May 21, 1968 H. HODSON 3,383,816

PRECAST FLOOR PANEL

Filed Oct. 7, 1964 3 Sheets-Sheet 1

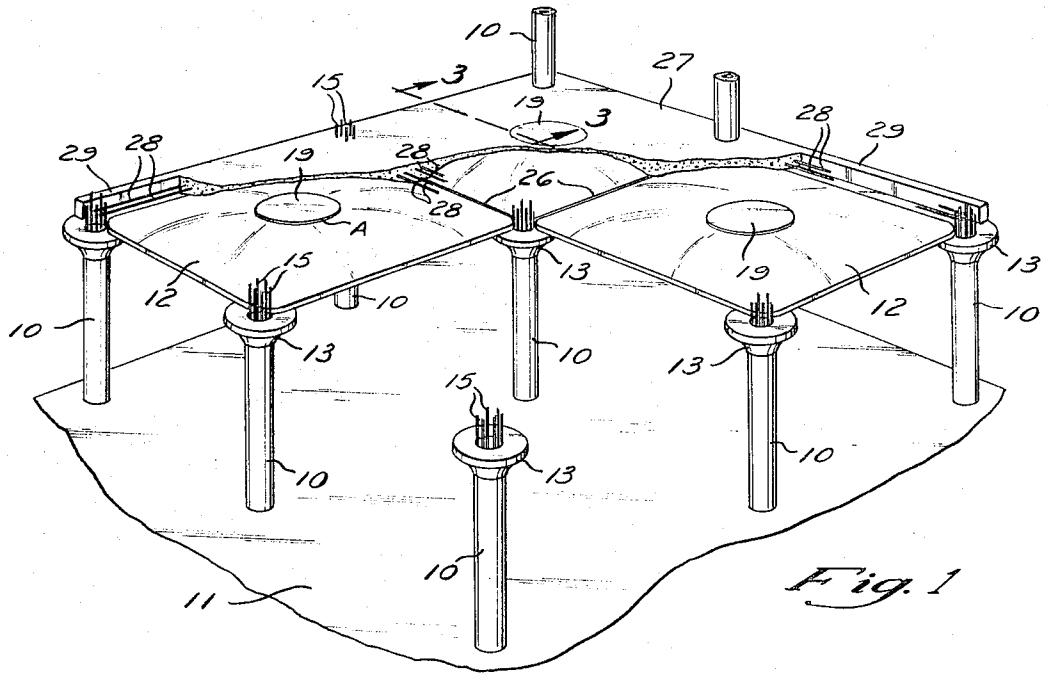


Fig. 1

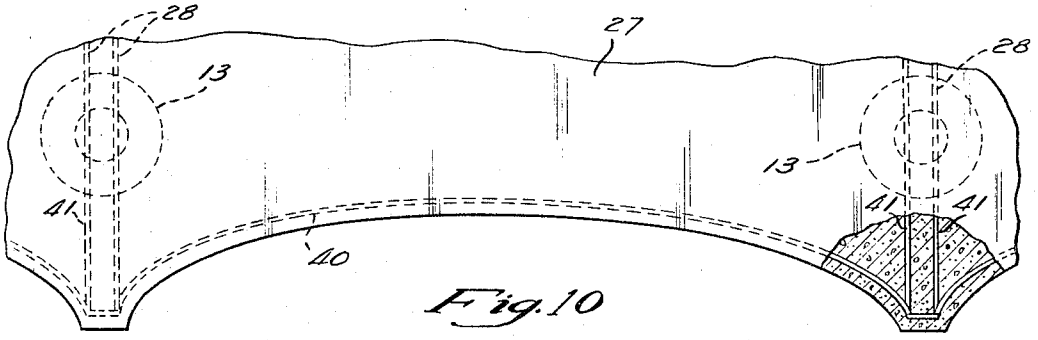


Fig. 10

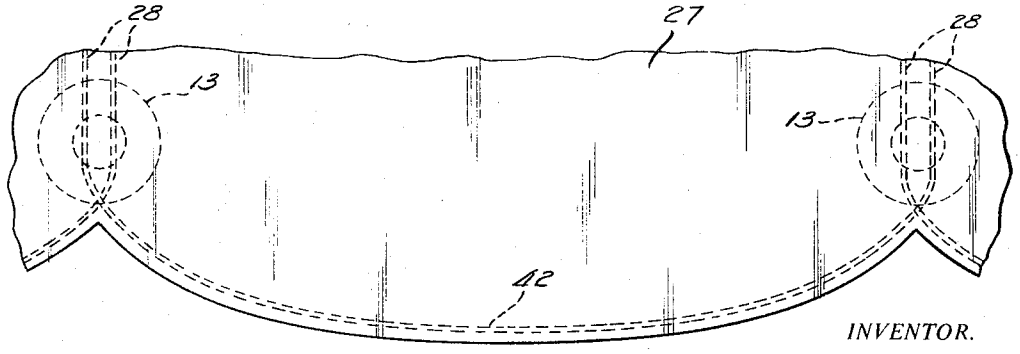


Fig. 11

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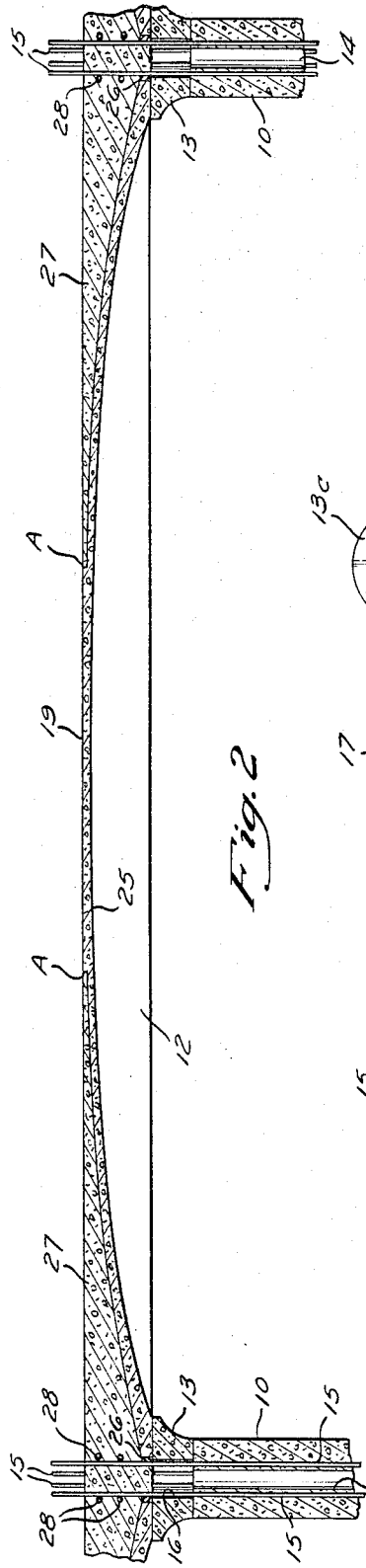


Fig. 2

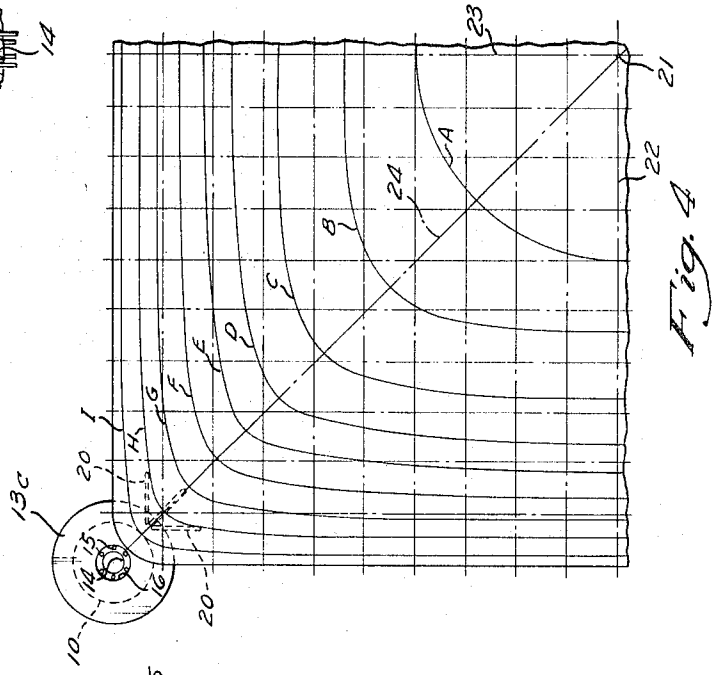


Fig. 4

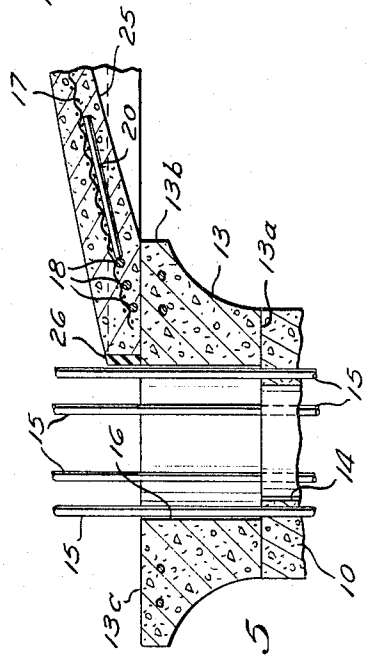


Fig. 5

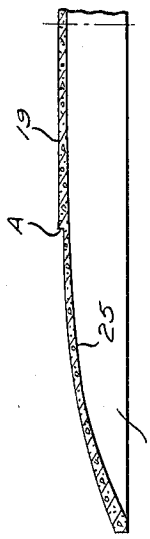


Fig. 3

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PRECAST FLOOR PANEL

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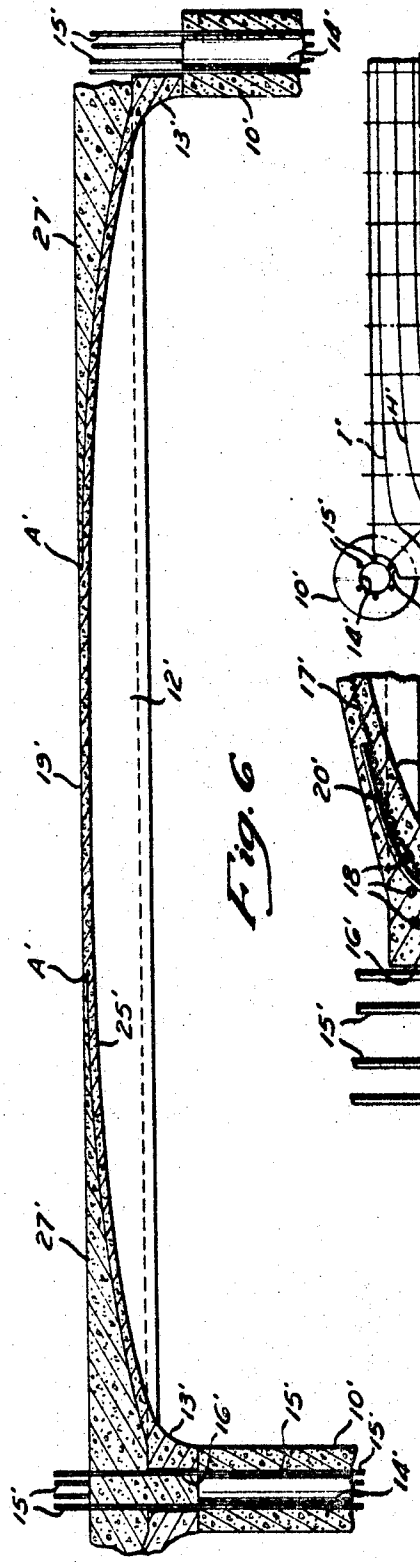


Fig. 6

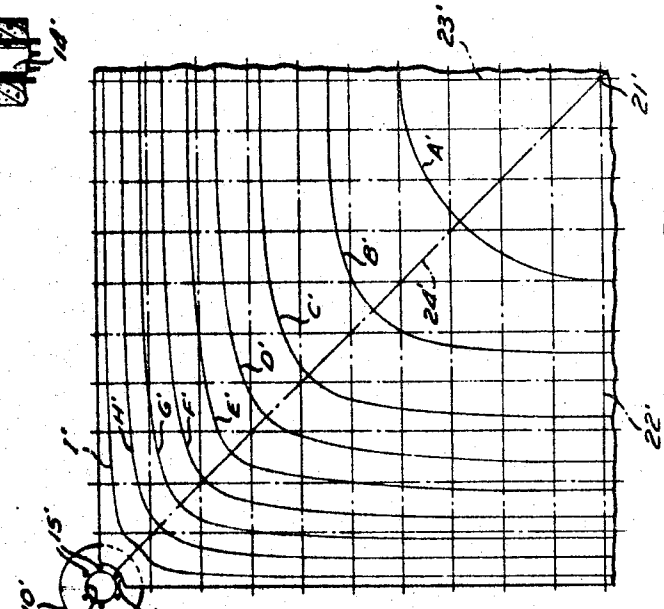


Fig. 8

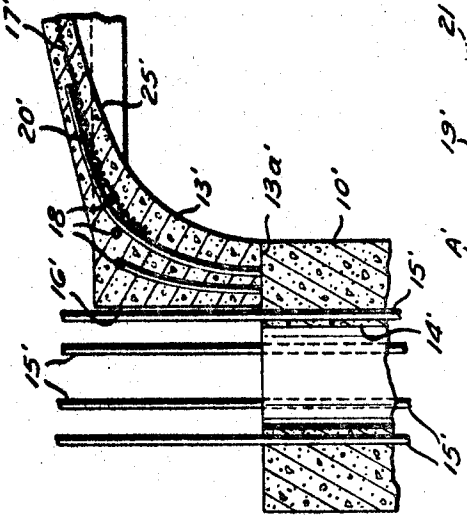


Fig. 9

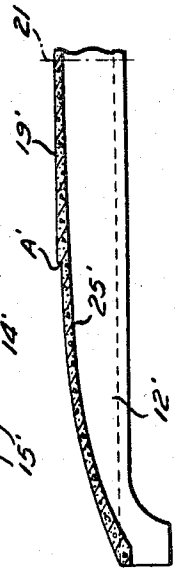


Fig. 7

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PRECAST FLOOR PANEL

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4 Claims. (Cl. 52—263)

ABSTRACT OF THE DISCLOSURE

This invention relates to a precast concrete floor panel and to a building structure embodying such floor panels.

It is a principal object of this invention to provide a novel and improved precast concrete floor panel which is concavo-convex, with its top surface convex, and is of a polygonal outline which enables it to be used as one of a plurality of identical floor modules arranged contiguous to one another in a complete floor of a building.

It is also an object of this invention to provide such a precast concrete floor panel having high strength for its weight.

Another object of this invention is to provide such a precast concrete floor panel which is adapted to be supported at the corners of its marginal edges only, thereby simplifying the construction of the complete building structure in which it is incorporated.

Another object of this invention is to provide such a precast concrete floor panel whose ratio of vertical dimension to horizontal span is comparable to that of standard slab and beam construction in buildings.

Another object of this invention is to provide such a precast concrete floor panel whose vertical thickness throughout its extent is substantially less than its rise from its marginal edges to its middle.

Another object of this invention is to provide a novel and improved building structure comprising upright support columns and a floor made up of a plurality of such precast concrete floor units, extending contiguous to one another and supported only at their corners by the columns, and additional concrete cast in plate over the precast floor units to provide therewith a continuous, generally flat floor surface.

Another object of this invention is to provide such a precast concrete panel which does not require customary slab reinforcing bars in the completed floor.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a fragmentary perspective view, with parts broken away for clarity, showing a building structure in accordance with a first embodiment of the present invention;

FIGURE 2 is a vertical section taken diagonally across one of the precast floor panels in the FIGURE 1 structure;

FIGURE 3 is a vertical half-section of the same floor panel taken along the centerline 3—3 in FIGURE 1 in a direction parallel to a pair of opposite side edges of this floor panel;

FIGURE 4 is a top contour plan view of one quadrant of this same floor panel;

FIGURE 5 is an enlarged fragmentary vertical sectional view taken at the support column at one corner of the floor panel in this first embodiment of the present invention;

FIGURE 6 is a vertical diagonal section through a floor panel constructed in accordance with a second embodiment of the invention;

FIGURE 7 is a vertical half-section of the same floor panel taken along a center line parallel to a pair of its opposite side edges;

FIGURE 8 is a top contour plan view of one quadrant of this second floor panel;

FIGURE 9 is an enlarged fragmentary vertical section taken at the support column at one corner of this floor panel;

FIGURE 10 is a plan view showing one edge reinforcement arrangement for the floor in the present building structure; and,

FIGURE 11 is a similar view showing a second edge reinforcement arrangement for the floor in the present building structure.

Referring to FIGURE 1, the building structure illustrated therein comprises a plurality of laterally spaced, vertically extending, precast or cast in place concrete columns **10**, which extend up from a ground floor **11**, and a floor supported by the columns. In accordance with the present invention, the floor comprises a plurality of precast concrete floor panels **12**, each of which is concavo-convex in cross-section and generally rectangular in outline. These floor panels at the corners of their marginal edges rest on precast or cast in place concrete capitals **13**, which rest on the upper ends of the respective columns **10**.

As shown in FIGURES 2 and 5, each column **10** preferably is formed with a central axial passage **14** to reduce cost and weight and to accommodate wiring and service pipes for the building. A plurality of vertically extending steel reinforcing rods or bars **15** are embedded in the concrete of each column at circumferentially spaced locations a short distance radially outward from the passage **14**. These reinforcing rods extend up beyond the upper end of each column.

Each precast concrete capital **13** has a central axial passage **16** which slidably receives the reinforcing rods **15** when the capital is inserted down onto the upper end of the respective column **10**. With this arrangement, the reinforcing rods center the capital on the column. The lower end **13***a* of each capital **13** has an outside diameter equal to that of the column **10** on which it rests. Upwardly from its lower end the capital has a progressively increasing outside diameter, and at its upper end it presents a cylindrical portion **13***b* of substantially larger diameter than that of the column. The capital presents a flat, annular top face **13***c* which is engaged by the corner portion of one or more of the floor panels **12**. Except at the outside edge of the building, each capital supports the respective corner portions of four neighboring floor panels.

Each floor panel **12** is an integral slab of precast concrete with a welded wire steel reinforcing mat or fabric **17** (FIGURE 5) embedded in it approximately midway between its top and bottom faces. This reinforcing mat **17** extends throughout substantially the entire width and breadth of the panel. Marginal edge reinforcing **18** may take the form of reinforcing rods extending around the periphery close to the edge. Corner reinforcing rods **20** may fan out from each corner.

The vertical thickness of the panel throughout its entire extent is extremely small compared to its horizontal span between the columns **10** which support it. Preferably, its thickness is less than 2 percent of its horizontal span (along its shortest marginal edge). Preferably, the panel is approximately uniform in thickness throughout its extent, except along its marginal edges where it is appreciably thicker.

As an illustrative example, for a precast floor panel having a length and width of 25 feet each and intended to support a live load of 50 pounds per square foot, the minimum thickness of the panel may be 1½ inches and its maximum thickness in the vicinity of its marginal edges may be 3 inches. This same panel may have a

total vertical dimension, from its bottom face along its marginal edges to its top face at the middle of the panel, of 20 inches. Thus, it will be seen that the rise of the panel is relatively small compared to its horizontal span and is comparable to the ratio of vertical-to-horizontal dimensions in standard slab and beam construction in buildings. Preferably, the rise-to-span ratio of the panel is less than 1 to 12.

The particular curvature of the present panel is a significant factor enabling it to have a substantial load-bearing capacity while at the same time having a relatively shallow rise and a small thickness. Also, the particular curvature of the floor panel is such that a plurality of such panels, each polygonal in outline (preferably rectangular), may be positioned in contiguous side-by-side relationship to constitute the base of a complete floor structure.

Referring to FIGURE 4, which is a contour plan view of the top face of one quadrant of the panel, the contour line A bounds a circular portion **19** at the middle of the panel which is flat and horizontal. As shown in FIGURE 2, the panel presents a shallow vertical shoulder of perhaps one or two inches in height at this line A.

The next contour line B in FIGURE 4 designates a coplanar, horizontal line on the top surface of the panel which is at a level two inches below the level of the flat central portion **19**. The top surface of the panel has a gradual curvature downward and radially outward from the shoulder at the contour line A to this second contour line B. The radial distance of contour line B from the center **21** of the panel is a minimum at the centerlines **22** and **23** and it increases gradually from each of these centerlines to a maximum along the diagonal line **24**, which extends radially from the center **21** to the corner of this quadrant of the panel.

The successive contour lines C, D, E, F, G, H and I in FIGURE 4 designate coplanar, horizontal lines on the top surface of the panel which are at successively lower levels at two inch vertical intervals. That is, the plane of contour line C is two inches below that of contour line B, and so on. Each of these contour lines has a radial distance from the center **21** of the panel which is a minimum at the centerlines **22** and **23** and which increases gradually from each centerline to a maximum along the diagonal **24**.

As shown in FIGURE 4, the radial distance between successive contour lines becomes progressively smaller along any radius outward from the center **21** of the panel. This means that the radius of curvature of the panel along any vertical plane becomes progressively smaller in a direction radially outward from the center toward the marginal edges of the panel. The entire top surface of the panel has a smooth and continuous convex curvature across its entire extent (except at the flat middle portion **19**) and is substantially free of any abrupt discontinuities or changes of direction because the changes of curvature are extremely gradual and adjoining portions of different curvature merge smoothly with one another.

As shown in FIGURES 2 and 3, the bottom surface **25** of the panel extends substantially parallel to its top face, except at the marginal edges. There the bottom face is flat, horizontal and co-planar.

Preferably, the curvature of the panel is such that 50% of the rise in each quadrant of the panel takes place in less than the first 25% along any radius inward from its marginal edge. In the particular example shown in FIGURES 2–4, 50% of the rise takes place between the marginal edges and a line between the contour lines E and F, which is less than 25% of the radial distance inward from a marginal edge to the center **21** along any radius. The form of curvature approximates the compressive funicular diagram for the various systems of self-loading and applied loading which will exist in the structural arrangement described. This curvature applies to the loading of any transverse section and assumes support along the outer edges of the panel. Since self-loading increases rapidly towards the outer edges, the curvature in this region increases correspondingly. Inward from these regions the curvature of the panel becomes progressively flatter, and the panel itself becomes horizontal at its center line assuming a symmetrical load condition. This relative flatness across the middle region of the panel enables the overall rise of the panel to be kept relatively moderate without unduly detracting from the load carrying capacity of the panel. In terms of the above analysis, the floor panel is essentially an arch section in which vertical load forces are resolved into axial compression lines, or funicular polygons, lying approximately along the axis of the precast unit. The adaptation of this geometrical concept to any plan shape, such as a square as shown, produces a surface of double curvature which introduces membrane forces, characteristic of dome action and capable of being sustained by suitable reinforcing **18** located in the periphery of the panel. Since the panel is supported at its corners, radial tension stresses are also generated in the areas near to the support, which may be sustained by the peripheral reinforcing **18** and corner reinforcing **20** shown. The reinforcing mat **17** is needed only to meet small bending stresses due to changes in loading pattern or thermal stresses. This same construction principle may also be embodied in concavo-convex floor panels of non-square, rectangular outline or of non-rectangular polygonal outline, such as hexagonal. In the case of non-square, rectangular panels, preferably the ratio of the length of the longer side of that of the shorter side should not exceed 1.33 to 1.

As shown in FIGURE 1, each precast concrete floor panel **12** is supported at its four corners by respective capitals **13** on the upper ends of support columns **10**. The corners of each floor panel are rounded and they pass just outside the respective passages or openings **16** in the capitals, as best seen in FIGURE 4.

The side edges of identical neighboring floor panels extend closely adjacent and parallel to one another, as shown in FIGURE 1, and the clearance between them is filled with non-shrink mortar **26**, before any load is added to the floor panels.

With all of the precast floor panels **12** in place, and with the openings **16** in the capitals suitably blocked at their upper ends, the floor structure is completed by pouring concrete **27** over the precast floor panels where they adjoin each other. If required by applied loads, steel reinforcing bars or rods **28** may be positioned extending horizontally above the side edges of the precast panels and generally parallel to those edges at suitable levels in the cast-in-place concrete **27**. A lateral beam **29** extends around the outer periphery of the assembly of precast floor panels **12**. This lateral beam **29** is disposed to withstand the laterally outward force caused by vertical loading on the adjacent floor panels **12**. It may be a steel beam, or a reinforced concrete beam. If the latter, it may be precast or may be cast-in-place at the same time as pouring the concrete **27**. This beam rests on the outermost capitals **13** in the assembly and may be closely adjacent the outside edges of the outermost floor panels **12**. The concrete is poured over the precast panels out to these beams, also. The concrete is poured until it reaches a level substantially flush with the flat surfaces **19** on the precast panels. The shoulder at the contour line A eliminates a feather edge of concrete which would otherwise occur. When this cast-in-place concrete has hardened, the completed floor presents a flat, horizontal top surface which is continuous across the several precast panels **12** embodied therein.

The complete building may have more than one floor constructed as described, with each lower floor supporting the columns for the next floor and with the columns disposed in vertical alignment as shown in FIGURE 1.

In the erection of the building, the precast columns **10** for supporting the floor above are positioned over the foundation and are shored and vertically supported in

their correct locations. Then the foundation concrete is placed in position. Alternatively, the columns are cast in place on the foundation.

Next, the capitals 13 are placed on top of the respective columns 10. The capitals may be centered laterally by the reinforcing bars 15, as described, or by suitable abutting shoulder joints on the column and the capital. The capitals may be adjusted vertically, if necessary, by mortar filling or by steel shims combined with packing. The position and structural continuity of the capital with respect to its support column 10 are assured by grouting where the capital is of precast concrete, or by welding the capital to the reinforcing bars embedded in the column where the capital is of steel.

The gradually increasing radius of each capital 13 from its lower end, where it is attached to the support column 10, to its upper end 13*b*, where it supports the precast floor panels 12, provides a gradual stress transition from the floor panels down to the support column.

In accordance with a second embodiment of the invention, shown in FIGURES 6–9, the capitals may be cast integrally with the precast floor panels. In this construction, at each corner of the floor panel 12' a capital member 13' is cast integral with the panel. This capital member 13' constitutes one quadrant of a complete annular capital. At each of the support columns, except at the outside of the building, the four adjoining panels present integral capital members 13' which together make up a complete annular capital. The corner reinforcing 20' may extend not only up into the panel corner but also down into the capital quadrant 13'. Non-shrink mortar is provided between the adjoining vertical edge faces of these capital members, as well as between the adjoining side edges of the panels themselves.

In other respects, the second embodiment is essentially similar in construction and principles of operation to the first-described embodiment. Therefore, it need not be described in detail. In FIGURES 6–9, the same reference numerals, with a "prime" subscript added, are applied to the features which correspond to those in the embodiment of FIGURES 2–5.

In place of the straight exterior reinforcing beam 29 of FIGURE 1, the floor may be reinforced laterally by outside compression members 40 as shown in FIGURE 10. The opposite ends of this member are disposed laterally outwardly from the adjacent capitals 13 and secured by suitable tension reinforcement 41 which returns over the column capital at each bay and to the reinforcing steel 28. Between its ends, each such member 40 is bowed laterally inwardly to resist the lateral loading. The cast-in-place concrete 27 is poured out to the outside reinforcing member 40, which is maintained under compression by this concrete.

Alternatively, as shown in FIGURE 11, the outside support may be a tension member 42 such as a bowed steel plate, or a plurality of bowed steel bars, whose opposite ends are disposed close to the adjacent capitals 13 and are rigidly attached thereto or to the reinforcing steel 28. Between its ends, this outside reinforcing member is bowed laterally outward. The cast-in-place concrete 27 is poured out to the member 42, which is maintained under tension by this concrete.

Any combination of straight-sided outside members 29, inwardly-bowed, compression members 40, and outwardly-bowed, tension members 42 may be provided, if desired.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A building structure comprising a plurality of laterally spaced, vertical supports,
   - a plurality of precast concrete floor panels on the upper ends of said supports,
   - each of said floor panels being of generally rectangular outline with a plurality of straight marginal edges and corners joining said edges and resting on said supports,
   - each of said panels having a concavo-convex configuration with its convex surface at the top,
   - each panel having a vertical rise from its marginal edges to its center which is less than 1/12 of its horizontal span along its shortest marginal edge,
   - the top surface of each panel having progressively inceasing convex curvature from the middle of the panel laterally outward toward its periphery characterized by horizontal contour lines which have radial distances from the center of the panel which are a minimum along the centerlines of the panel and increase progressively toward diagonals to the corners of the panel so as to provide a smooth, gradually changing, continuous convex curvature with maximum curvature close to the periphery of the panel along substantially the entire extent of its marginal edges and its corners, neighboring panels presenting respective marginal edges which extend substantially contiguous to one another,
   - The lower marginal edge of the periphery of each panel lying in a substantially horizontal plane,
   - the curvature of each panel being uninterrupted from each marginal edge to substantially the mid-portion thereof,
   - non-shrink mortar disposed between said contiguous marginal edges of neighboring panels,
   - and cast-in-place concrete overlying said precast panels and presenting therewith a substantially continuous flat floor surface.

2. A building structure according to claim 1, wherein each of said supports comprises an upstanding support column, and
   - a capital resting on the upper end of said column and extending upward therefrom with a gradually increasing horizontal dimension to provide a gradual stress transition between the floor and the column.

3. A building structure according to claim 2, wherein each of said floor panels has a segment of the respective capital cast integral therewith at each corner of the panel.

4. A building structure according to claim 3, wherein the capital segments at adjoining corners of neighboring panels rest on the same support column and together constitute a complete capital.

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