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(54) A WALL

(57) The invention relates to a method of making an insulated wall comprising:
i) providing a first wall panel and a second wall panel, wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;

ii) providing an insulation material;
iii) positioning the first wall panel next to the second wall panel, to form a cavity wall, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space;
iv) adding the insulation material to the combined intermediate space to make an insulated wall.

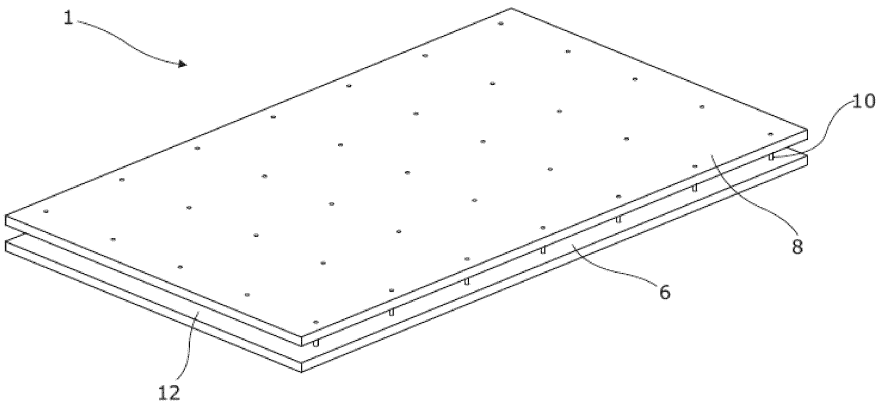

Figure 2

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Description

[0001] The present invention relates to an insulated wall and a method of making an insulated wall.

BACKGROUND TO THE INVENTION

[0002] It is known to manufacture concrete sandwich panels by casting a first concrete layer, applying an insulation layer and then pouring a second concrete layer on top of the insulation layer. This produces an insulated wall that is lighter than a solid concrete wall and facilitates transport to site. Such panels only have one molded side as the second concrete layer is typically poured on top of the insulation material and finished by trowelling. Typically, such panels comprise an insulation material of a predetermined size as designed by the insulation manufacturer.

[0003] There is a need for a method of manufacture of an insulated wall which is easy to install. Further, there is a need for a method of making an insulated wall which allows the end user to choose the type of insulation material for a given project. Further, there is a need to have flexibility in the thickness of a wall and not be limited to a pre-cut insulation material or prefabricated insulation. Further, there is a need to manufacture an insulated wall with two molded outer surfaces. Further there is a need for an insulated wall that does not have gaps or joints in the insulation. Further there is a need for a contiguously insulated wall that does not have gaps or joints in the insulation. Further, there is a need for a wall which can be recycled into the insulation and the concrete layers at the end of its use. Further, there is a need to enable circular use of insulation materials to recycle and/or reuse waste insulation material. Further, there is a need to reduce transportation costs of a wall, by limiting the distance the components travel.

[0004] It is, therefore, an object of the present invention to seek to alleviate the above identified problems.

SUMMARY OF THE INVENTION

[0005] According to a first aspect of the present invention, there is provided a method of making an insulated wall comprising:

i) providing a first wall panel and a second wall panel,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;

ii) providing an insulation material;

iii) positioning the first wall panel next to the second wall panel, to form a cavity wall, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space;

iv) adding the insulation material to the combined intermediate space to make an insulated wall.

[0006] According to a second aspect of the invention, there is provided a kit comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer,
wherein the insulation material is not provided in the intermediate spaces, and
wherein the intermediate spaces are for receiving the insulation material.

[0007] According to a third aspect of the invention, there is provided an insulated wall comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;

wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space, and
wherein the insulation material is in the combined intermediate space.

[0008] According to a fourth aspect of the invention, there is provided a recycled/waste material storage device comprising an insulated wall comprising a first wall panel and a second wall panel and a recycled/waste material,

wherein the recycled/waste material is a thermally

insulating material,
wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;
wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space, and
wherein the recycled/waste material is in the combined intermediate space.

[0009] According to the fifth aspect of the invention, there is provided a joint for a concrete wall, wherein the joint is a substantially elongate member, wherein the joint comprises a core load bearing part with an upper recess, a lower recess, a left recess and a right recess, wherein the upper recess and the lower recess each comprise an adhesive, wherein the left recess and the right recess each comprise a water/air tightening part.

DETAILED DESCRIPTION

[0010] The present invention relates to a method of making an insulated wall comprising:

i) providing a first wall panel and a second wall panel,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;

ii) providing an insulation material;
iii) positioning the first wall panel next to the second wall panel, to form a cavity wall, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space;
iv) adding the insulation material to the combined intermediate space to make an insulated wall.

[0011] It is an advantage of the present invention that the insulated wall is easy to install. Further, the method allows the end user to choose the type of insulation material for a given project and they are not limited to deciding this when they purchase the wall panels. This gives flexibility in deciding which insulation material meets their thermal requirements and their environmental requirements. A further advantage is that the thickness of the insulation layer is not controlled by the thickness of precut insulation. Manufacturers sell insulation of certain thicknesses, such as a foam or mineral wool product and it is costly to deviate from the readily available materials. The present invention allows the distance between the first concrete layer and the second concrete layer to be determined by the end user, as the intermediate space will be filled with insulation material on site. This is particularly useful where there are size constraints, and it is desired for the insulated wall to be as thin as possible, while having a predefined level of insulation. A more insulating material, with a lower U-value can then be installed on site. Conversely, where there is a desire for a thicker insulated wall with more insulation, the wall panel can be manufactured from the readily available materials. The present invention allows the distance between the first concrete layer and the second concrete layer to be larger or smaller, when necessary. The distance between the first concrete layer and the second concrete layer may be adjusted by selecting an appropriate connector.

[0012] It is a further advantage of the present invention that when the first wall panel and the second wall panel are positioned next to each other, the insulation is then added to the combined intermediate space, which means that there is not a gap in the insulation material. It is an advantage that there are no gaps in the insulation material. This further improves the thermal performance of the insulated wall as the insulation material is substantially continuous throughout the combined intermediate space and there is not a gap in insulation material between the first and second wall panels.

[0013] Further, the manufacture method reduces the environmental impact as the insulation material does not need to be shipped to the manufacturer of the wall panel but can be shipped directly to site. This results in lower transportation costs, and a lower carbon footprint as the insulation material does not travel as far. This increases flexibility to choose to use or reuse locally sourced insulation materials.

[0014] Preferably, the first wall panel has a length in the range of about 2 m to about 12 m, preferably, in the range of about 3 m to about 11 m, preferably, in the range of about 4 m to about 9 m, preferably about 8 m.

[0015] Preferably, the second wall panel has a length in the range of about 2 m to about 12 m, preferably, in the range of about 3 m to about 11 m, preferably, in the range of about 4 m to about 9 m, preferably about 8 m.

[0016] Preferably, the first wall panel and the second wall panel each independently have a length in the range of about 2 m to about 12 m, preferably, in the range of about 3 m to about 11 m, preferably, in the range of about 4 m to about 9 m, preferably about 8 m.

[0017] Such lengths are suitable for efficiently building

a wall. It is particularly preferred that the length of the wall panel is less than about 12 m, preferably less than about 11.5 m, preferably less than about 9 m, preferably less than about 8.8 m for ease of transportation, such as on a lorry.

[0018] Preferably, the length of the first wall panel and the second wall panel are substantially the same. This means that each wall panel can be used in any position, to allow the insulated wall to be built efficiently.

[0019] The length of the first wall panel and the second wall panel may be different. This allows a wall of a defined length to be built, even when the wall is not an exact multiple of a given wall panel length.

[0020] Preferably, the first wall panel has a height in the range of about 2 m to about 8 m, preferably about 3 m to about 5 m, preferably about 4 m, preferably about 3.8 m.

[0021] Preferably, the second wall panel has a height in the range of about 2 m to about 8 m, preferably about 3 m to about 5 m, preferably about 4 m, preferably about 3.8m.

[0022] Preferably, the first wall panel and the second wall panel each independently have a height in the range of about 2 m to about 8 m, preferably about 3 m to about 5 m, preferably about 4 m, preferably about 3.8m.

[0023] Such heights are suitable for buildings. In particular, current storeys of buildings are often about 4 m high, such as about 3.8 m high.

[0024] Preferably, the height of the first wall panel and the second wall panel are substantially the same. This allows a wall of substantially even height to be built.

[0025] The height of the first wall panel and the second wall panel may be different. This allows a wall of differing height to be built or accounts for any different levels or gradients of the floor.

[0026] Preferably, the first wall panel has a thickness in the range of about 20 cm to about 50 cm, preferably about 25 cm to about 40 cm.

[0027] Preferably, the second wall panel has a thickness in the range of about 20 cm to about 50 cm, preferably about 25 cm to about 40 cm.

[0028] Preferably, the first wall panel and the second wall panel each independently have a thickness in the range of about 20 cm to about 50 cm, preferably about 25 cm to about 40 cm.

[0029] Such thicknesses allow the first concrete layer and second concrete layer to have sufficient strength and allows the intermediate space to hold the desired amount of insulation material.

[0030] Preferably, the thickness of the first wall panel and the second wall panel are substantially the same. This allows the first wall panel and second wall panel to be easily aligned.

[0031] The thicknesses of the first wall panel and the second wall panel may be different. This allows a wall of differing thickness to be built.

[0032] Preferably, the first wall panel and the second wall panel are substantially a rectangular prism. This is an efficient shape for building a wall.

[0033] Preferably, the first concrete layer of the first wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably, in the range of about 5 cm to about 7 cm;

Preferably, the second concrete layer of the first wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably, in the range of about 5 cm to about 7 cm.

[0034] Preferably, the first concrete layer of the second wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably, in the range of about 5 cm to about 7 cm.

[0035] Preferably, the second concrete layer of the second wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably, in the range of about 5 cm to about 8 cm; preferably about 7cm.

[0036] Such thicknesses of the concrete layers balance the need for strength, while minimising the weight of the resulting insulated wall.

[0037] Preferably, the thickness of the first concrete layer of the first wall panel is substantially the same as the thickness of the first concrete layer of the second wall panel.

[0038] Preferably, the thickness of the second concrete layer of the first wall panel is substantially the same as the thickness of the second concrete layer of the second wall panel.

[0039] This allows the first wall panel and second wall panel to be easily aligned. Further, a uniformly sized combined intermediate space gives the same level of thermal insulation across the wall.

[0040] Preferably, the thickness of the first concrete layer of the first wall panel is less than the thickness of the second concrete layer of the first wall panel.

[0041] Preferably, the thickness of the first concrete layer of the second wall panel is less than the thickness of the second concrete layer of the second wall panel.

[0042] Preferably, the thickness of the first concrete layer of the first wall panel is greater than the thickness of the second concrete layer of the first wall panel.

[0043] Preferably, the thickness of the first concrete layer of the second wall panel is greater than the thickness of the second concrete layer of the second wall panel.

It is advantageous to have a thicker concrete layer at the inside of a building for structural support, while minimising the weight of the wall panel. For example, the concrete layer at the inside of the building may support roof beams or floor slabs.

[0044] Preferably, the first concrete layer of the first wall panel and the second concrete layer of the first wall panel are substantially a rectangular prism.

[0045] Preferably, the first concrete layer of the second wall panel and the second concrete layer of the second wall panel are substantially a rectangular prism.

[0046] Preferably, the first concrete layer of the first wall panel and the second concrete layer of the first wall panel are substantially parallel, preferably along the x

and/or y and/or z axis.

[0047] Preferably, the first concrete layer of the second wall panel and the second concrete layer of the second wall panel are substantially parallel.

[0048] Preferably, the first concrete layer of the first wall panel and the second concrete layer of the first wall panel are substantially straight, preferably substantially planar.

[0049] Preferably, the first concrete layer of the second wall panel and the second concrete layer of the second wall panel are substantially straight, preferably substantially planar.

[0050] Straight, for example planar, concrete layers allow efficient building methods.

[0051] The first concrete layer of the first wall panel and the second concrete layer of the first wall panel may alternatively be curved or shaped.

[0052] The first concrete layer of the second wall panel and the second concrete layer of the second wall panel may alternatively be curved or shaped.

[0053] Curved or shaped wall panels may be desirable in some building designs.

[0054] Preferably, the length of the first concrete layer of the first wall panel and the length of the second concrete layer of the first wall panel are different. Preferably, the length of the first concrete layer of the second wall panel and the length of the second concrete layer of the second wall panel are different. This allows different configurations of walls to be built, such as to build a wall with corners.

Preferably, the first wall panel and the second wall panel are arranged along the same axis. Preferably, the first concrete layer of the first wall panel lines up with the first concrete layer of the second wall panel. Preferably, the second concrete layer of the first wall panel lines up with the second concrete layer of the second wall panel. This is an efficient arrangement.

[0055] Preferably, the average distance between the first concrete layer of the first wall panel and the first concrete layer of the second wall panel is in the range between about 0.5 cm and about 2 cm, preferably, in the range of between about 0.5cm and about 1.5 cm, preferably about 1 cm.

[0056] Preferably, the average distance between the second concrete layer of the first wall panel and the second concrete layer of the second wall panel is in the range between about 0.5 cm and about 2 cm, preferably, in the range of between about 0.5cm and about 1.5 cm, preferably about 1 cm.

[0057] Preferably, the average distance between the first wall panel and the second wall panel is in the range between about 0.5 cm and about 2 cm, preferably, in the range of between about 0.5cm and about 1.5 cm, preferably about 1 cm.

[0058] It is advantageous for the first wall panel and the second wall panel to be as close as possible, whilst allowing space for thermal expansion.

[0059] Preferably the average distance is measured at about 15 °C and/or preferably at 50% relative humidity.

[0060] Preferably, the first wall panel and the second wall panel are positioned end to end.

[0061] Preferably, the first wall panel and the second wall panel are positioned next to each other in the x direction, that is, preferably the first wall panel and the second wall are positioned in a row. Preferably a joint between the first wall panel and the second wall panel extends in a substantially vertical direction. This allows an insulated wall to be built in a horizontal direction,

[0062] Preferably, the first wall panel and the second wall panel are positioned next to each other in the z direction, that is, preferably the first wall panel and the second wall are positioned in a column. Preferably a joint between the first wall panel and the second wall panel extends in a substantially horizontal direction. This allows an insulated wall to be built in a vertical direction,

[0063] Preferably the insulated wall comprises a plurality of wall panels as described herein, such as about 3 or more wall panels, preferably about 3 to about 100 wall panels, preferably about 8 to about 50 wall panels, preferably about 10 to about 20 wall panels. It will be appreciated that each additional wall panel will preferably share a combined intermediate space with at least one other wall panel, preferably at least about 2 other wall panels, preferably with at least about 3 other wall panels. It will be appreciated that where there are 3 or more wall panels, the wall will comprise a first wall panel, a second wall panel, a third wall panel etc, wherein the third and subsequent wall panels preferably have the features described herein for the first wall panel and or second wall panel. This allows a larger insulated wall to be built. The wall panels may be arranged in a x direction, or in a z direction, or in both a x direction and a z direction to form an insulated wall. Further, the wall panels may be arranged in a x direction, and/or y direction, and/or z direction to form an insulated wall.

[0064] A x direction is preferably substantially horizonal and a z direction is preferably substantially vertical.

[0065] Preferably, a joint is applied to join the first wall panel and the second wall panel. Preferably, a first joint is applied to join the first concrete layer of the first wall panel to the first concrete layer of the second wall panel and a second joint is applied to join the second concrete layer of the first wall panel to the second concrete layer of the second wall panel. Preferably, the joint is applied before the insulation material is added to the combined intermediate space. Further joints are preferably provided between further wall panels as described herein, the description of the joint herein also applies to the first joint and/or the second joint and/or further joints.

[0066] A joint has the advantage of making the step of adding the insulation material more efficient as there is not a gap between each concrete layer of the adjacent wall panels for the insulation material to blow out. Further the joint provides water tightening and air tightening to the insulated wall, to prevent ingress of rainwater and the like.

[0067] Preferably, when the joint is in a substantially horizontal direction, it comprises a load bearing part and a water/air tightening part, preferably, a loadbearing felt part/loadbearing cord part, and a water/air tightening rubber part. This increases the structural integrity of the insulated wall. Preferably the joint is a combined joint comprising a load bearing part and a water/air tightening part. This has the advantage of the user only having one item to apply to the joint and this having a dual load bearing and water/air tightening function. Preferably the joint is a combined joint comprising a loadbearing cord with an outer rubber part, preferably a loadbearing cord coextruded with an outer rubber part. Preferably the rubber part is a butyl rubber, silicone, polyurethane, polysulfide, acrylic or a combination of two or more thereof. Preferably in use, the joint is compressed between the first wall panel and the second wall panel. This has the advantage of the user only having one item to apply as the joint and this having a dual load bearing and water/air tightening function. Preferably, the joint is a combined joint comprising a load bearing felt part combined with a butyl rubber part. Preferably in use, the joint is compressed between the first wall panel and the second wall panel. This has the advantage of the user only having one item to apply as the joint and this having a dual load bearing and water/air tightening function.

[0068] Preferably, when the joint is in a vertical direction, it comprises caulk. Caulk is easy to install on site, such as using a caulk gun and provides water tightening and air tightening. Caulk preferably comprises silicone, polyurethane, polysulfide, acrylic or a combination of two or more thereof.

[0069] Preferably, the joint is a substantially elongate member, wherein the joint comprises a core load bearing part with an upper recess, a lower recess, a left recess and a right recess, wherein the upper recess and the lower recess each comprise an adhesive, wherein the surface of the left recess and the surface of the right recess each comprise a water/air tightening part. The core, upper recess, lower recess, left recess and right recess are described when viewed as a cross-section of the joint. This joint increases the structural integrity of the insulated wall. This has the advantage of the user only having one item to apply to the joint and this having a load bearing and water/air tightening function. Furthermore, the adhesive aids the application of the joint by sticking to a first wall panel, in a required position, before a second wall panel is applied. Preferably, the joint has a substantially symmetrical cross-section. This means that the upper and lower recesses are preferably substantially the same size and shape, and the left and right recesses are preferably substantially the same size and shape. This aids the application of the joint and reduces wastage. Further, this helps allow substantially even compression of the joint.

[0070] The upper and lower recesses are a convenient way to provide the adhesive. In use, the adhesive material in the upper recess will contact a first concrete wall panel, preferably the first concrete layer of the first wall panel and the adhesive material in the lower recess will contact a second wall panel, preferably the first concrete layer of the second wall panel. The joint may be positioned in other configurations as required, such as between second concrete layers of a first and second wall panel.

[0071] Preferably, the joint is positioned at the outer edge of the first and second wall panel. Preferably, the water/air tightening part of the left recess is visible between the first and second wall panel. Preferably, the water/air tightening part of the right recess is not visible. This shows the position of the joint. The opposite configuration is also envisaged.

[0072] Preferably, the joint is used in a substantially horizontal position. Preferably in use, the joint is compressed between the first wall panel and the second wall panel. This has the advantage of the user only having one item to apply as the joint and this having a dual load bearing and water/air tightening function.

[0073] Preferably, the core load bearing part has a substantially cross-shaped cross-section. Preferably, the core load bearing part comprises a rubber, preferably a synthetic rubber, preferably ethylene propylene diene monomer rubber (EPDM). Preferably, the core load bearing part has a Shore A hardness in the range of about 50 to about 90, preferably in the range of about 75 to about 85. These materials provide suitable strength to the core. Shore A hardness is preferably measured in accordance with ASTM D2240.

[0074] Preferably, the adhesive comprises caulk. Caulk preferably comprises silicone, polyurethane, polysulfide, acrylic, butyl rubber or a combination of two or more thereof. These materials help the joint to be held in place.

[0075] Preferably, the water/air tightening part comprises a rubber, preferably a synthetic rubber, preferably EPDM. Preferably, the water/air tightening part has a Shore A hardness in the range of about 30 to about 70, preferably in the range of about 55 to about 65. These materials provide suitable water/air tightening.

[0076] Preferably, the Shore A hardness of the core load bearing part is greater than the Shore A hardness of the water/air tightening part. Preferably, the core load bearing part has a Shore A hardness of at least about 10 more than the water/air tightening part, preferably about 10 to about 40 more.

[0077] Preferably, the cross-section of the joint is substantially cuboidal, preferably substantially square. This shape is desired because the adhesive material in the upper and lower recesses will contact the concrete wall panels, whereas the water/air tightening part in the left and right recesses are arranged substantially between the wall panels.

[0078] Preferably, the joint has a substantially symmetrical cross sectional area. This aids the end user in applying the joint.

[0079] Preferably, the joint has a cross-sectional area

of about 1 cm^2 to about 4 cm^2. Preferably the joint has a length of at least about 1 m, such as about 1 m to about 20 m. Preferably the length if the joint is equal to the length of the first or second wall panel. Preferably the joint is substantially continuous along multiple wall panels.

[0080] Preferably, the joint is provided on a roll, preferably, the length of the joint on the roll is about 10 m to about 200 m, preferably about 20 m to about 100 m, such as about 25, about 50 m, or about 100 m.

[0081] It will be appreciated that the joint may be used to join any concrete panels.

[0082] Preferably, the first wall panel and/or the second wall panel comprise reinforcement elements. Such reinforcement elements are known to provide resistance to tensile forces and reduce or prevent cracking. Preferably the reinforcement elements are substantially planar and are preferably embedded into the first concrete layer and/or the second concrete layer. Preferably each reinforcement element is embedded in either the first concrete layer or the second concrete layer, such that each reinforcement element is only in one layer. Preferably the reinforcement elements are in the form of a mesh. The reinforcement elements may be steel, or a non-metallic material.

[0083] Preferably, the reinforcement elements comprise a material selected from the group consisting of mineral fibres, organic fibres, thermoset polymer material, thermoplastic polymer material or fibre reinforced polymer, preferably, a fibre reinforced polymer, preferably, wherein the polymer is reinforced with fibres, preferably mineral fibres or organic fibres, glass fibres, carbon fibres, aramid fibres, basalt fibres, polyethylene fibres, Kevlar fibres, cotton fibres, hemp fibres, jute fibres, flax fibres or a combination of two or more thereof; preferably, the reinforcement elements comprises a glass fibre reinforced polymer.

[0084] Preferably, the first concrete layer and the second concrete layer are pre-cast. This has the advantage of giving the resulting wall panel a molded surface. This reduces further processing steps on site as the wall is molded to the desired shape and surface finish. Preferably the first concrete layer and the second concrete layer are smooth or textured, preferably smooth.

[0085] Preferably, wherein the first wall panel and the second wall panel are made by:

a) casting the first concrete layer into a mold,
b) arranging the plurality of connectors in the first concrete layer,
c) curing the first concrete layer
d) casting the second concrete layer into a mold,
e) connecting the first concrete layer to the second concrete layer via the connectors, and
f) curing the second concrete layer to form the first wall panel or the second wall panel.

The use of a mold gives the wall panel a desired shape and surface finish, preferably a smooth outer surface. It will be appreciated that the resulting wall panel has the connectors embedded in each of the first concrete layer and the second concrete layer and that the connectors span the intermediate space.

[0086] Preferably, step (a) comprises casting the first concrete layer into a mold with reinforcement elements, preferably wherein the reinforcement elements are positioned in the mold prior to casting the first concrete layer.

[0087] Preferably the connector is held in position by a positioning device. Preferably the positioning device comprises a polymer material. A positioning device preferably holds a connector in a substantially vertical position, preferably substantially perpendicular to the first concrete layer.

[0088] Preferably the positioning device is positioned during step (b). This allows the connectors to be correctly positioned by the positioning device after the first concrete layer has been cast.

[0089] A positioning device may be positioned in the mold prior to step (a). This allows the connectors to be correctly positioned and may be preferred if the positioning device is attached to a reinforcement element.

[0090] Preferably, step (d) comprises casting the second concrete layer into a mold with reinforcement elements.

[0091] Preferably, the thickness of the intermediate space of the first wall panel is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm.

[0092] Preferably, the thickness of the intermediate space of the second wall panel is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm.

[0093] Preferably, the thickness of the combined intermediate space wall is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm.

[0094] Such thicknesses of the intermediate spaces are suitable for containing the insulation material.

[0095] Preferably, the thickness of the intermediate space of the first wall is substantially uniform.

[0096] Preferably, the thickness of the intermediate space of the second wall is substantially uniform.

[0097] Preferably, the thickness of the combined intermediate space is substantially uniform.

[0098] Preferably, the method comprises sealing at least one edge of the combined intermediate space.

[0099] Preferably, the method comprises sealing at least one upstanding edge of the combined intermediate space.

[0100] Preferably, the method comprises sealing two upstanding edges of the combined intermediate space.

[0101] Preferably, the method comprises sealing the top edge of the combined intermediate space.

[0102] Preferably, the method comprises sealing the bottom edge of the combined intermediate space.

[0103] The top edge and the bottom edge refer to the

position of the combined intermediate space when the insulated wall is installed.

[0104] It is advantageous to seal one or more edges of the combined intermediate space to control where the insulation material is placed. This reduces the likelihood of the insulation material falling out of the combined intermediate space.

[0105] It is not necessary to seal all the sides, for example if the insulation material will stay in place without sealing.

[0106] Further, where one or more of the first and second wall panels may each be connected to another wall panel, it is desirable for the resulting combined intermediate space to be filled with insulation material, without any seals, for example without any seals between adjacent intermediate spaces.

[0107] The bottom of the combined intermediate space is preferably positioned on a surface and therefore may not require sealing. In some circumstances, the bottom edge may be sealed.

[0108] It is preferred that all of the edges of the combined intermediate space are sealed, for example by a seal, or by being positioned next to another item in order to efficiently introduce the insulation material.

[0109] Preferably, the one or more edges of the intermediate space are sealed using tape. This is easy to apply and remove at a later point. Further, a hole can be made in the tape to add the insulation material to the combined intermediate space.

[0110] Preferably the first wall panel and/or the second wall panel comprise at least two compartments, preferably about 2 to about 10 compartments, preferably about 3 to about 8 compartments. Preferably the compartments are formed by substantially vertical dividers. Preferably the dividers are formed of a mesh, preferably a plastic mesh. Such compartments allow the insulation material to be packed into the intermediate space. Preferably the compartments are interconnected, such as using a mesh such that insulation material can flow through the compartments. An advantage of vertical dividers is that the insulation material may be added from the top. Where the second wall panel is positioned above the first wall panel, the dividers preferably line up such that the compartments extend the height of the combined intermediate space.

[0111] Preferably, the insulation material is flowable. This allows the insulation material to be added to and fill substantially all of the combined intermediate space. Liquids, loose particles, such as loose fibres or granules, are all flowable as they can be moved from one location to another by pouring.

[0112] Preferably, the insulation material is poured or blown or injected into the combined intermediate space, preferably using pressurised air. Such methods are suitable for adding the insulation material into the combined intermediate space. They help ensure that the insulation material fills substantially all the combined intermediate space.

[0113] Preferably, poured means to send the insulation material flowing or falling from one container, to another location, preferably, the combined intermediate space.

[0114] Preferably, blown means to use a moving gas, preferably compressed air, to send the insulation material from one container, to another location, preferably, the combined intermediate space.

[0115] Preferably, injected means to force the insulation material from one container, to another location, preferably, the combined intermediate space

Preferably, the insulation material comprises fibres, granules, foam or a combination of two or more thereof, preferably, loose fibres, granules, foam or a combination of two or more thereof. Such materials are flowable and can be added to the combined intermediate space.

[0116] Preferably, granules have a particle size of less than about 25 mm, preferably, less than about 20 mm, preferably, less than about 10 mm, such as about 1 mm to about 25 mm, preferably about 5 mm to about 20 mm. The particle size can be measured by sieving.

[0117] Preferably, the fibres are loose fibres. Some fibres may be bonded to other fibres, but the bulk insulation material should preferably be flowable. This allows the insulation material to flow into the intermediate space. Preferably the loose fibres are not bound to each other with a binder.

[0118] Preferably the fibres have a number average diameter in a range of about 1 μm to about 5 mm, preferably about 2 μm to about 2 mm, preferably about 3 μm to about 1 mm, preferably about 4 μm to about 500 μm, preferably about 4 μm to about 10 μm.

[0119] Preferably the fibres have a number average length in a range of 1 μm to about 1 cm, preferably about 2 μm to about 1 mm, preferably about 3 μm to about 10 μm.

[0120] Preferably, the insulation material comprises fibres or granules, preferably, loose fibres or granules. These are particularly advantageous as they can be removed from the combined intermediate space when required, such as when a building is being renovated or demolished. The insulation material and the wall panels can then be reused or recycled which reduces the carbon footprint of the wall. Further, should there be a desire to change the insulation material, the existing insulation material can be removed. The insulation material is preferably, removed by suction. This is an efficient way to remove the material.

[0121] Preferably, the insulation material comprises organic material or mineral material, preferably mineral fibres, glass fibres, paper fibres, cotton fibres, cellulose fibres, sheep's wool, rice husks, silica aerogel granules, polystyrene granules, cork granules, expanded vermiculite granules, expanded glass granules , mineral fibre granules, wood chips, expanded perlite granules, flax, hemp, jute, coconut husks, expanded organic seeds, expanded plastics, polyurethane foam, polyethylene foam, polyisocyanurate foam, phenolic foam, urea foam, urea-formaldehyde foam, icynene foam or a combination of

two or more thereof, preferably mineral fibres, glass fibres or paper fibres, preferably loose mineral fibres, loose glass fibres or loose paper fibres, preferably loose mineral fibres and/or loose glass fibres.

[0122] Loose mineral fibres and/or loose glass fibres are particularly preferred due to their excellent thermal insulation properties and excellent fire resistance properties.

[0123] Preferably the insulation material comprises recycled/waste material, wherein the material is a thermally insulating material, preferably wherein the material used for its insulating is diverted from landfill. Preferably recycled/waste insulation material is circular use insulation material. Preferably recycled/waste insulation material has previously been used as an insulation material and is reused in the present invention. Preferably the recycled/waste material is an acoustically insulating material.

[0124] Preferably, the insulation material has a thermal conductivity of less than about 1 $W \cdot m^{-1} \cdot K^{-1}$, such as about 0.001 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$, preferably about 0.01 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$. Such thermal conductivities provide a suitable level of thermal insulation.

[0125] Preferably, the insulation material is substantially continuous throughout the combined intermediate space. Preferably, the insulation material is substantially continuous between the first wall panel and the second wall panel. Preferably, at least about 90 vol% of the combined intermediate space comprises the insulation material, preferably, at least about 95%, preferably, at least about 97%, preferably, at least about 98%, preferably, at least about 99%, such as about 90 % to about 100%, preferably, substantially all of the combined intermediate space comprises the insulation material. It will be appreciated that there will be air voids in the insulation material, and that the amount of insulation material present in the intermediate space preferably refers to the bulk of the insulation material, including the air voids which are formed by design, for example between fibres or granules.

[0126] It is preferable that the insulation material is distributed evenly throughout the combined intermediate space for energy efficiency. It is a particular advantage of the invention that the insulation material continues across where the first wall panel is next to the second wall panel.

[0127] Preferably, the intermediate space between the first concrete layer and the second concrete layer in the first wall panel and/or the second wall panel does not comprise an insulation material prior to step (iv). Preferably the first wall panel and the second wall panel provided in step (i) do not comprise an insulation material in the intermediate space. This allows the insulation material to be added in a controlled manner when the insulated wall is made. There is not existing insulation material to be worked around when the insulated wall is made. This has the advantage of producing a substantially uniform layer of insulation material in the intermediate space. Further this means that the insulation material can be defined by the end user.

[0128] Preferably, the intermediate space between the first concrete layer and the second concrete layer in the first wall panel and/or the second wall panel consists of the space between the first concrete layer and the second concrete layer and the plurality of connectors,

[0129] Preferably, at least one connector is embedded in both the first concrete layer and the second concrete layer. Preferably, each connector is embedded in both the first concrete layer and the second concrete layer, preferably such that each connector bridges the intermediate space.

[0130] Preferably, the plurality of connectors comprises a plurality of layer connectors. Preferably, the layer connector comprises a shaft with a first anchorage end and a second anchorage end, wherein the first anchorage end is embedded in the first concrete layer and the second anchorage end is embedded in the second concrete layer. Preferably, the first and second wall panels each comprise an array of layer connectors. Preferably, the layer connectors are arranged in substantially parallel lines. Preferably, the distance between each layer connector is in a range between about 20 cm and about 100 cm, preferably between about 40 cm and about 90 cm. The layer connector holds the second concrete layer away from the first concrete layer during fabrication and carries loads from one concrete layer to the other after the wall panel is installed.

[0131] When the first wall panel or the second wall panel are made, the layer connectors may be held in position by a positioning device. Preferably, the positioning device is an attachment to the reinforcement element or a polymer positioning device.

[0132] Preferably, the connector is a load transfer device. Preferably the load transfer device comprises a first retention member, a second retention and a guide member, whereby the guide member retains the first retention member and the second retention member at a predetermined angle, wherein the first retention member and the second retention member cross over in the guide member, wherein the first end of the first retention member and the first end of the second retention member are embedded in the first concrete layer, wherein the second end of the first retention member and the second end of the second retention member are embedded in the second concrete layer. Preferably the first retention member and/or the second retention member is a rod or a tie. An advantage of the load transfer device is it reduces twisting when the first or second wall panel is moved and reduces deflection after installation due to applied loads. Preferably, the first and second wall panels each comprise at least about 2 load transfer devices, preferably about 2 to about 4 load transfer devices. Preferably, the load transfer devices are arranged at opposing ends of each of the first and second wall panels.

[0133] Preferably, the connector comprises a mesh or girder.

[0134] Preferably, the connectors have a thermal con-

ductivity of less than about 1 $W \cdot m^{-1} \cdot K^{-1}$, such as about 0.001 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$, preferably about 0.01 $W \cdot m^{-1} \cdot K^{-1}$ to about 1$W \cdot m^{-1} \cdot K^{-1}$.

[0135] Thermal conductivity is preferably measured in accordance with ISO 22007-1:2017.

[0136] Such connectors increase the U-value of the insulated wall compared to using metal connectors.

[0137] Preferably, the connector, the layer connector and/or the first and second retention members comprises a fibre reinforced polymer, preferably, wherein the polymer is reinforced with mineral fibres or organic fibres, preferably glass fibres, carbon fibres, aramid fibres, basalt fibres, polyethylene fibres, Kevlar fibres, cotton fibres, hemp fibres, jute fibres, flax fibres or a combination of two or more thereof; preferably, the connector comprises a glass fibre reinforced polymer.

[0138] Preferably, the polymer comprises a thermoset polymer resin or a thermoplastic polymer resin, preferably vinyl ester resin, epoxy resin or a combination of both thereof.

[0139] Preferably, the fibre reinforced polymer comprises one or more filler, preferably wherein the filler is calcium carbonate, magnesium hydroxide, barium sulphate, wollastonite or Kaolin or a combination of two or more thereof. Fillers may be used to improve the tensile strength of the fibre reinforced polymer.

[0140] Preferably the connectors do not comprise metal. Metal will reduce the thermal insulation of the wall and is undesirable.

[0141] The guide member preferably comprises an insulation material such as mineral fibres bonded with a cured binder, or a foam.

[0142] The present invention relates to a kit comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer,
wherein the insulation material is not provided in the intermediate spaces, and
wherein the intermediate spaces are for receiving the insulation material.

[0143] Such a kit allows an insulated wall to be built.

[0144] Preferably, the kit further comprises a joint as described above.

[0145] Preferably, the kit further comprises a seal for sealing at least one edge of the intermediate space as described above.

[0146] Preferably, the kit comprises further wall panels, such as further first and/or second wall panels.

[0147] The present invention relates to an insulated wall comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;
wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space, and
wherein the insulation material is in the combined intermediate space.

[0148] Preferably, the insulated wall comprises a plurality of wall panels. The wall panels may be arranged next to each other in a horizontal orientation or in a vertical orientation.

[0149] Preferably the insulated wall is an external wall.

[0150] Preferably the insulated wall is an internal wall.

[0151] The present invention also relates to a construction or building comprising the first and second wall panels of the present invention.

[0152] Preferably the U-value of the insulated wall is less than about 0.24 $W/m^2.K$, preferably less than about 0.15 $W/m^2.K$, preferably wherein the U-value of this insulated wall is in the range of about 0.05 $W/m^2.K$ to about 0.24 $W/m^2.K$, preferably about 0.1 $W/m^2.K$ to about 0.2 $W/m^2.K$. Such values are thermally efficient.

[0153] The present invention further relates to a recycled/waste material storage device comprising an insulated wall comprising a first wall panel and a second wall panel and a recycled/waste material,

wherein the recycled/waste material is a thermally insulating material,
wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;
wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the

second wall panel form a combined intermediate space, and

wherein the recycled/waste material is in the combined intermediate space.

[0154] Such a waste insulation material storage device may have all the advantages and further features of the insulated wall described herein and provides a convenient and environmentally friendly way to reuse recycled/waste material.

[0155] Preferably, the recycled/waste material is recycled/waste insulation material.

[0156] Preferably the recycled/waste material is an acoustically insulating material.

[0157] Preferably, the recycled/waste material has a thermal conductivity of less than about 1 $W \cdot m^{-1} \cdot K^{-1}$, such as about 0.001 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$, preferably about 0.01 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$.

[0158] The present invention further relates to joint for a concrete wall, wherein the joint is a substantially elongate member, wherein the joint comprises a core load bearing part with an upper recess, a lower recess, a left recess and a right recess, wherein the upper recess and the lower recess each comprise an adhesive, wherein the left recess and the right recess each comprise a water/air tightening part, Further features of the joint are described above. Such a joint has particular utility in the present invention.

[0159] Example embodiments of the present invention will now be described with reference to the accompanying figures, in which

Figure 1 shows an elevated view of a first concrete layer.

Figure 2 shows an elevated view of a first wall panel.

Figure 3 shows an elevated view of a load transfer device.

Figure 4 shows an elevated view of a layer connector with a positioning device.

Figure 5 shows an elevated view of a layer connector with a positioning device.

Figure 6 shows a cross-sectional view of a first wall panel.

Figure 7 shows a side view of an insulated wall.

Figure 8 shows a cross-sectional view of an insulated wall.

Figure 9 shows a side view of an insulated wall.

Figure 10 shows a cross-sectional view of a horizontal joint.

Figure 11 shows a cross-sectional view of a horizontal joint installed between a first wall panel and a second wall panel.

Figure 12 shows compartments within the first wall panel.

Figure 13 shows a cross-sectional view of a joint.

[0160] Figure 1 shows an elevated view of a first concrete layer 6. The first concrete layer 6 has a plurality of connectors 10 embedded in it. Two types of connector 10 are shown. There are two load transfer devices 28, and 35 layer connectors 26. The connectors 10 are arranged in an even pattern across the surface of the first concrete layer 6. It will be appreciated that there could be more or less of the connectors present, as required. In some embodiments, no load transfer devices 28 are necessary. The first concrete layer 6 may be rotated by 180° and positioned on top of a second concrete layer 8 to form a first wall panel 1 as shown in figure 2.

[0161] Figure 2 shows that the connectors 10 are embedded in both the first concrete layer 6 and the second concrete layer 8 to define an intermediate space 12. To achieve this, the second concrete layer 8 is poured and then the connectors 10 in the first concrete layer 6 are embedded in the second concrete layer 8. This forms a first wall panel 1. It will be appreciated that a second wall panel 2 may be formed in an analogous way.

[0162] Figure 3 shows an elevated view of a load transfer device 28. The load transfer device 28 comprises a first retention member 36, a second retention 38 and a guide member 34, whereby the guide member 34 retains the first retention member 36 and the second retention member 38 at a predetermined angle, wherein the first retention member 36 and the second retention member 38 cross over in the guide member 34. In use, the first end 36a of the first retention member 36 and the first end 38a of the second retention member 38 are embedded in the first concrete layer (not shown), and the second end 36b of the first retention member 36 and the second end 38b of the second retention member 38 are embedded in the second concrete layer (not shown). The first retention member 36 and the second retention member 38 are shown as a rod or a tie.

[0163] Figure 4 shows an elevated view of a layer connector 26 held substantially perpendicular to the surface of the first concrete layer 6 with a positioning device shown as a polymer button 30. The layer connector 26 is shown embedded into a first concrete layer 6. The layer connector 26 comprises a shaft with a first anchorage end 26a and a second anchorage end 26b, wherein the first anchorage end 26a is embedded in the first concrete layer 6 and in a first wall panel, the second anchorage end 26b will be embedded in the second concrete layer 8 (not shown). The first concrete layer 6 is partially shown.

[0164] Figure 5 shows an elevated view of a layer connector 26 held substantially perpendicular to the surface of the first concrete layer 6 with a positioning device shown as a polymer chair 32. The layer connector 26 is shown embedded into a first concrete layer 6. The layer connector 26 comprises a shaft with a first anchorage end 26a and a second anchorage end 26b, wherein the first anchorage end 26a is embedded in the first concrete layer 6 and in use, the second anchorage end 26b will be embedded in the second concrete layer 8 (not shown). The first concrete layer 6 is partially shown.

[0165] Figure 6 shows a cross-sectional view of a first wall panel 1. The first wall panel 1 comprises a first con-

crete layer 6 and a second concrete layer 8 and an intermediate space 11 between the first concrete layer 6 and the second concrete layer 8. A plurality of connectors 10 extend from the first concrete layer 6 through the intermediate space 11 to the second concrete layer 8. The intermediate space 11 is shown partially filled with insulation material 14. It is preferable that the intermediate space 11 is completely filled with insulation material 14.

[0166] Figure 7 shows a side view of an insulated wall 15. This shows a first wall panel 1 joined to a second wall panel 2 via a joint 40. An upstanding edge 18, or a bottom edge 22, or a top edge 20 may be sealed prior to insulation material 14 (not shown) being introduced into the intermediate space 11 (not shown) to help retain the insulation material 14.

[0167] Figure 8 shows a cross-sectional view of an insulated wall 15. This shows a first wall panel 1 joined to a second wall panel 2 via a joint 40. Insulation material 14 fills the joint intermediate space 12 and is substantially continuous across the joint 40 between the first wall panel 1 and the second wall panel 2.

[0168] Figure 9 shows a side view of an insulated wall. A first wall panel 1 is shown joined to a second wall panel 2 via a vertical joint 51. The second wall panel 2 is shown on the righthand side of the first wall panel 1. Two further wall panels 55 and 57 are shown arranged above the first wall panel 1 and the second wall panel 2 respectively. There is a horizontal joint 52 between the first wall panel 1 and further wall panel 55, and between the second wall panel 2 and further wall panel 57. There is a vertical joint 51 between the further wall panels 55 and 57. This shows how a larger insulated wall can be made of a plurality of wall panels. Further wall panels may be installed to make a taller and/or longer wall.

[0169] Figure 10 shows a cross-sectional view of a horizontal joint 52. The joint 52 comprises a core-sheath structure with a load bearing part 54 as the core and a water/air tightening part 56 as the sheath.

[0170] Figure 11 shows a cross-sectional view of the horizontal joint 52 of Figure 10 installed between a first wall panel 1 and a second wall panel 2. As shown, the load bearing part 54 has substantially retained its shape. The water/air tightening part 56 has been compressed to fill more of the gap between the first wall panel 1 and the second wall panel 2 and to act as a joint. It will be appreciated that the joint is between the first concrete layer 6 of the first wall panel 1 and the first concrete layer 6 of the second wall panel 2.

[0171] Figure 12 shows compartments within the first wall panel. The first concrete layer 6 is as described for Figure 1, with the addition of dividers 60 separating the first concrete layer 6 into compartments 62. The dividers 60 are shown as a mesh and preferably comprise a plastic mesh. Five dividers 60 are shown and these extend along some of the layer connectors 26. This provides a convenient way for the dividers 60 to be held in place, however other securing means are possible. The dividers 60 may extend down each column of the layer connectors 26, or just some of the layer connectors 26.

[0172] Figure 13 shows a cross-sectional view of a joint 80. The joint comprises a core load bearing part 82 with an upper recess 84, a lower recess 85, a left recess 86 and a right recess 87, wherein the upper recess 84 and the lower recess 85 each comprise an adhesive, wherein the left recess 86 and the right recess 87 each comprise a water/air tightening part. The core load bearing part 82 is shown with a cross shaped cross-section which gives the four recesses described above. In use, the lower recess 85 and the upper recess 86 are each in contact with a concrete panel (not shown) and are sandwiched between them.

[0173] Within this specification embodiments have been described in a way which enables a clear and concise specification to be written, but it is intended and will be appreciated that embodiments may be variously combined or separated without parting from the invention.

[0174] For example, it will be appreciated that all preferred features described herein are applicable to all aspects of the invention described herein and vice versa.

[0175] Within this specification, the term "about" means plus or minus 20%, more preferably, plus or minus 10%, even more preferably, plus or minus 5%, most preferably, plus or minus 2%.

[0176] Within this specification, the term "substantially" means a deviation of plus or minus 20%, more preferably, plus or minus 10%, even more preferably, plus or minus 5%, most preferably, plus or minus 2%.

[0177] Within this specification, reference to "substantially" includes reference to "completely" and/or "exactly". That is, where the word substantially is included, it will be appreciated that this also includes reference to the particular sentence without the word substantially.

[0178] It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present invention and without diminishing its attendant advantages. It is therefore intended that such changes and modifications are covered by the appended claims.

Claims

1. A method of making an insulated wall comprising:

i) providing a first wall panel and a second wall panel,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first

concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;

ii) providing an insulation material;
iii) positioning the first wall panel next to the second wall panel, to form a cavity wall, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space;
iv) adding the insulation material to the combined intermediate space to make an insulated wall.

2. A method according to any preceding claim, wherein the first wall panel and the second wall panel each independently have a length in the range of about 2 m to about 12 m, preferably in the range of about 3 m to about 11 m, preferably in the range of about 4 m to about 9 m, preferably about 8 m; and/or

wherein the first wall panel and the second wall panel each independently have a height in the range of about 2 m to about 8 m, preferably about 3 m to about 5 m, preferably about 4 m, preferably about 3.8m; and/or
wherein the first wall panel and the second wall panel each independently have a thickness in the range of about 20 cm to about 50 cm, preferably about 25 cm to about 40 cm; and/or
preferably wherein the length, the height and the thickness of the first wall panel and the second wall panel are each independently substantially the same.

3. A method according to any preceding claim, wherein the first concrete layer of the first wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably in the range of about 5 cm to about 7 cm; and/or

wherein the second concrete layer of the first wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably in the range of about 5 cm to about 7 cm; and/or
wherein the first concrete layer of the second wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably in the range of about 5 cm to about 7 cm; and/or
wherein the second concrete layer of the second wall panel has a thickness in the range of about 4 cm to about 10 cm, preferably in the range of about 5 cm to about 8 cm; preferably about 7cm and/or
wherein the thickness of the first concrete layer of the first concrete panel is substantially the same as the thickness of the first concrete layer of the second concrete panel; and/or
wherein the thickness of the second concrete layer of the first concrete panel is substantially the same as the thickness of the second concrete layer of the second concrete panel; and/or
wherein the thickness of the first concrete layer of the first wall panel is less than the thickness of the second concrete layer of the first wall panel; and/or
wherein the thickness of the first concrete layer of the second wall panel is less than the thickness of the second concrete layer of the second wall panel.

4. A method according to any preceding claim, wherein the first concrete layer and the second concrete layer are pre-cast, preferably wherein the first wall panel and the second wall panel are made by:

a) casting the first concrete layer into a mold, with optional reinforcement elements,
b) arranging the plurality of connectors in the first concrete layer,
c) curing the first concrete layer
d) casting the second concrete layer into a mold, with optional reinforcement elements,
e) connecting the first concrete layer to the second concrete layer via the connectors, and
f) curing the second concrete layer to form the first wall panel or the second wall panel.

5. A method according to any preceding claim, wherein the insulation material is poured, or blown or injected into the combined intermediate space; and/or

wherein the insulation material comprises fibres, granules, foam or a combination of two or more thereof, preferably, loose fibres, granules, foam or a combination of two or more thereof; and/or
wherein the insulation material comprises organic material or mineral material, preferably mineral fibres, glass fibres, paper fibres, cotton fibres, cellulose fibres, sheep's wool, rice husks, silica aerogel granules, polystyrene granules, cork granules, expanded vermiculite granules, expanded glass granules , mineral fibre granules, wood chips, expanded perlite granules, flax, hemp, jute, coconut husks, expanded organic seeds, expanded plastics, polyurethane foam, polyethylene foam, polyisocyanurate foam, phenolic foam, urea foam, urea-formaldehyde foam, icynene foam or a combination of two or more thereof, preferably mineral fibres, glass fibres or paper fibres, preferably loose mineral fibres, loose glass fibres or loose paper fibres; and/or
wherein the insulation material has a thermal conductivity of less than about 1 $W \cdot m^{-1} \cdot K^{-1}$, such

as about 0.001 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$, preferably about 0.01 $W \cdot m^{-1} \cdot K^{-1}$ to about 1 $W \cdot m^{-1} \cdot K^{-1}$.

6. A method according to any preceding claim comprising sealing at least one edge of the combined intermediate space, preferably sealing at least one upstanding edge of the combined intermediate space, preferably sealing two upstanding edges of the combined intermediate space, optionally further sealing the top edge of the combined intermediate space; and/or
wherein the average distance between the first wall panel and the second wall panel is in the range between about 0.5 cm and about 2 cm, preferably, in the range of between about 0.5cm and about 1.5 cm, preferably about 1 cm.

7. A method according to any preceding claim, wherein the thickness of the intermediate space of the first wall panel is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm; and/or
the thickness of the intermediate space of the second wall panel is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm; and/or
wherein the thickness of the combined intermediate space wall is in the range of about 10 cm to about 25 cm, preferably about 15 cm to about 20 cm, preferably about 16 cm; and/or
wherein the insulation material is substantially continuous throughout the combined intermediate space, preferably wherein the insulation material is substantially continuous between the first wall panel and the second wall panel.

8. A method according to any preceding claim, wherein a joint is applied to join the first wall panel and the second wall panel, preferably wherein a first joint is applied to join the first concrete layer of the first wall panel to the first concrete layer of the second wall panel and a second joint is applied to join the second concrete layer of the first wall panel to the second concrete layer of the second wall panel; preferably wherein the joint is applied before the insulation material is added to the combined intermediate space, preferably wherein the joint, the first joint and/or the second joint comprise a load bearing part and a waterproofing part, preferably, a loadbearing felt part or a loadbearing cord part, and a waterproofing rubber part.

9. A method according to any preceding claim, wherein the connector comprises a plurality of layer connectors and optionally at least about two load transfer devices.; and/or
wherein the fibre reinforced polymer, is reinforced with mineral fibres or organic fibres, preferably glass fibres, carbon fibres, aramid fibres, basalt fibres, polyethylene fibres, Kevlar fibres, cotton fibres, hemp fibres, jute fibres, flax fibres or a combination of two or more thereof; and/or
wherein the polymer comprises vinyl ester resin, epoxy resin, polyurethane resin or a combination of two or more thereof.

10. A joint for a concrete wall, wherein the joint is a substantially elongate member, wherein the joint comprises a core load bearing part with an upper recess, a lower recess, a left recess and a right recess, wherein the upper recess and the lower recess each comprise an adhesive, wherein the left recess and the right recess each comprise a water/air tightening part, preferably wherein the joint is applied to join the first wall panel and the second wall panel according to any preceding claim.

11. A kit comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer,
wherein the insulation material is not provided in the intermediate spaces, and
wherein the intermediate spaces are for receiving the insulation material.

12. An insulated wall comprising a first wall panel and a second wall panel and an insulation material,

wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;
wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space, and
wherein the insulation material is in the combined intermediate space;

preferably wherein the insulated wall comprises a plurality of first wall panels and second wall panels.

13. An insulated wall according to claim 12, wherein the U-value of the insulated wall is less than about 0.24 $W/m^2.K$, preferably less than about 0.15 $W/m^2.K$, preferably wherein the U-value of this insulated wall is in the range of about 0.05 $W/m^2.K$ to about 0.24 $W/m^2.K$, preferably about 0.1 $W/m^2.K$ to about 0.2 $W/m^2.K$..

14. A recycled/waste material storage device comprising an insulated wall comprising a first wall panel and a second wall panel and a recycled/waste material,

wherein the recycled/waste material is a thermally insulating material,
wherein each of the first wall panel and the second wall panel comprise a first concrete layer, a second concrete layer, a plurality of connectors and an intermediate space between the first concrete layer and the second concrete layer,
wherein the connectors extend from the first concrete layer, through the intermediate space to the second concrete layer,
wherein the plurality of connectors each comprise a fibre reinforced polymer;
wherein the first wall panel is adjacent to the second wall panel, wherein the intermediate space of the first wall panel and the intermediate space of the second wall panel form a combined intermediate space, and
wherein the recycled/waste material is in the combined intermediate space.

15. A kit according to claim 11, or an insulated wall according to claim 12 or 13, or a waste insulation storage device according to claim 14, further comprising the feature of any of claim 2 to 10.

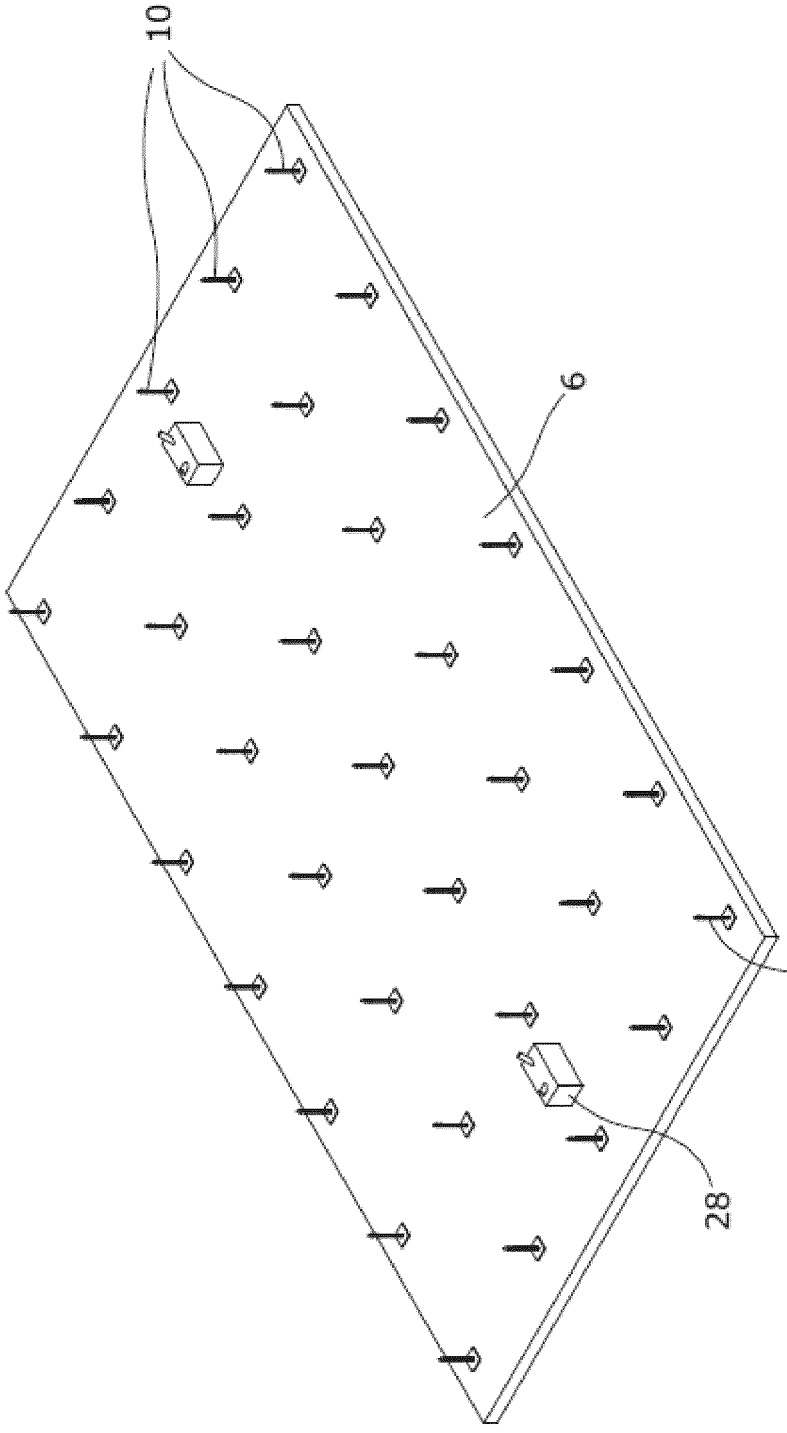

Figure 1

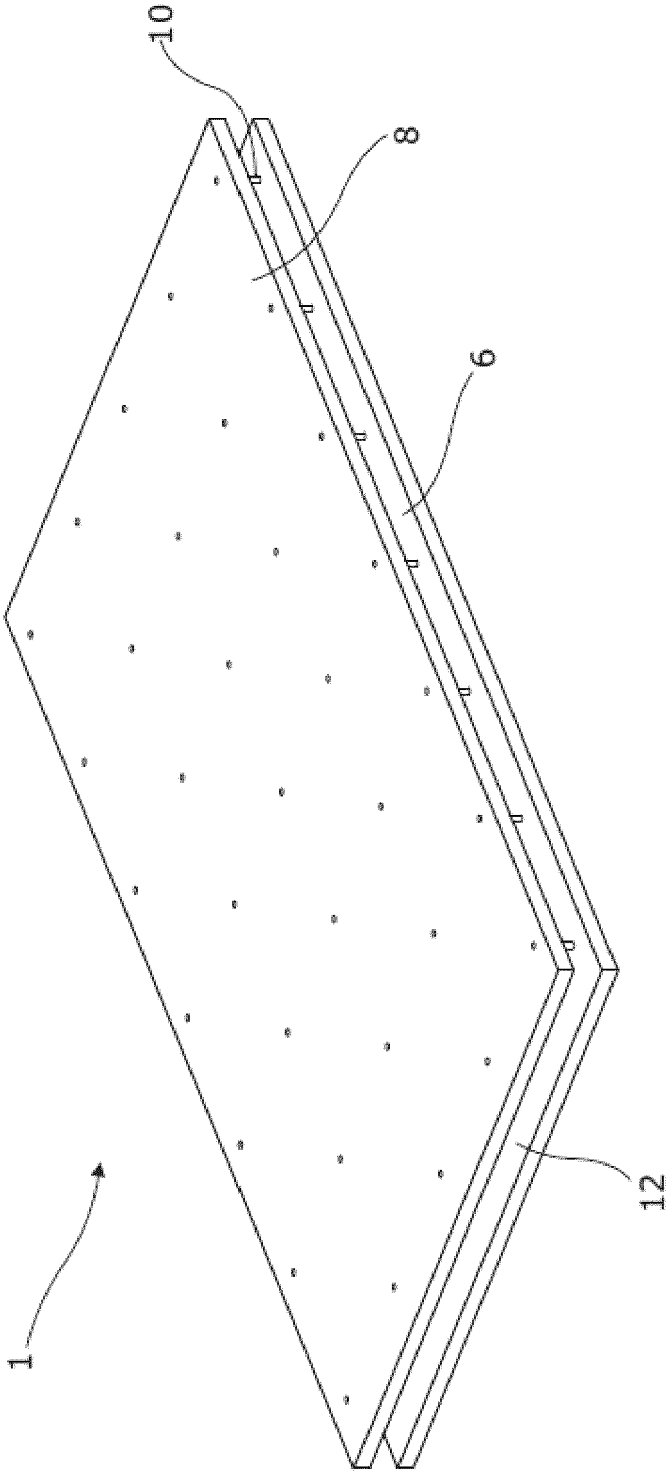

Figure 2

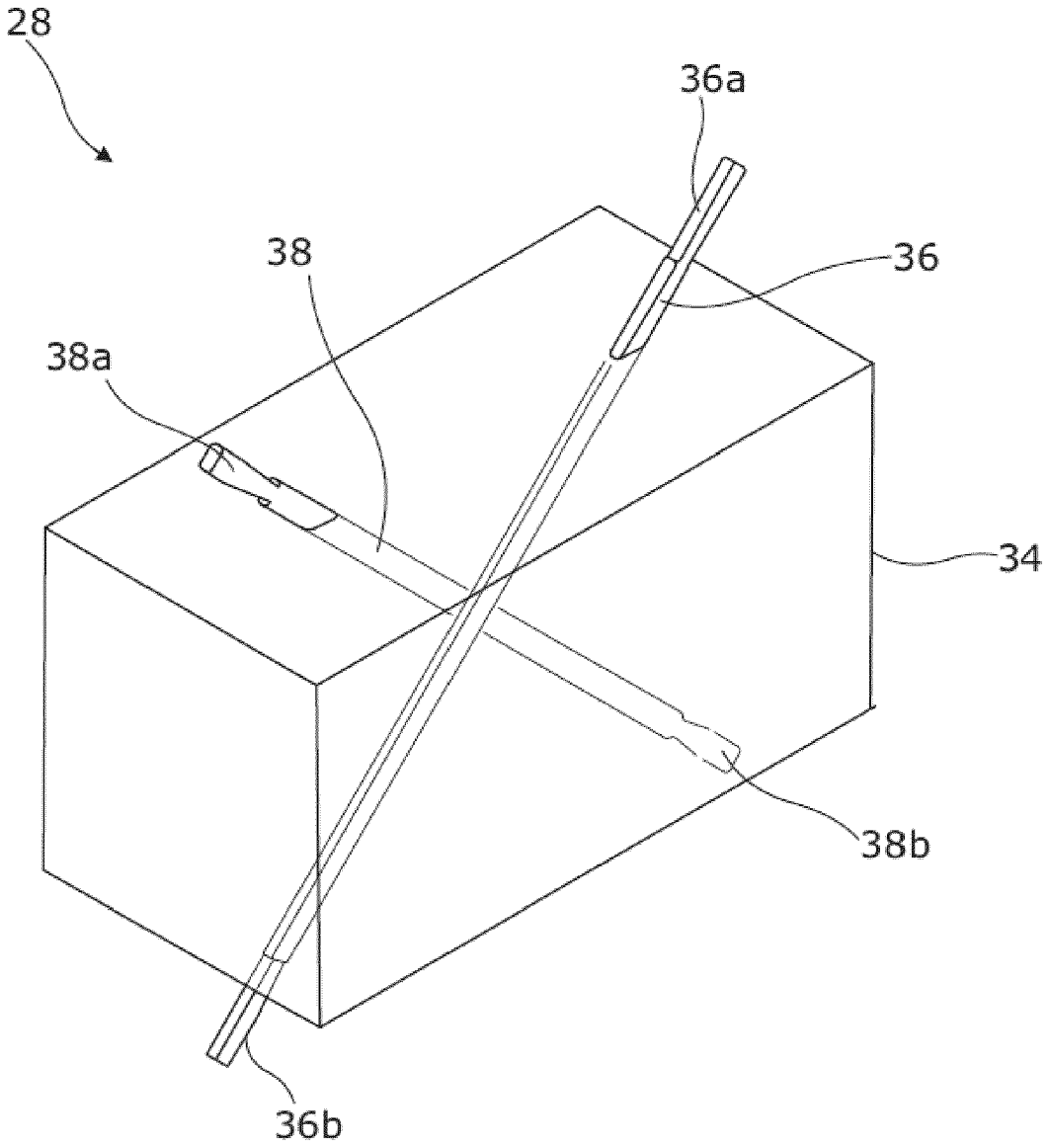

Figure 3

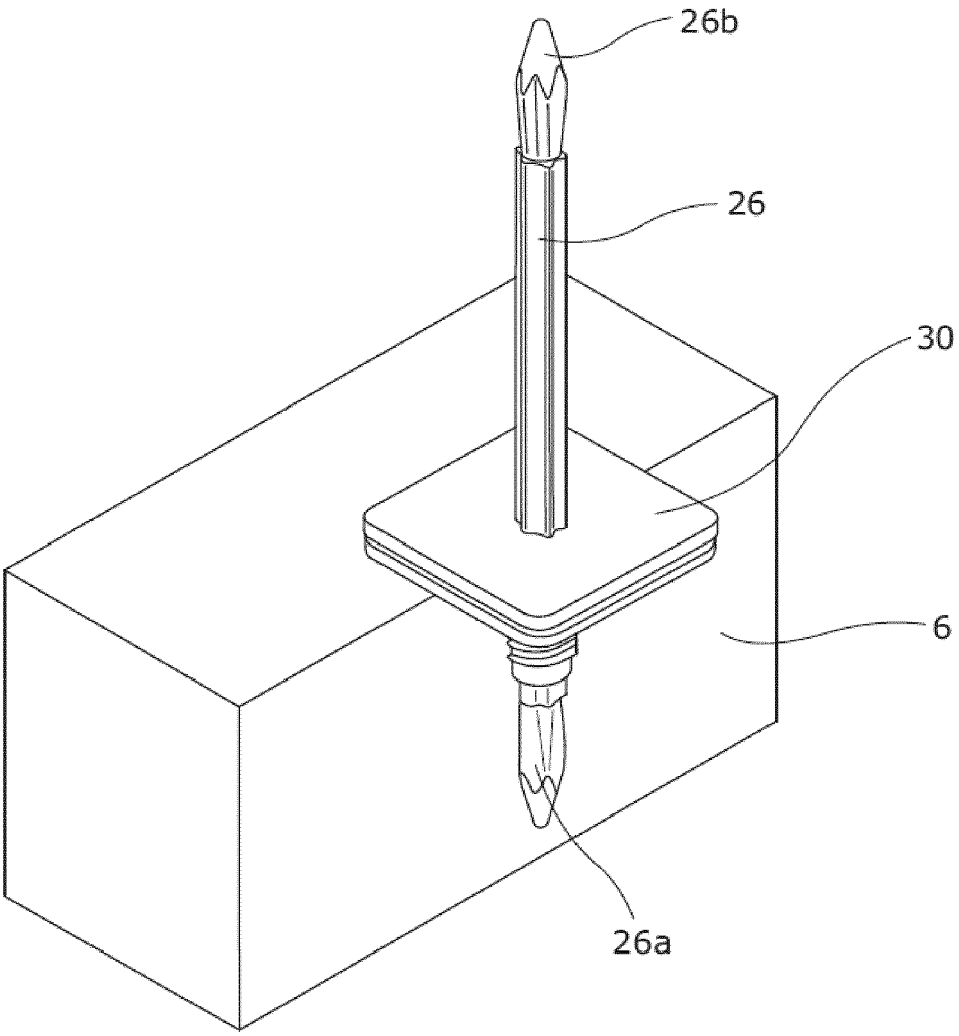

Figure 4

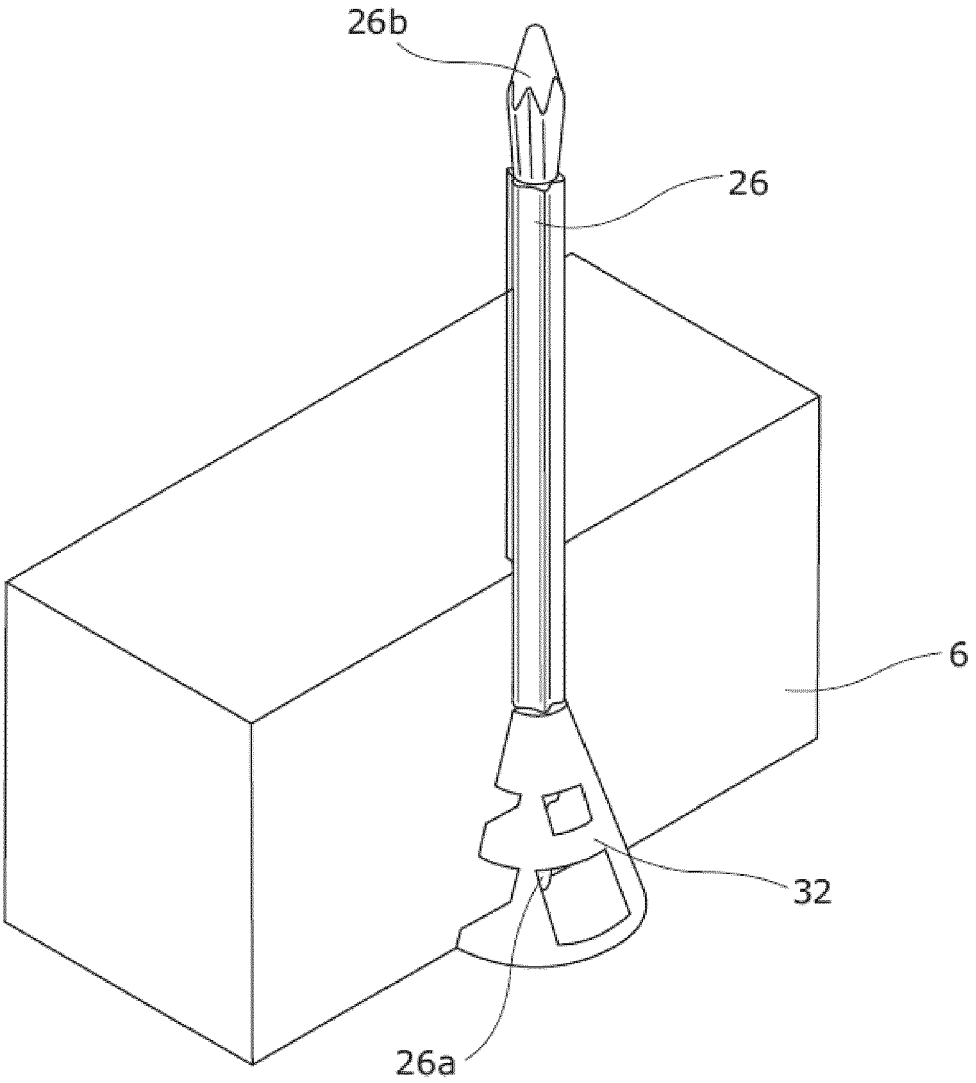

Figure 5

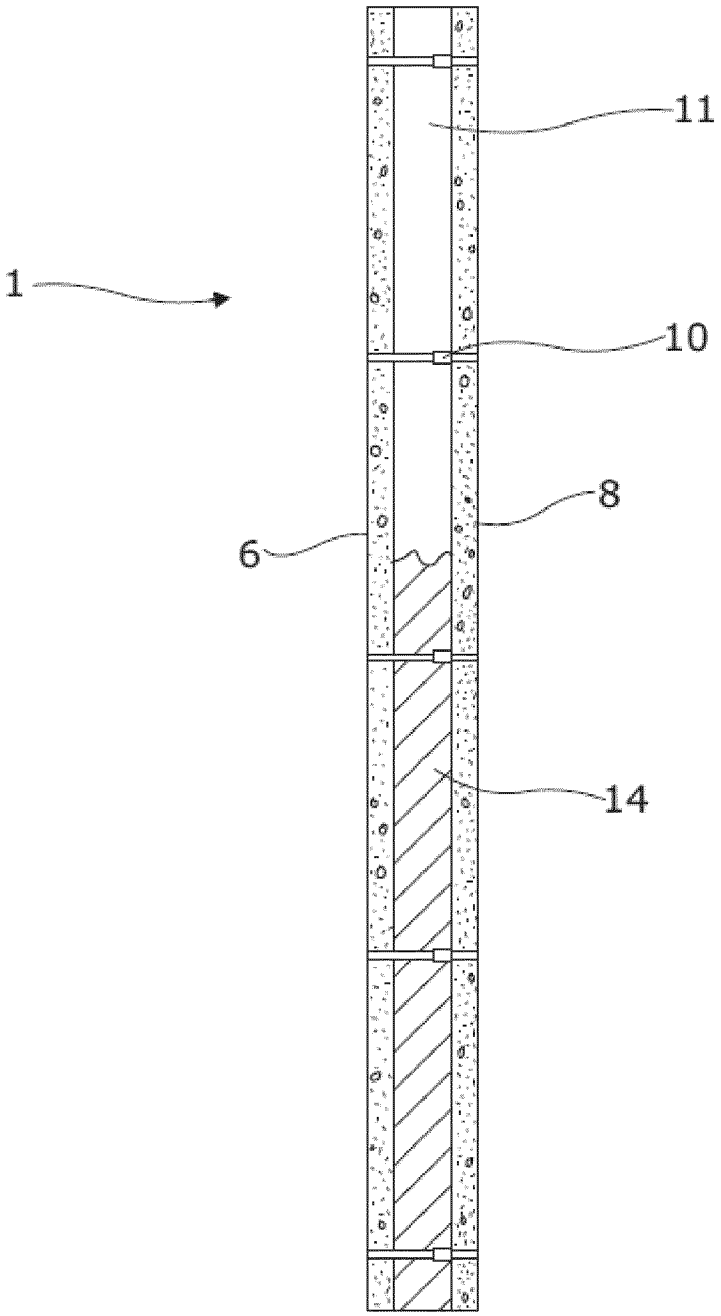

Figure 6

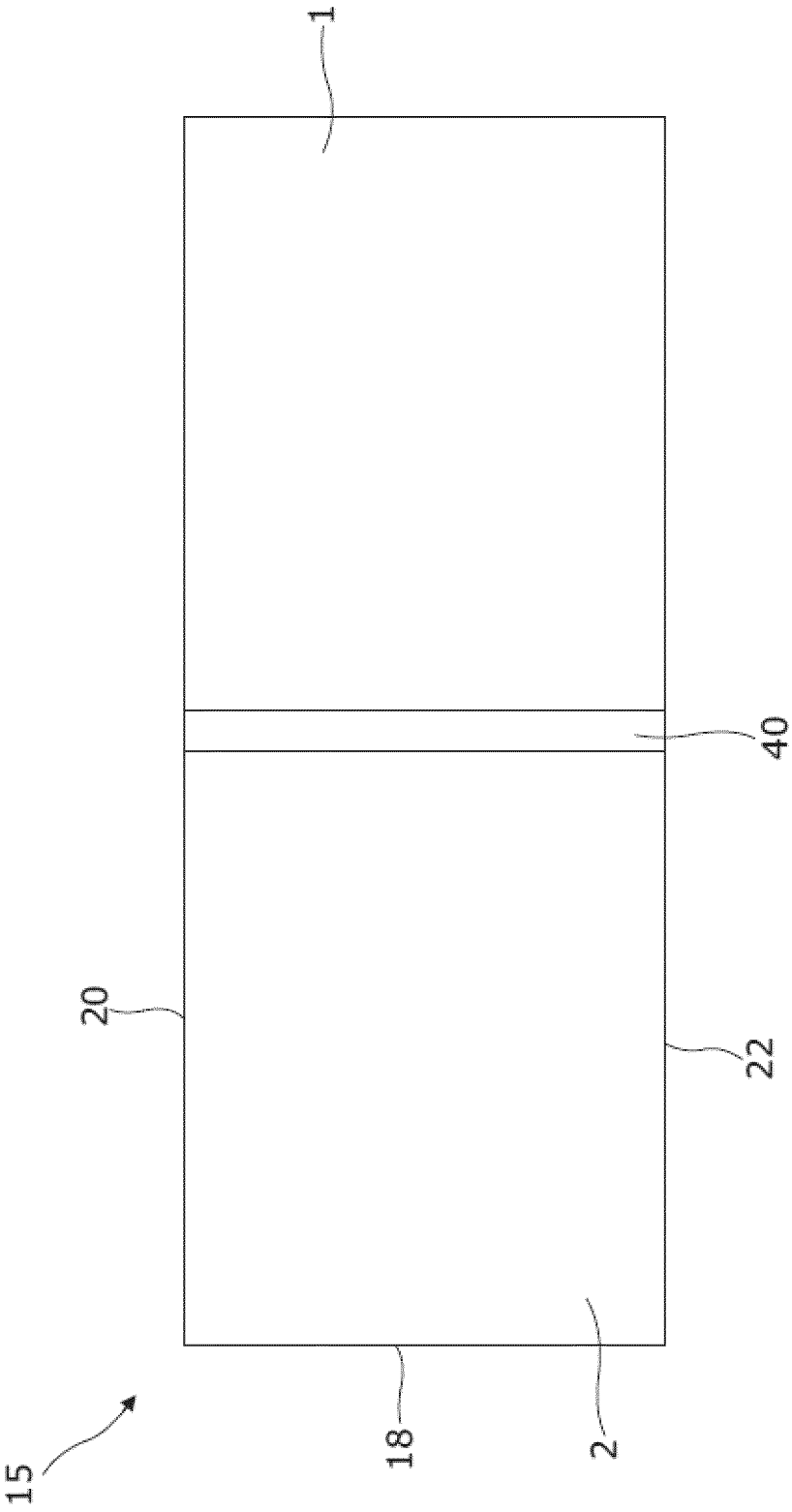

Figure 7

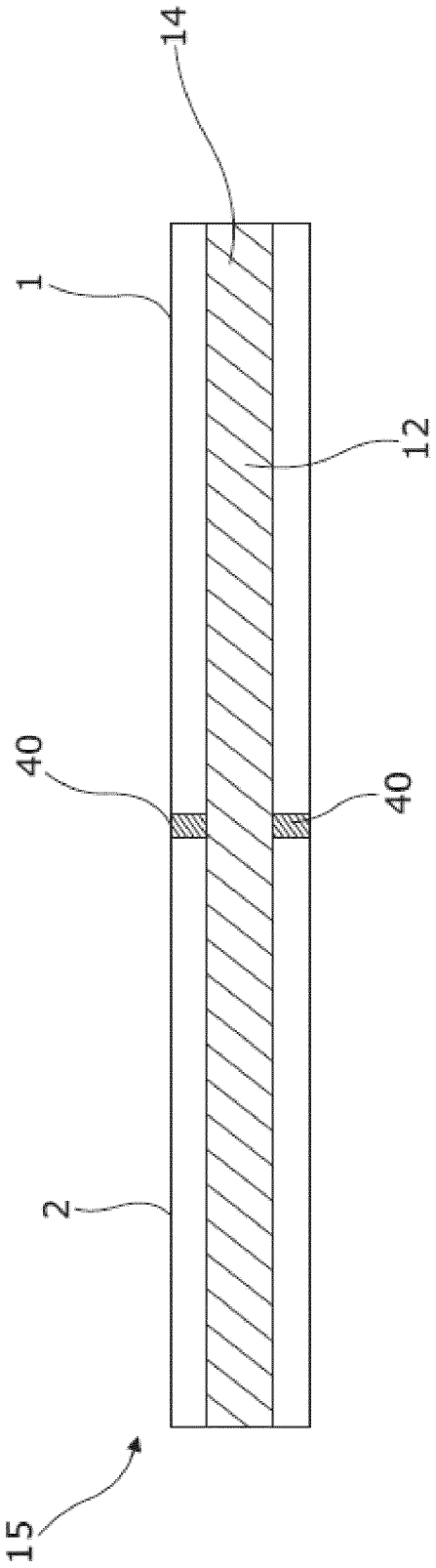

Figure 8

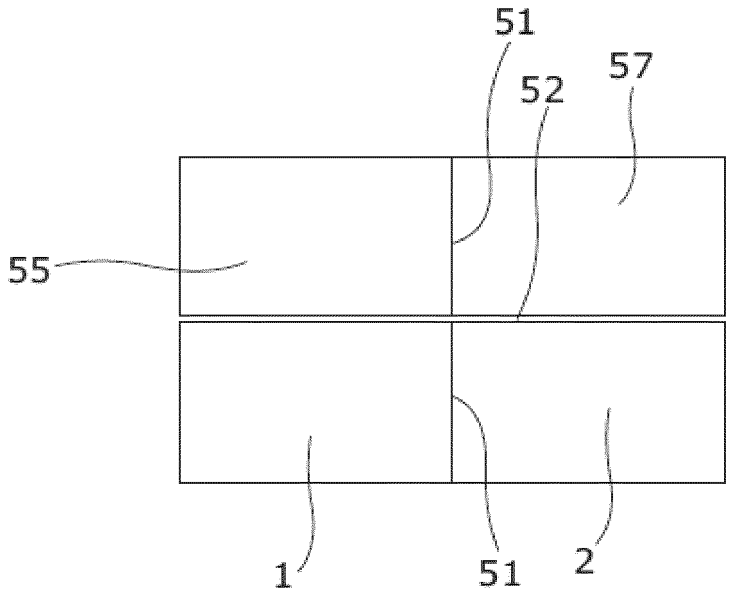

Fig. 9

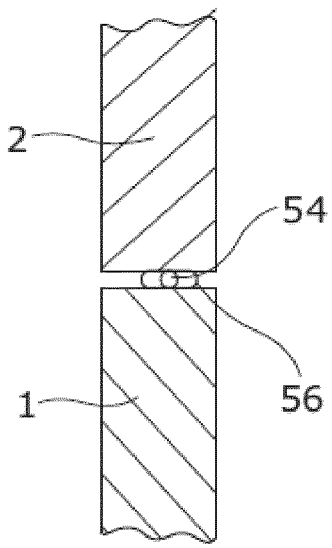

Fig. 11

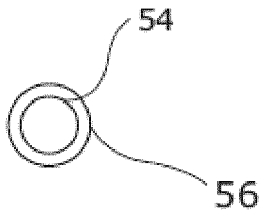

Fig. 10

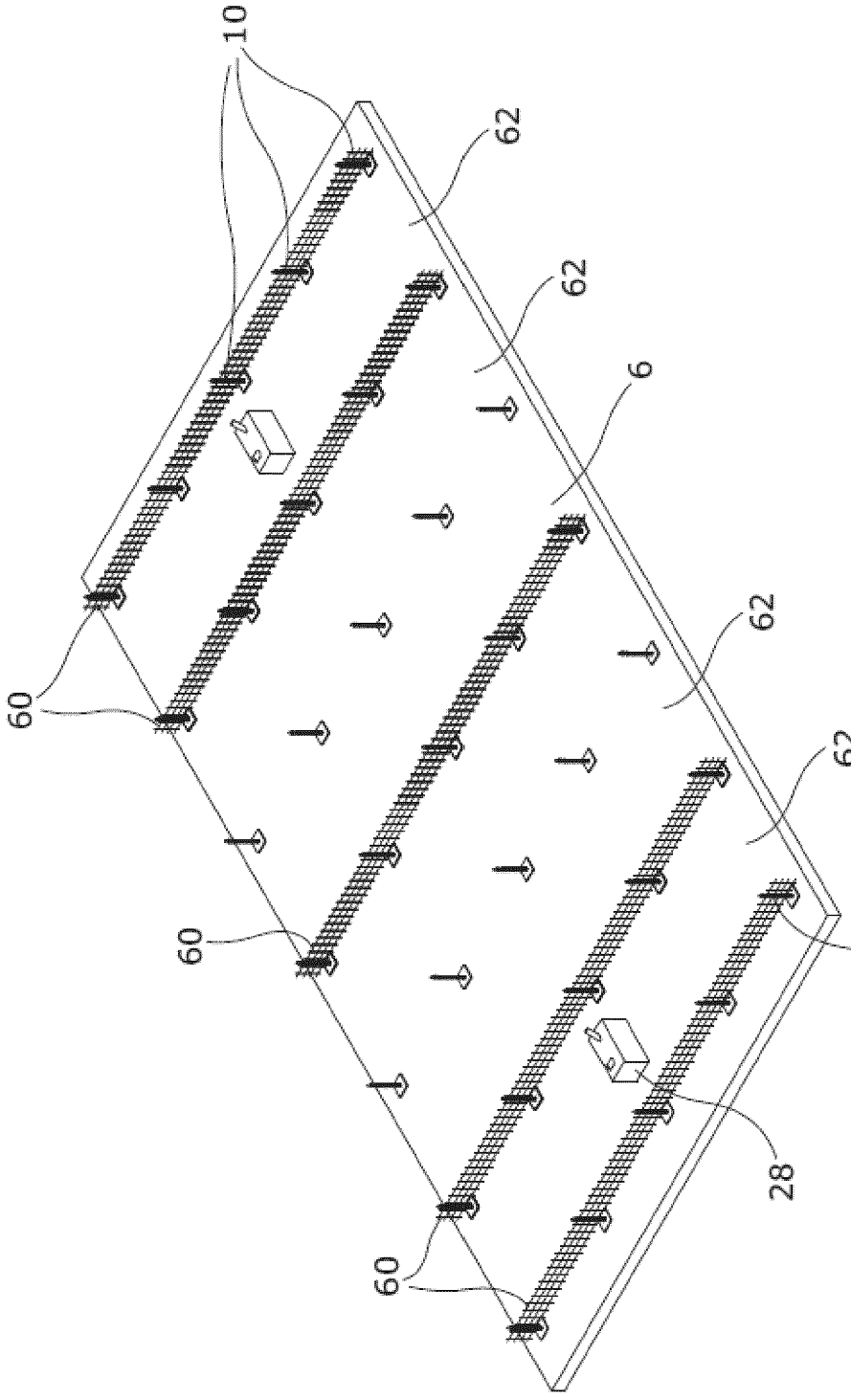

Figure 12

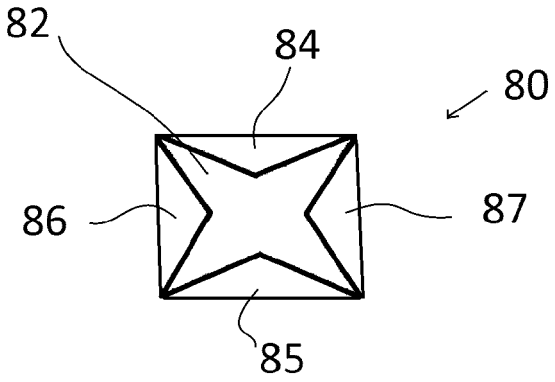

Figure 13

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EUROPEAN SEARCH REPORT

Application Number
EP 20 19 6428

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 263 638 B1 (LONG SR ROBERT T [US]) 24 July 2001 (2001-07-24) * column 2, line 65 - column 5, line 42; figures 1-8 * * column 1, line 66 - column 2, line 22 *	1-15	INV. E04B1/04 E04B1/80 E04C2/288
L	US 4 829 733 A (LONG ROBERT T [US]) 16 May 1989 (1989-05-16) * This document completes the disclosure of Document D1 - US 6 263 638 B1 with respect to the details and materials of the connectors; column 2, line 45 - line 50; figure 1 *	1-15	
A	EP 2 522 788 A2 (COMPOSITE TECHNOLOGIES CORP [US]) 14 November 2012 (2012-11-14) * paragraph [0013]; figure 1 *	10	
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E04B
E04C
B28B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 September 2020	Melhem, Charbel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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