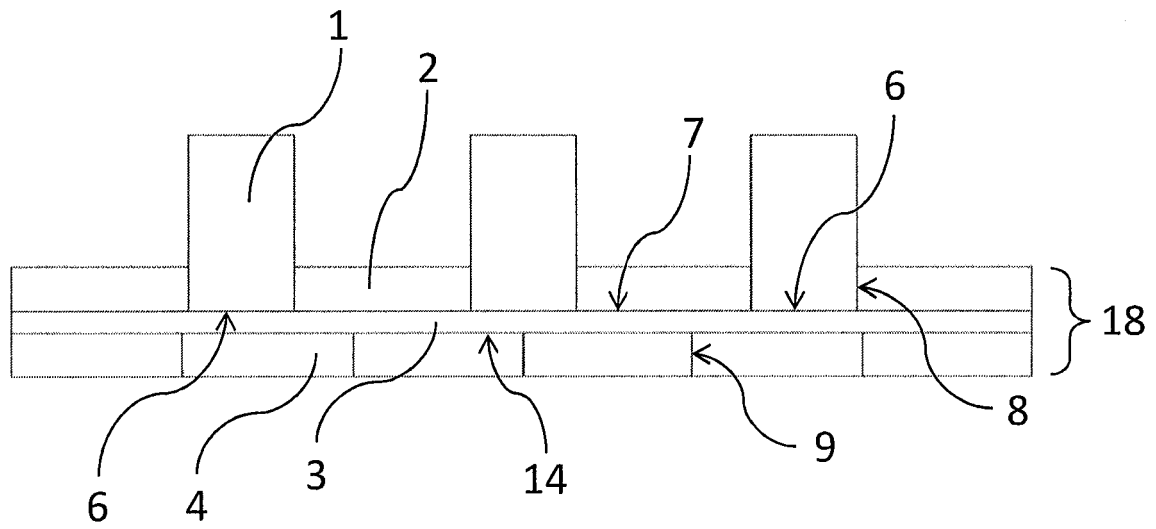


Fig. 3

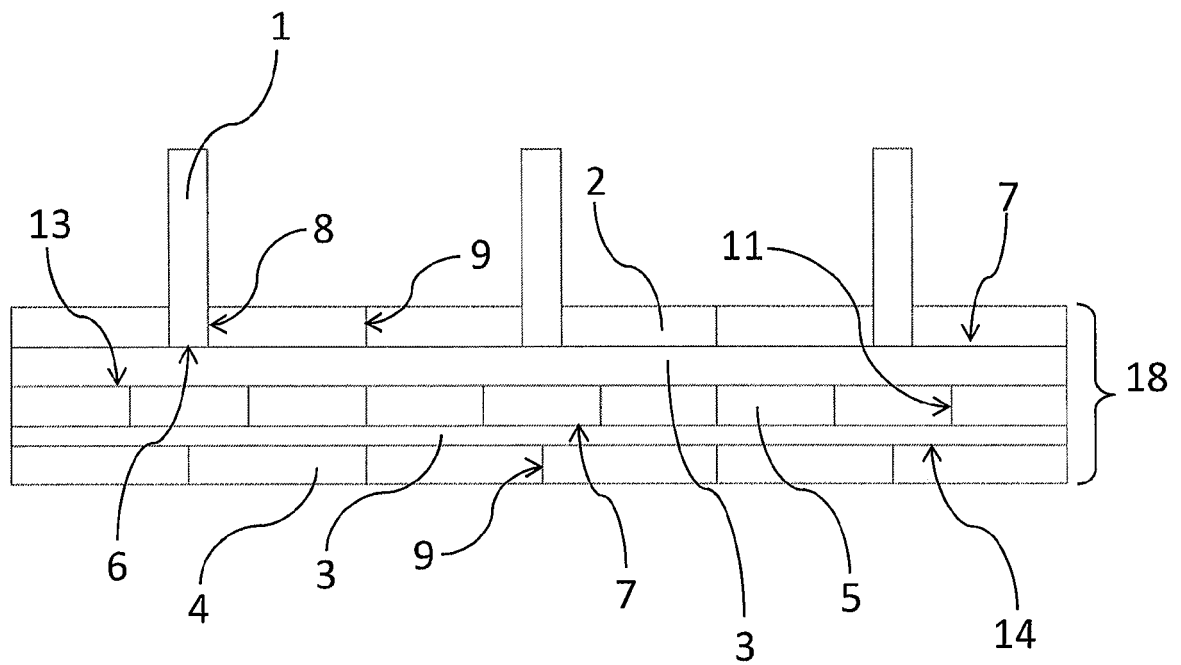


Fig. 4

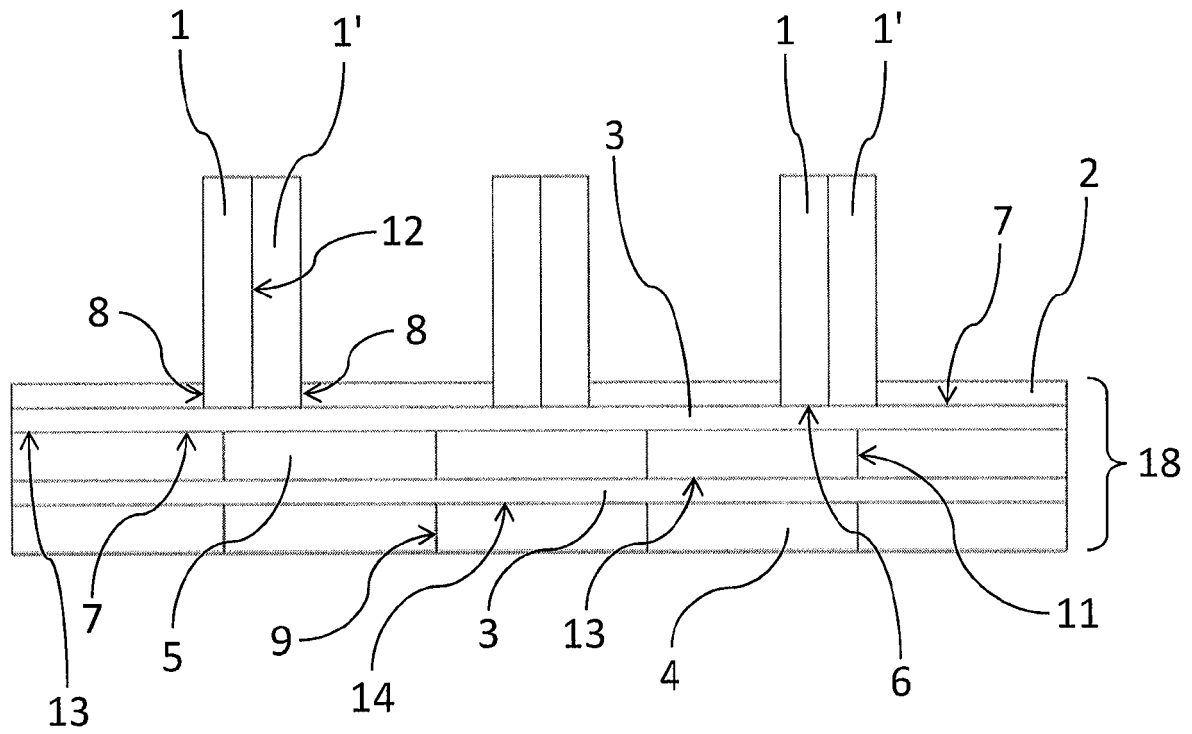


Fig. 5

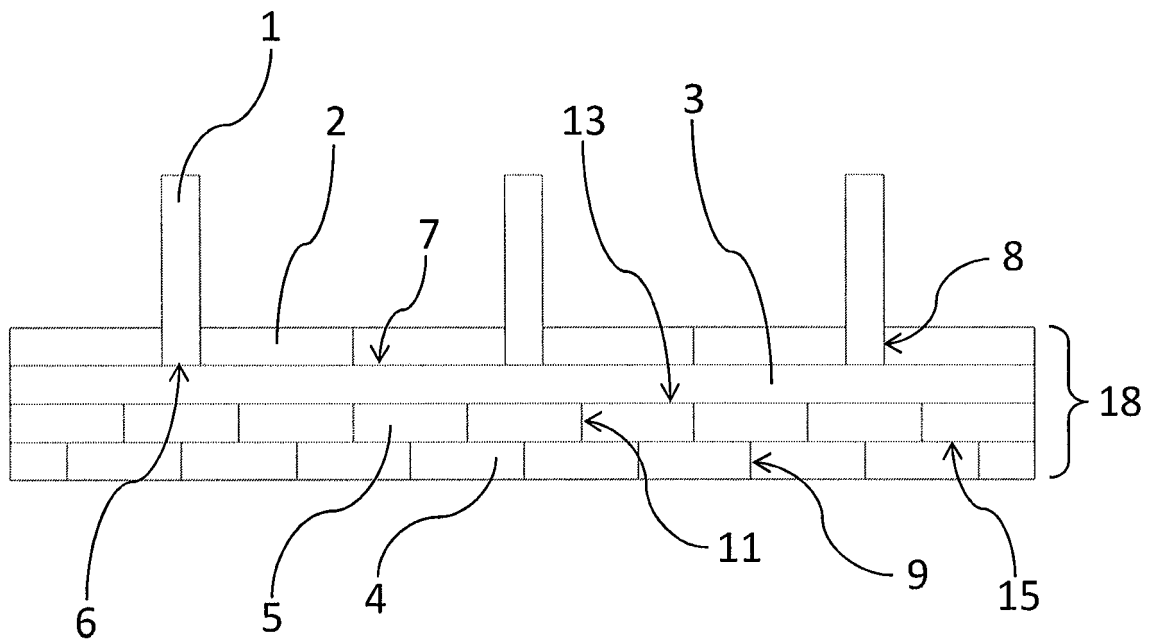


Fig. 6

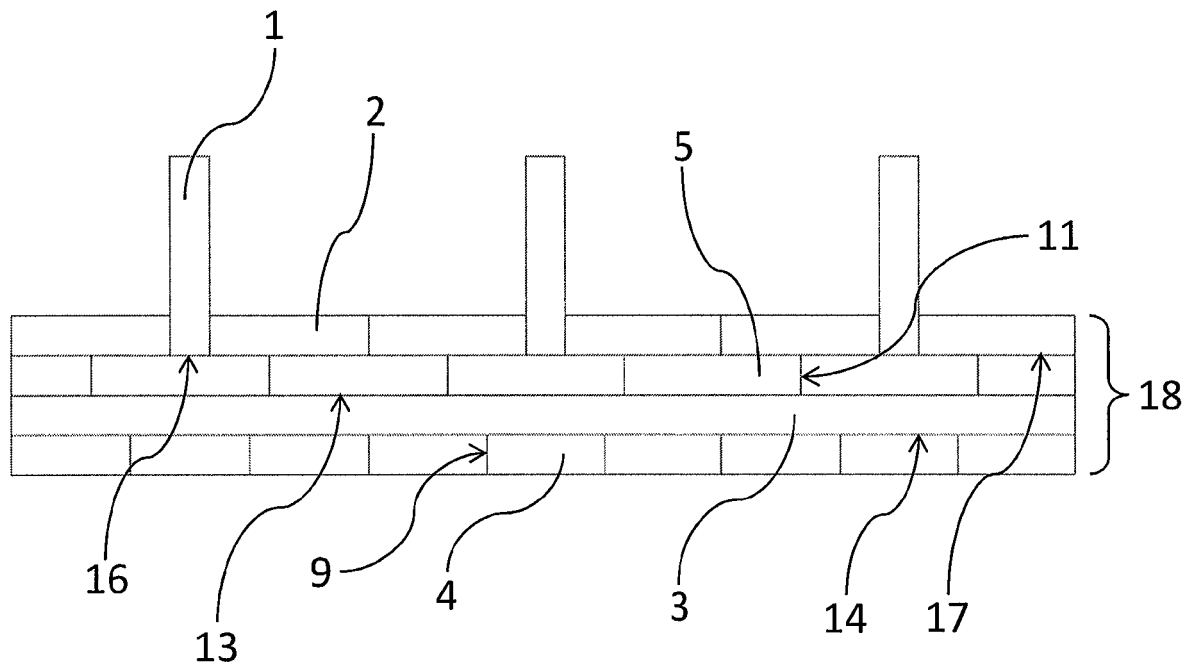


Fig. 7

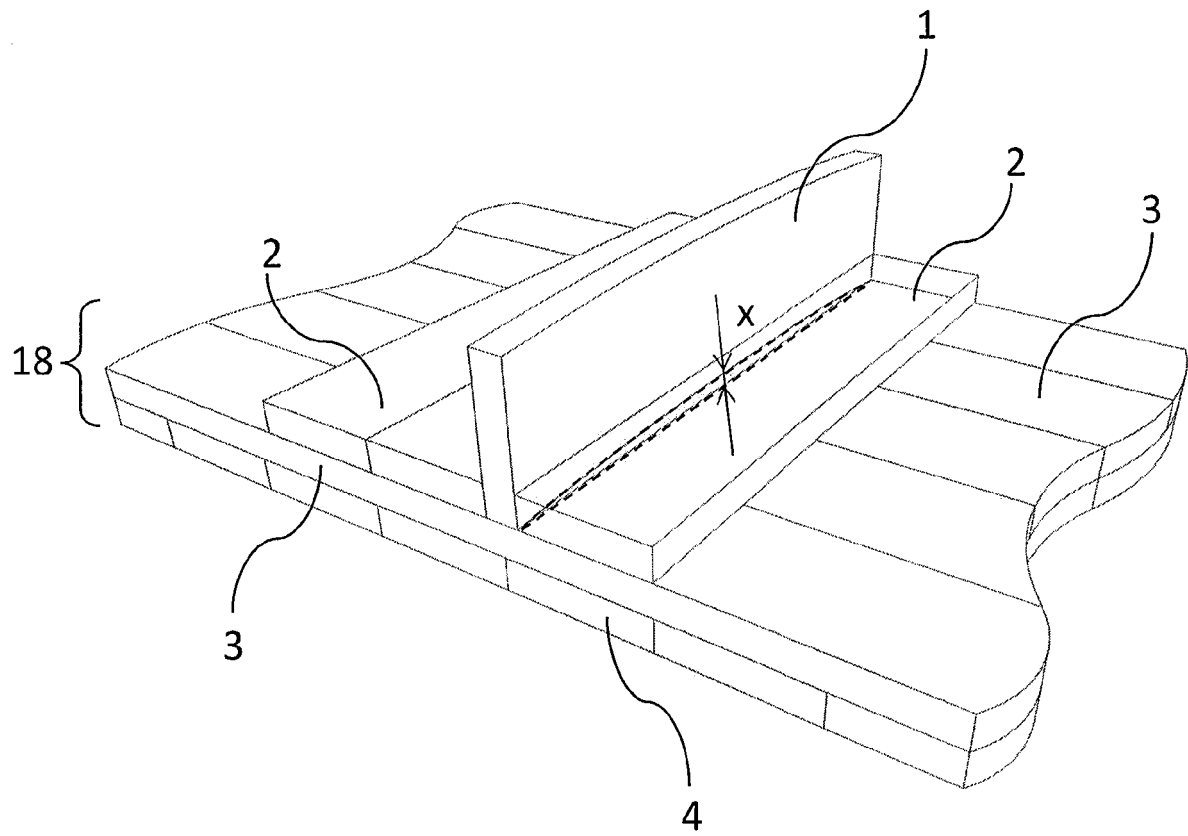


Fig. 8

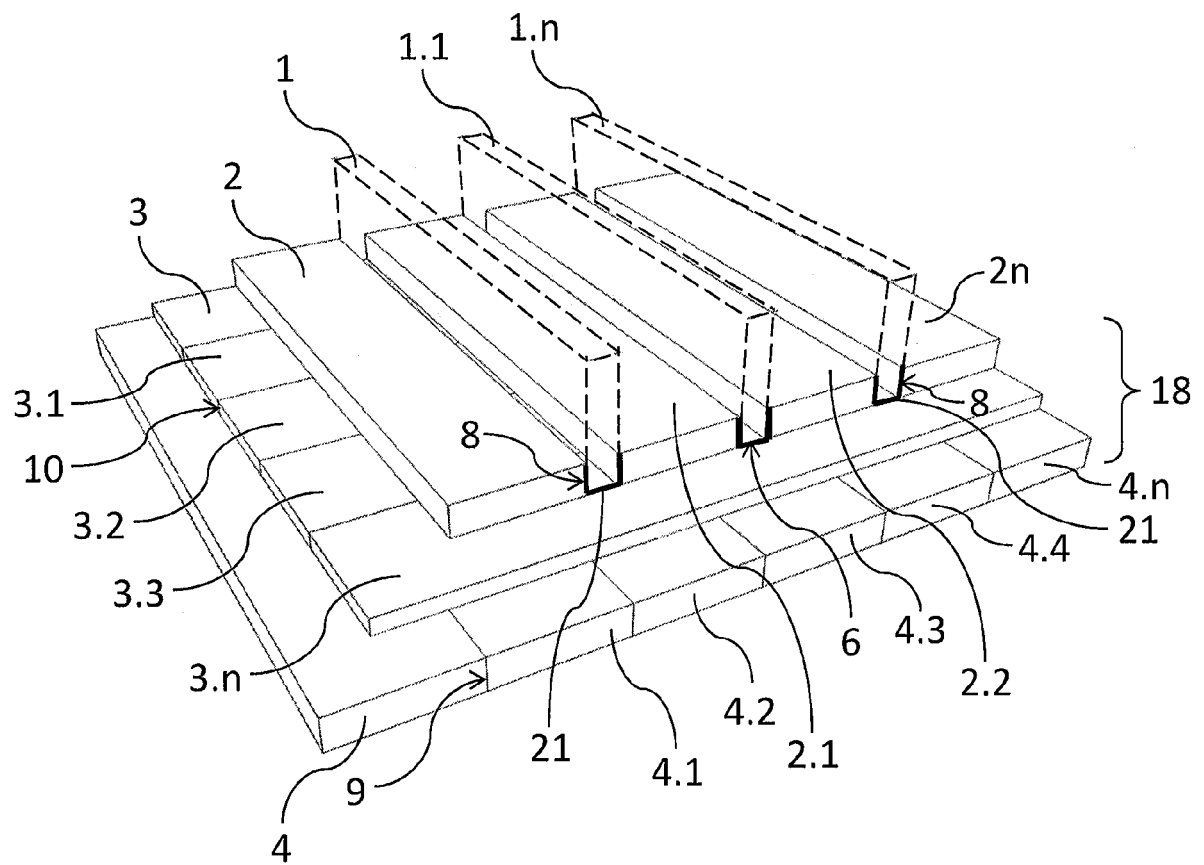


Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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