Nov. 10, 1964 R. VAN BIJLEVELT 3,156,071

BUILDING STRUCTURE

Filed June 22, 1959 3 Sheets-Sheet 1

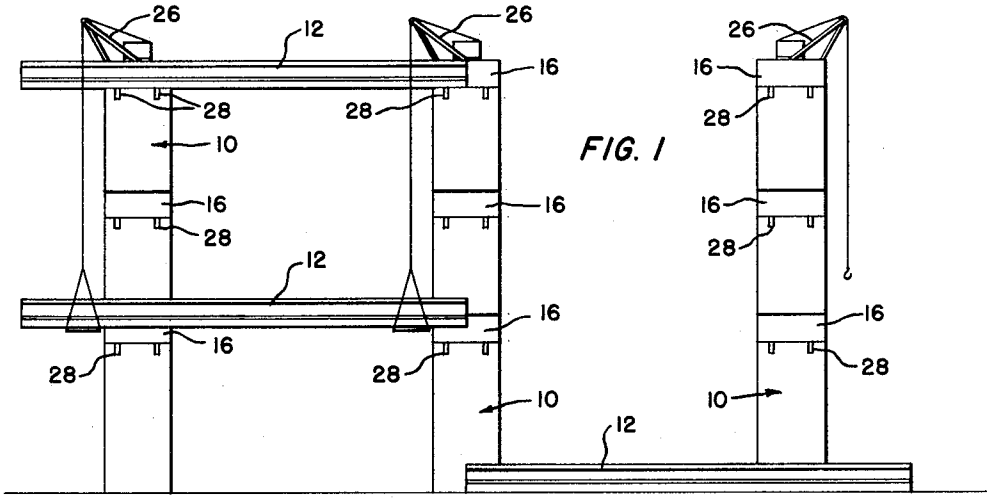

FIG. 1

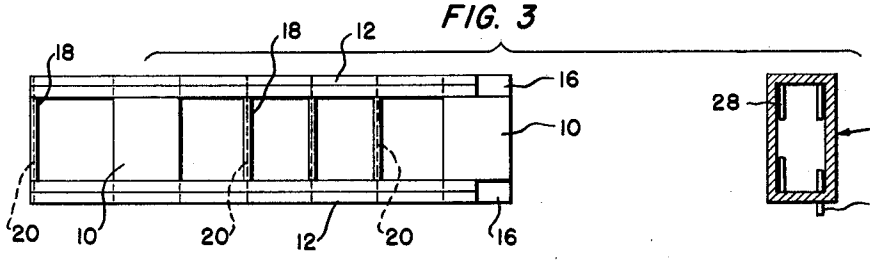

FIG. 3

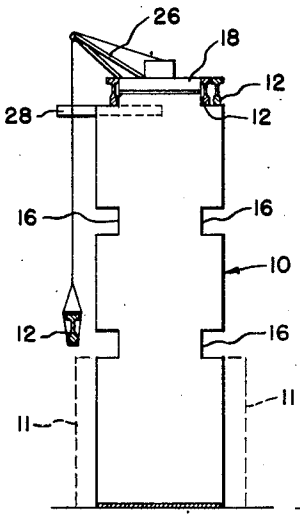

FIG. 2

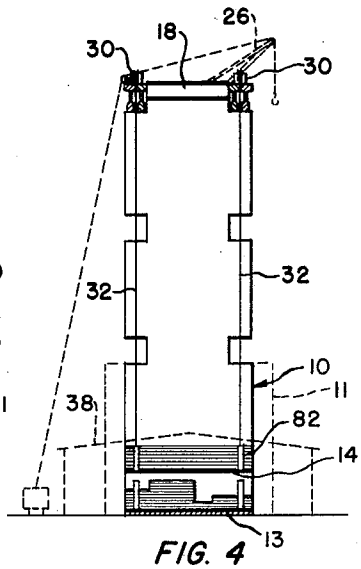

FIG. 4

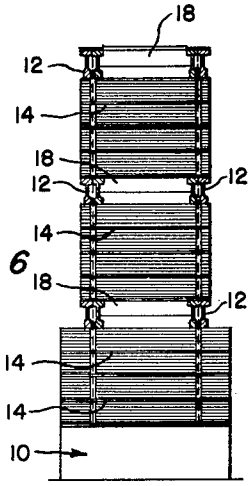

FIG. 6

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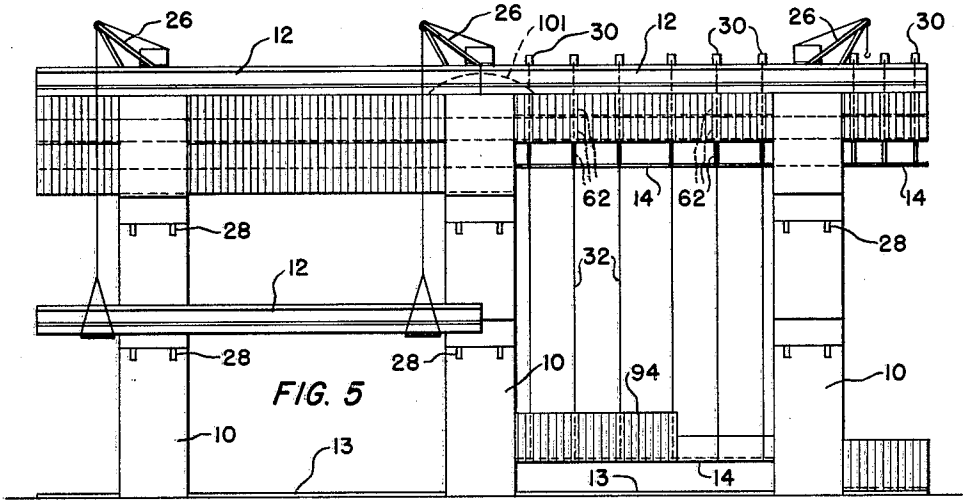

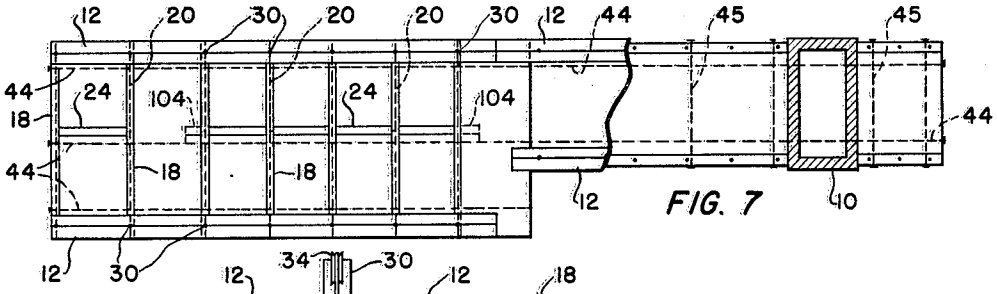

FIG. 7

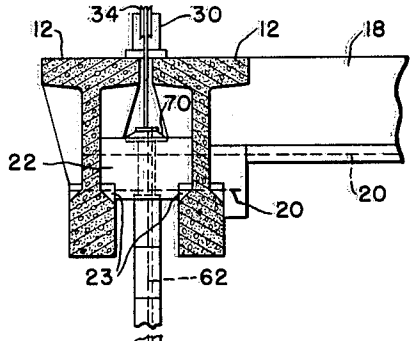

FIG. 8

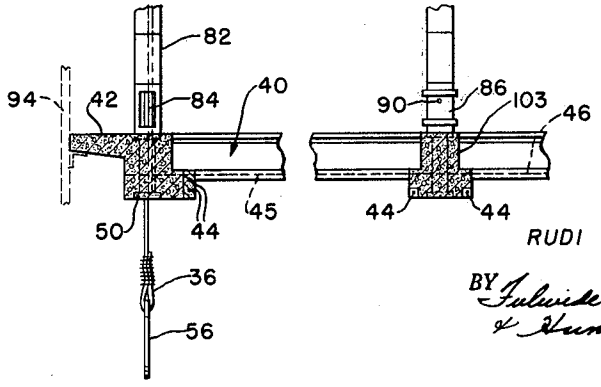

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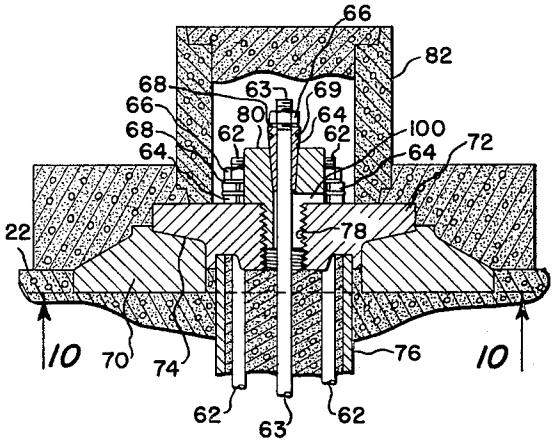
FIG. 9



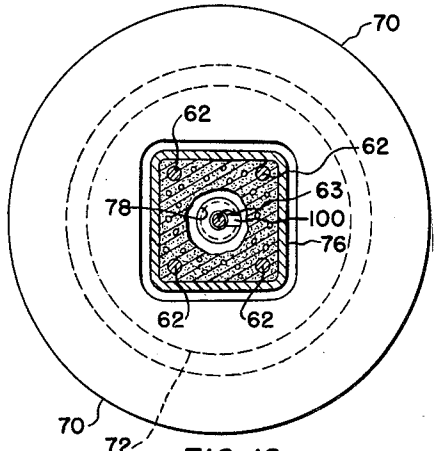


FIG. 10

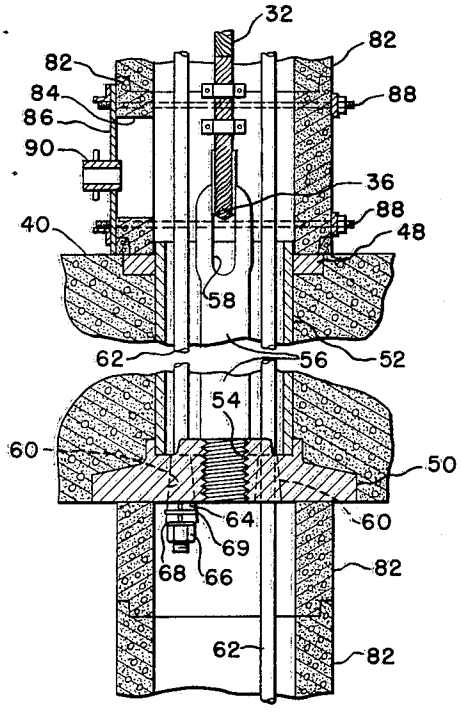


FIG. 11

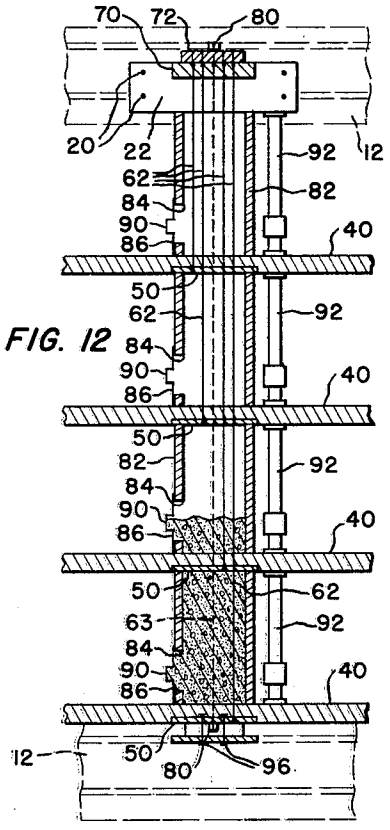


FIG. 12

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United States Patent Office

3,156,071
Patented Nov. 10, 1964

3,156,071

BUILDING STRUCTURE

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Filed June 22, 1959, Ser. No. 821,989
1 Claim. (Cl. 50—534)

The present invention relates to a multi-story building structure and a method for erecting such building structure, and more particularly relates to structures wherein the floors or stories thereof are built at ground level and thereafter hoisted into position and suspended from beams of the building structure.

According to the present invention one or more vertically extending pillars are erected, preferably through the use of upwardly sliding molds or slip forms, and these pillars form the vertically supporting structure for the usual roof and floor slabs of the building. The pillars are preferably made hollow so that elevator shafts, stairs, utilities, or even complete rooms can be provided in the pillars. The pillars are self-supporting, and may be used for housing heating conduits, waste disposal chutes, dumbwaiters, and various utility lines. As will be seen, these pillars not only serve as a structure for supporting subsequently erected components of the building, but also serve as a means for bringing materials from lower levels to higher levels. It is one of the features of the present invention that this transport of materials is not of any great magnitude, but the pillars are available for use in transporting the limited flow of materials and supplies that must be carried to the upper levels.

The pillars are the sole means for transmitting building loads from the building structure to the ground, and in this way excavation need only be made for the pillars. This is in contrast to the excavation necessary in constructing conventional buildings, wherein the whole column and foundation beams must be set down in excavated areas.

After the construction of the pillars, beams are arranged on the ground adjacent to or between the pillars, and winches or booms located on top of the pillars are operated to raise the beams by usual lifting cables or the like. If space is limited, the booms with their associated winches will be located on top of the pillars, but if space permits the winches can remain at ground level and only the booms will be placed on top of the pillars. Pockets, niches, cutaway portions, or brackets in the sides of the pillars are each adapted to receive a pair of beams as will be more particularly described hereinafter, and the beams are thereafter rigidly secured in position. Pairs of beams are raised and fitted on both sides of the pillar, and extending between a pair of pillars so that, for example, for each set of four stories, there are arranged two or more pairs of beams in parallel relationship, one pair on one side of the pillars, and the other pair of beams on the opposite side of the pillars. Where desired, a single large beam may be used instead of a pair of beams.

During this time a roof, roof slab or complete story is being built at ground level, and a plurality of individual winches or raising means are arranged along the length of these beams to raise the roof or story. A corresponding plurality of cables are trained from the winches, between the beams or through openings in the beams, and downwardly to ground level. At ground level the lower ends of these cables are attached at various points to a slab or floor of a completely built story, which floor or slab is preferably of a monolithic construction formed by casting concrete within peripheral forms located on the ground. The slab is provided with fittings to accept the ends of the plurality of cables just mentioned. This first slab to be raised is preferably the floor of the first story. Although the roof slab or construction

above the uppermost story can also be raised, this presents certain difficulties, and it is more expeditious to construct the roof slab or construction in place at the top of the building.

The beam winches are operated to raise the first floor slab or story to a position approximately even with the underside of the beams, and this slab or story will form the roof of the following story of the building which will next be raised. This slab or story is then secured to the beams. Alternatively, as will be seen hereinafter, this slab may be raised to a level approximating that of the upper surface of the beams, and another slab secured to the undersides of the beams to define a story of beam height in between such slabs.

The lifting cables are disconnected from the slab or story just raised, and are then moved downwardly to connection with another slab or completely built story which has been poured, cast, or built at ground level as before.

While each slab is at ground level, the interior walls may be erected and plumbing, utilities, and other fixtures installed. Then, by raising this slab about ten or twelve feet, it will form a shelter for the next slab or story. The finish work, such as finish flooring, painting, and plastering, may be completed on this raised slab. With this arrangement the finish work can be accomplished simultaneously with the construction work on the slab or story below. In addition, a temporary shelter of canvas, sheet metal, or the like can be constructed over the suspended story to protect the finish work in progress on that slab. Thus, while the rough construction is being accomplished on the ground level, all of the details and finishing work may be completed on the suspended story. It will be apparent that with this arrangement there is no necessity for elevating concrete and other materials to any great height in order to complete construction of the floors or stories.

The beam winches are again operated to raise the suspended story to its uppermost position where it serves as the uppermost story. Hanger rods are then installed between that floor and the beam, and the lifting cables are disconnected for use in raising subsequent slabs. It is particularly noted that the floors are suspended either between the pillars or under the overhang of the beams, and are supported by the hanger rods. The floors do not rest upon columns as in conventional building construction, and therefore considerable space is saved. In addition, the use of the great tensile strength of the hanger rods permits the use of columns between floors which are slender and occupy little space compared to the large compression columns of conventional multi-story buildings.

It is especially noted that each floor or slab is suspended from the beams with a separate set of hanger rods, cables, or other high tensile strength members.

The floor slabs which have been raised to their final positions are tied to the pillars by an arrangement of post tensioned cables or tie members so that the pillars, beams, and slabs are all tied together in a solid, integral structure. In addition, one or more hanger rods may be post tensioned to equalize or balance the stresses on the supporting elements for each of the floors. The manner of effecting such post tensioning will be described in greater detail hereinafter.

It is contemplated that approximately four stories or slabs may be suspended from each set of beams, and thereafter an additional set of beams are installed adjacent the pillars, the beam winches transferred, and the operation of raising four additional floors repeated, and so on for the number of stores planned.

In comparison, the conventional "lift-slab" construction requires a great number of columns under compression, and the number of floors is limited because of the

instability of the structure at the time of lifting the first floors. Also, the columns are necessarily relatively close to each other, depending upon the construction and strength of each floor, to support the span between the columns, and the free space which characteristics the present invention is not present.

Although the above discussion has been directed to a structure which includes a pair of pillars, with pairs of vertically spaced beams disposed therebetween, this is merely by way of example and not to be construed as limiting the present invention. For example, it is contemplated that each beam may in fact constitute one single beam or arrangement of two or more closely adjacent girders, and the beam or beams may take the form of steel structural members, or preferably prestressed concrete structures. Further, it is possible that only a single pillar will be used, and the beams arranged in cantilever fashion with the floor slabs suspended beneath them. Also, various suspension members other than hanger rods are contemplated, and a variety of constructions for the floor slabs may also be devised, it being important only that the floor slab that is eventually raised be monolithic so as to support its own weight plus the live load between the points where the hoisting cables, and later the hanger rods, are attached. Individual slabs or floors are suspended from the beams between the pillars, or from that portion of the beams extending beyond the pillars, and each floor slab is supported from the beams by a separate set of cables or hanger rods. It is noted that when the slabs are suspended from projecting or overhanging beam portions the maximum bending moment is reduced in that portion of the beams between the pillars.

It is another advantage of the present invention that hollow columns may be arranged between the floors and about the grouped hanger rods. Jacks can then be arranged adjacent these columns and in contact with the floor and the ceiling slabs of the story, and the jacks operated to provide desired prestressing of the hanger rods. Thereafter, the columns may be filled with concrete, cement-mortar, or grout so that when the mortar is solidified and the jacks removed, the stresses in the hanger rods and tension column will be adjusted as desired. This will be explained in further detail hereinafter.

Other objects and features of the present invention will be readily apparent to those skilled in the art from the following specification and appended drawings wherein is illustrated a preferred form of the invention, and in which:

FIGURE 1 is a front elevational view of a building structure according to the present invention;

FIGURE 2 is a cross section of the building structure of FIGURE 1;

FIGURE 3 is a plan view of the building structure illustrated in FIGURE 1;

FIGURE 4 is a cross section through the building structure during the construction thereof, illustrating one of the upper stories partially raised and forming a roof or shelter for the construction of the next succeeding story;

FIGURE 5 is a front elevational view illustrating the present building structure in a partially completed state;

FIGURE 6 is a cross section of the building illustrating the manner in which sets of floors are suspended beneath their respective sets of beams;

FIGURE 7 is a plan view of a building structure according to the present invention, and in which transverse tie beams are used because of the greater width of the structure;

FIGURE 8 is a detail view illustrating the manner in which a floor is raised to its proper position beneath supporting beams;

FIGURE 9 is a detail sectional view of the top anchorage of a set of suspension rods to a slab or beam, as the case may be;

FIGURE 10 is a view taken along line 10—10 of FIGURE 9;

FIGURE 11 is a detail sectional view illustrating the means for connecting the lifting cable to the slabs, and the anchorage for securing the lower ends of the suspension rods to the floor slabs; and

FIGURE 12 is a schematic view illustrating the arrangement of a set of hanger rods for the individual slabs, and the jacks for post-tensioning said hanger rods, the hanger rods being illustrated uniformly spaced apart merely for the purpose of clarity.

Referring now to the drawings, and particularly to FIGURES 1 through 7 thereof, the novel building structure constructed in accordance with the method of the present invention comprises one or more vertically disposed structures or pillars **10** which, as will be seen, serve to support a plurality of girders or beams **12**, which in turn serve to support a plurality of floor slabs such as slabs **13** and **14**, FIGURE 4. Pillars **10** carry or transfer to the ground all the bearing loads of the present structure, and the beams **12**, which are rigidly secured to pillars **10**, serve as an anchorage for the upper ends of a plurality of hanger rods for supporting the various floor slabs. In addition, during the construction of the present building structure, beams **12** serve to support a plurality of winches or other lifting means which operate to raise or elevate the various floors or completely built stories to their proper positions.

A detailed description of these various components will next be made to afford a better appreciation of their individual functions in relationship to each other. Pillars **10** may be made in almost any cross sectional configuration, but are shown in the usual rectangular configuration, and are constructed of concrete. The concrete is poured in a mold which slides upwardly during the construction of the pillar so that the same mold may be used throughout the entire height of the pillar, thereby obviating any necessity for scaffolding and other cumbersome arrangements. For greater stability, pillars **10** may include a wider lower portion, as indicated in dotted outline at **11**, FIGURES 2 and 4. The added cross section of the lower portion may be added after use of the sliding molds has produced a pillar of uniform width, or the molds may be adjusted in their width as they are slid upwardly. Since pillars **10** are the only load bearing structures in contact with the ground, it will be apparent that the amount of excavation needed for the present building structure is considerably less than that for conventional buildings. Each pillar **10** is preferably of fairly generous size so that prefabricated floors, stairs, and materials and equipment for the installation of elevators, and the like may be hoisted and secured in place in the interior of the pillars, along with the usual dumb-waiters and chutes, and utility lines for power, water, gas, waste, and the like. Pillars **10** thus serve as a means for transporting such materials as may be needed at the various floor levels, and the use of cranes for raising men and materials is substantially eliminated.

As best illustrated in FIGURES 1 and 2 wherein three pillars **10** are shown by way of example, each pillar **10** is formed to include pockets or cutaway portions **16** which are molded in the concrete and adapted to closely receive one or more beams **12**. Beams **12** are preferably arranged in pairs at opposite sides of pillars **10** and extend longitudinally between the pockets **16** of one pillar **10** and the pockets **16** at the same level of the next pillar **10**. In addition, a plurality of tie members **18** are disposed laterally between the two pairs of beams at either side of pillars **10**, and a wire, cable or plurality of wires or cables **20** are preferably disposed through the body of each tie member **18**, through the pairs of beams **12** at the ends of each member **18**, and through concrete anchors or bridges **22** carried between the beams **12** of each pair of beams. These cables **20** are then post-tensioned to effect a solid or integral connection between pillars **10**, beams **12**, members **18**, and bridges **22**, FIGURE 8, and are thereafter securely fixed at their outer ends to the outer sides of beams **12**. A strong, three-dimensional

post-tensioned structure is thereby afforded from which the floor slabs may be suspended, as will be seen.

Concrete bearing bridges 22 are disposed between the beams 12 of each pair of beams and act to support or anchor the upper ends of the hanger rods for the various floors, as will be seen. The tie rods or cables 20 rigidly secure bridges 22 against lateral movement, and bridges 22 bear against lower flange areas 23 of beams 12 for support.

When the width of the building structure is to be comparatively great, such as sixty feet or more, for example, intermediate beams 24, FIGURE 7, may be disposed longitudinally between the transversely disposed tie members 18 and secured thereto for greater rigidity and more secure support of the suspended floor slabs. If desired, beams 24 may also be provided with post-tensioning cables for securement to tie members 18.

Since beams 12 may be as great as eight feet in height, they are difficult to handle, and large booms 26, FIGURE 1, are therefore arranged on top of pillars 10 to lift beams 12 into position alongside their respective cutaway portions 16. However, the hoist mechanism for booms 26 may also be placed on top of pillars 10, but if space provides it is preferred to place the hoist mechanisms on the ground, as indicated in dotted outline. Beams 12 must next be moved laterally to their positions within pockets 16, and for this purpose a sliding rail arrangement 28 may be provided, as shown diagrammatically in FIGURE 2. Rails 28 are designed to slide outwardly beneath the suspended or hoisted beam 12, and then the beam 12 is lowered to rest thereon. Thereafter, rails 28 are slid inwardly to place beams 12 in their proper location. Since the detail construction of rails 28 is not a part of the present invention, a detailed description thereof will not be made. It is important only that some such arrangement as rails 28, rather than swinging booms for example, be provided to handle the very large and ponderous beams 12. Once beams 12 are in position in the uppermost pockets 16 at the top of the building structure, beams 12 are rigidly secured to pillars in any suitable manner.

Beams 12 then provide support for a plurality of lifting means or beam winches 30, FIGURES 4, 5, and 8, which are arranged in longitudinally spaced relationship along the length of beams 12. Winches 30 may take the form of any suitable winch for raising substantial loads, their detailed construction is not important. However, it is desirable that the various winches 30 be connected in series, so that should one winch 30 fail, the other winches 30 will also cease to operate. In this way, the vertical lifting movement of floor slabs will be uniform throughout the area of the floor slabs. Any suitable means may be employed for measuring the tensile strength in the lifting cables to thereby insure that the slab will be lifted uniformly throughout its area. Thus, for example, each lifting winch could be positioned upon a diaphragm filled with oil so that the oil will be placed under a pressure corresponding to the force in the lifting cable. This pressure can then be measured and the force in the cable calculated.

A plurality of lifting cables 32, FIGURE 5, are secured at their upper ends to beam winches 30, are trained over a corresponding plurality of pulleys 34, FIGURE 8, located atop each pair of beams 12, and are preferably formed at their lower ends into a loop 36 which is maintained by removable clamps, as shown in cross section in FIGURE 11. Each of the loops 36 is, in turn, adapted to be connected at various points over the area of the floor slab. In this way, a floor slab may be evenly raised by the various lifting cables 32 to its proper position. Thereafter, as will be seen, the lifting cables 32 are disconnected after hanger rods 62, FIGURE 8, are arranged for the support of the slabs.

In FIGURES 4 and 5 there is illustrated a floor slab 14 which has been constructed on a leveled ground area between a pair of pillars 10 and which has been raised about 10 or 12 feet. Beneath this slab 14, the next slab 13 is being constructed, slab 14 serving as a shelter for the construction in progress on slab 13. To protect the construction already accomplished on slab 14, a temporary shelter 38, shown in dotted outline, may be arranged over both slabs 13 and 14. The roof of this temporary shelter may be temporarily fastened to the hoist cables if desired. Shelter 38 protects the workers and equipment from the elements, and it may be heated to permit the pouring of concrete during the winter if desired. Thus, construction can proceed at any time of the year. It is contemplated that rough construction will be accomplished on each slab when it is in the position of slab 13, and finish construction will be made on each slab when it assumes the position of slab 14. In this way, all materials, equipment, and workmen are concentrated in one area, and obvious organizational advantages accrue as compared with the usual building construction in which workmen and equipment are scattered throughout the structure. When each finished story is placed in its final position, it is ready for occupancy, and the savings to the building owner which are thereby effected will be apparent.

Preferably floor slabs 13, beams 12, 18 and 24, and most of the other components of the building structure are prefabricated in sections and transported to the building site. However, if desired, the floor slabs and beams may be poured or cast on the ground between or adjacent pillars 10. The floor slabs and beams, in any case, are preferably prestressed to afford a light weight and strong structure.

Each slab, hereinafter designated generally by the numeral 40, includes a slab edge formed in the shape of a spandrel beam 42 which extends longitudinally between a pair of pillars 10. Prestress cables, rods, or tie members 44, FIGURE 8, are disposed at spaced intervals in a longitudinal direction through the edge sections of each slab 40 and, as will be seen, are carried into pillars 10 and secured thereto, by post-tensioning to securely locate each slab 40 in position between the pillars 10, and also to mate slabs 40 with pillars 10 to form a monolithic construction. In addition, a plurality of similar rods or tie members 46 are transversely disposed at spaced intervals along the length of slab 40, and are prestressed to afford increased strength for each slab 40, as is well known. Intermediate beams 103, FIGURE 8, can be suspended, if desired, from tiebeams 18 to reduce the floor span.

Each slab 40, FIGURE 11, has molded therein a floor collar 48 in its upper surface, and an annular rod anchor washer 50 in its lower surface. A sleeve, pipe, tube, or cylinder 52 is vertically disposed between collar 48 and washer 50 and is welded or threaded thereto. This integral combination is cast into the concrete of each slab 40 when it is poured.

Each rod anchor washer 50 is provided with a threaded central opening 54 which is adapted to threadably accept a ventically extending fitting 56 which includes an upper eye 58 for accepting loop 36. Spaced about the central opening 54 are a plurality of circumferentially arranged tapered openings 60, one for each floor which is to be suspended beneath the particular beams or pair of beams 12 under consideration. That is, if an anchor washer 50 were associated with the uppermost slab, and three slabs 40 were to be suspended beneath this uppermost slab, the anchor washer 50 thereof would be provided with four openings 60, one for supporting the uppermost slab, and three openings 60 for supporting each of the three slabs 40 beneath it. However, for standardization, each of washers 50 could be made with the same number of openings 60.

The purpose of each of the openings 60 is to accommodate a suspension means or hanger rod 62, a plurality of which are used to support the floor slabs 40. Thus, in FIGURE 11 the lower end of a hanger rod 62 is dis-

posed downwardly through a tapered opening 60, and a plurality of conical wedge sections 64 are disposed about the periphery of rod 62 and within opening 60. The lower end of rod 62 is threaded, and a nut 66 is threaded thereon, and a washer 68, provided between nut 66 and the plurality of wedges 64. Nut 66 prevents wedges 64 from falling out during assembling or during hoisting of a slab. Wedges 64 function as a chuck in that the tensile force acting upon rod 62 causes wedges 64 to be urged inwardly for gripping rod 62. Wedges 64 are provided with internal circumferentially disposed grooves for better gripping action. The greater the tensile force on rod 62, the stronger the gripping action of wedges 64 so that each rod 62 is firmly secured in position. Snap 69 is carried in an exterior groove of wedges 64 for holding them together prior to their insertion in opening 60.

The upper end of each hanger rod 62 is similarly secured to beams 12, or preferably to concrete bridges 22, as best illustrated in FIGURES 8 and 9. Thus, an annular collar pad 70 is embedded in each bridge 22, thereby providing a greater bearing area, and an annular rod anchor washer 72 is carried upon an inwardly and downwardly sloping surface 74 of pad 70. The upper end of the metal sleeve 76 is w lded or threaded at its upper end to washer 72 and extends downwardly to the lower portion of bridge 22 where it is welded to a collar (not shown), which is the same as collar 48, as illustrated in FIGURE 11. As will be apparent, sleeve 76 and pads 70 and 72 are most conveniently disposed in concrete bridge 22 at the time bridge 22 is cast or molded.

The hollow interior of sleeve 76 serves to accommodate the plurality of rods 62, and each of these rods 62 extends through an opening in rod anchor washer 72, each such hole is arranged in a manner identical with that of holes 60 in anchor washer 50. Anchor washer 72 is identical in all respects to anchor washer 50, except that anchor washer 72 is inverted to provide support for the upper ends of anchor rods 62. Thus, the plurality of openings (not shown) in washer 72 accommodate the upper ends of rods 62, and in each opening there are disposed a plurality of wedges 64 which, together with washers 68 and nuts 66, serve to secure the upper ends of rods 62 in the tapered openings of anchor washer 72.

A central threaded opening 78 is provided in anchor washer 72, and threadably accepts a rod stool 80 which includes a central opening which tapers upwardly at its upper portion to accommodate another set of wedges 64 for securing the upper end of a centrally located anchor rod 63, shown in dotted line in FIGURE 12, all in a manner similar to that described for the anchorage of rods 62 disposed within the openings of washer 72 which are arranged about opening 78. An identical rod stool 80 is also provided at the lower end of anchor rod 63 where rod 63 is disposed through the lowermost suspended floor slab. The central rod 63 is an extra rod which extends from the anchor washer 72 to the lowermost slab, FIGURE 12, and provides a safety factor in case one of the rods 62 should break. If a rod 62 breaks, the stress would be transferred through the grout or mortar in the tension column to the central rod 63.

Before the various floor slabs 40 are raised into position, FIGURE 12, a column of hollow concrete blocks 82, FIGURE 11, are arranged about each grouping of anchor rods 62. An opening 84, FIGURE 11, is provided in one of the concrete blocks 82 which rests upon the upper surface of a floor slab 40. Opening 84 is covered by a plate 86 secured in position by nut and bolt assemblies 88, and plate 86 is provided with a laterally disposed sleeve 90 welded to plate 86. Sleeve 90 serves as an inlet passageway for the introduction of concrete or grout within the column and spaces defined by blocks 82 and sleeves 52 and 76. Thus, when all of the floor slabs 40 have been raised to their operative positions grout is pumped through sleeve 90 into the interior of blocks 82. The concrete or grout will be transferred from one floor level to the next through openings 54 and 60 which do not have wedges 64 therein. It is noted that at intermediate floors 40, wedges 64 are disposed through only one opening 60, leaving space for grout to be pumped through any other opening 60. The rod stool 80 is provided with a grout passageway 100.

The concrete or grout not only serves as a fire protection for anchor rods 62, but also forms a compression column for prestressing rods 62 after it has solidified within the blocks 82. More particularly, at the time the grout is being introduced into the column, or even prior thereto, a plurality of jacks 92 are placed in position as illustrated in FIGURE 12. These jacks 92 are operated to elongate the various rods 62 before the concrete or grout is poured, so that after the grout sets or solidifies the jacks may be removed and the rods 62 will be under a prestress force. The grouting of the columns between the various floor slabs, and the actuation of the various jacks 92 may be altered in sequence, as desired, to provide equal or various compression forces in each of the columns between the slabs 40. One preferred method of prestressing these rods 62 is to first elongate the longest rod 62 and the central rod 63 by operating the lowermost jack 92, with the other jacks 92 in position between the various floors. Thereafter the portion of the column between the lowermost slab and the slab above it is grouted and the grout allowed to solidify. Next, the lowermost jack 92 is removed, and all other jacks loosened to relieve the compression in itself and to relieve the tension in the rods 62 above the part that is grouted in. Next, the rod for the next lowest floor, along with the rods extending to the lowest floor which have already been elongated in their lower portions, is elongated by operation of its associated jack 92, and the elongation is continued sufficiently to make the compressive stress in that portion of the column the same as the lowest column which has already been stressed. The column portion is then grouted, and after it is solidified, its jack 92 removed, the other jacks loosened, and so on, in the manner described for the lowermost story. The compressive stress in each column portion for each story would then be the same. This gives rigidity to the arrangement of columns, slabs, and beams. The floors suspended from the set of beams described thus become rigidly associated with the beams from which they are suspended.

In the discussion thus far made of the support of the various floor slabs 40 on anchor rods 62, particular embodiments and examples have been mentioned, but this is merely by way of example and not by way of limitation. Thus, for example, the floor slabs 40 could be arranged to all hang or be suspended by one large rod, although to provide best efficiency the rod section should be reduced in size as it proceeds downwardly. This could be done, for example, by connecting different sized rods by couplings having different threaded openings. In addition, the anchor rods could be a solid, circular, high tensile strength steel rod, or it could take the form of a cable with many twisted strands or even an arrangement of glass fibre. The anchor rods could be bars, forms of structural steel, cables, tubes, pipes, or the like. That is, it is important only that it form a strong tension member for suspending the slabs 40. In this regard it is emphasized that the columns formed by blocks 82 are not necessarily under any compression except for the compression introduced in prestressing rods 62, that is, the columns are not like the conventional compression columns of usual building structures, and are markedly smaller in cross section to save material and gain room.

Summarizing the above description, the building structure of the present invention is constructed in the following manner. Pillars 10 are erected, and the cutout or pocket portions 16 are formed therein to receive beams 12. In addition, the sliding rail arrangement 28 is installed in each pocket 16. The hoists 26 are operated to

raise the uppermost set of beams 12. Thus, as seen in FIGURE 2, each of these uppermost beams 12 are raised into position adjacent the uppermost pocket 16, and onto the rails 28. These rails 28 are then actuated in any suitable manner to move beams 12 inwardly into position within pockets 16, as illustrated. Other methods for moving beams 12 into position within pocket 16 may be provided, and the rail arrangement 28 mentioned is merely illustrative of one way of accomplishing such movement.

Assuming that three pillars 10 have been erected, for example, as seen in FIGURE 1, four beams will be longitudinally arranged adjacent to or between each of the pillars 10, making a total of eight beams. In FIGURES 1 and 2, two of these beams are shown in place on one side of a pillar 10, and one of the beams 12 for the other side of pillar 10 is shown in position, with the remaining beam 12 being raised by hoists 26. It is noted that beam 12 is arranged to overhang the end pillars 10 in cantilever fashion, whereby the maximum bending moment between pillars 10 is desirably reduced. Also, as seen at 101, FIGURE 5, post-tension cables may be arranged in arched form to connect the beams together to convert them into a continuous beam to further reduce the maximum bending moment. These beams 12 may be prefabricated in sections or as one piece and then brought to the site, or may be erected on the site, as desired. Further, as previously mentioned, beams 12 are preferably made of prestressed concete in substantially I beam configuration, although other structural materials and forms may also be used.

Concrete bridges 22 are then arranged between the pairs of beams 12. Next, tiebeams 18 are raised into position, and are secured to beams 12. As best illustrated in FIGURE 3, tie rods 20 extend laterally and are spaced at longitudinal intervals. If the lateral distance between beams 12 is comparatively great, further beams 104 may be raised and secured in position between and to pillars 10, their ends being shown in dotted lines in FIGURE 7. In this case the tiebeams 18 would be extended between beams 12 and 104.

A three-dimensional post-tensioned structure is then created by post-tensioning tie members 20. Beams 24 may also be post-tensioned with longitudinal tie members (not shown) when such beams 24 are used. Such post-tensioning is afforded by the disposition of wires or cables 20 through tiebeams 18, concrete bridges 22, and beams 12, and also through beams 24 where applicable. Further, it is noted that the floor slabs are preferably made of prestressed concrete, and include rods, cables, or tie members 44 and 45 which extend longitudinally and laterally, respectively, through the slabs. Ties 44 are secured to pillars 10 after the floor slabs are raised into their proper position, and ties 45 are preferably installed on the ground and raised with the slabs. FIGURE 7 illustrates a building structure in which pillars 10 of different sizes are used because of the difference in width of various wings of the building structure. Many other variations will occur to those skilled in the art. After the beams 12 and tie members 18 are rigidly secured in position, the floor slabs 40 are next to be hoisted. As best seen in FIGURE 4, one such floor slab 14 has been constructed and already raised by lifting cables 32 to a distance of about ten or twelve feet to do finishing work at that level. A curtain wall 94 has also been built upon slab 14, as shown in FIGURE 5, and will form the wall of that story and the story above when slab 14 is raised into position. It will be apparent that such a curtain wall 94 could be installed on any floor slab and made one or more stories in height, as desired. This would reduce labor costs and promote efficiency of construction.

With slab 14 in the position illustrated, FIGURE 5, finish work, such as finish flooring, painting, and plastering, are being accomplished, and rough construction is also in progress on slab 13. One story interior walls are erected on slab 13 at this time, along with doors, fixtures, and plumbing. All material flow is substantially horizontal, and the lifting of materials to great heights is substantially eliminated. In addition, since all the floors are raised into position, no jacks or forms are needed for building each floor upwardly upon a lower floor, as is the case with conventional construction, and there is no necessity for a separate set of molds for each floor. No bearing walls are required and every story is built on the ground level. This, of course, means a great savings in building costs.

If it is wished to use the room between the upper and lower surfaces of beams 12 as a story, a roof slab may be constructed at a level parallel with the upper part of the beam, and another slab constructed parallel with the lower part of the beam. These slabs are not suspended by rods, but are fastened directly to beams 12. Thereafter, slab 14 would be raised into position as the uppermost story of the structure. For each lifting cable, a rod 62 is then secured from rod anchor 50 of the uppermost slab 40 to the rod anchor washers 72 on concrete bridges 22. Then loop 36 with its removable clamps is disengaged from fitting 56, and fitting 56 is removed from the anchor washer 50 of the raised slab 40. Each of the fittings 56 are then threaded to the anchor washers 50 for the next slab 40 to be raised, the various lifting cables 32 are then downwardly disposed through the central openings 54 of washers 50 of the uppermost slab 40, and are then engaged with the eyes 58 of fittings 56 by means of loops 36 and the re-attached clamps therefor. Thereafter the second highest story slab 40 is raised into position, and the procedure repeated to secure it in position by its own set of rods 62. This procedure is continued until four stories are in position.

After the four slabs 40 are in position, the lifting cables 32 are removed and replaced by an additional rod 63 which may be prestressed to take up or transmit prestressing through all floors. These central rods 63 also provide a 100% safety factor in the event that there is a failure of any of the rods 62. Thereafter the jacks 92 are placed in position in the sequence of prestressing and grouting is followed, as above described. The winches 30 and the jacks 92 are removed, and an additional set of beams 12 are raised into position within the second highest set of pockets 16. The slabs 40 just above these latter beams 12 are anchored to beams 12 by any suitable arrangement, such as by the bolt and plate assembly 96, FIGURE 12.

Additional tie members 18 and concrete bridges 22 are secured in position as before, and the lifting winches 30 are transferred from the upper beams 12 to the beams 12 just raised into position. Winches 30 are secured to these beams 12, or to bridges 22 where more than one beam 12 is used, and are operated to raise floor slabs for suspension from the beams 12, all in an identical manner to that described for the first-mentioned beams 12. The procedure is continued until the desired number of stories have been constructed. Because the floors are suspended, it is noted that the lowest story may be disposed above the ground, leaving a large free area at ground level for parking space or the like.

Thus, it will be seen that a novel building structure and building method has been provided by the present invention. Floor slabs 40 are suspended from beams between columns and from the cantilever portions of the beams, with individual lifting means 30 carried by the beams and actuable remotely to raise the slabs. The floor slabs 40 which are suspended from beams 12 are each supported by a separate set of cables or rods 62. The slabs 40 are not secured to any columns or pillars for support, but are supported by beams 12, and merely anchored in position by securement to pillars 10, as by the wires or cables 44.

While certain embodiments of the invention have been specifically disclosed, it is understood that the invention

is not limited thereto as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claim.

I claim:

A method of constructing a building comprising the steps of erecting at least one self-supporting, vertically disposed pillar; connecting beam means to said pillar so that said beam means extends from said pillar; mounting a plurality of hoist means to said beam means; connecting lifting members between said hoist means and a first floor slab; operating said hoist means to raise said floor slab; connecting a first plurality of tension members between said first floor slab and said beam means to suspend said floor slab beneath said beam means; disconnecting said lifting members from said first floor slab; connecting the lifting member to a second floor slab; operating said hoist means to raise said second floor slab; connecting a second plurality of tension members between said second floor slab and said beam means to suspend said second floor slab beneath said first floor slab; disconnecting the lifting member from the second slab; connecting said lifting members to a third floor slab and so on and repeating the operation until the desired number of floor slabs are suspended; inserting jacks between the various floor slabs; forming columns between the floor slabs and around the pluralities of tension members for the reception of solidifiable material; and operating the jacks to produce tension loads in said pluralities of tension members, filling said columns with solidifiable material to maintain said tension loads, and removing said jacks in an order suitable to produce the desired post-tensioning of said pluralities of said tension members.

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