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(54) **BUILDING STRUCTURE AND MODULAR CONSTRUCTION METHOD**

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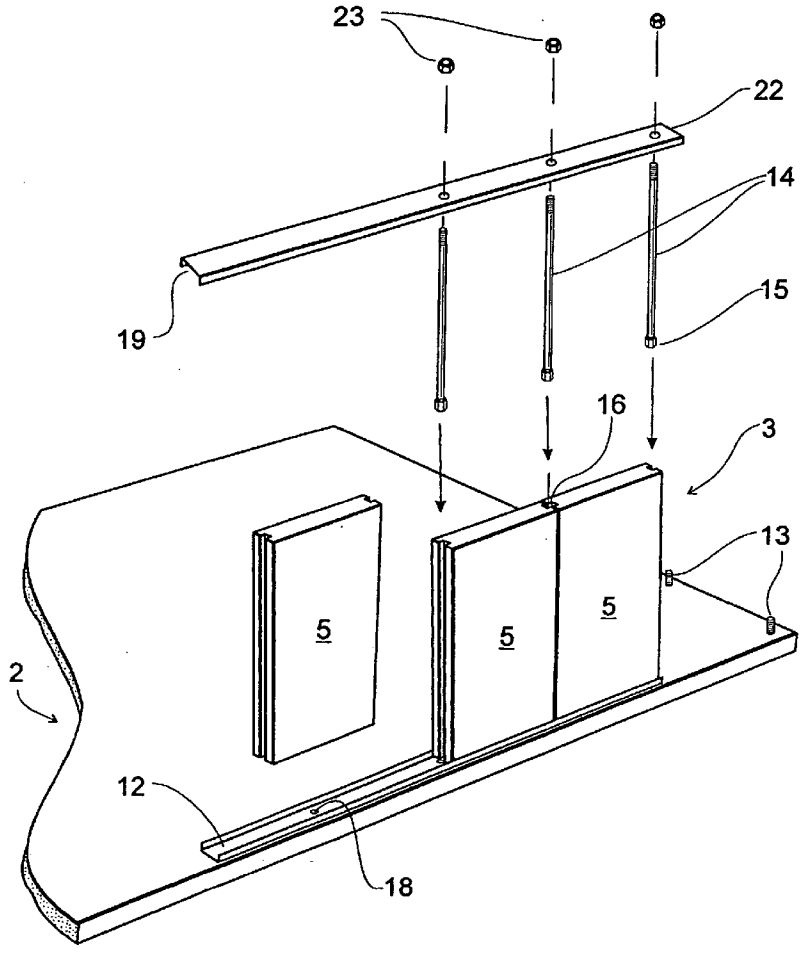
(57) **ABSTRACT**

A building structure comprising one or more modular panels (**5**); a wall locating member (**12**) positioned between a base (**2**) and the one or more modular panels (**5**); a top member (**19**) placed on top of the modular panels (**5**); and a plurality of tie rods (**14**). The modular panels (**5**) when adjoining to form a wall create longitudinal cavities (**16**) within the wall. The plurality of tie rods (**14**) extend through said longitudinal cavities (**16**) and secure said top member (**19**), walls (**3**) and wall locating member (**12**) to the base (**2**).



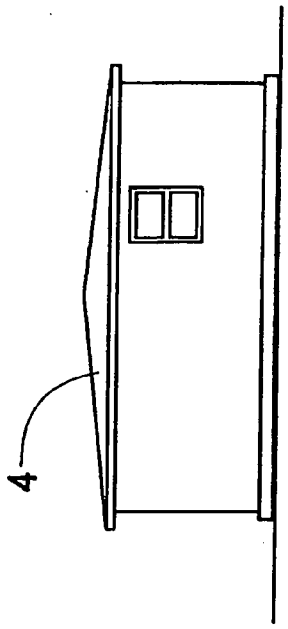


FIG. 1B

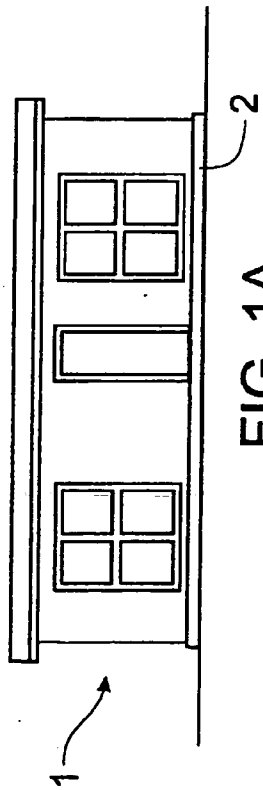


FIG. 1A

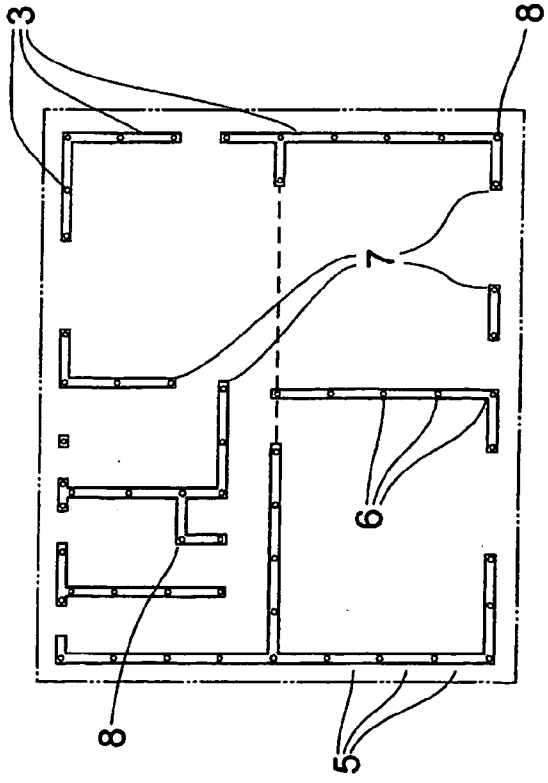


FIG. 1C

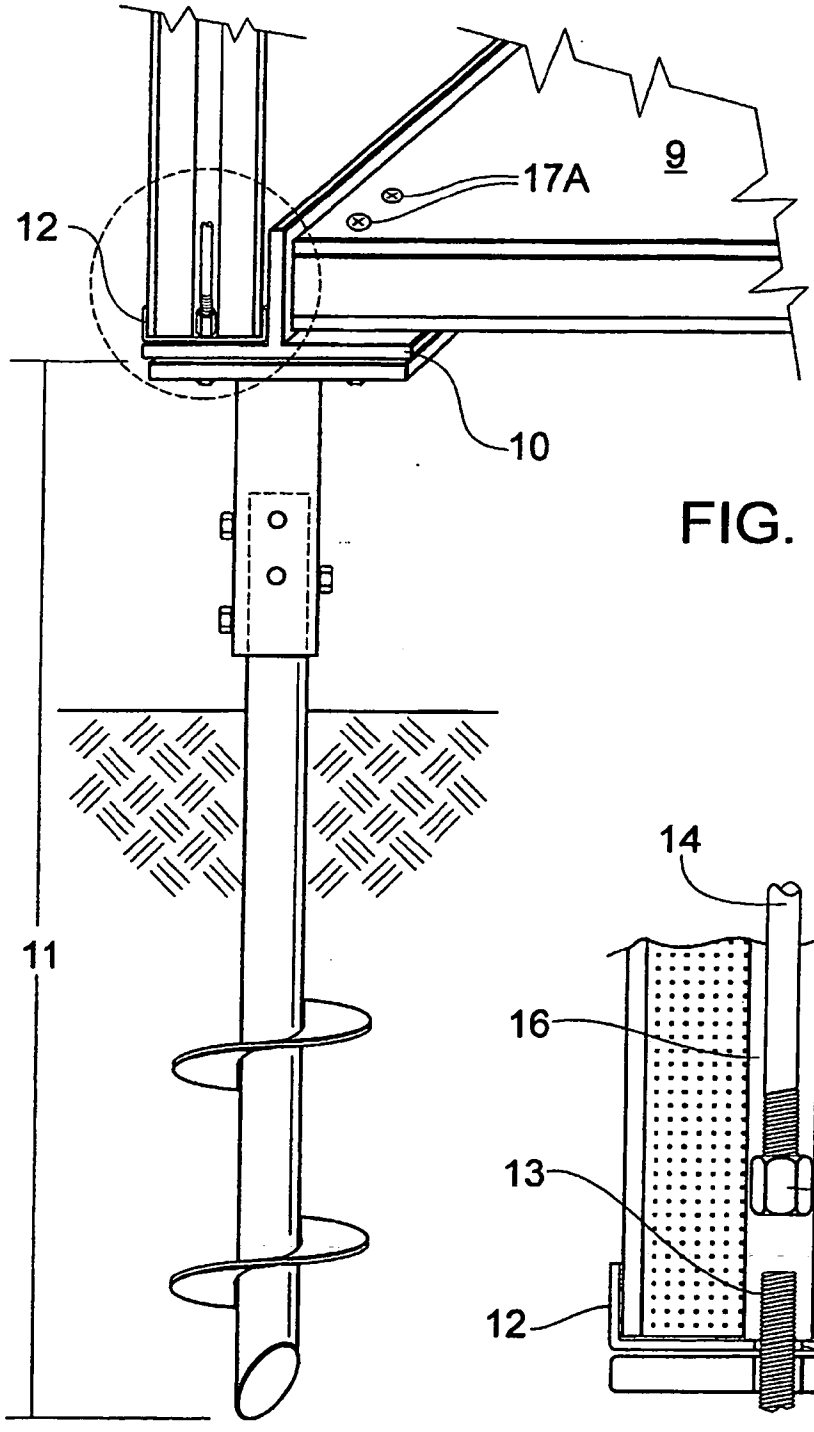


FIG. 2A

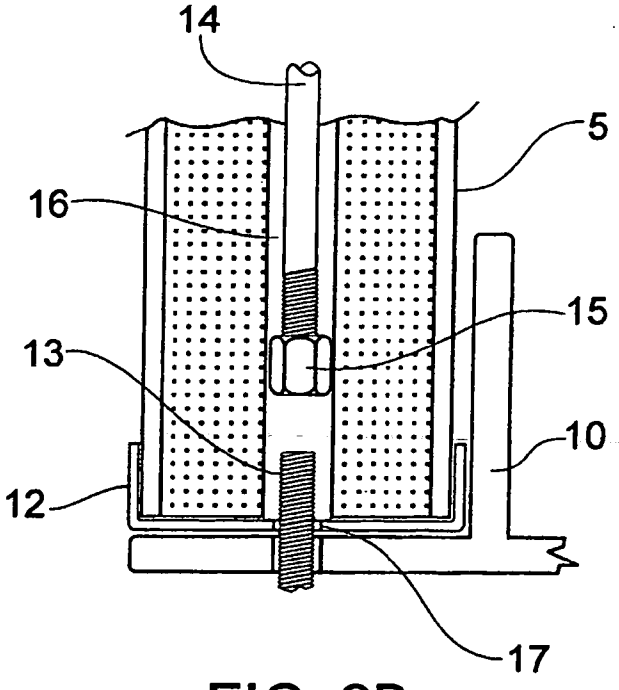


FIG. 2B

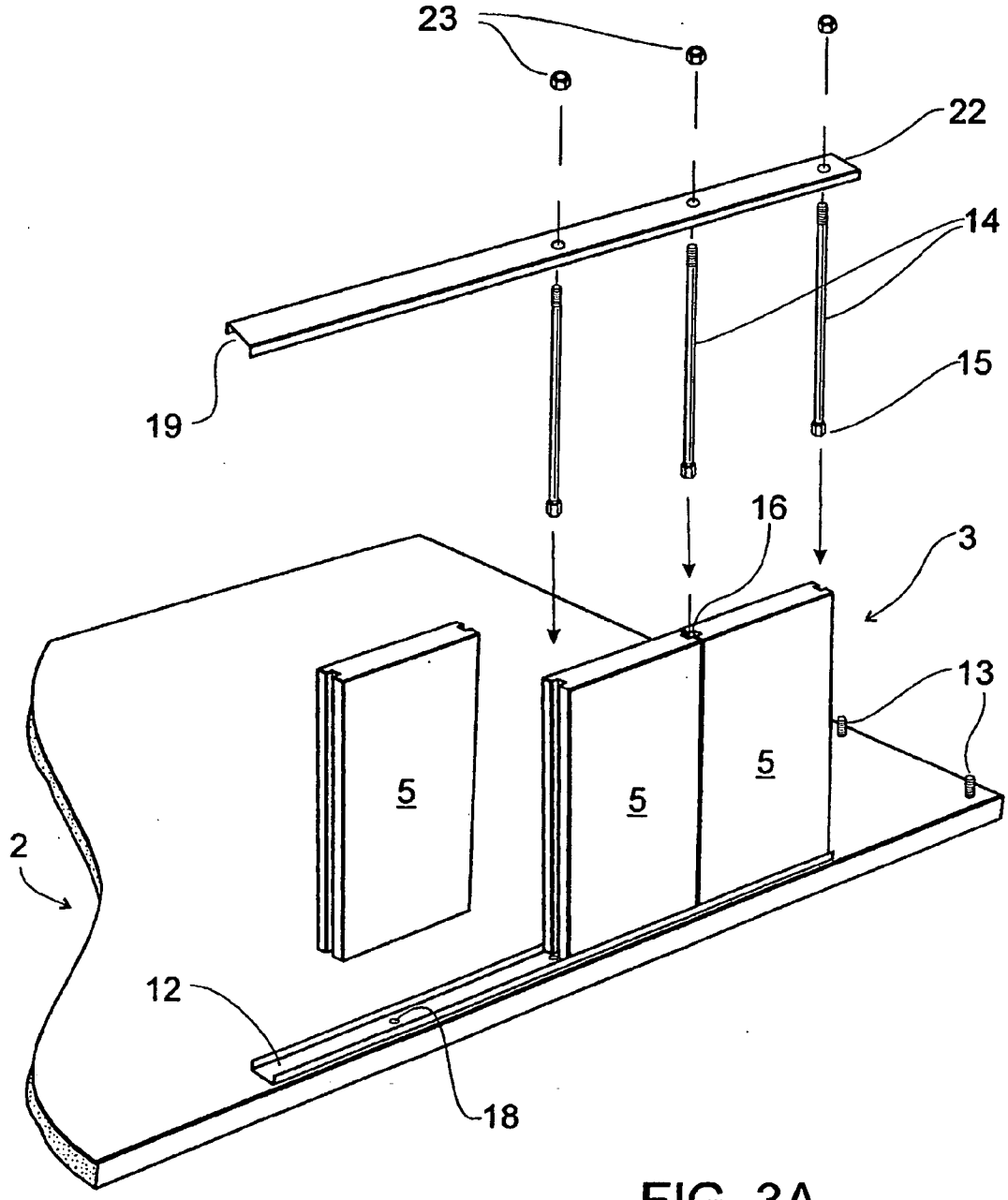


FIG. 3A

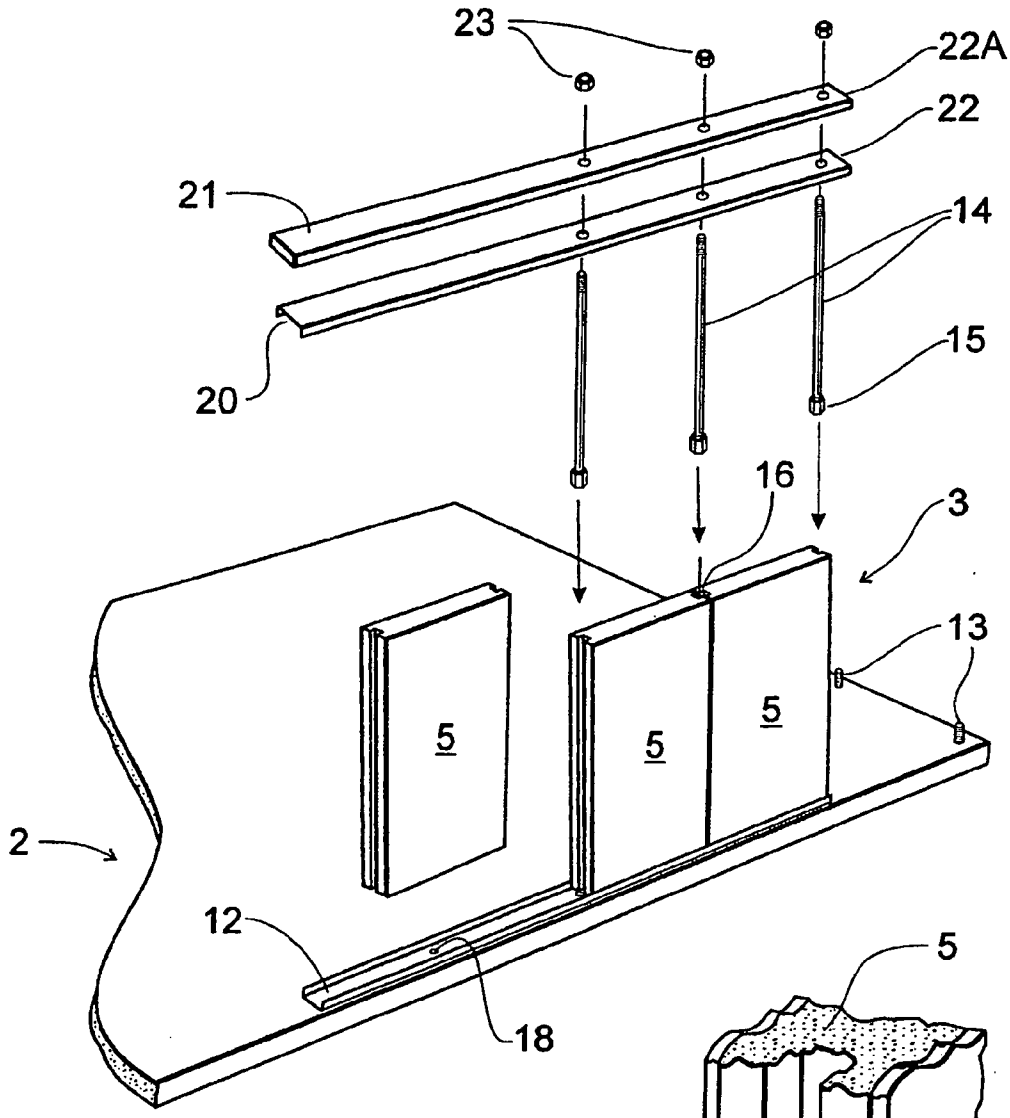


FIG. 3B

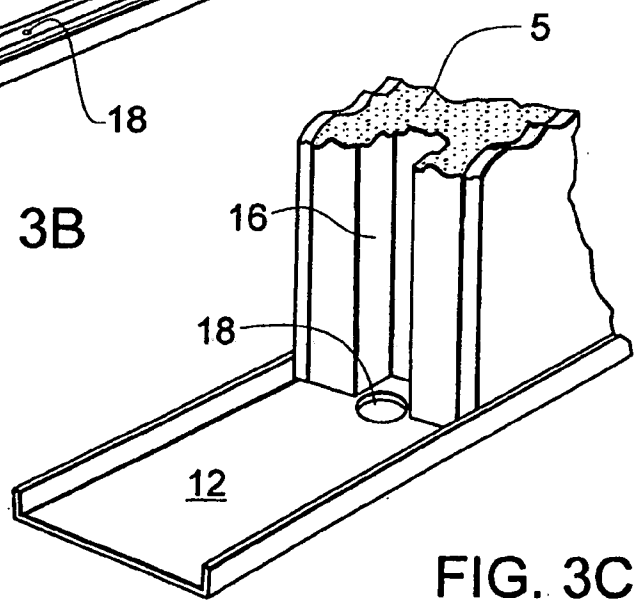


FIG. 3C

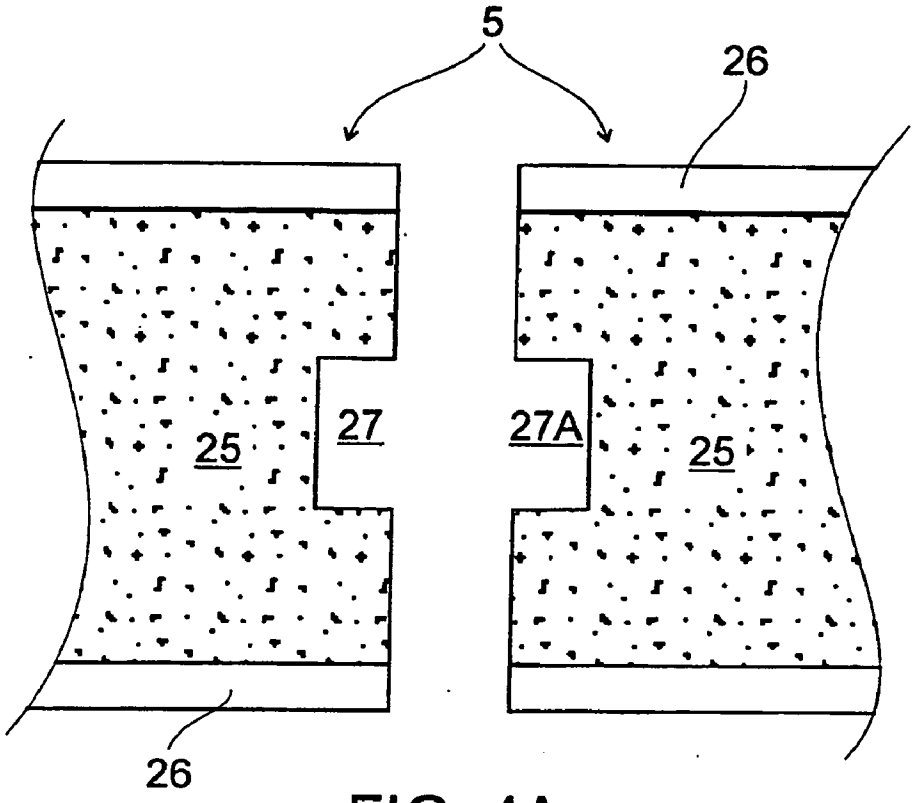


FIG. 4A

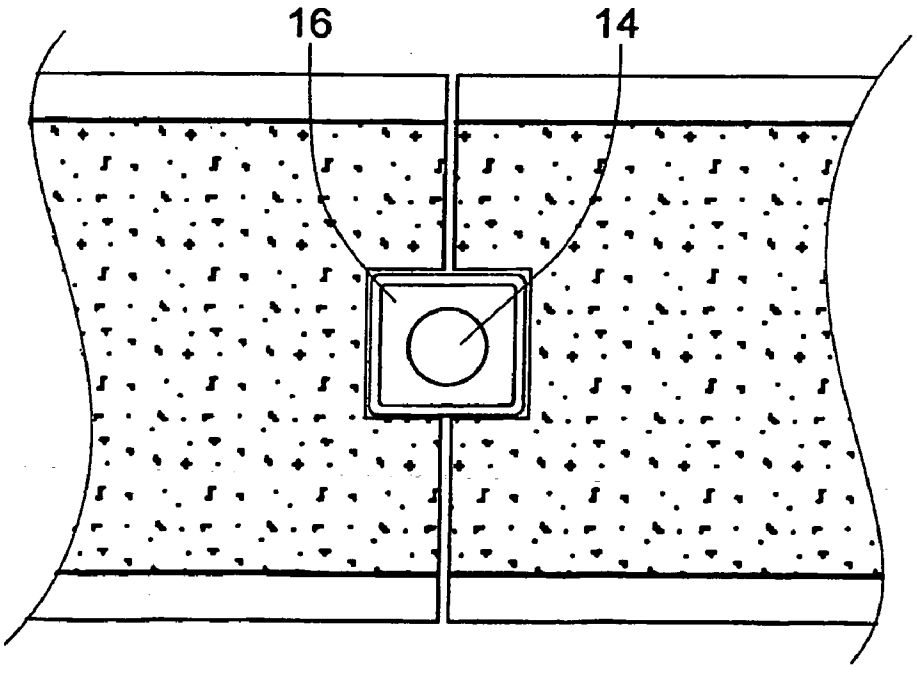


FIG. 4B

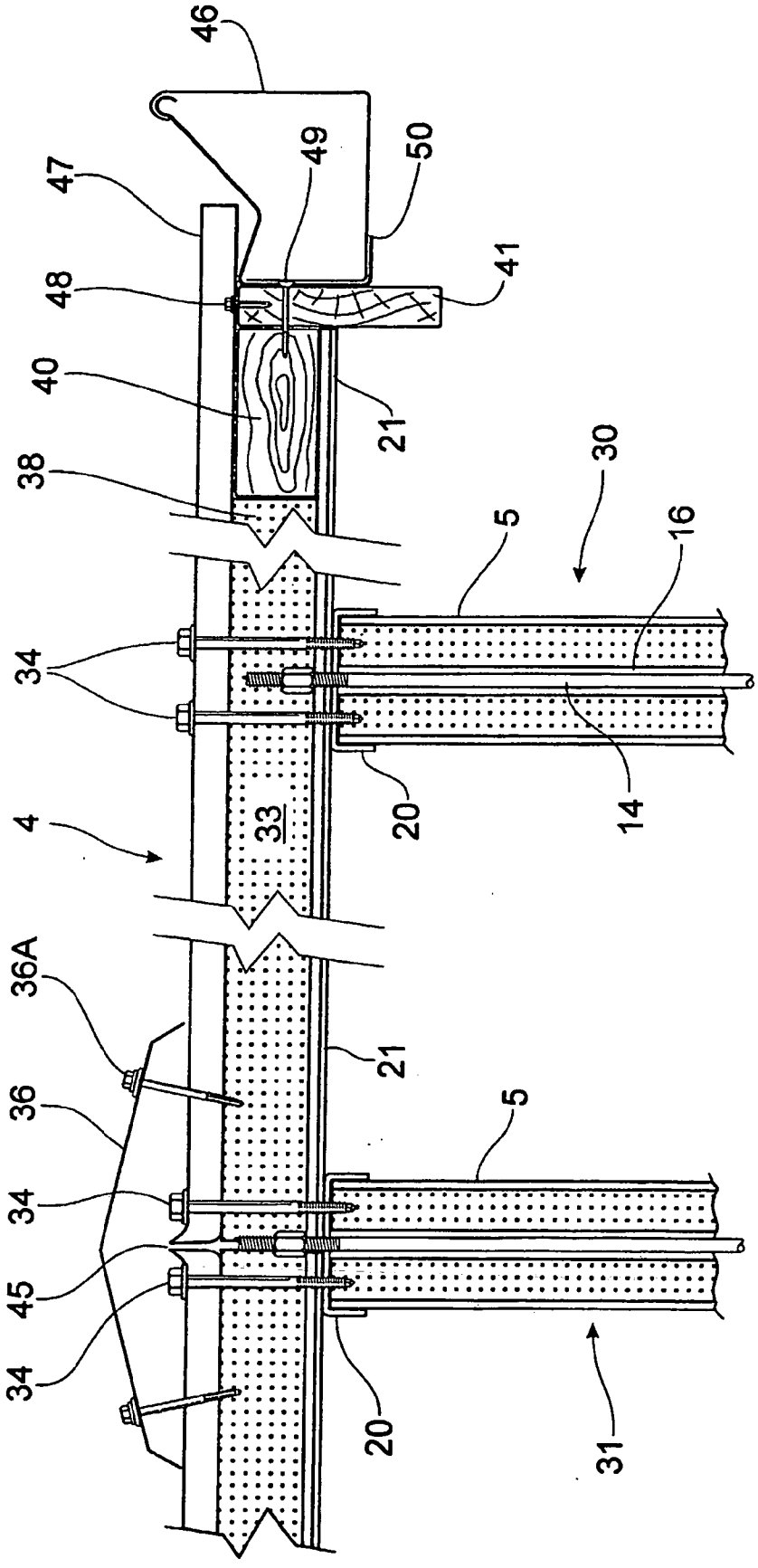

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FIG. 5

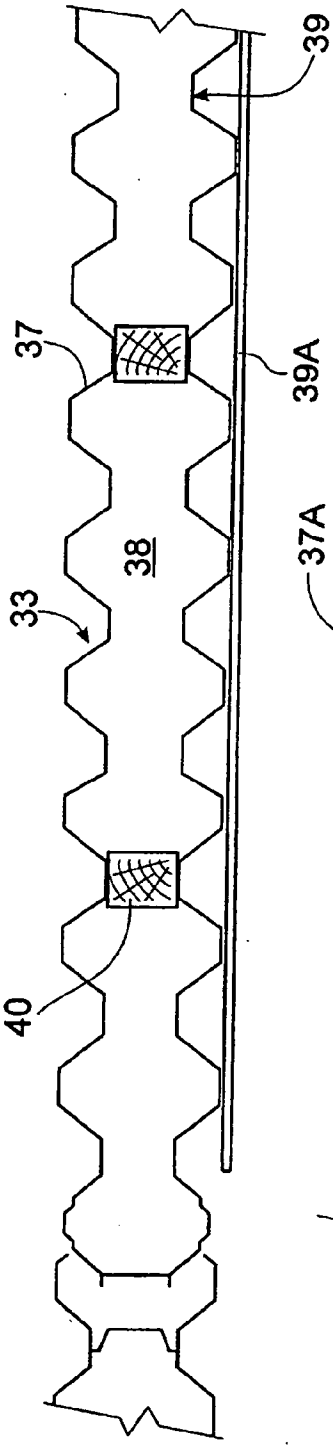


FIG. 6A

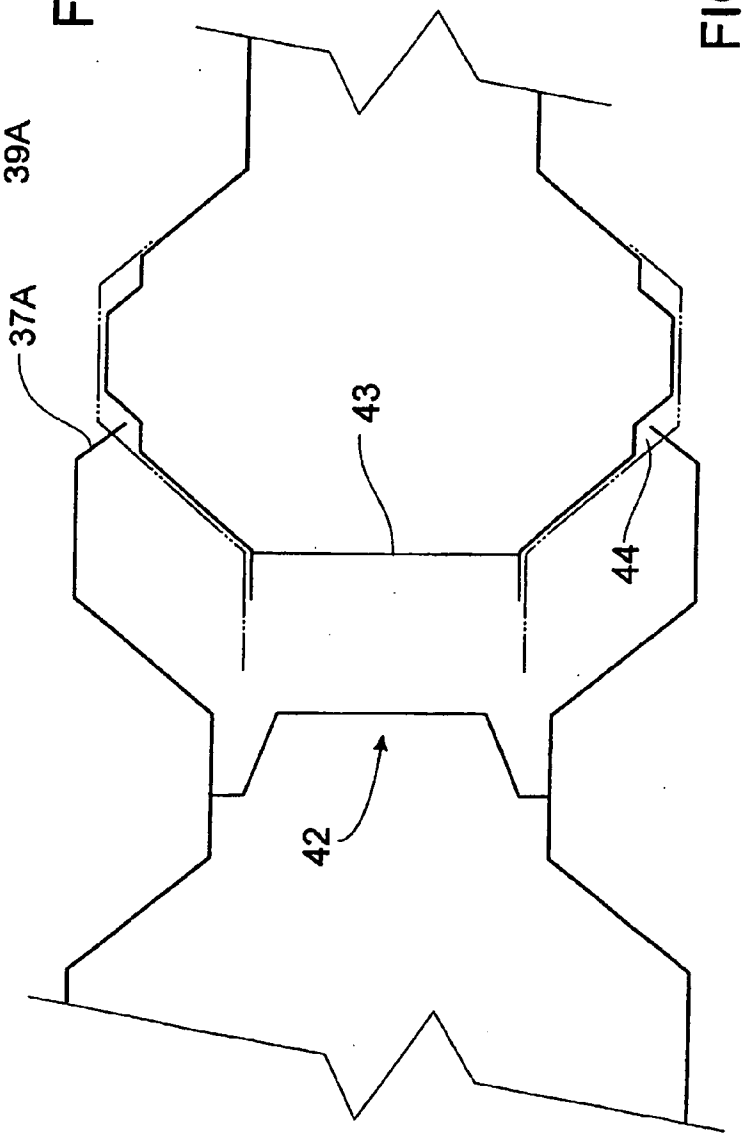
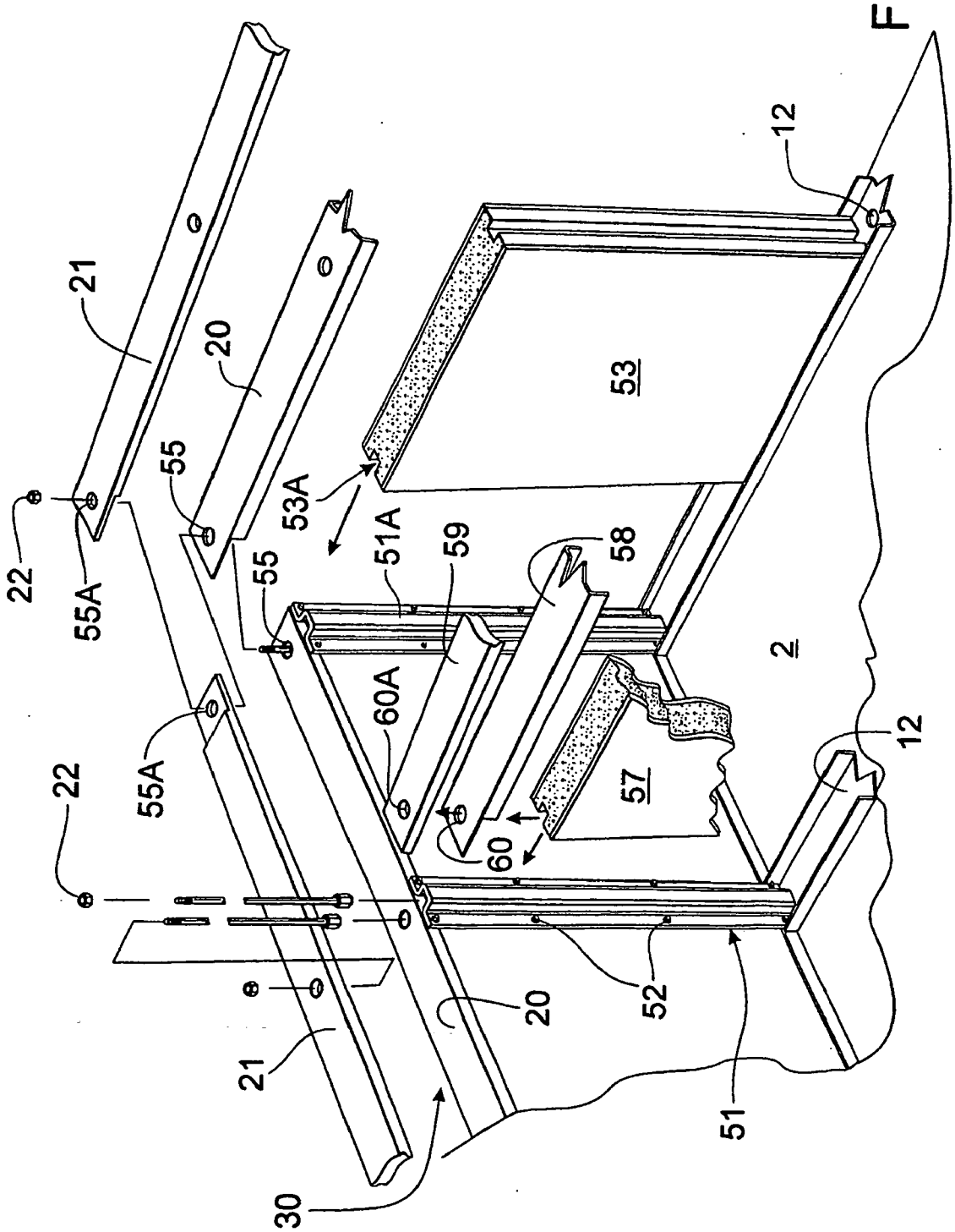


FIG. 6B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51A
59
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55A
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52
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21
51
30

FIG. 7

BUILDING STRUCTURE AND MODULAR CONSTRUCTION METHOD

[0001] THIS INVENTION relates to building structures employing modular structural panels and also to an improved construction method for assembling such modular panels to form such a building.

BACKGROUND TO THE INVENTION

[0002] The prior art is replete with modular building structures and associated construction methods, many of which suffer from a variety of problems. Amongst such problems are included the complexity of assembling elaborate framing systems to which modular panels are attached, the inconvenience attendant the use of plural individual fasteners to fix structural panels to one another, and the poor structural strength of some modular structures.

[0003] An example of a prior art modular construction arrangement which employs a plurality of fasteners is U.S. Pat. No. 4,858,398 in the name of Ricchini. Ricchini discloses a structure using proportionally sized panels secured together by turn-lock fasteners inserted through aligned openings in adjacent sides of panels.

[0004] A further exemplary prior art construction arrangement is that disclosed in French Patent Document Number 2389724 in the name of Batimpro S A. This document discloses a modular building using panels having adjacent vertical sides of complementary shapes. The panels are joined together by screws and are reinforced with metal plates at the location of the joints.

[0005] Reference may also be made to the method and apparatus for manufacturing foamed plastics laminated panels for modular building applications as disclosed in the applicant's Australian Patent No. 620338. Panels manufactured in the manner described therein are an example of those suitable for use with the present invention. One particular advantage of the applicant's previously disclosed method is that the panels may be conveniently fabricated at the building site.

OBJECT OF THE INVENTION

[0006] It is an object of the present invention to provide a building structure employing modular panels which overcomes or ameliorates at least some of the problems associated with the prior art.

[0007] It is a further object of the invention to provide a construction method employing modular panels which is simple but maintains the structural integrity of a completed building structure, thus providing a more convenient alternative to those presently available.

[0008] A yet further object of the invention is to provide a laminated modular panel adapted for use with the building structure and/or construction method which may also be expediently fabricated.

[0009] Further objects will be evident from the following description.

DISCLOSURE OF THE INVENTION

[0010] In one form, although it need not be the only or indeed the broadest form, the invention resides in a building structure comprising:

[0011] one or more modular panels;

[0012] a wall locating member positioned between a base and the one or more modular panels;

[0013] a top member placed on top of the modular panels; and

[0014] a plurality of tie rods;

[0015] wherein, said modular panels when adjoining to form a wall create longitudinal cavities within the wall; and

[0016] wherein, the plurality of tie rods extend through said longitudinal cavities and secure said top member, walls and wall locating member to the base.

[0017] It is preferable that the modular panels comprise recesses on opposing longitudinal sides (herein after referred to as the longitudinal recess) of the adjoining panels, thereby defining, in use, the longitudinal cavity between the adjoining modular panels.

[0018] The top member provides a capping and/or compression feature to the walls of the building structure. The top member may comprise a capping member and/or a compression member.

[0019] Suitably the wall locating member and the top member, when it is a capping member, are both C section channelling. For the wall locating member the C channelling is placed so as to form a U and for the capping member the C channelling is placed so as to form an inverted U over the top of the modular panels.

[0020] In one form an upright channel member may be fixed to one face of a modular panel for locating modular panels to form a corner or internal wall.

[0021] In preference the tie rods possess high tensile strength.

[0022] The tie rods may be releasably engageable with mounts provided at predetermined positions along the base.

[0023] In preference the modular panels are of a laminated construction.

[0024] The modular panels are suitably formed from foamed plastics laminated panels having at least one outer skin member.

[0025] The modular panels may comprise an additional longitudinal aperture for accommodating a tie rod, located some distance in from the longitudinal recess, for the formation of a corner or join.

[0026] It is preferable that the base includes a floor structure, which may optionally be of modular construction, also employing laminated panels. Suitably the laminated panels for the floor comprise a ribbed outer steel skin, a foamed plastic core and a ribbed inner skin. The laminated floor panels made of a ribbed construction are preferably lined with composite flooring, waterproof ply or timber floor.

[0027] The building structure may also include a roof structure supported by the walls, which roof may also be of modular construction, employing further laminated panels. The laminated panels for the roof may comprise a ribbed outer steel skin, a foamed plastic core and a ribbed inner

skin. The ribbed roof panel construction is preferably lined with fiber-cement board, plasterboard, random grooved ply or timber.

[0028] In a further form the invention resides in a method of construction including the steps of:

[0029] placing one or more wall locating members on a base;

[0030] erecting one or more modular panels on the wall locating members to form one or more walls;

[0031] engaging adjacent modular panels to define longitudinal cavities between longitudinal recesses formed on upright sides of said modular panels;

[0032] placing a top member on the upper edge of the modular panels;

[0033] inserting tie rods through the top member and longitudinal cavities;

[0034] connecting the tie rods to the base to secure the top member, modular panels and wall locating member thereto, to form walls.

[0035] The step of placing the top member on the upper edge of the modular panels may comprise the steps of;

[0036] placing a capping member on the upper edge of the modular panel; and

[0037] is placing a compression member on top of the capping member.

[0038] In a yet further form, the invention resides in a modular panel for use in the abovementioned building structure or method of construction, wherein said modular panel comprises:

[0039] a core of foamed plastics material;

[0040] at least one outer skin member bonded to said core;

[0041] two longitudinal recesses on opposing longitudinal sides of the modular panel which define, in use, a longitudinal cavity extending along the junction between adjoining modular panels.

[0042] The modular panels may have an additional longitudinal cavity, sized so as to receive a tie rod, wherein the longitudinal cavity is located toward an end of the modular panel but inwardly from the longitudinal recess.

BRIEF DETAILS OF THE DRAWINGS

[0043] To assist in understanding the invention, preferred embodiments will now be described with reference to the following figures in which:

[0044] **FIG. 1A** is a front elevation of an exemplary building structure;

[0045] **FIG. 1B** is an end elevation of the building structure;

[0046] **FIG. 1C** is a schematic plan view of the building structure showing the arrangement of modular panels comprising the walls;

[0047] **FIG. 2A** is an enlarged partial sectional view of the structure's base showing the junction of the floor structure with an outer wall;

[0048] **FIG. 2B** is an enlarged sectional view of the portion of **FIG. 2A** in the circle.

[0049] **FIG. 3A** is an exploded isometric view illustrating the erection of modular panels to form a wall, wherein the top member is a capping member;

[0050] **FIG. 3B** is an exploded isometric view illustrating the erection of modular panels to form a wall, wherein the top member comprises a capping member and a compression member;

[0051] **FIG. 3C** is an enlarged detail view of an optional arrangement for locating the bottom side of the modular panels;

[0052] **FIG. 4** are enlarged sectional plan views of the aligned laminated panels showing the configuration of the positive positioning profiles on the laminated panels;

[0053] **FIG. 5** is an enlarged partial sectional view of the roof area showing an arrangement of the fascia;

[0054] **FIG. 6A** is an end elevation of a modular roof panel;

[0055] **FIG. 6B** is an enlarged detailed view of the showing the positioning profiles on the roof panels;

[0056] **FIG. 7** is an exploded isometric view showing the arrangement of corner junctions and tee-junctions of the walls; and

DETAILED DESCRIPTION OF THE DRAWINGS

[0057] In general, **FIG. 1** shows a building structure **1** in the nature of a small dwelling which may be constructed in accordance with the invention. The structure includes a base **2**, a number of walls **3** and a roof **4**. The walls, whether external or entirely internal, are composed of modular panels **5**. The modular panels are fabricated to a typical module size of 900 mm wide by 3.0 m high. In some situations larger panels may be used, particularly to accommodate the pitch of a roof. The modular panels are secured to the base by tie rods (described later) which are disposed along the walls at 900 mm centres **6**. Additional tie rods are disposed at the sides of openings in the walls **7** and at the comers **8** of the building structure.

[0058] The wall panels may be erected on a concrete or timber floor or, as illustrated in **FIG. 2**A, on a floor comprised of further laminated panels attached to screw-in foundations. In the later arrangement, the base **2** comprises floor panels **9** supported by an inverted T member **10** mounted on screw-in foundations **11**.

[0059] **FIG. 2A** also shows floor panels **9** are mounted to the other half of the inverted T member **10** (the inner most horizontal face). The floor panels **9** are generally attached via screws **17**A.

[0060] **FIG. 2B** shows a wall locating member **12**, in the form of a C section channel, mounted on the outermost half of the inverted T member **10**. The modular wall panels **5** are located in the wall locating member **12**. Threaded studs **13**, for securing respective tie rods **14**, are fastened to the horizontal face of the outer most half of the inverted T

member **10** by welding, screwing or the like and protrude through the wall locating member **12** and into longitudinal cavity **16** for engagement with a nut **15** fastened to the end of each tie rod **14**. The tie rods **14** extend through respective longitudinal cavities **16** provided in the upright wall panels **5**. The studs project through the wall locating member **12**, via an aperture **17**.

[**0061**] The overall arrangement of wall panels may be better understood by reference to the exploded view of the base **2** and partially completed wall **3** shown in **FIG. 3A and 3B**. In accordance with the invention, individual wall panels **5** are erected and aligned such that the longitudinal cavities **16**, which are defined when the panels adjoin one another, correspond to the studs **13** and cooperating apertures **18** in the wall locating member **12**.

[**0062**] Each tie rod **14** is inserted into a respective longitudinal cavity **16** and engaged with a stud **13** disposed at the lower extremity of the cavity **16**. The top member **19** is then placed so as to form an inverted U over the top side of the wall panels. Apertures **22** in the top member **19**, are sized to accommodate the shaft of the tie rods **14** and are spaced so as to correspond to the studs **13**. Thus the upper ends of the rods protrude through said apertures **22** in the top member **19** when they are positioned on the modular wall panels. The upper end of the tie rods **14** may be screw threaded and engageable with a nut **23** to facilitate the tensioning thereof. The nuts **23** are engaged with the rods and tightened against the top member **19**.

[**0063**] **FIG. 3B** illustrates the partial completion of a wall, similar to that of **FIG. 3**A, but wherein the top member **19** comprises a capping member **20** and a compression member **21**. The compression member **21** is placed on top of the capping member **20**. Apertures **22** and **22**A in both the capping member **20** and compression members **21** respectively, are sized to accommodate the shaft of the tie rods **14** and are spaced so as to correspond to the studs **13**. Thus the upper ends of the rods protrude through said apertures **22** and **22**A in the capping member **20** and the compression member **21** when they are positioned on the modular wall panels. The upper end of the tie rods may be screw threaded and engageable with a nut **23** to facilitate the tensioning thereof. The nuts **23** are engaged with the rods and tightened against the compression member **21**.

[**0064**] **FIG. 3C** illustrates in detail the locating the modular panels **5** placed in the wall locating member **12**, so that the cavity **16** is aligned with the cooperating aperture **18** in the wall locating member **12**, to allow the tie rods **14** to engage with the base **2**.

[**0065**] For ease of description the subsequent embodiments will describe the top member comprising a capping member and a compression member. It will be appreciated by the person skilled in the are that the exact nature of the top plate may vary depending on the building type under construction and the exact location of the top plate(s) within the building construction.

[**0066**] In an alternative embodiment (not illustrated), the rods are externally screw threaded at both lower and upper ends thereof. The lower end engages with an internally screw threaded stud adapted, for example, for friction fitting in holes drilled into a concrete floor. Further alternatives for securing the tie rods will be apparent to the skilled addressee. The use of tie rods, preferably of high tensile strength, in accordance with the invention overcomes problems with fasteners, such as screws or the like, being pulled out of the modular panels in high wind load conditions. The invention also overcomes any requirement for local reinforcement of the modular panels which might otherwise add to the cost and complexity of panel fabrication.

[**0067**] **FIG. 4** shows in plan a schematic of one form of the longitudinal recesses formed on the upright sides of the wall panels. The lightweight panels **5** comprise a core **25** of foamed plastics, such as polyurethane and outer skins, such as fiber-cement sheeting **26**. The core is typically 66 mm thick whilst the skins are between 4.5 and 7.5 mm. The modular panels may be made of a thinner inner skin and a thicker outer skin. The thinner inner skin is typically 4.5 mm while the thicker outer skin is typically 7.5 mm. The thicker outer skins may suitably be stucco fiber, whilst the inner skins may suitably be a plasterboard or timber finish. The longitudinal cavity **16** is formed from the two recesses **27** and **27**A on the facing edges of the panels, as shown on the panels which are aligned with one another in **FIG. 4A**.

[**0068**] When the panels are adjoined, see **FIG. 4B, a** longitudinal cavity **16** is formed between the recesses **27** and **27**A. The cavity is sized for accommodating a tie rod **14**. Further subsidiary cavities **29** may be provided immediately under the panel skins for accommodating building services such as electrical wiring (not shown).

[**0069**] A first embodiment of a roof for the building structure is illustrated in **FIG. 5**. In this embodiment the roof **4** has a minimum pitch, typically of from 3 to 10 degrees, and is supported directly by the external walls **30** and by the internal walls **31**. The roof may also be comprised of modular panels as discussed in more detail below in relation to **FIG. 6A**.

[**0070**] The roof panels **33** are secured at one end to the external walls **30** by screws **34** which pass through the roof panels **33**, compression member **21** and capping member **20** before engaging with the modular wall panel **5**. At the other end, near the ridge, the screws **34** securing the roof panels engage with supporting internal walls **31** in the same manner as with the external walls **30**. The peak portion of the roof panels is covered by ridge capping **36** which extends over the roof panel securing screws **34**, which capping is secured to the roof by further screws **36**A.

[**0071**] As shown in **FIG. 6**A, the modular roof panels **33** in this embodiment include a 25 mm ribbed steel outer skin **37** and an injected polyurethane foam core **38** which has a 25 mm ribbed steel inner skin **39**, the panel is typically 100 mm thick. The underside of the roof panel is lined (**39**A). The roof lining (**39**A) may be 4.5 mm fiber-cement board, 10 mm plasterboard, random grooved ply or a timber ceiling screwed directly onto the ribbed steel inner skin. Suitably the roofing panel is hi-tensile spandeck steel sheeting. Wooden support blocks **40** are embedded in the core at spaced locations along one side of the roof panel to provide mounting points for the fascia panel **41**, shown in **FIG. 5**.

[**0072**] The floor panels described in **FIG. 2** may also be made of a similar panel construction as the roof panels described above and in reference with **FIG. 6**. More preferably the floor panels are also formed from hi-tensile spandeck steel sheeting. When formed by the hi-tensile

spandeck steel sheeting, the floor panels are lined with either composite flooring, waterproof ply or a timber floor applied directly onto the sheeting by screws or glueing.

[0073] The use of hi-tensile spandeck sheeting for roof and floor panels has the advantage of having high strength, light weight, and being able to span up to 7 metres, thereby providing easy of construction whilst reinforcing the building strength.

[0074] The enlarged detail view of the roof panel joint in **FIG. 6B** shows the arrangement of a projection **42** and cooperating recess **43** formed in the sides of the foam core **38** of a roof panel **33**. The enlargement shows a ridge **37**A of the outer roof skin extending laterally past the core such that, when two cooperating roof panels are engaged, the extended ridge **37**A clips over the ridge nearest the side of an abutting roof panel. The core may also be undercut in the vicinity of the projection so as to produce a longitudinal cavity **44** when the roof panels are clipped together. This cavity may accommodate building services in the same manner as the subsidiary cavities provided in the wall panels.

[0075] Returning to **FIG. 5**, the outer roof skin is turned-up **45** at the peak end edge thereof to minimise any leakage. The roof skin also extends past the foam core **38** and coplanar embedded wooden blocks **40**, so as to overhang the guttering **46** at the fascia end **47**. The wood or metal fascia panel **41** is suspended under the valleys of the overhung roof skin by screws **48** and attached to the embedded support blocks **40** by a further series of screws **49**. The screws which are sunk into the fascia support blocks also pass through gutter brackets **50** which brackets in turn support the guttering **46**.

[0076] The drawings in **FIG. 7** show the arrangement of the corners and tee-junctions of walls, in particular, the alternative arrangements of the capping and compression members at these junctions. A completed outer wall **30** is shown in place upon the base **2**, with a capping member **20** and compression member **21** on the top side thereof engaged by tie rod nuts **22**. The wall junctions commonly include positioning profile members **51** which are attached upright to the completed wall **30** at selected positions by screws **52**. Wall locating members **12** are fixed upon the floor surface or base **2** to locate the modular panels making up the walls.

[0077] An outer wall panel **53** is shown ready to be positioned at the corner of the structure, whereby the recess **53**A in the upright side of the outer wall panel cooperates with the nose **51**A of the positioning profile member. At a corner the capping member **20** to be placed on one of the walls will have about 75 mm removed from the inner side of the C channelling. The remaining horizontal and outer side faces of the C channelling capping member then run to the outer edge of the corner.

[0078] The capping member **20** on the joining wall simply adjoins or overlaps the capping member with a side partially removed. The compression members **21** at the comer joint are machined to half thickness for the length of the comer joint, thus forming half thickness tongues. These half thickness tongues are arranged so that the compression members interlace or overlap, resulting in an even thickness of the compression members at the comer. One of the modular panels forming the comer join has an additional longitudinal cavity, capable of receiving a tie rod **14**. This additional longitudinal cavity is located so as to be at the centre of the corner join. Apertures **55** and **55**A are provided on the capping members **20** and compression members **21** to facilitate fixing the members together and corresponding to the additional longitudinal cavity of the modular panel, thereby contributing to the structural integrity of the building.

[0079] **FIG. 7** also shows the tee-junction arrangement of an internal wall where a tie rod in an intersecting wall is not in immediate proximity, but is provided at the intersecting end of the internal wall. The internal wall panel **57** (shown in fragmentary form) engages with the respective positioning profile member **51**, in a similar fashion as two engaging panels (recall **FIG. 4B**), thereby defining a longitudinal cavity. The capping member **58** and compression member **59** include apertures **60** & **60**A at their extremities. The capping member **58** and compression member **59** are then disposed on the top side of the internal wall comprised of like panels **57**. The tie rod **14**, provided for the end of the internal wall, may then be inserted through the apertures **60** and **60**A and down into the cavity for securing the internal wall **57**.

[0080] Throughout the specification the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or a specific collection of features.

1. A building structure comprising:

one or more modular panels;

a wall locating member positioned between a base and the one or more modular panels;

a top member placed on top of the modular panels; and

a plurality of tie rods;

wherein, said modular panels when adjoining to form a wall create longitudinal cavities within the wall; and

wherein, the plurality of tie rods extend through said longitudinal cavities and secure said top member, walls and wall locating member to the base.

2. The building structure of claim 1, wherein the top member is a capping member.

3. The building structure of claim 1, wherein the top member is a compression member.

4. The building structure of claim 1, wherein the top member comprises a capping member and a compression member.

5. The building structure of claim 1, wherein the modular panels comprise recesses on opposing longitudinal sides of the adjoining panels, thereby defining, in use, the longitudinal cavity between the adjoining modular panels.

6. The building structure of claim 1, wherein the wall locating member and the top member are both C section channelling.

7. The building structure of claim 1, wherein an upright channel member is fixed to one face of a modular panel for locating modular panels to form a comer or internal wall.

8. The building structure of claim 1, wherein the tie rods are releasably engageable with mounts provided at predetermined positions along the base.

9. The building structure of claim 1, wherein the modular panels are of a laminated construction.

10. The building structure of claim 9, wherein the modular panels are formed from foamed plastics laminated panels having at least one outer skin member.

11. The building structure of claim 1, wherein the modular panels comprise an additional longitudinal aperture, located inwardly from the longitudinal recess, for accommodating a tie rod in the formation of a comer or join.

12. The building structure of claim 1, wherein the base includes a floor structure, which may optionally be of modular construction, also employing laminated panels.

13. The building structure of claim 12, wherein the laminated panels for the floor comprise a ribbed outer steel skin, a foamed plastic core and a ribbed inner skin, and preferably the floor is lined with composite flooring, water-proof ply or timber floor.

14. The building structure of claim 1, further comprising a roof structure supported by the walls.

15. The building structure of claim 14, wherein the roof structure is also of modular construction, and employing further laminated panels.

16. The building structure of claim 15, wherein the laminated panels for the roof comprise a ribbed outer steel skin, a foamed plastic core and a ribbed inner skin and are preferably lined with fibre-cement board, plasterboard, random grooved ply or timber.

17. A method of construction including the steps of:

placing one or more wall locating members on a base;

erecting one or more modular panels on the wall locating members to form one or more walls;

engaging adjacent modular panels to define longitudinal cavities between longitudinal recesses formed on upright sides of said modular panels;

placing a top member on the upper edge of the modular panels;

inserting tie rods through the top member and longitudinal cavities;

connecting the tie rods to the base to secure the top member, modular panels and wall locating member thereto, to form walls.

18. The method of construction of claim 17, wherein the step of placing the top member on the upper edge of the modular panels comprises the steps of;

placing a capping member on the upper edge of the modular panel; and

placing a compression member on top of the capping member.

19. A modular panel for use in the building structure of claim 1 or method of construction of claim 17, wherein said modular panel comprises:

a core of foamed plastics material;

at least one outer skin member bonded to said core;

two longitudinal recesses on opposing longitudinal sides of the modular panel which define, in use, a longitudinal cavity extending along the junction between adjoining modular panels.

20. The modular panels of claim 19, wherein the modular panel further comprises an additional longitudinal cavity, sized so as to receive a tie rod; wherein the longitudinal cavity is located toward an end of the modular panel but in from the longitudinal recess.

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