United States Patent

[11] 3,604,174

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[45] Patented **Sept. 14, 1971**

[54] **LIGHTWEIGHT STRUCTUAL PANEL**
3 Claims, 15 Drawing Figs.

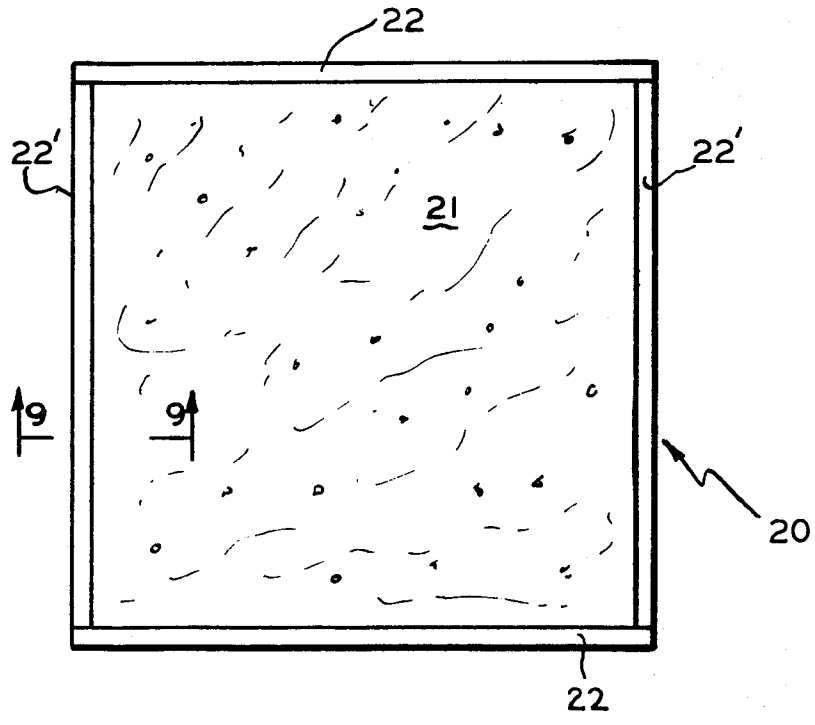
[52] **U.S. Cl.** **52/601,** 52/656
[51] **Int. Cl.** **F04c 2/04,** F04c 2/34
[50] **Field of Search** 52/600, 601, 596, 477, 656, 612, 231, 729–732

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Assistant Examiner—James L. Ridgill, Jr.
Attorney—Bruns & Jenney

ABSTRACT: A structural building unit in the form of a panel that is lightweight yet strong and fireproof. The panel is comprised of light aggregate concrete bounded by a structural steel frame that serves initially as a form and subsequently as a connecting device. The unit, which is interiorly reinforced, can be utilized for exterior and interior walls, and for floors, ceilings and roofs.



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SHEET 1 OF 2

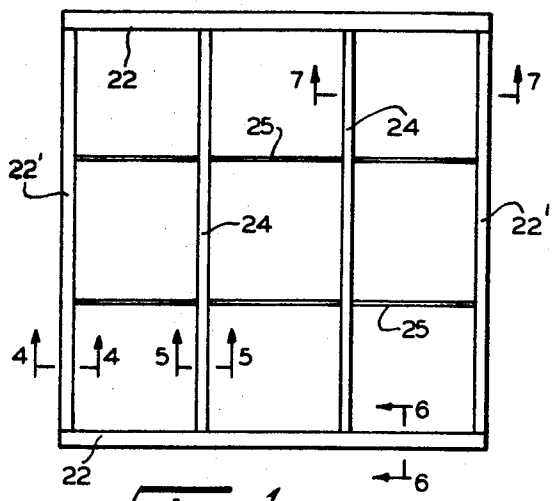


Fig. 1

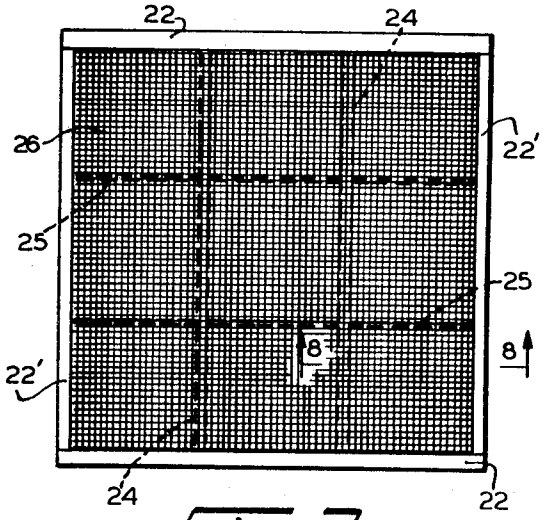


Fig. 2

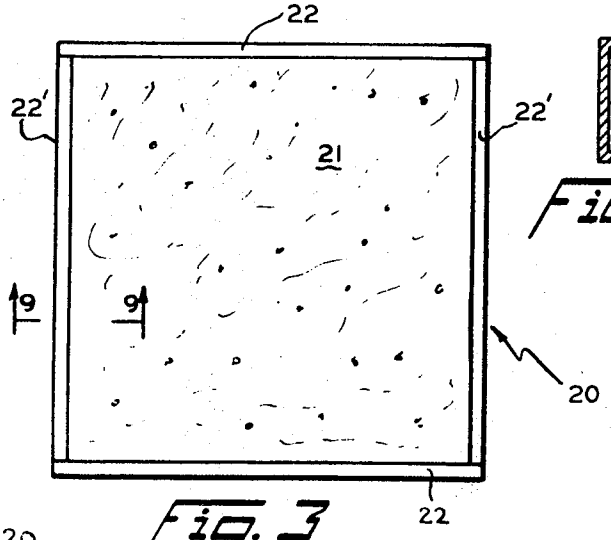


Fig. 3

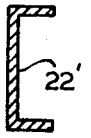


Fig. 4

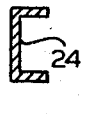


Fig. 5

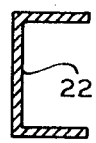


Fig. 6

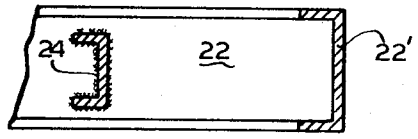


Fig. 7

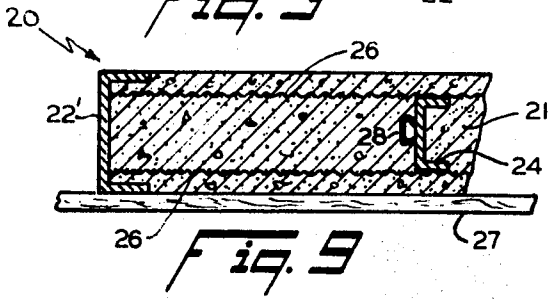


Fig. 9

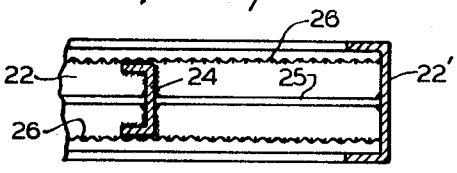


Fig. 8

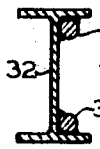


Fig. 10

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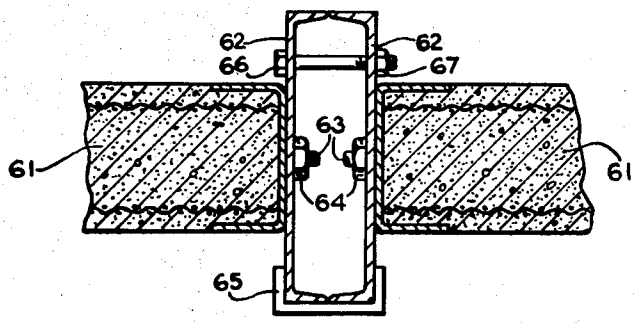


Fig. 14

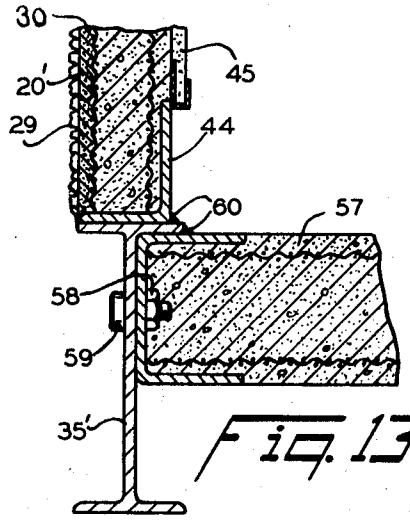


Fig. 13

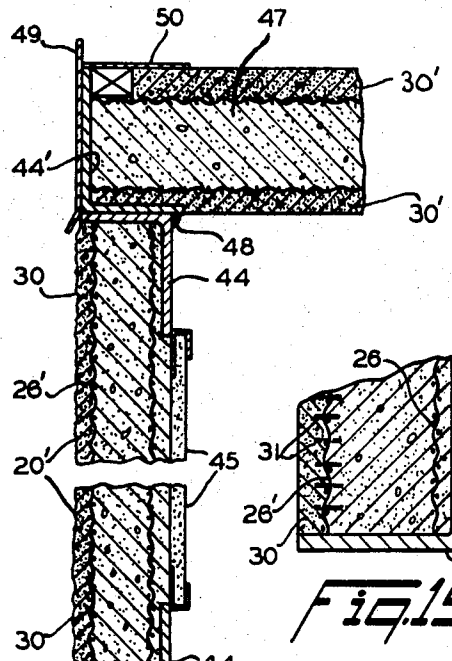


Fig. 15

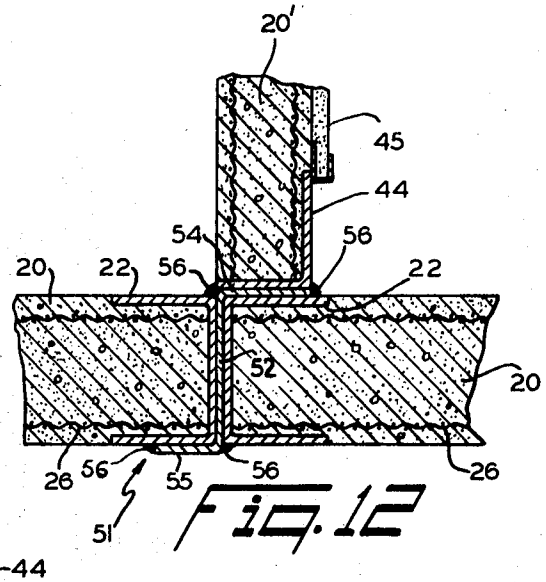


Fig. 12

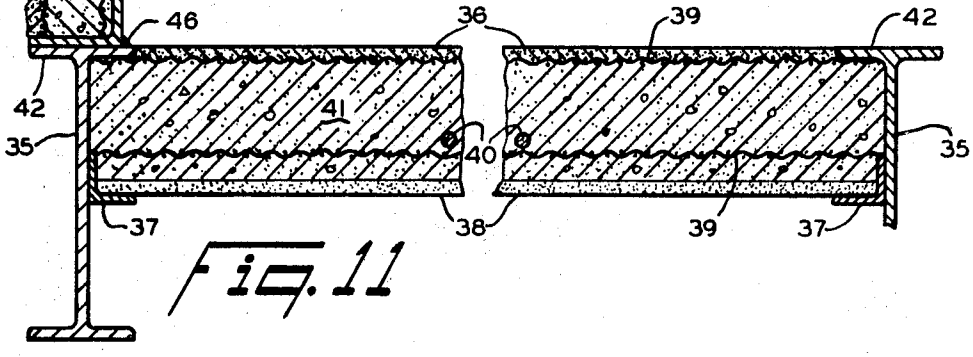


Fig. 11

LIGHTWEIGHT STRUCTUAL PANEL

BACKGROUND OF THE INVENTION

This invention relates generally to building structures, and has particular reference to a preformed, lightweight structural panel of novel construction.

A substantial number of building components in panel form have been developed heretofore but most are limited to specific uses or have certain disadvantages. Thus, many of the panels that are structural or load bearing are not ornamental while others that are ornamental are not designed to be load bearing with the result that it may be necessary to use both types in a building to supplement one another. Similarly, panels suited for exterior portions of a building are frequently unsuited for interior use, and vice versa. Also, many structural panels require the addition of insulation and fireproofing which is a disadvantage, and a further disadvantage is that preformed building panels are often unduly heavy and cumbersome making it both difficult and expensive to transport them from the place of manufacture to the building site.

SUMMARY OF THE INVENTION

The preformed building panel of the invention is lightweight and at the same time strong. Its structural arrangement, in conjunction with the materials used, results in a fireproof unit that also has good insulating properties.

The panel is for most applications a rectangular concrete slab the edges of which are bounded by or contained within a structural steel frame that is formed of channel or angle iron shaped members. This frame serves as a form when the concrete is poured and as a convenient connecting means when the panel is being incorporated in a building. The panel is lightweight because a very lightweight aggregate is used for the concrete, and the particular aggregate also contributes to the good insulating properties as will be explained. Because they are relatively light, completed panels can be economically transported to the building site or, in the alternative, the frames only can be delivered to the site and the panels cast on the job.

The strength of the panel is due to its structural steel frame and also to a reinforced diaphragm located in the panel interior. This diaphragm comprises additional structural steel members which connect opposite sides of the frame and pieces of wire mesh that occupy the area enclosed by the frame and are maintained in spaced relation to one another by the interior structural members.

The building panel of the invention is versatile in that it is readily usable for interior or exterior walls, or for a floor, ceiling or roof. For either exterior or interior use various types of topping materials can be cast in one or both sides of the panel. In addition, for interior use, the panel sides can be covered with paint, wallpaper, fabric, wood paneling and the like. If desired, even greater structural strength can be achieved by forming the panel so that a layer of high-density concrete is bonded to one or both sides of the lightweight aggregate concrete.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of the structural frame of the panel and its interior structural reinforcing members;

FIG. 2 is a view corresponding to FIG. 1 with the addition of the interior wire mesh-reinforcing members;

FIG. 3 is a top plan view of a completed panel embodying the invention, the panel resting on one side in a substantially horizontal position;

FIG. 4 is a cross-sectional view of a frame member, taken on line 4—4 in FIG. 1;

FIG. 5 is a cross-sectional view of a structural reinforcing member, taken on line 5—5 of FIG. 1;

FIG. 6 is a cross-sectional view of a frame member, taken on line 6—6 of FIG. 1.

FIG. 7 is a fragmentary cross-sectional view through the frame, taken on line 7—7 of FIG. 1;

FIG. 8 is a fragmentary cross-sectional view through the frame and reinforcing means, taken on line 8—8 of FIG. 2;

FIG. 9 is a fragmentary cross-sectional view through the panel, taken on line 9—9 of FIG. 3;

FIG. 10 is a vertical cross-sectional view of a light-gauge structural member reinforced by welded rod elements;

FIG. 11 is a fragmentary, vertical cross-sectional view of a building structure using the panels of the invention;

FIG. 12 is a fragmentary, vertical cross-sectional view of a floor-interior wall application of the panels;

FIG. 13 is a fragmentary, vertical cross-sectional view of a floor-exterior wall application of the panels;

FIG. 14 is a fragmentary, vertical cross-sectional view of a roof application of the panels; and

FIG. 15 is an enlarged cross-sectional view through a portion of a panel showing the shear wire detail.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and in particular to FIGS. 1–9 the preformed panel of the invention, indicated generally at 20 in FIGS. 3 and 9, includes a concrete slab 21 that is bounded by or contained within a structural steel frame. The frame is formed of elongated structural metal bar members, which term as used herein is intended to include structural steel or iron members having a channel, angle, "I", "T" or "Z" cross-sectional configuration, or having a circular or polygonal cross section as in the case of metal rods or tubes. In the embodiment disclosed in FIGS. 1–9, the frame is formed of two pairs of channel members 22 and 22′ welded or otherwise rigidly secured together at the corners of the frame, the channels in one pair of members being deeper than in the other as shown in FIGS. 1, 4 and 6.

To provide the panel with the desired qualities of lightness, good insulation and fireproofing, a special concrete is employed. This concrete can be made with a lightweight, inert aggregate and Portland cement, the lightweight aggregate taking the place of the heavy sand or gravel usually used. In the alternative, a foamed or cellular concrete can be used. When a lightweight aggregate is utilized, the aggregate is derived from expanded perlite or from the mineral vermiculite, the latter being marketed under the name Zonolite. The weight of this material is in the order of one-fourth that of sand or gravel, and it is known to possess excellent insulating properties.

An advantage of a panel that is comprised principally of a material such as concrete is that it can be constructed easily and economically on or off the job, casting the concrete in previously assembled frames. Additionally, and as will be described hereinafter, a castable material can be formed with a variety of surface finishes or can be made to incorporate various kinds of topping materials. Such a panel thus has considerably more versatility than panels comprised chiefly of wood, metal or composition board.

As best shown in FIG. 1, the frame 22, 22′ is provided with interior reinforcing means in the form of structural metal bar members 24 and 25. Members 24 are channels of less width than the frame channels, FIGS. 4–6, the members extending between one pair of opposite frame sides and being rigidly secured thereto as by welding. Bar members 25 are rods that extend between the other pair of frame sides to which they are secured by welding. Rods 25 are disposed at right angles to the channel members 24, the rods passing with a close fit through bores in the channel webs and being welded to the channels for added strength and rigidity as best shown in FIG. 8.

In addition to the bar members 24 and 25, the reinforcing means for the frame and the completed panel includes a pair of wire mesh members 26, the members being flat pieces or webs of the mesh which occupy substantially all of the area enclosed by the frame, see FIG. 2. The two wire mesh members are tack welded to the opposite sides of channels 24 whereby they are maintained in spaced, substantially parallel relation

to one another within the frame, FIGS. 8 and 9. If desired, the edges of the wire mesh members can also be welded or otherwise secured to the frame members 22, 22' for still greater strength.

The bar members 24, 25 and wire mesh members 26 together form a reinforcing diaphragm—or double diaphragm—that is an important part of the panel structure. Thus, the two spaced mesh members give added strength to the concrete slab and inhibit thermal and structural stresses that can cause cracks. In addition, the wire mesh strengthens the channel members 22, 22' and 24, and helps to keep them from bowing or getting out of alignment. The reinforcing diaphragm as a whole imparts structural strength to the completed panel unit, and serves to keep it from getting out of plumb or warping as well as helping to resist horizontal shear.

In the manufacture of the panel, the members 22, 22' are secured together to form the frame after which the reinforcing members 24, 25 are welded or otherwise secured in position, the reinforced frame at this stage being as shown in FIG. 1. Thereafter, the two wire mesh members 26 are secured in position, FIGS. 2 and 8, and the frame with its interior reinforcing means is then ready to receive the concrete. The concrete can be poured at the plant where the frames are manufactured, or the frames can be taken in skeletal form to the jobsite and the concrete poured there.

To cast the concrete in the frame, the latter is positioned on its side on a suitable broad 27 or other flat surface, FIG. 9, and the frame and board provide the necessary form. The form is filled so that the concrete is flush with the outside surfaces of the frame channels, as indicated in FIG. 9, the concrete flowing through the wire mesh members 26 and around the members 24, 25 so that the reinforcing means is completely surrounded and concealed from view. A good bond is obtained between the lightweight concrete 21 and the reinforcing means but, if desired, additional interlocking can be secured by providing the channel members 24 with projecting keys such as that shown at 28 in FIG. 9. When the concrete 21 has set, the finished panel can be removed from the form board 27 and after a period of curing, the panel is ready for use.

It was stated above that in its use of a castable material as a principal component, the panel of the invention lends itself to a variety of surface treatments. As an example, the upper surface of board 27 can have varying degrees of roughness or can be provided with a surface design or pattern, which roughness or pattern will be reflected in the panel side formed by the board. It is also possible to cast different types of topping material in the panel as by covering the board 27 within the panel frame with brick or stone facing, or ceramic tile which facing or tile becomes incorporated in the concrete when it is cast. Similarly, it is relatively simple to cast in the concrete, on either or both sides of the panel, stone chips of marble or granite, a panel 20' having stone chips 29 on one side thereof being shown in FIG. 13 where the panel forms a part of a building exterior wall.

In addition to different kinds of surface finishes or toppings, panel 20 can be cast in such a way that it has a layer of high-density concrete on one or both sides, the high-density concrete being employed to give the panel still more structural strength. The high-density layer normally occupies the panel area outside a wire mesh member 26, and in FIG. 11 the vertical, exterior wall panel 20' is provided with such a layer 30. To guard against the possibility of shear at the surface between the two types of concrete in the vertical panel of FIG. 11, the wire mesh member 26' at this junction may be provided with additional shear-inhibiting wires 31 which project substantially perpendicularly from the plane of the mesh as shown in the enlarged detail of FIG. 15.

While the reinforcing bar members 24 are shown in the panel of FIGS. 1–9 as having a channel configuration, it will be understood that members having other configurations such as the I-beam 32 of FIG. 10 can also be used. The structural element of FIG. 10 also illustrates an additional possible way of reducing the weight of the panel. Thus, I-beam 32 is relatively light because it is formed of thin-gauge steel. The beam is reinforced, however, by welding longitudinally extending steel rods 34 to it and this gives the beam a load-bearing strength equal to that of a thicker gauge or deeper beam.

FIGS. 11–14 illustrate some different applications of the panel of the invention in constructing a building. FIG. 11 is a fragmentary vertical section through a section of a building, or building module, that can be combined with other like sections to provide, for example, a classroom or to add to an existing room or building. The section is supported by large, spaced I-beams 35 and the flooring 36 that extends between these beams is formed in situ. To this end, angle irons 37 are welded to the beams to support a reinforced board 38 or steel plate that becomes the bottom of a form. The upper portions of the I-beams 35 serve as the sides of the form, and the ends are provided by transverse structural members (not shown). Structural reinforcing means such as the bar and wire mesh members 24, 25 and 26 of panel 20 are secured in position in the form, only mesh members 39 and members 40 being shown in FIG. 11. The concrete 41, which preferably is also the lightweight aggregate concrete, is poured into the form until its upper surface is flush with the top flanges 42 of the I-beams as shown.

A preformed or precast panel 20' embodying the invention forms a portion of the outer wall of the building section. In this panel, the structural bar members 44 forming its frame having an "L" or angle cross-sectional configuration rather than the channel shape of the panel 20 frame. Thus, it is not necessary or particularly desirable to have an exposed channel side on the building exterior, the entire outside surface of the panel 20' being concrete as shown. As noted above, panel 20' is provided with a layer 30 of high-density concrete and, if desired, this can be covered with a suitable topping or facing of one of the materials previously mentioned.

On the side of panel 20' that forms an interior wall, the angle frame members 44 are exposed, the member at the bottom of the panel serving as a baseboard in a typical school construction. The panel side forming an interior wall may be covered in a school classroom with a chalkboard 45 or, for other applications, the panel can be covered with real or imitation wood paneling, tile, wallpaper or paint. In the construction shown in FIG. 11, the wall panel 20' is secured in position by welding its frame 44 to the top flange 42 of I-beam 35 as indicated at 46.

The roof of the building section of FIG. 11 is formed of panels such as a panel 47 having a construction substantially like that of sidewall panel 20'. Panel 47 may be provided with outside layers 30' of high-density concrete, and the panel is secured in position by welding its frame member 44' to the frame member 44 of the panel 20' as shown at 48. The roof paneling is provided with suitable flashing strips 49 and 50. The building section shown in FIG. 11 can be preassembled and then transported by flatbed truck to the building site. Similar sections can be added to the ends of FIG. 11 section to provide a longer structure, and additional sections can be connected to the right hand I-beam 35 to provide a wider structure. Depending upon the application, a wall panel such as panel 20' may or may not be connected to the right I-beam.

FIG. 12 illustrates one possible means for securing a pair of panels 20 together in a floor. In this construction, a Z-plate 51 is positioned between the panels, the plate having a central vertical leg or web 52 and upper and lower horizontal flanges 54, 55 that extend in opposite directions from the upper and lower edges of the vertical leg. If the right-hand panel 20 is adequately supported, this panel can through the Z-plate be made to support, or partially support, the left-hand panel, the flanges 54 and 55 of the plate respectively overlying the right panel and underlying the left panel. The floor panels 20, Z-plate 51 and a vertical partition wall panel 20' are rigidly secured together by welds indicated at 56.

FIG. 13 corresponds to the lower left hand portion of FIG. 11 and illustrates an alternative flooring arrangement. In this modification, the floor is made up of precast panels 57 that

have the same construction as panel **20** except that the structural member frame has welded or otherwise rigidly secured to the inside thereof a plurality of nuts **58** which register with holes (not shown) through the frame. These provide the means for securing the panels **57** to the supporting I-beams **35'**, capscrews **59** passing through registering holes in the beams and being threaded into the nuts as shown. The provision of the nuts **58** and capscrews **59** is another way (in addition to welding) of utilizing the panel frame for the connecting means that secures the panels in position; other well-known interconnecting means can, of course, also be utilized for this purpose. The FIG. **13** arrangement includes a wall panel **20'** that is the same as the panel **20'** of FIG. **11**, and this wall panel, the upper flange of the I-beam and the frame of the floor panel **57** are welded together as indicated at **60**.

FIG. **14** is a detail which illustrates one way a pair of panels **61**, similar to panels **20**, can be connected together in a roof. To this end, the panel frames are secured to structural channels **62** by means of outwardly projecting studbolts **63** that are welded or otherwise rigidly secured to the frames. These pass through registering holes (not shown) in the channels **62** and have nuts **64** threaded thereon. The channels **62** can be connected together by another channel **65** held in position as by welding or setscrews; in the alternative, the members **62** can be connected by through bolts **66** and nuts **67** as shown at the top of FIG. **14**.

From the foregoing description it will be apparent that the invention provides a novel and unusually versatile performed building panel. As will be understood by those familiar with the art, the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed are, therefore, to be considered in all respects as illustrative rather than restrictive, the scope of the invention being indicated by the appended claims.

1. A lightweight load-bearing building panel comprising a single, substantially rectangular slab of lightweight cellular concrete, a structural metal frame formed of angle or channel iron members extending continuously around the edge of the slab, the frame serving initially as a form for the concrete and subsequently as a connecting means for securing the panel in position in a building, and reinforcing means wholly embedded within the slab so as to be concealed from view, the reinforcing means including structural metal bar members of less width that the frame members the ends of which are rigidly secured to opposite sides of the frame and wire mesh members coextensive with and extending continuously across the frame, said wire mesh members being fixedly secured directly to the frame and to the bar members on opposite sides thereof so as to be held in spaced relation to one another separated by the bar members

2. A panel as defined in claim **1** together with a layer of high-density concrete bonded to at least one side of said lightweight cellular concrete.

3. A lightweight load-bearing building panel comprising a substantially rectangular slab of lightweight foamed concrete; a structural metal frame serving initially as a form for the concrete and subsequently as a connecting means for securing the panel in position in a building; the sides of the slab being substantially flush with the frame edges; and reinforcing means wholly embedded within the slab so as to be concealed from view, the reinforcing means being in the form of a double diaphragm the overall thickness of which is less than the thickness of the frame, the diaphragm including flanged structural metal bar members the ends of which are rigidly secured to one pair of opposite frame sides, structural metal rod members the ends of which are rigidly secured to the other pair of opposite frame sides, the rod members passing through the bar members and being rigidly secured thereto at the points of intersection, and a pair of wire mesh members fixedly secured directly to the bar member flanges so as to be held in spaced relation to one another by the members, the wire mesh members being coextensive with and extending continuously across the frame and being fixedly secured to the frame at the peripheral edges thereof whereby the mesh members increase the effective width of the bar member flanges without appreciably increasing the weight of the panel.