

Feb. 16, 1971

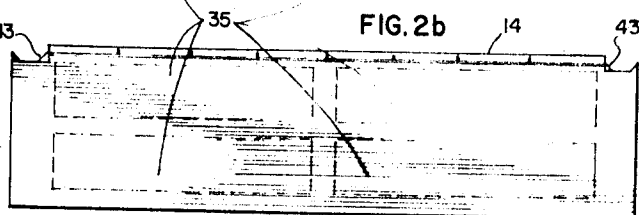
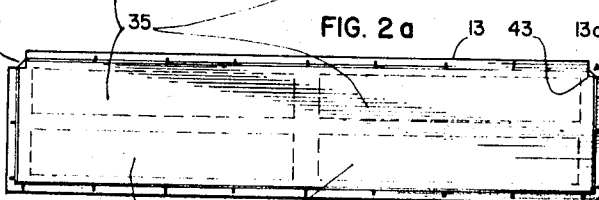
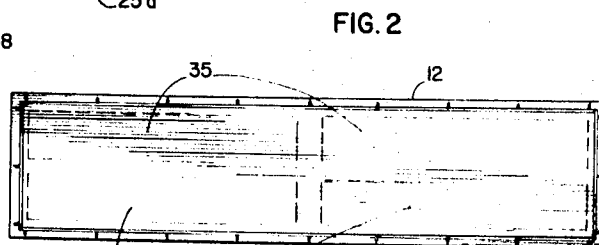
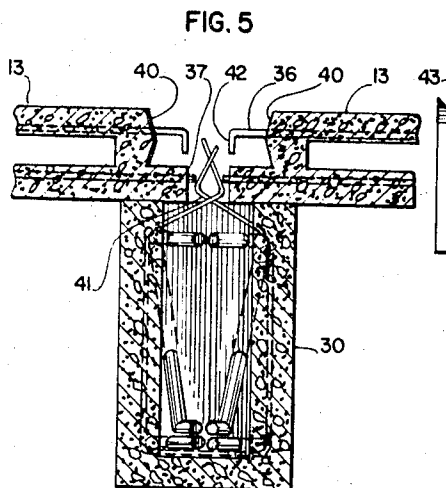
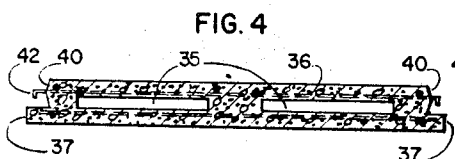
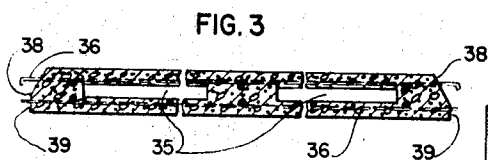
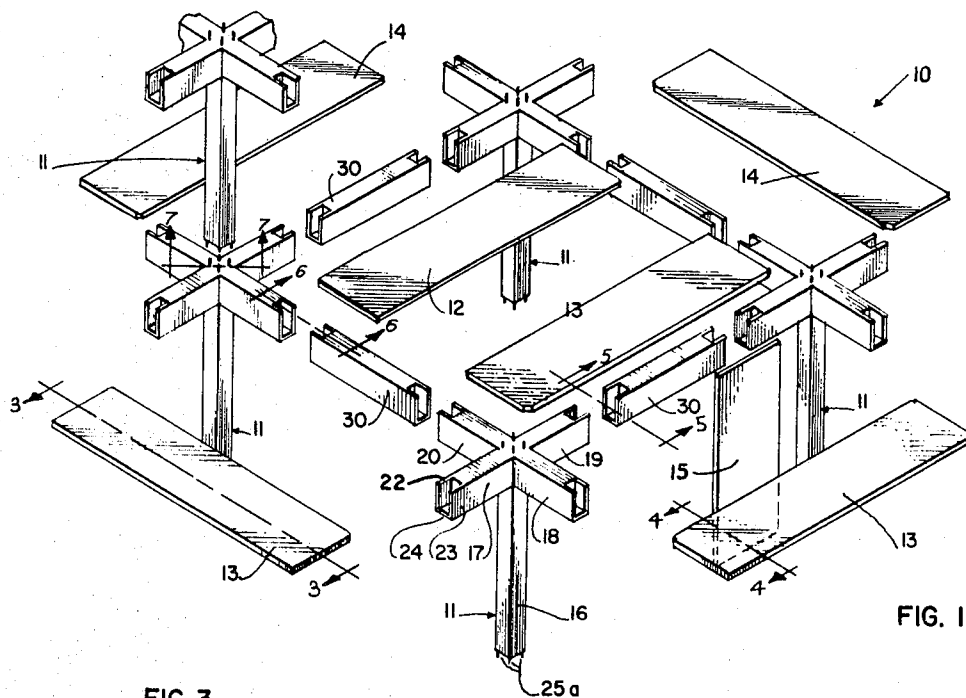
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3,562,979

BUILDING CONSTRUCTION

Original Filed Oct. 23, 1967

9 Sheets-Sheet 1



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FIG. 6

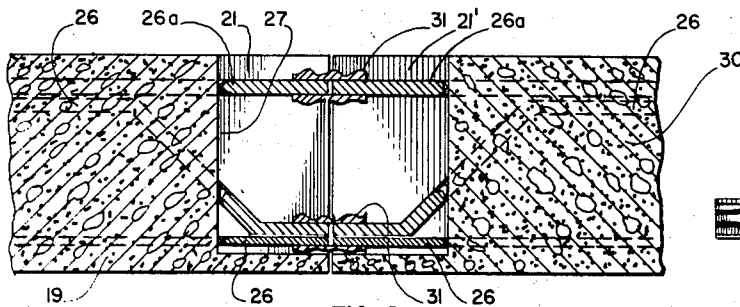


FIG. 6a

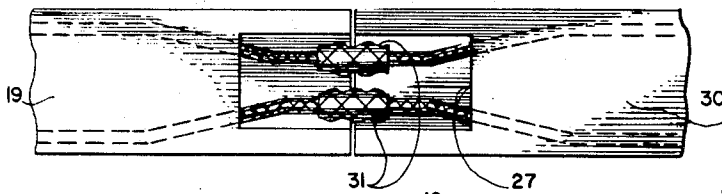


FIG. 7

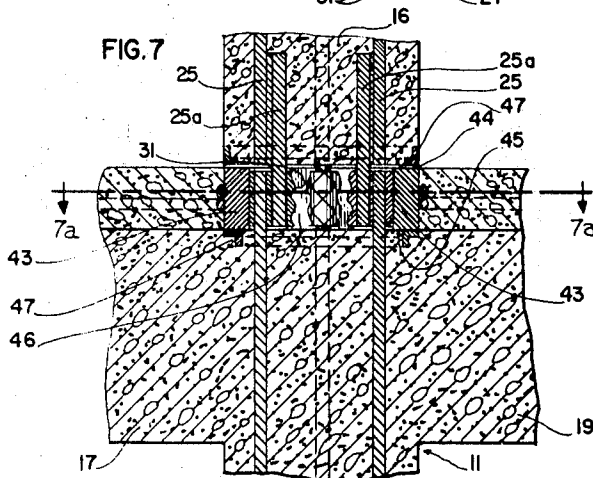


FIG. 7a

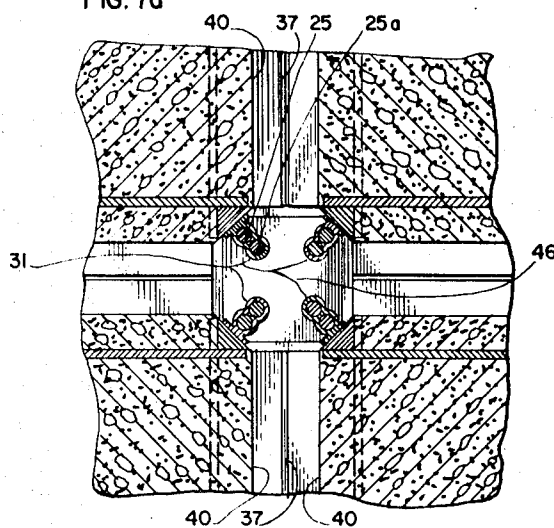


FIG. 8

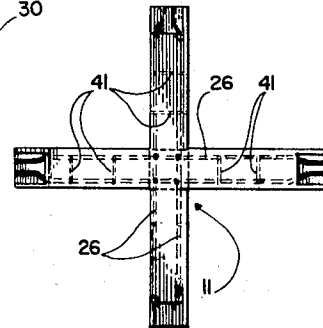


FIG. 8a

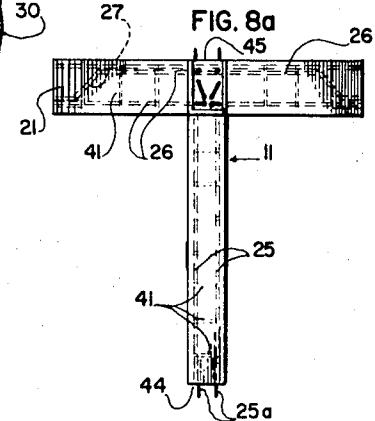


FIG. 9

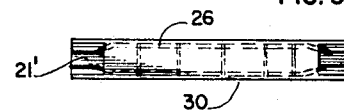
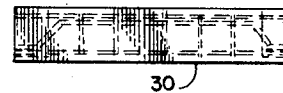


FIG. 9a



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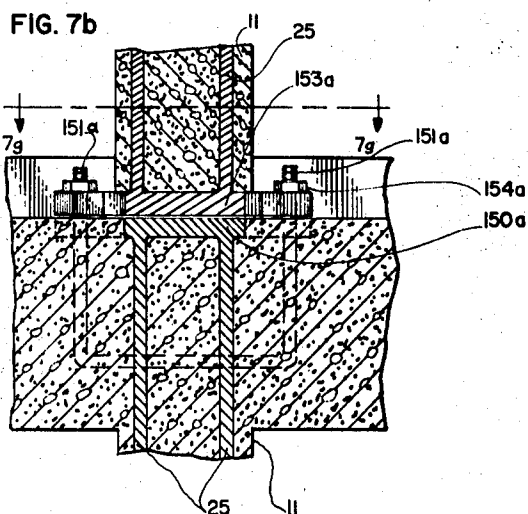


FIG. 7g

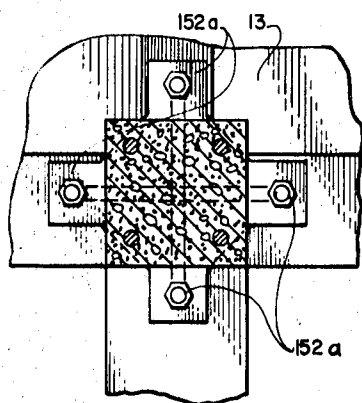


FIG. 24a



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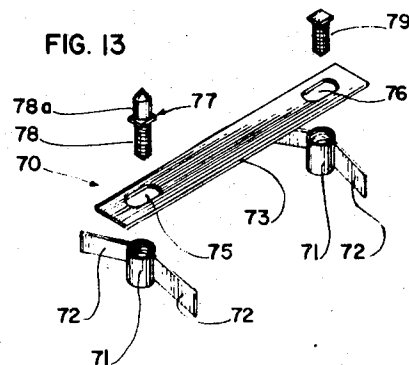
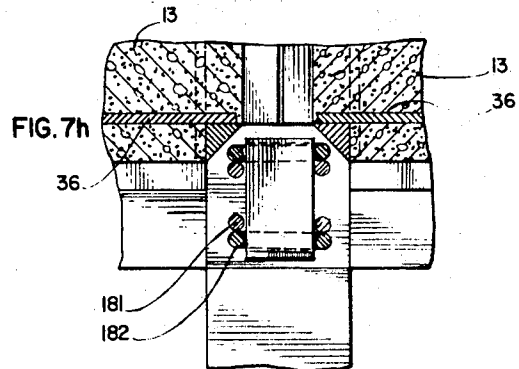
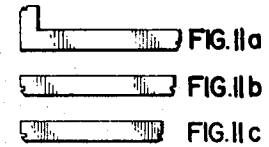
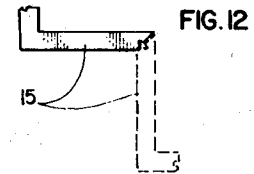
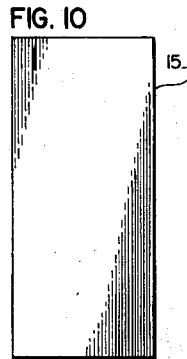
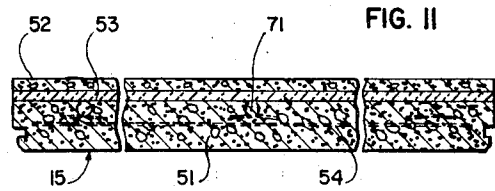
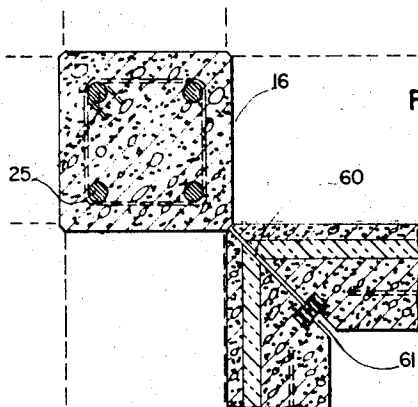
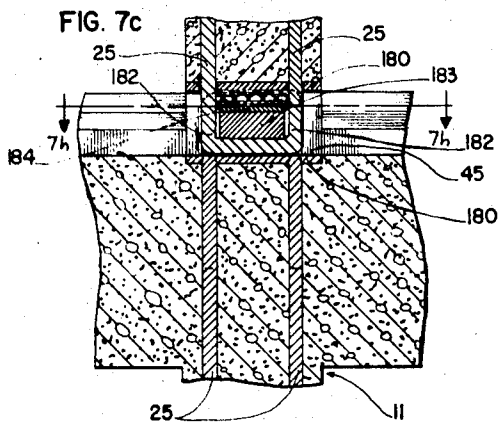
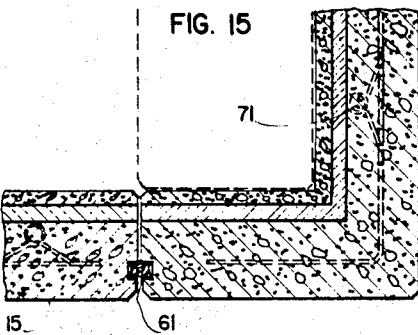
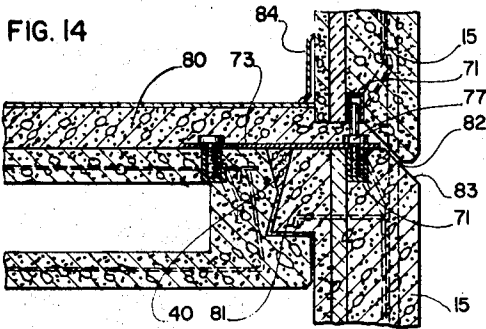
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3,562,979

BUILDING CONSTRUCTION

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9 Sheets-Sheet 4



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3,562,979

BUILDING CONSTRUCTION

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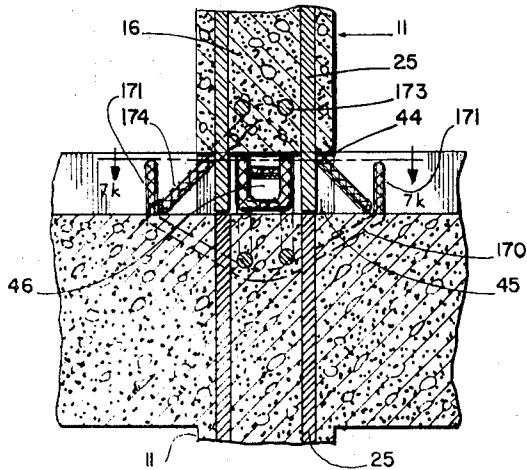


FIG. 7f

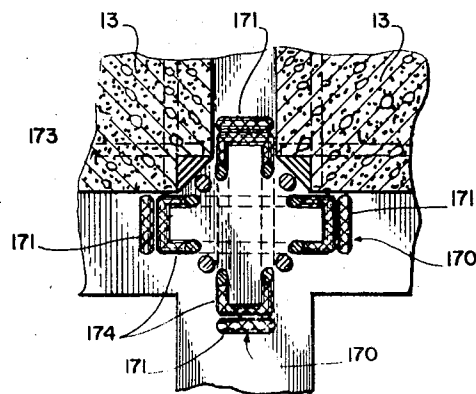


FIG. 7k

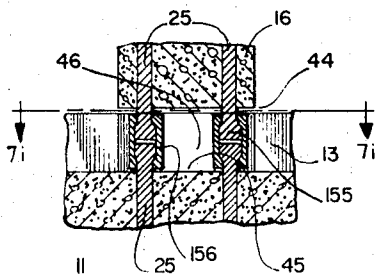


FIG. 7d

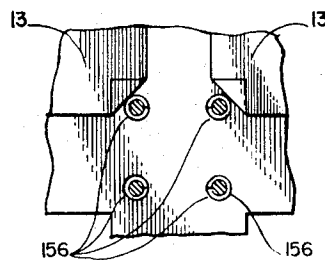


FIG. 7i

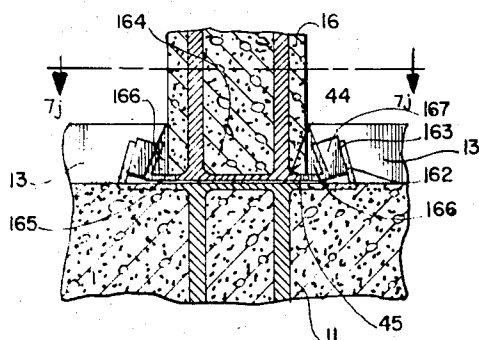


FIG. 7e

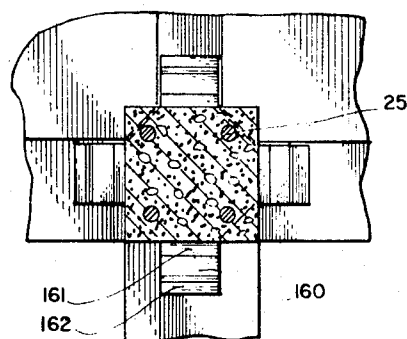


FIG. 7j

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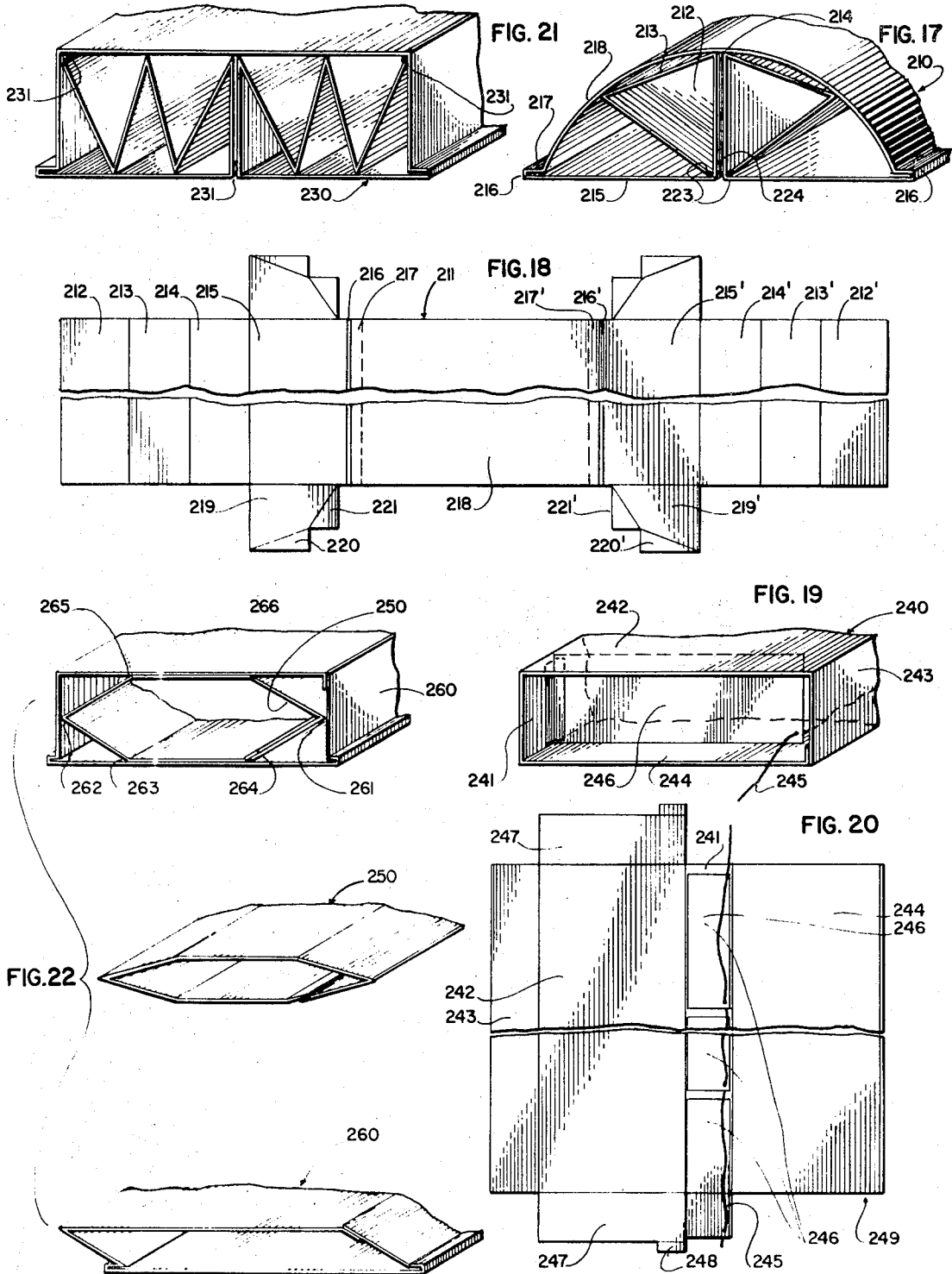
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BUILDING CONSTRUCTION

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9 Sheets-Sheet 6



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BUILDING CONSTRUCTION

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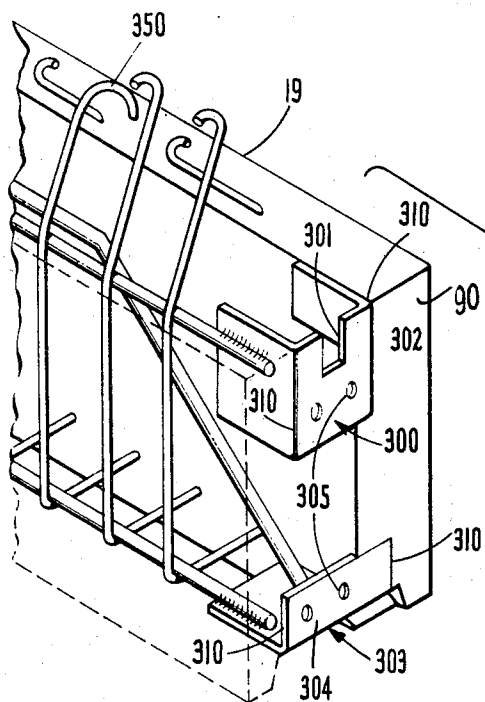


FIG. 23

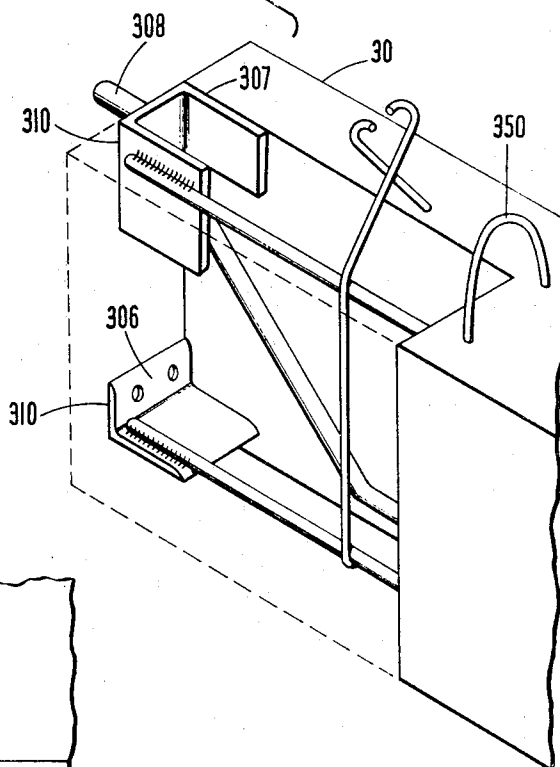
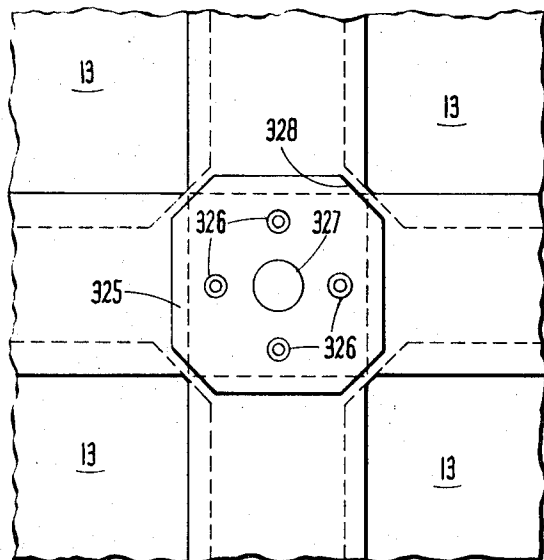


FIG. 29



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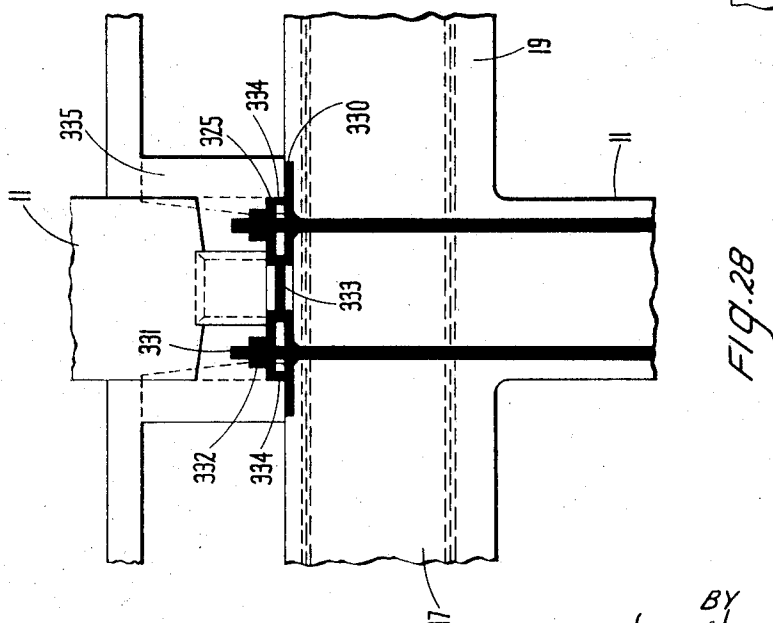
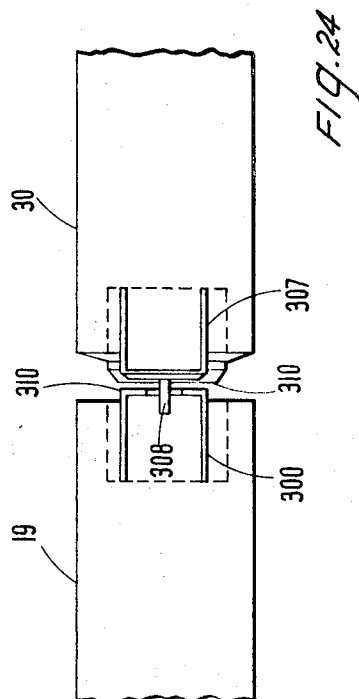
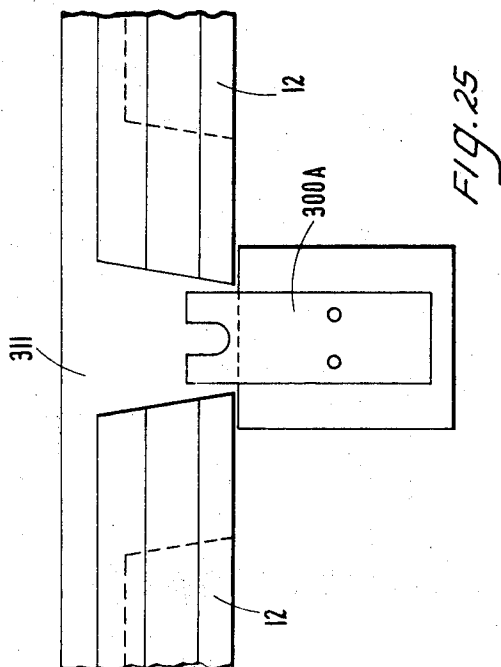
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BUILDING CONSTRUCTION

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9 Sheets-Sheet 8



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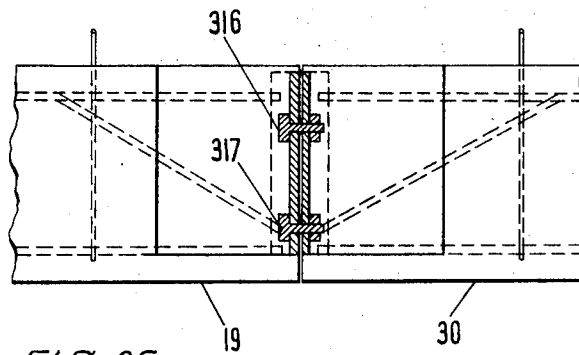


FIG. 26

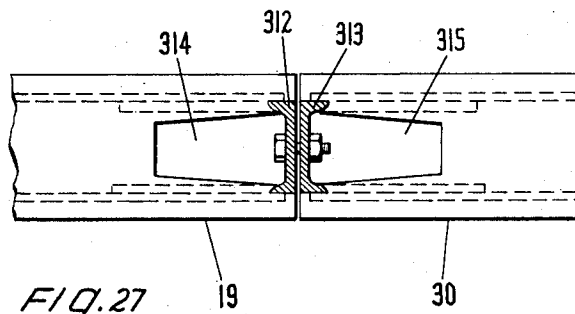


FIG. 27

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BUILDING CONSTRUCTION

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Continuation of application Ser. No. 677,195, Oct. 23,

1967. This application Dec. 16, 1968, Ser. No. 808,033

Int. Cl. E04c 3/34; E04b 1/04, 5/04

U.S. Cl. 52—125

29 Claims

ABSTRACT OF THE DISCLOSURE

A building construction in modular form is provided for use in homes, schools, offices and other structures. Prefabricated or precast columns having integral cross arms are key components in the structure of this invention. In addition, novel modular floor slabs, exterior panels and concrete coring devices are provided in building constructions of this invention.

RELATED APPLICATION

This application is a continuation of my copending application S.N. 677,195, filed Oct. 23, 1967, and now abandoned, which application was a continuation-in-part of my application S.N. 527,450, filed Feb. 15, 1966, and now abandoned.

BACKGROUND OF THE INVENTION

Many prefabricated constructions are known in the building industry but are often limited in usage due to cost, difficulty of assembly, lack of versatility or for other reasons. This invention overcomes some of the difficulties of previous prefabricated or precast constructions in that it provides for modular building constructions having great rigidity and strength with a minimum number of types of modular units which can be rapidly and economically assembled to form a variety of structures.

BRIEF DESCRIPTION OF THE INVENTION

According to the invention, a modular building construction comprises a building skeleton made up of a plurality of concrete columns with each column carrying integral radiating arms in cross formation. Ends of the arms of one column are rigidly joined to ends of the arms of at least one other column to form a rigid modular building frame. A plurality of concrete floor/ceiling slabs preferably rest on the radiating arms. Preferably adjacent cross arms are rigidly joined together through intermediate tie beams. The building frame or skeleton is covered with concrete exterior wall slabs in modular form or with lightweight interlocking modular panels and the interior of the building frame can be divided into suitable rooms or compartments by the use of modular wall panels carrying interlocking means at their edges or other conventional interior panel constructions.

Preferably the columns, cross arms, tie beams, floor/ceiling slabs and outer wall slabs are formed of concrete. The floor/ceiling slabs and wall slabs are preferably provided with hollow spaces to reduce weight while maintaining cross sectional area and strength over long spans. The hollow spaces are preferably provided by the use of inexpensive cores positioned in molds when the slabs or other concrete members are formed. Preferably the cores are constructed to allow flat shipment and compact storage yet provide for expansion into rigid forms of substantial size.

It is a feature of the invention that the skeleton construction of the columns, cross arms and tie beams used provides rigidity and acts as a means for mounting wall panels and other components of varying types without

the need for the wall panels and other components to provide strength or rigidity to the over-all building construction. The components of this invention can be used in combination as described herein or by themselves with other conventional components if desired.

A key component of the building construction of this invention is the cross arm column which preferably has provisions for being easily picked up and lowered by construction cranes, allows adjustability between members of the skeleton while providing rigid, strong, final joints and provides for fireproof construction.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, objects and advantages of the present invention will be better understood from the following specification when read in conjunction with the accompanying drawings in which:

FIG. 1 is an exploded view of a preferred embodiment of a building construction in accordance with the present invention;

FIGS. 2, 2a and 2b are top views of module floor slabs thereof;

FIG. 3 is a cross sectional view taken through line 3—3 of FIG. 1;

FIG. 4 is a cross sectional view taken through line 4—4 of FIG. 1;

FIG. 5 is a cross sectional view taken through line 5—5 of FIG. 1 showing a completed joint between two side edges of two floor slabs resting on a cross arm tie beam joint;

FIG. 6 is a cross sectional view taken through line 6—6 of FIG. 1 showing a completed joint;

FIG. 6a is a top view of the joint shown in FIG. 6;

FIG. 7 is a cross sectional view taken through a completed joint between two axially extending column and cross arm members taken along line 7—7 of FIG. 1;

FIG. 7a is a top plan view of the joint shown in FIG. 7 taken along line 7a—7a thereof;

FIGS. 7b, 7c, 7d, 7e and 7f are cross sectional views taken on a vertical plane through the center of aligned columns in alternate joint constructions of this invention;

FIGS. 7g, 7h, 7i, 7j and 7k are cross sectional views through lines 7g—7g to 7k—7k of FIGS. 7b, 7c, 7d, 7e and 7f respectively;

FIG. 8 is a top plan view of a column and cross arm component of this invention;

FIG. 8a is a side view thereof;

FIG. 9 is a top plan view of a preferred embodiment of a tie beam component;

FIG. 9a is a side view thereof;

FIG. 10 is a side view of an exterior wall slab of this invention;

FIG. 11 is a top plan view thereof;

FIGS. 11a, 11b, and 11c are top plan views of alternate sizes for module exterior wall slabs as illustrated in FIGS. 10 and 11;

FIG. 12 is a top plan view of an alternate embodiment of the exterior wall slabs of this invention;

FIG. 13 is an exploded view of a connector useful in the preferred embodiment of this invention;

FIG. 14 is a side view of a joint between components of this invention;

FIG. 15 is a top plan view of still another joint construction in accordance with this invention;

FIG. 16 is an enlarged plan view of the element shown in FIG. 12 positioned with respect to a column member of this invention;

FIG. 17 is a fragmentary perspective view of a core element in accordance with this invention;

FIG. 18 is a plan view of a blank for the coring element shown in FIG. 17;

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FIG. 19 is a fragmentary perspective view of an alternate embodiment of the coring element of this invention;

FIG. 20 is a plan view of a blank therefor;

FIGS. 21 and 22 are in views of alternate embodiments of coring elements in accordance with this invention;

FIG. 23 is an exploded perspective view with parts broken away of a tie beam to cross arm connection in accordance with this invention;

FIG. 24 is a top plan view thereof;

FIG. 24a is an end view of a gasket strip of this invention;

FIG. 25 is a cross sectional view through the joint member of a tie beam and overlying floor slabs in an alternate embodiment of this invention;

FIG. 26 is a side plan view of an alternate embodiment of a tie beam and cross arm joint;

FIG. 27 is a top plan view thereof;

FIG. 28 is a cross sectional view of a vertical plane through the center of an alternate embodiment of a column to column joint; and,

FIG. 29 is a top plan view of an element of said joint.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference now to the drawings and more particularly FIG. 1, a building construction 10 in exploded form is shown made up of column components 11, tie beams 30, floor/ceiling slabs 12, 13 and 14 and exterior wall slabs 15. All of these components are prefabricated preferably of cement or other cementitious type material commonly used in the building industry. By selecting predetermined module size components, a variety of structures can be built with a minimum number of diverse size components. In the preferred embodiment, the components are dimensioned on a four foot square module unit although other preselected sizes can be used.

The building skeleton is made up of groups or modules preferably comprising four column components 11 vertically arranged to form a first level upon which can be placed additional column components to provide a second or any practical number of additional layers or floors in a building construction. Similarly, additional modules can be formed on a single level by adding additional columns 11, wall slabs 15 and floor/ceiling slabs if desired. Each column 11 has a vertical portion 16 carrying at its upper end integral cross arms 17, 18, 19 and 20 preferably of equal size. The arms 17-20 lie substantially in a plane perpendicular to the axis of column portion 16. The end of each cross arm is formed with a recess 21 defined by vertical walls 22 and 23 connected at their bottoms by a horizontal wall 24.

As best shown in FIGS. 1, 8 and 8a, reinforcing rods 25 extend longitudinally through the vertical column portion 16 of each column component preferably adjacent each of the four corners and outwardly of the upper end. Extension rods 25a are welded or otherwise joined to the lower ends of each rod 25 and extend downwardly of the lower end of each portion 16. Similarly, reinforcing rods 26 extend adjacent the four corners of each of the cross arms past the end walls 27 of the recesses and freely into the recesses 21. The reinforcing rods 25 and 26 are known in precast concrete construction and conventional weight rods can be used and positioned in the columns and tie beams during fabrication using conventional procedures. In some cases the rods can be replaced with wire elements or other commonly reinforcing means for concrete construction. Preferably transversely extending wire elements 41 are provided at spaced intervals embedded in the cross arms, tie beams and column portions 16 surrounding the rods 25 and 26 and acting as additional reinforcements as is known in the art.

In a preferred embodiment tie beams 30 best shown

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in FIGS. 1, 9 and 9a are used extending between ends of longitudinally aligned arms. The tie beams preferably have cross sections equal to the cross section of the arms of the column components 11 and are similarly fitted with recesses 21' identical with recesses 21.

Rigid joints are formed between tie beam ends and arm ends as shown in FIGS. 6 and 6a. The ends are butted as shown in FIG. 6 with recesses 21 and 21' facing each other to form a basically rectangular hollow recess. Preferably the ends of rods 26 at the upper portion of both the arms and tie beams are inclined downwardly at an angle and then freely outwardly parallel with the lower rods 26 of arms 19 and tie beams 30. Similar rods 26 of the tie beams butt the rods 26 of the arms and a collar 31 is crimped over each of the free butting rod ends to form rigid joints therebetween. After the collars 31 are crimped the hollow recesses formed by recesses 21 and 21' are then filled with a grouting material of any conventional nature which may be for example conventional hydraulic cement. Thus, a strong, rigid joint can be formed between the ends of the arms and the tie beams as in the building skeleton construction shown in FIG. 1 in exploded form.

In FIG. 6 an alternate joint construction is shown wherein extension rods 26a are welded to each of the top rods 26 of the tie beam and arm at portions embedded in the concrete. The extension rods are butted and joined by a crimped collar 31. This construction gives maximized strength against both compression and tension at the joints.

In some cases, the arms of the column components can be extended and the need for tie beams eliminated by butting arms of adjacent column components against each other and forming joints of the type shown in FIGS. 6 and 6a. While it is preferred to use crimped connections, it will be obvious to those skilled in the art that various joint arrangements can be made between the reinforcing rods of the components of this invention. In some cases, the reinforcing rods can extend beyond the recesses or can comprise hook members for interlocking with adjacent ends of similarly designed components. Of course the number of reinforcing rods employed in each tie beam, arm, or column section can vary as desired depending upon the load to be placed on the structure and its ultimate desired strength in the module construction.

In a particularly preferred joint construction between an arm such as 19 of column 11 and a tie beam 30 as illustrated in FIG. 23, provision is made for adjustability to overcome any variation in manufacturing tolerances between the tie beam and the cross arm end. In addition, the joint is flameproof because of the concrete and steel construction with all exposed portions being of concrete or a covering grouting. A crane can be used to pick up the components, and the tie beams can be positioned by a crane prior to final joining with the tie beam maintained in position even after the crane is withdrawn.

In this embodiment, the cross arm end 90 is provided with a top C-shaped bracket 300 embedded in the concrete and welded to the reinforcing bars as shown. The bracket 300 has a vertically extending U-shaped notch 301 and a flat joining face 302. A bottom L-shaped bracket 303 is welded to the reinforcing bars and embedded in the concrete with its flat joining face 304 outward. Attachment holes 305 are provided in both brackets for positioning of the reinforcing rods as a grid structure in a casting form to allow locating the rods as desired in the precast concrete structure. Each tie beam end is provided with a mating bracket 306 having a face designed to overlie face 304 and welded to reinforcing rods of the tie beam. A top C-shaped bracket 307 is embedded in the concrete and welded to the reinforcing bars of the tie beam. A horizontal locking and carrying pin 308 extends outwardly from the bracket

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307. In use, the column 11 is positioned in its vertical position and preferably a second cross arm column opposing the first is also positioned. A tie beam such as 30 having ends of the type shown in FIG. 23 is then lowered into place with the pins 308 resting in the slots 301 and the joining faces of all of the brackets engaging each other, or being slightly spaced from each other as best shown in FIG. 24. Since the pins 308 will support the tie beam, the crane used for lifting the tie beam into place can be disconnected and used in other parts of the construction site while final joining is accomplished. Final joining to provide a solid rigid joint is carried out by welding along edges 310 in accordance with conventional practice. Shims (not shown) can be positioned between joining faces prior to welding to take up excess space and allow for adjustment prior to welding. After joining, all steel surfaces of the brackets are covered with grout to form a fireproof construction. This joint is particularly useful for load bearing tie beams and cross arms and can be used for all cross arm ends and all tie beam ends. It is also possible to use alternate joint construction in alternate cross arms of a single column if desired. Particularly where joints are made between tie beams and cross arm ends which are not primarily load bearing, it may be desirable to use other joint constructions such as the joint shown in FIG. 26. The alternate ends of the cross arms of a single column can be provided with different joint devices.

While it is preferred that the bracket 300 be separated from the lower bracket 303 and be positioned with its top flush with the top of the cross arm as shown in FIG. 23, this positioning and construction can be varied considerably. For example, as shown in FIG. 25, brackets 300 and 303 are integrally formed as a single C-shaped extension 300a of bracket 300 extending downwardly. The U-shaped notch portion of the bracket 300a extends above the top of the cross arm column into the space between floor slabs such as 12 and a grouting 311 forms a top surface for the floor slabs and the space between the floor slab ends. In some embodiments, the top bracket 300 along with bracket 307 as shown in FIG. 23 can extend upwardly beyond the top surface of the cross arm and tie beam respectively. When the floor slabs such as 12 are positioned above the cross arm and tie beam, they act to increase the strength of the tie beam and have a diaphragm-like effect as well as the effect of increasing rigidity of the building construction.

In still another embodiment of a cross arm to beam connection, a bolted connection is used as shown in FIGS. 26 and 27. In this construction, C-shaped channels 312 and 313 are welded to the reinforcing rods and embedded in ends of members 19 and 30 respectively with grouting recesses 314 and 315 being provided respectively. High tensile bolts 316 are passed through corresponding holes in the brackets after the tie beams and cross arms are positioned as best shown in FIG. 26 making use of the grouting recesses 314 and 315. After mechanical connection is made, the grouting recesses can be filled or in some cases where fireproofing is not necessary, may be left empty if desired. Preferably all of the cement components carry means for enabling handling and positioning by a construction crane. Thus pick up loops 350 are provided on the cross arms and tie beams as illustrated in FIG. 23.

The floor/ceiling slabs of the present invention are preferably formed with hollow chambers 35 as best shown in FIGS. 2, 2a, 2b, 3 and 4. Preferably four chambers 35 extend longitudinally through the slabs and permit maintaining a desired thickness of concrete while reducing weight and thereby greatly increasing strength at least against forces applied to the top and bottom of the slabs. The hollow chambers can be of various sizes and dimensions depending on the type of core elements used to form the chambers during molding of the floor/ceiling slabs.

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Preferably the slabs each have reinforcing rods 36 of the type previously described extending both longitudinally and transversely. Preferably the side edges of the slabs each have a facing vertical wall 37 and a rebated portion formed with reversely angled longitudinally extending surfaces 40. The ends of the slabs are preferably each formed with a vertical wall 39 and an angled inwardly extending surface 38.

The corners of the basic three slabs 12, 13 and 14 are designed differently depending on the position in which they are to lie on the building skeleton. Thus, slab 12 has square corners and is adapted to lie in the middle of a bay as shown in FIG. 1 with its ends resting on opposed tie beams or arms. Slab 13 carries two corner portions 13a reinforced with metallic supports 43 which are adapted to lie between the bottom of one column and the top of another in the position shown in FIG. 1. Slab 14 has slightly elongated ends with reinforced corners such as 43 adapted to overlie cantilever sections of the cross arms as suggested in FIG. 1 with portions 43 positioned between the top of one column and the bottom of another.

In the module building construction, the ceiling/floor slabs are laid on top of the arms and tie beams as suggested in FIG. 1. Slabs 12 are substantially rectangular and are preferably middle slabs positioned with their ends resting on parallel arms and tie beams and with their sides adjacent corresponding slabs. Slabs such as 13 are placed on the outside edge of a bay with two slabs 13 each overlying half of a tie beam as best shown in FIG. 5. The floor/ceiling slabs can overlie each bay formed in the building skeleton or, since the skeleton is rigid by itself, in some embodiments the top of at least some bays can be left opened. Reinforcing rods 36 of the slabs extend outwardly of their ends and can be interlocked with adjacent slabs if desired although this is not necessary.

FIG. 5 illustrates positioning of two slabs 13 in side by side relationship over a tie beam 30. Rebated side edges can be locked together by filling the recess therebetween with conventional grouting as previously described. In the joint shown in FIG. 5 the transverse reinforcing member 41 has an upwardly extending portion lying between the side edges acting to further anchor grouting (not shown) which completes the joint.

In most applications, the recess formed by the setback or rebated edges of the ceiling/floor slabs are filled with grouting material which is sufficient to smooth the surface on which top flooring may be laid and to lock the elements together due to the bending of the reinforcing rod ends as illustrated at 42 and the reverse angle of surfaces 40.

The preferred joint between an upper column component 11 and an underlying axially aligned column component 11 is best illustrated in FIGS. 7 and 7a. The lower portion of the upper column portion 16 is formed with extension reinforcing rods 25a welded or otherwise secured parallel to the ends of rods 25 which are cut off at the bottom edge 44 of each portion 16. Thus, extensions 25a are parallel to reinforcing rods 25 and extend outwardly of the bottom 44 so as to lie parallel to and adjacent upwardly extending rods 25. The upper portions of the rods 25 coming from the upper portion of a column are crimped together with their corresponding extension rods 25a by a collar such as 31 as previously described. As shown in FIG. 7 this joint provides for a butting face of each rod 25 of the upper column portion axially aligned with a butting face of a rod 25 of the lower portion 44. The butting faces act to bear some of the load while a rigid joint is formed by the extension portions 25a. In some cases collars 31 can be eliminated and the rods 25 welded to extensions 25a. The extension portions 25a are preferably molded in the columns when they are cast or prefabricated. Part of the load of the upper column 11 is borne by the metallic corners 43 of the floor slabs as

best shown in FIGS. 7a and 7. The collars 31 can be welded to corners 43 as shown in FIG. 7a although this is optional. Preferably metal angle irons 47 are cast in the bottoms and tops of the columns as best shown in FIG. 7 to provide load bearing edges and prevent chipping during erection of the skeleton. Thus, corners 43 extend between the bottom 44 and the top portion 45 of each of the columns. Due to the spacing of the column portion 44 from portion 45 by the floor slabs a recess 46 is formed in the joint between the column components. Since there is a recessed edge to each floor slab as illustrated in FIGS. 4 and 7a, a crimping tool can be passed into the cavity 46 to form or crimp the collars 31. Similarly grouting or suitable waterproofing and gasketing material can be positioned in the cavity 46 after completion of the crimping operation to reinforce the joint construction.

In the alternate embodiments of the joints between the bottom 44 of one column component 11 and the top 45 of a second column component 11, extension rods 25a are eliminated. In the joint shown in FIGS. 7b and 7g the top of the column 11 is provided with a metallic facing plate 150a preferably welded or secured to top ends of reinforcing rods 25. Two crossed U-shaped connecting rods are embedded in the column and have threaded ends 151a extending upwardly through holes provided in the facing plate 150a. Preferably plate 150a carries four outwardly extending tabs 152a through which ends 151a extend. A second facing plate 153a preferably identical to plate 150a is welded to lower portions of rods 25 at bottom 44. The plates 153a and 150a are butted in joining two column components 11 in vertical alignment and nuts 154a applied and tightened to form a joint. This joint as well as the joint illustrated in FIG. 7, will support the upper column component without the need for bracing during construction or until the cross arms of the upper column are joined to supporting components. In this joint the recess 46 is eliminated.

In the embodiment of FIGS. 7c and 7h, identical flat metallic plates 180 are welded to rods 25 in the positions shown. Pairs of rods 25 of each column component pass through a plate 180 and form two upwardly extending inverted parallel U-shaped extensions 181 and corresponding parallel downwardly extending U-shaped extensions 182. Extensions 181 are offset from the axes of rods 25 as shown in FIG. 7h. Upon positioning of the column components, one above another, extensions 181 and 182 are parallel and define a passageway 183 in which a locking wedge is positioned to lock the components together. After wedge locking, conventional grouting is placed in recess 46 to complete the joint.

In the embodiment of FIGS. 7d and 7i, rods 25 extend upwardly and downwardly from the top and bottom of each column and have enlarged ends 155 with butting faces. A split collar 156 is crimped about facing ends 155 at each of the four connections in the joint to form a rigid joint which supports the upper column. Grouting as previously described is preferably used to fill recess 46 and complete the joint.

In the embodiment of FIGS. 7e and 7j the top of column component 11 has a flat plate 160 welded to ends of rods 25 with four outwardly extending tabs 161 positioned preferably 90 degrees apart. Ends 162 of each tab are turned over preferably at an acute angle and their top edges 163 define a first periphery greater than the periphery of column portion 16. The bottom of column component 11 has a second plate 164 welded to rods 25 and substantially identical to plate 160 but having its acute angled tabs 165 bent over at 166 with edges defining a second periphery smaller than said first periphery. In the joint, plates 160 and 164 butt each other and four wedges 167 are forced between each set of bent over tabs 162, 166 to form a rigid joint with the elimination of recess 46 and the need for grouting. Of course any spaces at the joint can be filled with grouting if desired.

The wedge locking effect of the joint shown in FIGS. 7e

and 7j can also be achieved with modification of plates 160, 164 as by the use of circular plates having over-turned edges.

In the embodiment of FIGS. 7f and 7k, recess 46 is maintained as described with relation to FIGS. 7 and 7a. Rods 25 are cut flush with top 45 and two identical steel brackets 170 are embedded in cross formation in the top portion of column component 11. Brackets 170 are generally U-shaped in front view as shown in FIG. 7f and have integral inverted U-shaped freely extending portions 171 at either end. Preferably rods 25 of column portion 16 extend downwardly to butt ends of rods 25 of top 45 of an underlying column component 11. The bottom of the column portion 16 carries two identical crossed, embedded, generally V-shaped steel brackets 173 having inverted U-shaped ends 174 extending downwardly. Ends 174 and 171 interlock as best shown in FIG. 7k to support the upper column component 11. Portion 171 can be bent over and interlocked with portions 174 after positioning of the columns as shown in FIG. 7f. Preferably in this construction grouting is used to fill recess 46 and complete the joint. The upper column component 11 should be braced or supported in position until the grouting has hardened to complete the joint.

In a particular preferred embodiment of a joint between the bottom of one column 11 and the top of an underlying column 11 a welded connection is used in conjunction with levelling and plumbing bolted connections as illustrated in FIG. 28. In this embodiment, a plate 325 is welded to reinforcing rods not shown of the bottom of the top column 11 and provides four bolt holes 326 and a central aperture 327 along with angled corners 328 adapted to be positioned adjacent floor slabs such as 13. A bottom plate 330 generally similar to plate 325 but having a larger cross sectional area is welded to reinforcing bars of the underlying column 11 and has four upwardly projecting screw spindles 331 passing through holes 326 when the columns are interlocked with each other as shown in FIG. 28. Bolts 332 are threaded on the spindles 331 and a projection or separate centrally located metal disc 333 is positioned between plates 326 and 330. Thus, when the columns are assembled as shown in FIG. 28, they can be rocked about the intermediate plate 333 and levelled as by tightening selected ones of bolts 332. After both of the column portions 11 are in vertical alignment, the peripheral edge of plate 325 is welded to plate 330 as by a bar weld indicated at 334. Conventional grouting can then be used as at 335 to fill all recesses in the joint structure. In some cases grouting or shims can be positioned between plates 325 and 330 prior to welding to stabilize the columns. It is preferred to use this joint construction to provide for maximum adjustability during construction and preferably to use this joint structure in conjunction with the adjustable joint construction shown in FIGS. 23-25 for the tie beams and cross arms to again maximize adjustability and provide for maximized crane usage in a building construction.

Turning now to the exterior wall slabs or panels, a typical wall panel is shown at 15 in FIG. 11, comprising a concrete layer 51 with an interior thin concrete layer 52 sandwiching a foam or other insulating layer 53 therebetween. Preferably the concrete layer 51 is provided with hollow spaces or cores in the same manner as the floor slabs previously described. Reinforcing rods 54 or other conventional concrete reinforcing means are preferably embedded in the layer 51. The side plan view shown in FIG. 10 illustrates a module unit 15 which may for example have a width of four feet and a height of ten feet corresponding to a complete module panel reaching from ceiling to floor. Heights of seven feet and three feet may also be provided for door and sill heights respectively. These three heights of the panels are sufficient to provide for all exterior walls surfaces. FIGS. 11a, 11b and 11c show top views of varying size and configuration panels useful in outer wall construction.

FIG. 12 illustrates joining of two module panels such as 15 having angled corners, to form a corner joint 60 better illustrated in FIG. 16. The joint 60 has a gasket member 61 extending throughout the length of the joint in corresponding channels provided on facing 45 degree angled surfaces of the panel edges. The gasket 61 as best seen in FIG. 24a preferably comprises an elongated hollow cavity 62 and a resilient neoprene or other long-life rubber body portion 63. Preferably at least two surfaces carry adhesive means 64 which can be any of the well-known rubber cements covered by a conventional protective tear strip. This particular gasket permits compression of the gasket causing a tight seal in addition to adhesive sealing which reinforces the seal and provides a waterproof joint having long life. Other gasket means can be used in place of gasket 61.

FIG. 15 indicates still another joint between two wall panels 15 employing a gasket 61 as above described.

Preferably all four edges of the wall panels 15 have embedded wing connection means 70 which rigidly join the panels to each other or to other components of the building construction. The connection means 70 comprises a pair of internally threaded tubes 71 having integral wing extensions 72 extending outwardly and downwardly on each side thereof. A facing plate 73 is provided having apertures 75 and 76 aligned with the threaded apertures of the tubes 71. Tubes 71 are preferably embedded at the edges of the concrete wall panels as best shown in FIGS. 11 and 14 as is the facing plate 73. Pin connectors 77 are provided having a threaded end 78 and a non-threaded plug end 78a. Other connectors comprise flat headed screws 79. Thus, when adjacent or stacked wall panels are to be connected, tubes 71 present in each panel are aligned and connecting pins such as 77 as shown in FIG. 14 are used to form a joint. Where a flat floor 80 or other material is to lie directly over the joint the flat headed screw 79 is used as shown in FIG. 14. Preferably three connection means 70 are provided on each peripheral edge of each exterior wall panel.

The connection means 70 can also be used in the floor slabs. The connection means serve a dual function in that they are used to form joints and in addition are helpful in handling the panels or slabs. Thus, pins 77 can be positioned and used to attach lifting crane hooks to the panels to lift them into position in a stack or building construction.

As best shown in FIG. 14, the panels 15 preferably have a hooked inwardly extending top 81 defining a means for keying and locking the wall panels 15 with a floor/ceiling slab. The bottom of each wall panel preferably has an angled wall 82 adapted to overlie the top angled wall 83 of an identical panel 15 permitting a planar surface to be presented on the outside of a building when wall panels 15 are stacked as in a first and second story construction fragmentarily shown in FIG. 14. The wall panels further interlock with the floor/ceiling slabs by the hooked portion 81 overlying adjacent walls 40 as previously described. Various conventional moldings such as 84 can be employed in the module building construction as shown in FIG. 14.

While panels 15 have been referred to as exterior wall panels they can also function to provide room or partitioned sections in the interior of a building structure of this invention.

From the above description, it will be understood that there is provided module components for the formation of single or multiple bays in a building skeleton and wall construction on a single level or on a plurality of levels. The components described can be put together in various described configurations as desired. It is a feature of this invention that by pre-selecting the dimensions of the components, the number of components can be minimized to a small number of standard sizes. Thus, by using standard components, joints and sizes, one can plan a particular layout and immediately calculate the specific

number of each of the components and their standard sizes necessary for construction of the layout. For example, a single structural bay can be made consisting four column components 11, eight floor/ceiling panels and four tie beams 30. Using a 4'-0" dimensional module the cross arms are 9'-0" from end to end of aligned arms. Tie beams 30 are 8'-00" long. Column components 11 are 9'-4" high. The cross sectional dimensions of the concrete cross arms, tie beams and column portions 16 are 1'-0" x 1'-4". The floor/ceiling panels are 6" in depth, 4'-0" wide and 16'-5" long. With these components a standard bay 26'-0" x 26'-0" is made with a maximum enclosed space which can be 676 sq. ft. The total amount of concrete necessary for such a bay would be 5075 cu. ft. weighing about 73,680 pounds. Additional bays can be added by multiplying the number of components as desired.

While a variety of sizes and lengths can be used for the cross arms and tie beams, it is preferred that each joint between a cross arm and tie beam lie approximately one-fourth the distance between vertical columns 11 of each bay in order to obtain minimum moment stresses at the joints.

While it is preferred to preform or precast the components of this invention before delivery to a site where a building is to be constructed, the components can be formed on the construction site if desired.

Turning now to a description of core elements which are preferred for use in forming the hollow spaces in the concrete slabs in accordance with this invention, preferred embodiments of core elements are shown in FIGS. 17-22. It should be understood that these core elements are useful to form hollow spaces or passageways in many types of molded constructions. Other core elements can be used in the slabs of the present invention.

An important feature of the novel core elements of this invention is the use of inexpensive, lightweight materials which can be shipped and stored flat and folded just prior to usage to an expanded form. The expanded form has an enclosed substantially hollow shape reinforced with a plurality of gusset members.

The word "paper" as used herein refers to lightweight stock sheet material which preferably has a paper base. Preferably the paper materials are impregnated or coated with waterproofing compounds in a know manner to prevent loss of strength when exposed to wet concrete during molding or casting. Suitable materials include kraft paper, cardboard, corrugated paper and the like. In the preferred embodiment, forty point chip board is used.

In the preferred embodiment of the core element shown in FIG. 17, the element 210 is formed from a flat sheet of chip board 211 cut in the outline shown and having a series of prescored lines along which the sheet is to be folded in use. The sheet 211 can have substantial lengths depending upon the length of the hollow passageway desired in a concrete or other section to be cast. Normally the length will be determined by the size of the hollow passageway desired. The sheet 11 can be shipped or stored in its flat form shown in FIG. 18.

The core element 210 is formed by folding along the prescored lines indicated to form gusset members 212, 212', 213, 213', 214, 214', outer sections 215, 215', corner portions 216, 216', 217, 217' and semicircular portion 218. Preferably the end edges of sections 212 and 212' carry a pressure-sensitive adhesive indicated at 223 and portions of walls 214 and 214' carry a similar adhesive 224 which acts to hold the expanded form 210 in position when folded as shown in FIG. 17. After folding of the gusset members into the form shown in FIG. 17, end flaps 219, 219' are folded over to close the front end with tabs 220, 220' and 221, 221', which also carry pressure-sensitive adhesive, folded over and sealed to close the front end. Similarly the rear end is closed by the corresponding rearwardly extending flaps.

The doubled over corner sections 216, 216' strengthen

the structure and permit support by conventional clips or wires in a mold cavity to position the core elements and permit concrete or other material to be poured there-around. After hardening of the poured material, the paper elements can remain in the concrete and due to their inexpensive construction do not add materially to the cost of the final products which may be floor/ceiling slabs as previously described. In some cases where the passageways extend to the end of the cast sections, the paper material can be removed from the passageways after formation and hardening of the concrete.

FIG. 21 illustrates an alternate embodiment wherein a single flat sheet is folded into a generally rectangular form 230 with adhesive means 231 holding the ends of the sheet in a central portion thereof in place. Closing flaps similar to flaps 219, 219' can be used at ends of the form 230. The zig zag gusset members are adhesively secured by adhesive means 231.

In the alternate embodiment of the core element shown at 240 in FIGS. 19 and 20, a flat sheet 249 is cut. Flaps 246 are positioned on section 241 and have ends glued to the face of section 241 whereupon their free ends can be folded outwardly and transversely of a rectangular form to be folded with panels 242, 241, 243, and 244 as shown in FIG. 19.

The sheet 249 is preferably prescored along the lines shown and folded into the position shown in FIG. 19 just prior to use. The folding of the hinges of transverse gusset portions, 246 is preferably accomplished by means of a tie string 245 passing through holes provided at the free ends of the gusset portions. The tie string is knotted to provide for preselected spacing between the hinges when the rectangular outline is formed and the string pulled. As in the embodiment of FIG. 17, adhesive means can be used on the free end of panel 244 to lock the form in shape. End flaps 247 are employed along with adhesively connected tabs 248 to close ends of the core element 240. In some cases the form shown in FIG. 19 can be constructed and then folded flat prior to shipment.

In the embodiment shown in FIG. 22, two separate elongated polygonal elements 250 and 260 are combined to form a single core element having an expanded form. Element 250 has the cross sectional form of a six-sided figure while element 260 has a rectangular cross sectional outline. Each of the forms 250 and 260 can be expanded from flat sheets or tubular elements can be formed and compressed into their flat form for shipment. Upon assembly of elements 250 and 260 element 250 is slipped within element 260 after first applying adhesive at points 261, 262, 263, 264, 265 and 266. The adhesive can be precoated on the paper forms. When pressure-sensitive adhesives are used, conventional tear strips which can be discarded overlie the adhesive strips. Water or other solvent activated adhesives may also be employed in any of the embodiments of this invention. Suitable end flaps can be provided to close ends of the combined core elements shown in FIG. 22.

The scored lines between sections or panels of the geometric forms of the embodiments of FIGS. 17-22 can be conventional pressed lines or other weakened portions to facilitate folding. Alternatively, the fold lines may merely be printed on the sheet stock or eliminated if desired.

While specific embodiments of this invention have been shown and described, it should be understood that many modifications thereof are possible. For example, various ones of the elements can be substituted with other known structures. The various elements described can be used by themselves in other constructions. The cross section of the column, cross arms and tie beams can be circular rather than square or rectangular as shown. The term "cross formation" as used herein refers to the use of at least two arms on the column components 11 although four arms as in the embodiment of FIG. 1 is preferred. The various column joint constructions can be used to inter-

connect cross arms and tie beams or other elongated components in end to end relationship.

What is claimed is:

1. A modular building construction comprising a building skeleton comprising a plurality of precast, reinforced concrete columns each carrying integral radiating arms in cross formation with ends of an arm of one column rigidly joined to ends of an arm of at least one other column to form a rigid modular building frame, a plurality of concrete floor/ceiling slabs resting on said radiating arms, at least two of said columns being disposed in axial alignment with one column over a second column, said one column being supported upon one of said floor slabs which lies partially between said one column and said second column, reinforcing rods extending longitudinally through said columns and having ends extending upwardly thereof, rod ends of said one column being rigidly joined to rod ends of said second column in a chamber defined in part by an end of said one floor slab.
2. A modular building construction comprising a building skeleton comprising a plurality of precast, reinforced concrete columns each carrying integral radiating arms in cross formation with ends of an arm of one column rigidly joined to ends of an arm of at least one other column to form a rigid modular building frame, a plurality of concrete floor/ceiling slabs resting on said radiating arms, at least two of said columns being disposed in axial alignment with one column over a second column and each defining a top and a bottom, reinforcing rods extending longitudinally through said columns, said top of said second column carrying a first facing plate and said bottom of said one column carrying a second facing plate butted against and joined to said first plate, said plates being joined together by a locking member extending therethrough and embedded in one of said columns.
3. A modular building construction comprising a building skeleton comprising a plurality of precast, reinforced concrete columns each carrying integral radiating arms in cross formation with ends of an arm of one column rigidly joined to ends of an arm of at least one other column to form a rigid modular building frame, a plurality of concrete floor/ceiling slabs resting on said radiating arms, at least two of said columns being disposed in axial alignment with one column over a second column and each defining a top and a bottom, reinforcing rods extending longitudinally through said columns, said top of said second column carrying a first facing plate and said bottom of said one column carrying a second facing plate butted against and joined to said first plate, said plates being joined together by a wedge locked between bent tabs of said first and second plates.
4. A building construction in accordance with claim 1 wherein said reinforcing rod ends extend upwardly and downwardly thereof, said rod ends being enlarged and defining butting faces joined together by crimped collars.
5. A modular building construction comprising a building skeleton comprising a plurality of precast, reinforced concrete columns each carrying integral radiating arms in cross formation with ends of an arm of one column rigidly joined to ends of an arm

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- of at least one other column to form a rigid modular building frame,
 a plurality of concrete floor/ceiling slabs resting on said radiating arms,
 at least two of said columns are disposed in axial alignment with one column over a second column and each column defining a top and a bottom,
 reinforcing rods extending longitudinally through said columns and downwardly from said column bottoms,
 said column tops having embedded therein upwardly extending first bracket means,
 said column bottoms having downwardly extending second bracket means for engaging said first bracket means of said second column and interlocking said one column and said second column with said downwardly extending rods of said one column butting the top of said second column.
6. A building construction in accordance with claim 1 wherein said joined rod ends comprise parallel inverted U-shapes interlocked by wedge means.
7. A modular building construction comprising
 a building skeleton comprising a plurality of precast, reinforced concrete columns each carrying integral radiating arms in cross formation with ends of an arm of one column rigidly joined to ends of an arm of at least one other column to form a rigid modular building frame,
 a plurality of concrete floor/ceiling slabs resting on said radiating arms,
 at least two of said columns being disposed in axial alignment with one column over a second column and each defining a top and a bottom,
 reinforcing rods extending longitudinally through said columns,
 said top of said second column carrying a first facing plate and said bottom of said one column carrying a second facing plate butted against and joined to said first plate,
 said first and second facing plates being separated by a rocking means,
 threaded means extend between said first and second facing plates for vertically aligning said columns by rocking movement about said rocking plate prior to welding of said first and second plates together.
8. A precast, cementitious, modular building component comprising,
 an elongated column section having a top and bottom edge and a plurality of cross arms lying in cross formation in a plane substantially perpendicular to the axis of said column,
 at least one of said arms being disposed at an angle of substantially 90 degrees to its adjacent arm,
 said arms each defining a joining end,
 a first plurality of metallic reinforcing rods embedded in and extending longitudinally through said arms, and a second plurality of metallic reinforcing rods embedded in and extending longitudinally through said column,
 said joining end of each arm comprising a metallic plate acting as an end joining means for attaching said arms to adjoining members,
 said plate comprising means for supporting a mating structure in horizontal alignment prior to a final joining operation and acting as a horizontal engagement means.
9. A modular building component in accordance with claim 8 and further comprising a plurality of adjacent identical modular building components forming a building skeleton with an end of an arm of at least one column rigidly joined to an end of an arm of another column to form a rigid modular building frame,
 and a plurality of concrete floor/ceiling slabs resting on said cross arms.
10. A modular building component in accordance with

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- claim 9 wherein said cross arms are positioned at the top of said column section and said plate carries a generally U-shaped notch for receiving a support peg.
11. A modular building component in accordance with claim 8 wherein said top and bottom column edges carry joining plates for joining one said component to another in vertical alignment,
 said top and bottom plates being joined to said plurality of reinforcing rods.
12. A modular building component in accordance with claim 11 wherein said second plurality of metallic reinforcing rods extend through said top plate for a mechanical attachment thereof with a bottom plate of a vertically aligned component.
13. A precast integral, cementitious, modular building component comprising,
 an elongated column section having a top and bottom edge and a plurality of integral cross arms integral with said column lying in cross formation in a plane substantially perpendicular to the axis of said column,
 at least one of said arms being disposed at an angle of substantially 90 degrees to its adjacent arm,
 said arms each defining a joining end,
 at least one of said joining ends having end joint means for abutting and being securely joined to a joining end of another structural member,
 a first plurality of metallic reinforcing rods embedded in and extending longitudinally through said arms,
 and a second plurality of metallic reinforcing rods embedded in and extending longitudinally through said column.
14. A modular building component in accordance with claim 13 and further comprising said at least one joining end having integral means for supporting a mating joint structure of an adjoining member prior to a final joining operation.
15. A modular building component in accordance with claim 14 wherein said joint structure provides means for providing adjustment of said building component with respect to a member to be joined thereto.
16. A modular building component in accordance with claim 13 and having two said cross arms.
17. A modular building component in accordance with claim 13 and having four said cross arms.
18. A modular building component in accordance with claim 13 wherein end joint means comprises an exposed metallic plate defining an area adapted to be joined to a mating means on an adjoining member.
19. A modular building component in accordance with claim 13 wherein said end joint means comprises an exposed metallic plate and said means for supporting, comprises said plate which carries a generally U-shaped notch for receiving a support peg.
20. A modular building component in accordance with claim 19 wherein said plate defines holes therein for connection of bolts.
21. A modular building component in accordance with claim 20 wherein said cross arms are positioned at the top of said column section.
22. A modular building component in accordance with claim 13 and further comprising a plurality of adjacent identical modular building components forming a building skeleton with an end of an arm of at least one column rigidly joined to an end of an arm of another column to form a rigid, modular, substantially continuous precast, building frame,
 and a plurality of concrete floor/ceiling slabs resting on said cross arms.
23. A modular building component in accordance with claim 22 wherein said joined arms are rigidly joined through an intermediate precast tie beam.
24. A modular building component in accordance with claim 22 wherein said first plurality of rods extend beyond said joining ends and said joined arms are joined by

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crimped collar connections about ends of said first plurality of rods.

25. A modular building component in accordance with claim 22 wherein said floor/ceiling slabs each comprise,

side edge walls having upper portions disposed inwardly of the periphery thereof,

end walls having upper portions disposed inwardly thereof,

reinforcing means extending from side to side of said slab and from end to end thereof with freely extending sections of said reinforcing means acting as joining means at said sides and ends,

and said slabs defining hollow portions therein to increase strength by reducing over-all weight while maintaining a preselected thickness.

26. A modular building component in accordance with claim 13 wherein said top and bottom column edges carry joining plates for joining one of said components to another in vertical alignment,

said top and bottom plates being joined to said second plurality of reinforcing rods.

27. A modular building component in accordance with claim 26 and further comprising a second identical modular building component arranged with the bottom of one component joined to the top of the other component,

said top plate of one component comprising a first support means carrying a plurality of overturned tabs arranged thereabout and defining a first periphery,

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said bottom plate of the other component comprising a second support means carrying a second plurality of overturned tabs arranged thereabout and defining a second periphery lying within said first periphery, and wedge means disposed between said first and second plurality of tabs to lock said support means together.

28. A modular building component in accordance with claim 27 wherein said reinforcing rods extend through one of said plates to permit attachment of said component to an identical component.

29. A modular building component in accordance with claim 13 and further comprising means for carrying thereof by a crane.

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