United States Patent

Shelley

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[54] MODULAR BUILDING STRUCTURE

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[73] Assignee: Shelley Systems, Inc., Rio Piedras, P.R.

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[21] Appl. No.: 880,316

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 762,668, Aug. 14, 1968, Pat. No. 3,503,170.

[52] U.S. Cl. 52/79, 52/227, 52/234

[51] Int. Cl. E04h 1/00, E04c 3/10

[58] Field of Search 52/227–229, 234, 52/236, 79, 223

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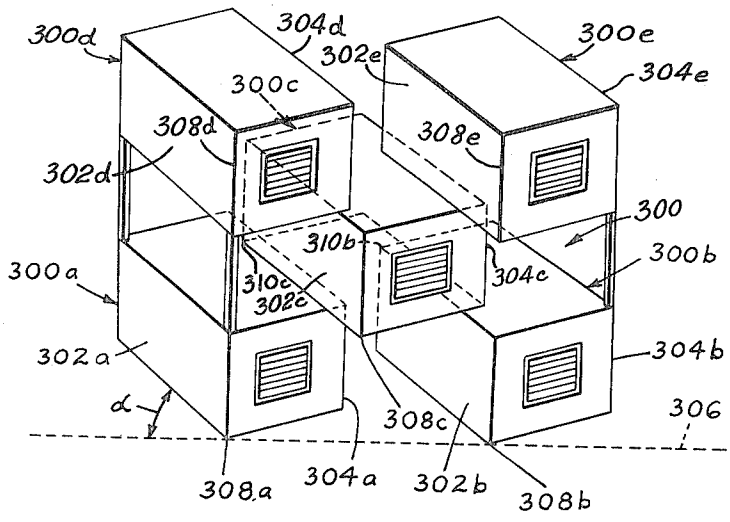
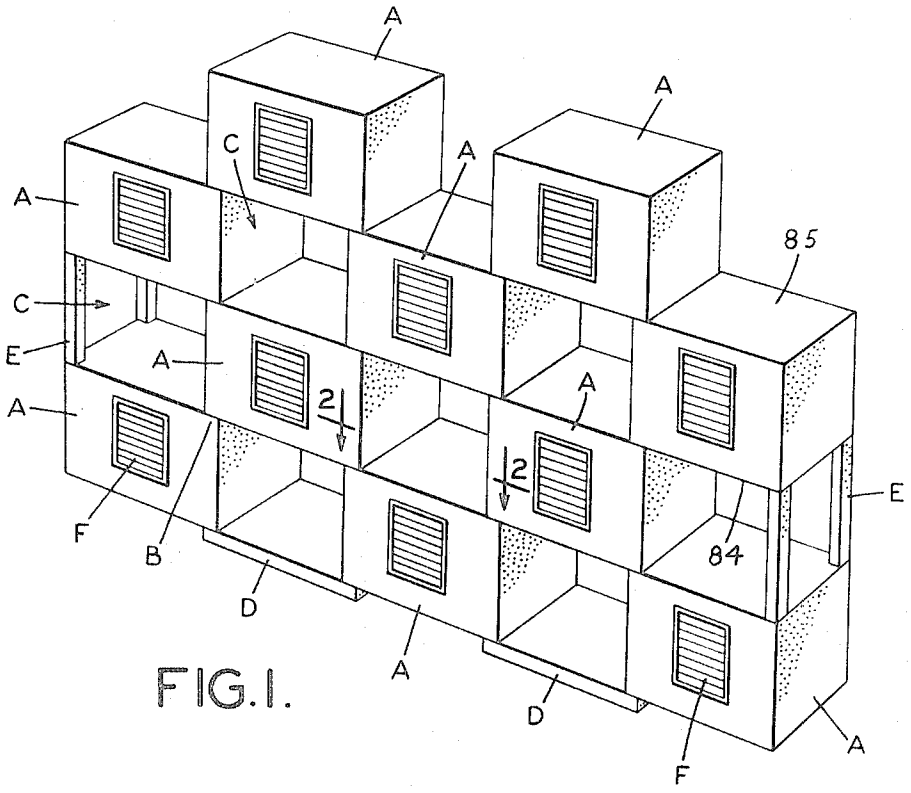
Primary Examiner—Frank L. Abbott
Assistant Examiner—James L. Ridgill, Jr.
Attorney—Lee C. Robinson, Jr.

[57] ABSTRACT

A modular building structure comprised of a plurality of prebuilt boxlike units, each having sidewalls, a ceiling and a floor slab, which are stacked to form successive stories of a building. The units are positioned such that there is an open space between any two units on the same floor level. The interior units at intermediate levels are each stacked between at least four other units. In one embodiment the boxlike units have load-bearing vertical columns which are located inwardly with respect to the sidewalls, and the units are stacked such that at least portions of the sidewalls overlap sufficiently that one or more of the load-bearing columns of the upper and lower units are aligned. In high-level embodiments these columns are post-tensioned to form a unitary assembly. In some embodiments the units are arranged with their sidewalls perpendicular to the front of the building, while in other cases each of the walls meets the length of the building at an angle other than 90°.

18 Claims, 11 Drawing Figures

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A
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C
A
85
C
E
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F
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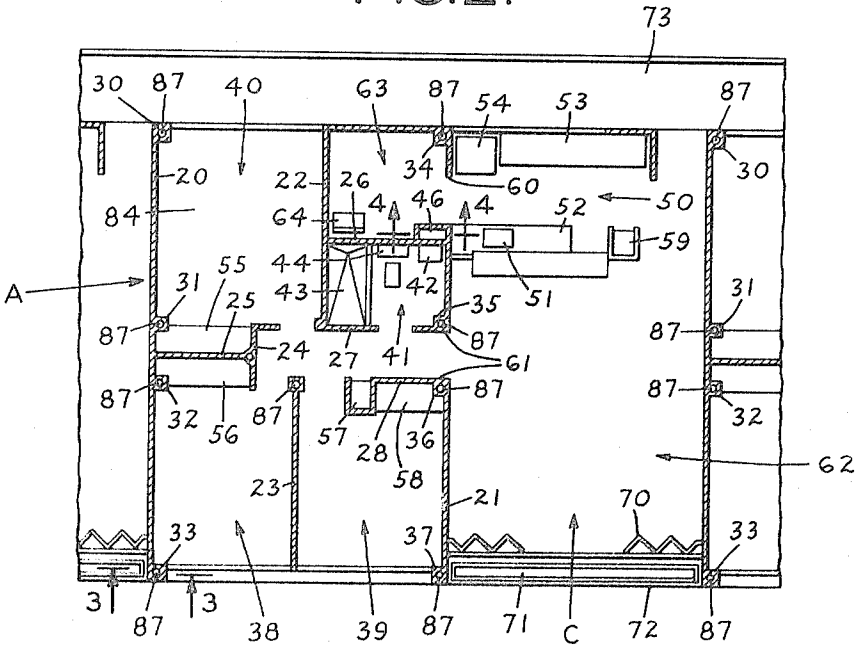
FIG. 1.

FIG. 2.


73
30
87
40
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30
20
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64
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61
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28
36
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62
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FIG. 3.

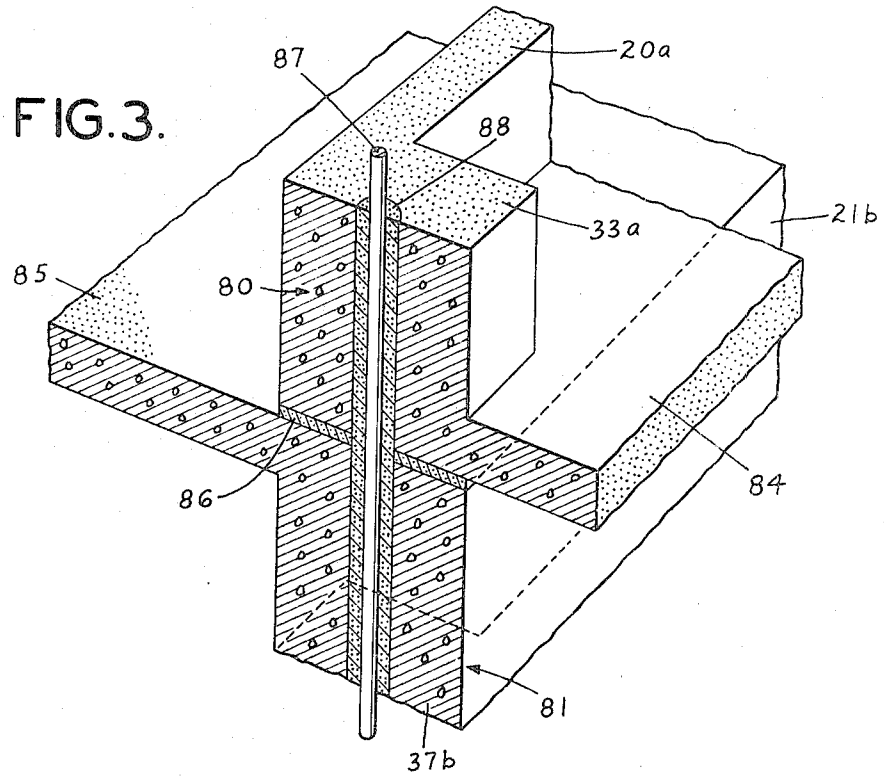
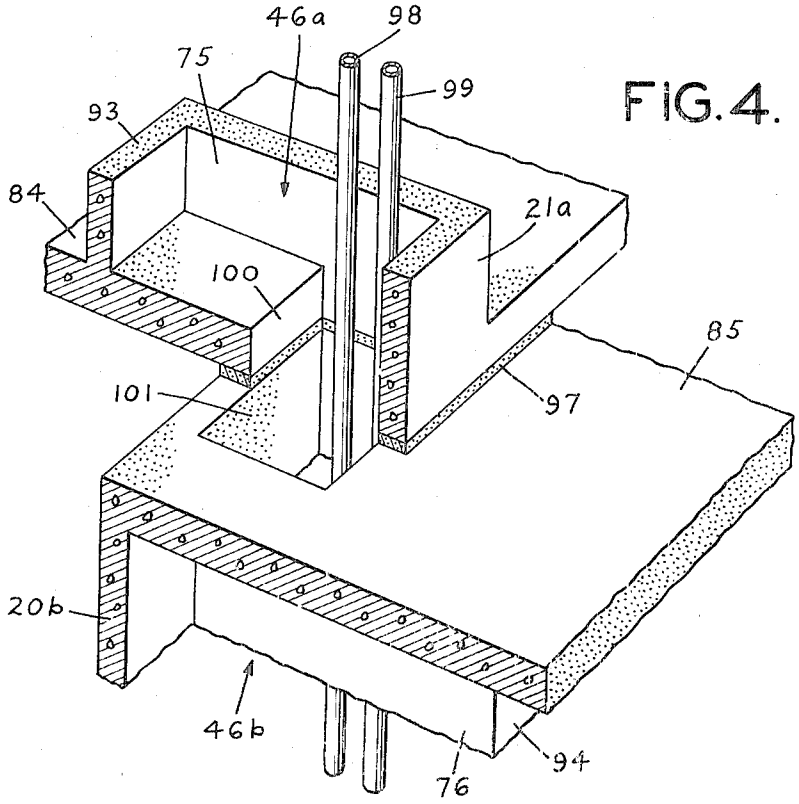

87
20a
88
33a
21b
85
80
86
84
81
37b

FIG. 4.


46a
98
75
99
93
84
21a
100
85
101
97
20b
46b
94
76

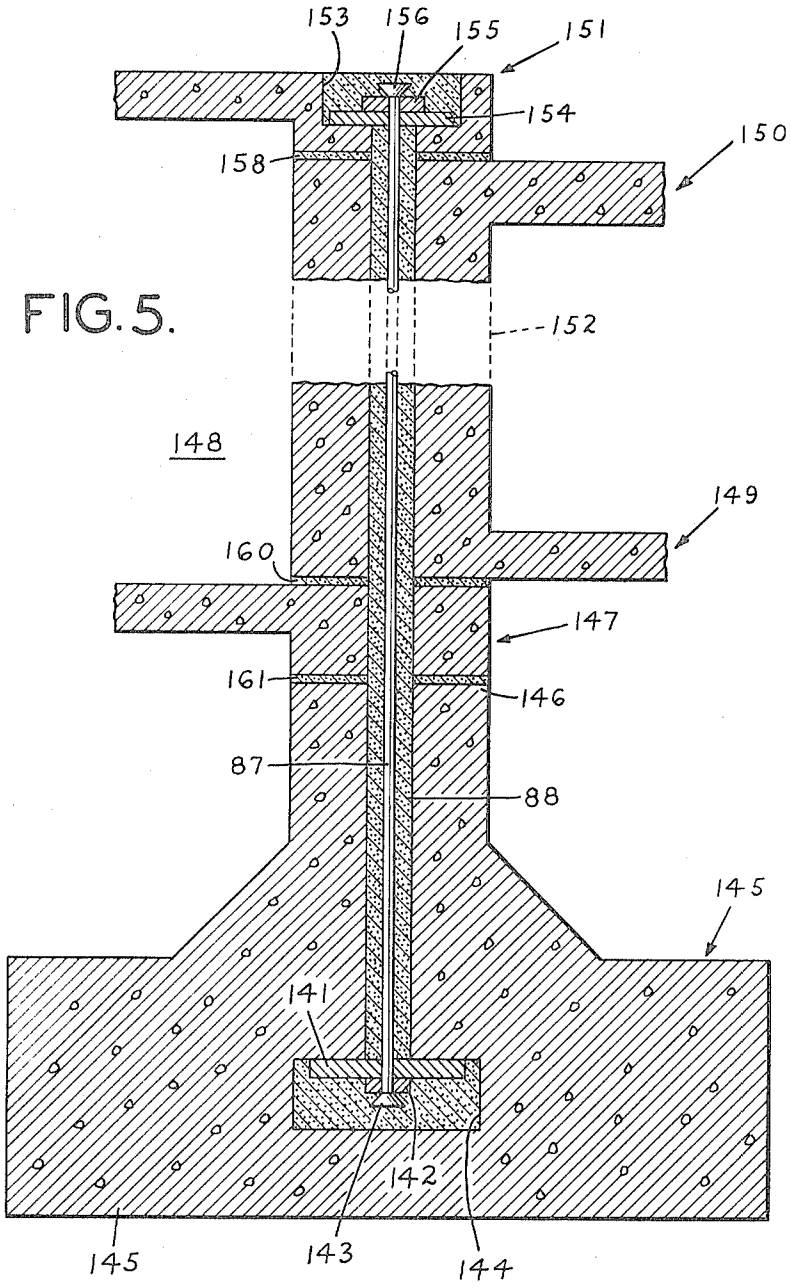

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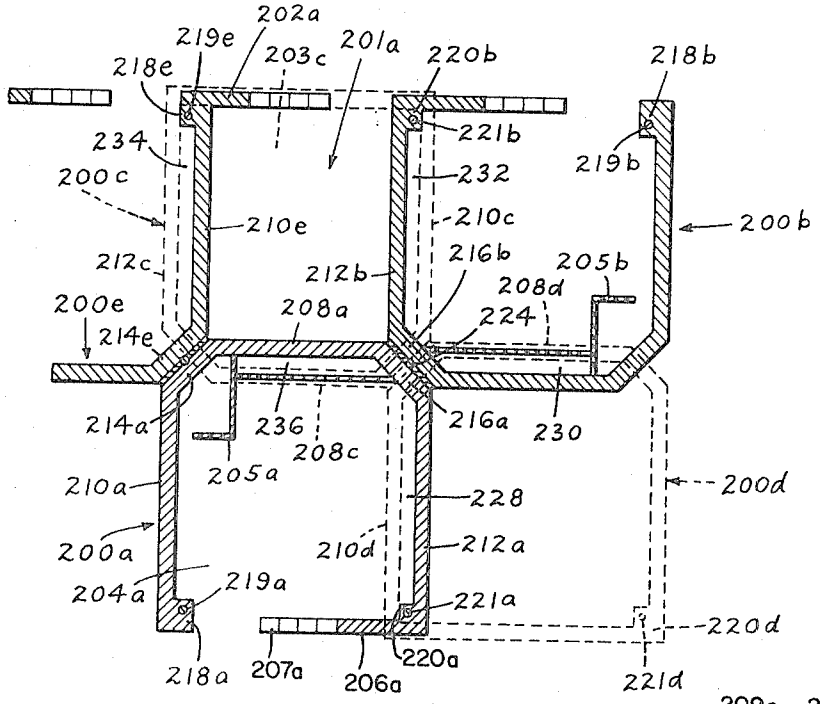
FIG. 5.

FIG.6.



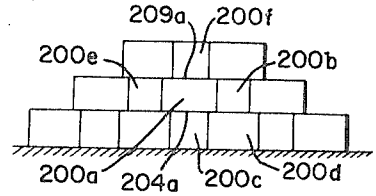


FIG.6A

FIG.7.

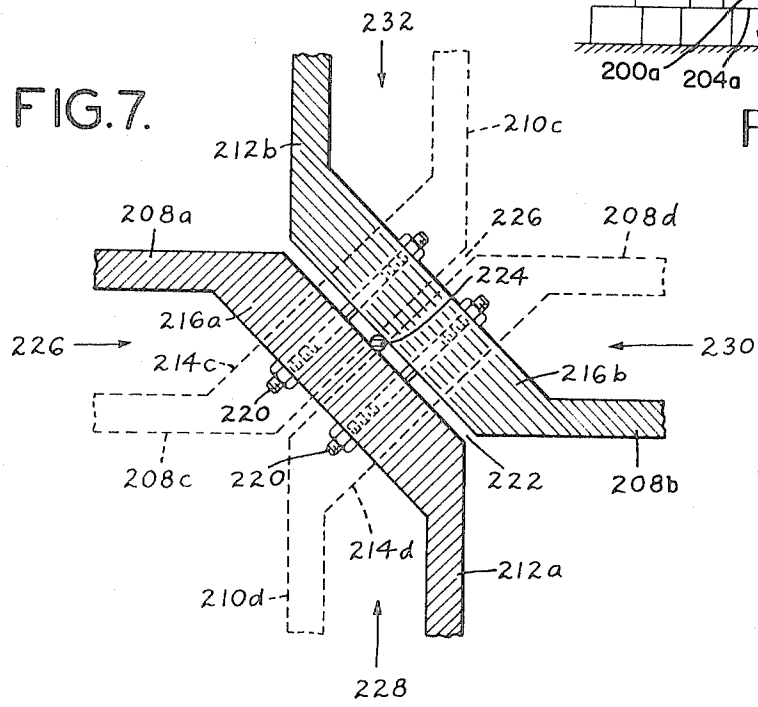


FIG. 8

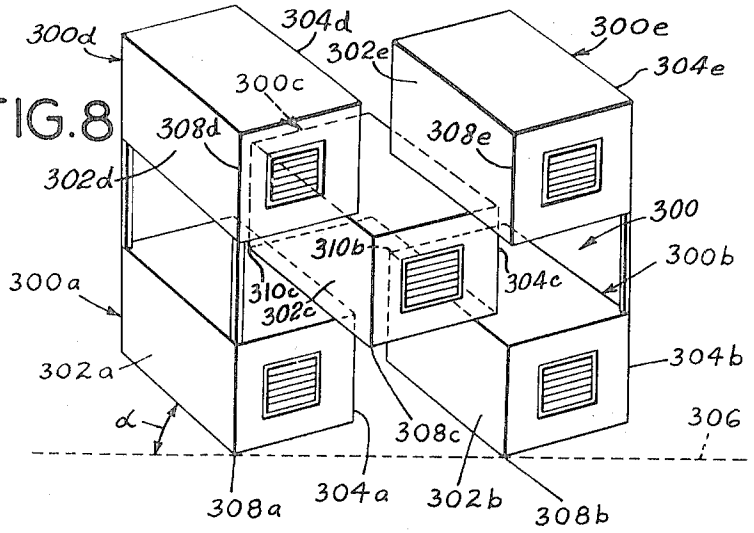


FIG. 9.

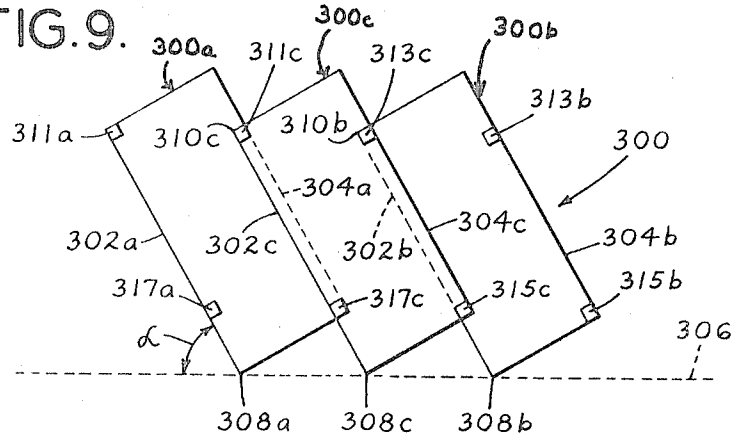
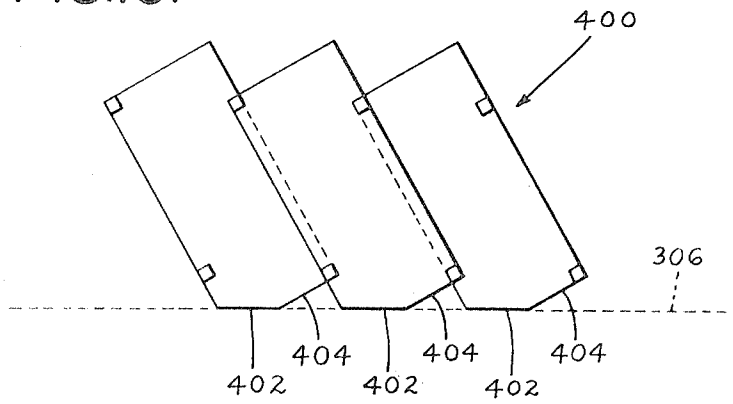


FIG. 10.



MODULAR BUILDING STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 762,668 filed Aug. 14, 1968, by Shelley W. Shelley, now U.S. Pat. No. 3,503,170.

BACKGROUND OF THE INVENTION

The present invention relates to modular building structures and more particularly to such structures which include a series of boxlike units of precast material such as concrete.

In several types of prior modular constructions using preformed units, the units were stacked such that the sidewalls of upper and lower units were aligned, or partially aligned, to bear the weight of the units stacked above. A great disadvantage of such constructions is that the sidewalls of the preformed units must be made thick enough to support the structure above it. This adds to the cost of the materials as well as to the cost of hoisting the units into the final assembly.

A further disadvantage of several construction systems employed heretofore is that the vertical stacks of preformed units not structurally interlinked with one another. Another disadvantage of some prior constructions is that shafts for utilities must be installed after assembly of the building, which increases the cost of the building. A still further disadvantage of many previous systems is that upon final assembly the appearance of the building is monotonously uniform and thus unattractive.

SUMMARY OF THE INVENTION

The present invention overcomes the above and other disadvantages by providing a modular building structure of preformed boxlike units, each having sidewalls, a ceiling and a floor slab, which are stacked in a staggered fashion such that there is an open space between any two units on the same floor level. Thus the interior units at intermediate levels are each stacked between four or more other units. The open spaces are used for additional living space as well as for other uses.

The individual boxlike units preferably are of open construction, in which the sidewalls, floor and ceiling are precast of concrete or other building material. The front, back and any intermediate walls may also be formed of concrete or other material, either during or after the assembly of the remaining walls. The units are assembled in stacked relationship and are provided with a substantial overlap at the sides thereof. The units are firmly interconnected and are positioned such that there is an open space between each two units in the same horizontal plane, with upper and lower units covering at least a portion of the open spaces at the intermediate levels. The arrangement is such that each of the units at the intermediate levels is stacked between four other units.

In some important embodiments of the invention, the preformed units are arranged in a skewed manner such that their sidewalls meet the front of the building at an oblique angle. This arrangement gives the building an appearance of irregular shape, causes an attractive play of lights and shades, and exhibits other esthetic qualities often not present in many prior modular structures. In addition, the apartments and balconies in buildings of this skewed embodiment have a great deal of privacy and a variety of views.

In certain important embodiments of the invention, the boxlike units are supported by load-bearing columns which protrude from the surfaces of, and in some cases are made part of, the sidewalls. The units are stacked such that some of the load-bearing columns of the upper and lower units are in vertical alignment. In high-level embodiments these columns are post-tensioned by rods or cables passing through the columns to form a unitary assembly having the interior units at intermediate levels structurally interlinked with at least four other units of adjacent unit stacks.

In several advantageous arrangements, the rear or front of the structure or both are provided with a corridor or walkway,

which communicates with an elevator shaft or staircase. The corridor may be precast and supported by cantilever beams from the front walls of the units, or it may be held in place by the vertical support columns. In another embodiment the corridor is formed from an integrated cantilever slab projecting from the floor slab of one unit and the ceiling slab of the unit under the adjoining open space. In still other embodiments the corridor or walkway is positioned between two or more units.

Although buildings constructed in accordance with the invention may be employed for various purposes, in cases in which the buildings are used to provide apartments or other living accommodations, each boxlike unit preferably contains the bedrooms with an intervening bath, and the open space between the units is formed into a dining and living space. In some units the kitchen is located in the basic unit; in others it is located in the open space between the units, and in still other parts of the kitchen are located in both the unit and the open space. The kitchen enclosure advantageously is located close to the utility shaft for easy connection of the utilities. In a preferred design, the bath unit is adjacent to the kitchen facilities so that both use common utility lines.

In cases in which the buildings are used as hotels, dormitories, small apartments or similar structures, each boxlike unit may comprise a separate living enclosure, and the spaces between the units may also comprise separate living enclosures. Each unit advantageously may be provided with two sets of utility facilities, one servicing the unit itself and one servicing the adjacent space.

In some embodiments the end units are provided with special precast subunits which receive kitchen, libraries or closet facilities.

The open spaces of the uppermost floor may have special precast ceilings, for example of flat or U-shaped configuration, to cover them.

In one preferred construction, the columns have central openings through which the post-tensioning cables are extended at the end of the assembly. In some high-level embodiments, only a certain number of floors are provided with the post tension cables. In low buildings, or in the upper part of high buildings, the post-tensioning cables can be replaced by rods which are not post tensioned but are bolted, welded, grouted or otherwise connected to the units.

There is thus provided a structural interlinkage or interconnection between the stacks of units. Since the load-bearing columns support the structure above, the sidewalls of the units do not have to be made as thickly, thus reducing the cost of materials and of assembly.

In several embodiments of the invention the shaft for the utilities, such as electricity, gas, water, sewage and the like, is disposed in a predetermined location as part of the precast units, ready for assembly into the final building structure. The utility shaft also may accommodate ducts for heating, air-conditioning systems and other utilities.

In other embodiments a construction is provided in which the units, in addition to being staggered, are overlapped at one or more of their sides sufficiently beyond the width of the sidewalls to form a continuous vertical space for the utility shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention, as well as further objects and features thereof, will become more fully apparent from the following description of certain preferred embodiments, when read with reference to the accompanying drawings, wherein:

FIG. 1 is a diagrammatic front perspective view of one embodiment of the invention showing an assembly of the boxlike modular overlapping units placed in position to form a building structure.

FIG. 2 is an enlarged sectional view of a living unit taken along the line 2—2 of FIG. 1, together with certain additional parts.

FIG. 3 is an enlarged fragmentary perspective view taken along the line 3—3 of FIG. 2, with certain portions shown in section, of two overlapped portions of superimposed building units of the embodiment of FIG. 1, including a post-tensioning cable extending between the units.

FIG. 4 is an enlarged fragmentary perspective view taken along the line 4—4 of FIG. 2, with certain portions shown in section, of a utility column and adjacent parts of two overlapped building units of the embodiments of FIG. 1.

FIG. 5 is an enlarged fragmentary vertical sectional view of a cable extending through a foundation slab, a single boxlike unit, as well as a ceiling slab of a unit of the embodiment of FIG. 1 and the attachments at the cable's lower and upper ends.

FIG. 6 is a fragmentary horizontal sectional view illustrating an assembly of living units of another embodiment of the present invention.

FIG. 6A is a diagrammatic front view of a portion of a building showing a way of stacking the units of FIG. 6 in upper, lower and intermediate levels.

FIG. 7 is an enlarged fragmentary horizontal sectional view of the structure which joins the corners of four units of the embodiment of FIG. 6.

FIG. 8 is a diagrammatic front perspective view of a third embodiment of the invention showing an assembly of the boxlike modular overlapping units placed in position with their sidewalls forming an acute angle with the front of the complete building structure.

FIG. 9 is a diagrammatic plan view of the embodiment of FIG. 8.

FIG. 10 is a diagrammatic plan view of a fourth embodiment of the present invention.

DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a building structure having a series of preformed modular boxlike units A which are overlapped at B. Between the units A are interspaces C which may provide additional living space and may be closed off at their front and back. The interspaces at ground level preferably are provided with floor slabs D, either cast in place or prefabricated, which extend a short distance beneath the adjacent boxlike units A. The units A at the sides of the building are in vertically spaced relationship with each other and are provided with connecting columns E, which may be replaced by continuous walls. Each of the units A includes one or more end windows or openings F.

FIG. 2 is illustrative of a typical apartment or dwelling within the building. The apartment comprises a single boxlike unit A which is provided with a floor **84**, a ceiling **85** (FIG. 1), sidewalls **20** and **21** and interior partitions **22**, **23** and **24** extending from front to back. Additional interior partitions **25**–**28** extend in the transverse direction to divide the apartment into its various rooms. In some good embodiments the partitions as well as the exterior walls of the unit A serve as structural support members for the building, although in other advantageous arrangements the partitions and in some cases the exterior walls need not have a structural function. Vertical enlargements or columns **30**–**37** are disposed at spaced intervals along the inner surfaces of the sidewalls **20** and **21** and are arranged to accommodate post-tensioning cables **87**.

The boxlike unit A additionally includes a utility column **46** for the water, gas and sewage lines, electrical cables, air-conditioning and heating ducts and other utilities. The interior is partitioned to form front bedrooms **38** and **39**, a rear bedroom **40** and a bathroom **41** having a washbasin **42**, a bath or shower **43**, and a toilet **44**. These bathroom facilities are connected to the utility shaft **46**, both for entrance of water and disposal of sewage.

The interspace C between the unit A and the adjacent unit contains a kitchen **50** having a sink **51**, a kitchen cabinet and stove **52**, a table **53** and a refrigerator **54**. Closets are provided at **55**, **56**, **57** and **58** within the unit A and at **59** within the interspace C. It will be noted that the sidewall **20** has no openings therein but that the sidewall **21** has openings at **60** and **61** which communicate with the kitchen **50** and a living room **62** within the interspace. A utility room **63** is formed within the unit A adjacent the opening **60**, and a laundry may be placed at **64** in the utility room.

The front of the living room **62** is provided with folding doors **70** and flower boxes **71** upon the balcony **72**. The rear of the apartment has a walkway or corridor **73** extending to suitable elevators or stairs (not shown). This walkway or corridor is supported from the columns **30** and **34** by cantilevers (not shown) or other structures.

In the illustrated embodiment the boxlike units A advantageously are precast as integral, one-piece assemblies at a location remote from the building site. Thus, the floor **84**, the ceiling **85**, the sidewalls **20** and **21**, the interior partitions **22** through **28**, the columns **30** through **37**, the utility shaft **46** and even the flower boxes **71** are all produced as a single unit. One particularly advantageous way of preparing such units is disclosed in copending U.S. application Ser. No. 790,305, filed Jan. 10, 1969, by Shelley W. Shelley.

In other good embodiments the floors, ceilings and sidewalls are assembled in prefabricated units, and some or all of the interior partitions and other remaining components are installed at the building site.

In FIG. 3 there is shown the overlapping of a bottom corner **80** of an upper unit A and the upper corner **81** of a lower unit A. The floor slab **84** is integral with a structural column **33***a* in the upper unit A, and the ceiling slab **85** is integral with a structural column **37***b* in the lower unit A. The space **86** between the corners is sealed by means of grouting or other sealing materials.

The units A are held together by one or more cables or rods **87**, which extend through a vertical space **88** in the columns **33***a* and **37***b*. The space **88** is grouted after the cable or rod has been tensioned in position. Each cable or rod may extend through all of the units vertically from the ground to the top, or it may extend through only some of the units depending upon the structural requirements of the particular building.

Referring to FIG. 4, there is shown a utility shaft **46***a* formed by a sidewall **21***a* of one of the boxlike units and an inside partition **93**. For the immediately subjacent boxlike unit a utility shaft **46***b* is formed by a sidewall **20***b* and an inside partition **94** and is disposed in overlapping relationship with the shaft **46***a*. In the illustrated embodiment the walls **21***a*, **93** and **20***b*, **94** are integrally formed with the floor and ceiling structures **84** and **85**, respectively, although in other cases they may be fabricated separately of asbestos, cement or other material and may be provided with removable panels to allow access for repairs. The space between the overlapping portions of the units is sealed by grout **97**.

The utility shafts **46***a* and **46***b* communicate with each other through openings **100** and **101** in the overlapping portions of the floor and ceiling slabs **84** and **85**. The utility shafts accommodate various pipes **98** and **99** for conducting water, sewage, or other utilities. The utilities may be placed in position prior to the assembly of the units A and connected from one unit to the next upper or lower unit, after the units are in place. In the illustrated embodiment, however, the utilities are placed within the shafts after the units have been assembled. The utility conduits are usually in a straight line, and sufficient space is provided to permit whatever utilities are necessary, with connections to the kitchen, bathroom and other outlets in each unit.

In forming the utility shafts **46***a* and **46***b*, it will be noted that the shafts only partially overlap. The extra, nonoverlapping spaces **75** and **76** are used for access or for repair purposes. To achieve this partial overlapping, the floor plans of the units are made with a reverse arrangement for alternate floors. It is not necessary that the floor plans of the overlapping units be mirror images of each other, as long as the openings for the utility shafts are aligned when the building is assembled.

In FIG. 5, one end of a post-tensioning cable 87 or rod is mounted by means of plates 141 and 142 and a securing device 143 in an enlarged grout-filled opening 144 within the footing structure 145 of the building. This footing structure is buried in the ground and extends upwardly to a point 146 directly below a floor slab 147. The floor slab 147 is positioned directly below the interspace 148 between adjacent modular units 149 on the ground floor. An upper modular unit is indicated at 150. A top slab 151 rests on the modular unit 150 and extends over the interspace between the unit 150 and its adjacent unit.

The broken space indicated at 152 indicates that any number of modular units may be positioned between the lowermost unit 149 and the uppermost unit 150. The top slab 151 is provided with a recess 153 which receives two plates 154 and 155 and a securing device 156 for the upper end of the post-tensioning cable 140. The recess 153 is then filled in with grout or other suitable material. The spaces indicated at 88, 158, 160 and 161 also are filled with grout.

Because of the post-tensioning cables 87, all the boxes or units A are unitarily assembled together with the overlapping portions B highly compressed. In addition, the walls and partitions of each unit are provided with vertical reinforcing cables or rods (not visible in the drawings) during casting. The assembled units act both vertically and horizontally to provide a monolithic structure, with both the floor and ceiling slabs tied together and with the vertical walls and partitions sandwiched therebetween.

The building is particularly resistant to earthquakes because of the high rigidity of the individual boxes and because of the flexibility of the entire structure, due to the overlapping and staggered arrangement of the boxes. Each of the interior intermediate units is post-tensioned not between two other units but between four other units on the four corners thereof.

Referring now to FIGS. 6, 6A and 7, another embodiment of the present invention is shown as comprising a series of substantially identical preformed modular units 200*a*, 200*b*, 200*c*, 200*d*, 200*e* and 200*f*. The units 200*c* and 200*d* are located one floor beneath the units 200*a*, 200*b* and 200*e* and are partially overlapped by them. Between the units 200*b* and 200*e* is an interspace 201*a*. The interspace 201*a* is partially closed at one end by partitions 202*a* and is bounded at its other end by the unit 200*a*. The unit 200*c* includes a ceiling slab 203*c* which forms the floor of the interspace 201*a*. The floor slab (not visible in FIGS. 6 and 7 but shown in FIG. 6A) of the unit 200*f* immediately above the interspace 201*a* forms its ceiling. The interiors of the units 200*a* and 200*b* are partitioned by walls 205*a* and 205*b*, respectively, into bedrooms, bathrooms, closets, etc.

As the embodiment of FIGS. 6, 6A and 7 is intended primarily for use as a hotel or motel, no provisions for kitchen facilities are shown. However, other embodiments intended as housekeeping structures do provide kitchen facilities.

The unit 200*a* has a floor slab 204*a* and a ceiling slab 209*a*. Partially closing one end of the unit 200*a* is a front wall 206*a* having a window 207*a*. Opposite the front wall 206*a* is a rear wall 208*a*. Extending perpendicularly from opposite ends of the front wall 206*a* are sidewalls 210*a* and 212*a*. Joining the sidewall 210*a* to the rear wall 208*a* is a reinforced wall 214*a*. The wall 214*a* makes interior angles of 135° with the walls 208*a* and 210*a*. Similarly, a reinforced wall 216*a* joins the sidewall 212*a* to the rear wall 208*a* and makes interior angles of 135° therewith. The units 200*b*, 200*c*, 200*d*, 200*f*, etc., likewise are precast with angularly extending reinforced walls at the front or back corners of the units. In other embodiments the reinforcing walls make complimentary interior angles between 90° and 180° with at least some of the remaining walls.

As best shown in FIG. 7, the reinforced wall 216*a* of the unit 200*a* is joined with the corresponding reinforced wall 216*b* of the unit 200*b* by bolts 220, thus linking these units at their corresponding corners. Similarly, the reinforced wall 214*a* is bolted to the corresponding reinforced wall 214*e* of the unit 200*e*, and the reinforced wall 214*c* of the unit 200*c* is bolted to the reinforced wall 214*d* of the unit 200*d*. At each floor level, the staggered units are assembled by connecting the corresponding corner walls of a select number of units. Both the assembled units and the interspaces between the units are used as rooms. In some low-level embodiments the bolts 220 are omitted, while in other embodiments the bolts may be replaced by horizontal rods or pegs to prevent relative movement between the units.

Adjacent the interior corner formed at the juncture of the walls 206*a* and 210*a* is an integrally cast support column 218*a*. At the interior corner formed at the juncture of the walls 206*a* and 212*a* is a support column 220*a*. These support columns are aligned over similar columns in units beneath the unit 200*a* and under similar columns in units above the unit 200*a*. Cables 219*a* and 221*a* pass vertically through the aligned columns to post tension the stacked and overlapped units. In a like manner, the units 200*b*, 200*d* and 200*e* have corresponding vertical support columns 218*b*, 220*b*, 221*d* and 218*e*, with their respective post-tensioning cables 219*b*, 221*b*, 221*d* and 219*e*.

Beneath the walls 216*a* and 216*b* and perpendicular to them, are the corner walls 214*c* and 214*d* of the units 200*c* and 200*d*, respectively. The walls 214*c* and 214*d* are joined in a manner similar to the walls 216*a* and 216*b* with a space 226 between them for the vertical cable 224. The walls 216*a* and 216*b* rest upon and are supported on the walls 214*c* and 214*d*. The cable 224 passes through the centers of the spaces 222 and 226 and is used to post tension both pairs of walls. The cable 224 also post tensions units above and below the units 200*a*, 200*b*, 200*c* and 200*d*.

The end mountings for the cables 219*a*, 219*b*, 219*e*, 221*a*, 221*b* and 221*d* are similar to the mountings of the embodiment of FIG. 5. The spaces 222 and 226 are filled with grout or other suitable material to seal them.

The sidewall 212*a* of the unit 200*a* overlaps the underlying sidewall 210*d* of the unit 200*d* beyond the width of the sidewall 210*d* so that a space 228 is created. Likewise, the rear wall 208*b* of the unit 200*b* overlaps the rear wall 208*d* of the unit 200*d* beyond the width of the wall 208*d* to create a space 230. In a similar manner, the wall 212*b* overlaps the wall 210*c* to create a space 232, the wall 210*e* overlaps the wall 212*c* to create a space 234, and the wall 208*a* overlaps the wall 208*c* to create a space 236. In a preferred embodiment, some or all of these spaces are used to accommodate utilities. The floor and ceiling slabs are provided with suitable holes at their overlapping portions which align with corresponding holes in the slabs beneath and above to form a vertical utility shaft. These utility shafts pass through substantially the entire height of the assembled structure.

Referring to FIGS. 8 and 9, a third embodiment of the present invention is shown as comprising an assembly of preformed modular boxlike units which in general are similar to the type discussed above with reference to FIG. 1. In FIG. 8 the individual units are identified by the reference character 300 followed by an alphabetical suffix to denote the position of the unit within the assembled structure. The unit 300*c* is stacked over the spaced-apart units 300*a* and 300*b* and beneath the spaced-apart units 300*d* and 300*e*; with one of its sidewalls 302*c* extending beyond the corresponding sidewalls 304*a* and 304*d* of the units 300*a* and 300*d* and its other sidewall 304*c* extending beyond the corresponding sidewalls 302*b* and 302*e* of the unit 300*b* and 300*e*. In the complete assembly the units are stacked and overlapped with open spaces between the units at the same horizontal plane or level. These open spaces are used as additional living areas or as balconies.

The sidewalls 302*a*, 302*b*, 302*c*, 302*d*, 302*e*, 304*a*, 304*b*, 304*c*, 304*d* and 304*e* of the units 300 are skewed with respect to the length of the building, as represented by the line 306, meeting it at oblique angles. In the embodiment of FIG. 8 the angle α is of the order of 60° and preferably should lie within the range of from about 10° to about 80° for best results. The front corners 308*a*, 308*b* and, 308*c*, 308*d* and 308*e* of the

units **300** are disposed in an imaginary vertical plane which defines the length of the building.

The building additionally includes a series of support columns which are aligned in a manner similar to that of the embodiment of FIG. **1**. The columns of the unit **300***c* will be described in detail, but it is to be understood that the units **300***a* and **300***b* have corresponding columns (which are also numbered correspondingly in FIG. **9**). One support column **311***c* is positioned at a rear corner **310***c* of the unit **300***c* adjacent the sidewall **302***c*. A second support column **313***c* is positioned intermediate the ends of the sidewall **304***c* and is directly opposite the column **311***c* on a line parallel to the length of the building. The column **313***c* is aligned directly over the rear corner **310***b* of the unit **300***b* when the building is assembled. A third support column **315***c* is positioned in the front corner of the unit **300***c* in diagonally opposite relationship with the column **311***c*. A fourth support column **317***c* is positioned intermediate the ends of the sidewall **302***c* and is directly opposite the column **315***c* on a line parallel with the length of the building. The support columns are integrally formed with the units during the casting operation and may be provided with post-tensioning cables after assembly in a manner similar to that described heretofore.

Referring now to FIG. **10**, a fourth embodiment of the invention is shown comprising a series of preformed units **400** arranged in a skewed manner with respect to the length of the building in a manner similar to that of the embodiment of FIG. **8**, that is, at an oblique angle. The embodiment of FIG. **10** is substantially the same as the embodiment of FIG. **8** except that the units **400** are not completely rectangular. A portion **402** of each of the front walls **404** is parallel to the length of the building rather than at an acute angle to it. This allows the units **400** to have two front views.

By arranging the individual boxlike units at acute angles in the manner shown in FIGS. **8–10**, the building gives the appearance of irregular shape, the play of shades and light is attractive, and the structure exhibits other esthetic advantages. In addition, the apartments and balconies have a great deal of privacy, a greater variety of views are afforded, and the buildings are wind catching.

Although the various boxlike units in the embodiments of FIGS. **1–9** have been shown and described as being rectangular, in other advantageous arrangements the units are of nonrectangular configuration, as shown in FIG. **10**, for example. The opposite sidewalls of the units may converge or diverge relative to one another, and triangular units, circular units, or units of still other geometric shapes may be employed without departing from the spirit or scope of the invention. The term "boxlike," as used herein, is intended to denote a building unit which defines a substantially enclosed space, with or without floors and ceilings, of substantially any geometric configuration.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of limiting any of the features shown and described or portions thereof, but it is recognized that various modifications may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and a floor slab, the units being stacked in upper, lower and intermediate levels with a portion of each unit overlapping a portion of another unit at a different level such that adjacent sidewalls at successive levels are in staggered, noncoplanar relationship with each other, and column means for structurally connecting the units, said column means including a series of vertical support columns monolithically formed with the staggered sidewalls and projecting laterally therefrom, the support columns on the sidewalls of upper boxlike units resting on top of the support columns of adjacent lower boxlike units, the units being positioned so that there is an open space between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and the lower levels partially enclosing the open space at the intermediate level.

2. A modular building structure as recited in claim **1** wherein each boxlike unit has a vertical shaft for utilities extending through the unit.

3. A modular building structure as recited in claim **2** wherein the location of the utility shaft within each boxlike unit in the intermediate level is a mirror image of the location of the utility shaft in the boxlike unit in the adjoining upper and lower levels, the utility shafts of adjacent boxlike units in different levels being in communication with each other.

4. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and a floor slab, the units being stacked in upper, lower and intermediate levels with a portion of each unit overlapping a portion of another unit at a different level such that adjacent sidewalls at successive levels are in staggered, noncoplanar relationship with each other with a substantial overlap therebetween, the units being positioned so that there is an open space between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and the lower levels partially enclosing the open space at the intermediate level, and post-tensioning members extending through the overlapping units to post tension at least one unit between the four other units.

5. A modular building structure as recited in claim **4** wherein the post-tensioning members comprise vertical support columns integrally and monolithically projecting from the sidewalls of each boxlike unit, and means for connecting selected ones of the columns, at least some of the columns of adjoining upper and lower boxlike units being in sufficient vertical alignment with each other to allow the connecting means to extend through the support columns.

6. A modular building structure as recited in claim **4** wherein each of the boxlike units includes an interior partition.

7. A modular building structure as recited in claim **6** wherein the interior partitions are integral with the units.

8. A modular building structure as recited in claim **7** wherein the interior partitions acting in conjunction with at least one sidewall define a vertical utility shaft within each unit.

9. A modular building structure as recited in claim **8** including means defining openings in the ceiling and floor slabs of each boxlike unit to provide communication between the vertical utility shafts.

10. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and floor slab, the units being stacked in upper, lower and intermediate levels with a portion of each unit overlapping a portion of another unit at a different level beyond the combined width of the sidewalls, and column means for structurally connecting the units, said column means including a series of vertical support columns monolithically formed with the staggered sidewalls and projecting laterally therefrom, the support columns on the sidewalls of upper boxlike units resting on top of the support columns of adjacent lower boxlike units, the units being positioned so that there is an open space between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and the lower levels partially enclosing the open space at the intermediate level.

11. A modular building structure as recited in claim **10** wherein the overlapping portion of a unit at a given level and the overlapping portion of an adjacent unit at a different level partially define a vertically extending space through the units, and means for containing utilities disposed within said vertically extending space.

12. A modular building structure as recited in claim **11** wherein the connecting means includes means passing verti-

cally through the support columns for post tensioning adjoining units together.

13. A modular building structure comprising a plurality of boxlike units, each of which has sidewalls, a ceiling, a floor slab and at least two angularly disposed corner walls, each of the corner walls meeting two of the sidewalls at obtuse angles, the units being stacked in upper, lower and intermediate levels with at least one of the corner walls of each unit in a given level abutting at least one corner wall of another unit in that level and resting on at least one corner wall of a unit in an adjoining lower level, adjacent sidewalls at successive levels being in staggered, noncoplanar relationship with each other, and means for structurally connecting the units, the units being positioned so that there is an open space between three adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and lower levels partially enclosing the open space at the intermediate level.

14. A modular building structure as recited in claim 13 wherein the connecting means includes vertical support columns projecting from the sidewalls of each boxlike unit which are aligned with the vertical support columns of adjoining upper and lower boxlike units, first post-tensioning means extending vertically through the support columns, and second post-tensioning means extending vertically through the pairs of abutting corner walls.

15. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and a floor slab, the units being stacked in upper, lower and intermediate levels such that adjacent sidewalls at successive levels are in staggered, noncoplanar relationship with each other, and column means for structurally connecting the units, said column means including a series of vertical support columns monolithically formed with the staggered sidewalls and projecting laterally therefrom, the support columns on the sidewalls of upper boxlike units resting on top of the support columns of adjacent lower boxlike units, the units being positioned so that there is an open space between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and lower levels partially enclosing the open space at the intermediate level, said units being arranged in skewed manner such that selected corresponding corners of the units lie in a single vertical plane and the sidewalls of the units form oblique angles with the vertical plane.

16. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and a floor slab, the units being stacked in upper, lower and intermediate levels such that adjacent sidewalls at successive levels are in staggered, noncoplanar relationship with each other, and post-tensioned column means for structurally connecting the units, said column means including a series of vertical support columns monolithically formed with the staggered sidewalls and projecting laterally therefrom, the support columns on the sidewalls of upper boxlike units resting on top of the support columns of adjacent lower boxlike units, the units being positioned so that there is an open space between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, the units in the upper and lower levels partially enclosing the open space at the intermediate level, each unit overlapping a portion of another unit at a different level, said units being arranged in a skewed manner such that selected corresponding corners of the units lie in a single vertical plane and the sidewalls of the units form an oblique angle with the vertical plane.

17. A modular building structure comprising a plurality of boxlike units each of which has sidewalls, a ceiling and a floor slab to define a first living enclosure, the units being positioned so that there is an open space between adjacent units, a ceiling slab and sidewalls bridging and enclosing the open space to define a second living enclosure, and means within one of said boxlike units for defining a pair of utility areas, one of the utility areas servicing the first living enclosure defined by said one unit and the other utility area servicing the second living enclosure defined by the adjacent open space.

18. A building structure comprising a plurality of boxlike units having exterior walls and interior partitions, the units being stacked in upper, lower and intermediate levels with only a portion of each unit overlapping a portion of another unit at a different level such that adjacent sidewalls at successive levels are in staggered, noncoplanar relationship with each other, the units being positioned so that there is an open living area between adjacent units in the same level and so that there is at least one unit in the intermediate level which is stacked between at least four other units, column means monolithically projecting from the sidewalls of the units and serving as structural support members for the building, and means for post tensioning the one unit at the intermediate level between the four other units.

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