

[54] **BINARY PRECAST CONCRETE TRIANGULATED BUILDING SYSTEM**
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[51] Int. Cl.**E04b 5/04, E04b 5/23**
[58] Field of Search.....**52/263, 236, 234, 52/237, 319, 334, 605, 611, 601**

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[57] **ABSTRACT**
The invention relates to a prefabricated building structure utilizing precast concrete steel reinforced T-shaped building elements and precast concrete steel reinforced hexagonal shaped columns. The T-shaped building elements are arranged in building units to form the framework of the building structure, said units respectively constituting the floors and roof of the structure and being vertically aligned and spaced apart by means of the columns. Each building element comprises a diamond shaped slab and an integral beam extending along the major axis of the slab on the under side thereof. The hexagonal shaped columns are each provided with a plurality of vertically spaced annular shelves upon which the ends of the T-shaped building elements on the major axes thereof rest. Moment connections are welded in the field between adjacent slabs and between the building elements and columns.

11 Claims, 12 Drawing Figures

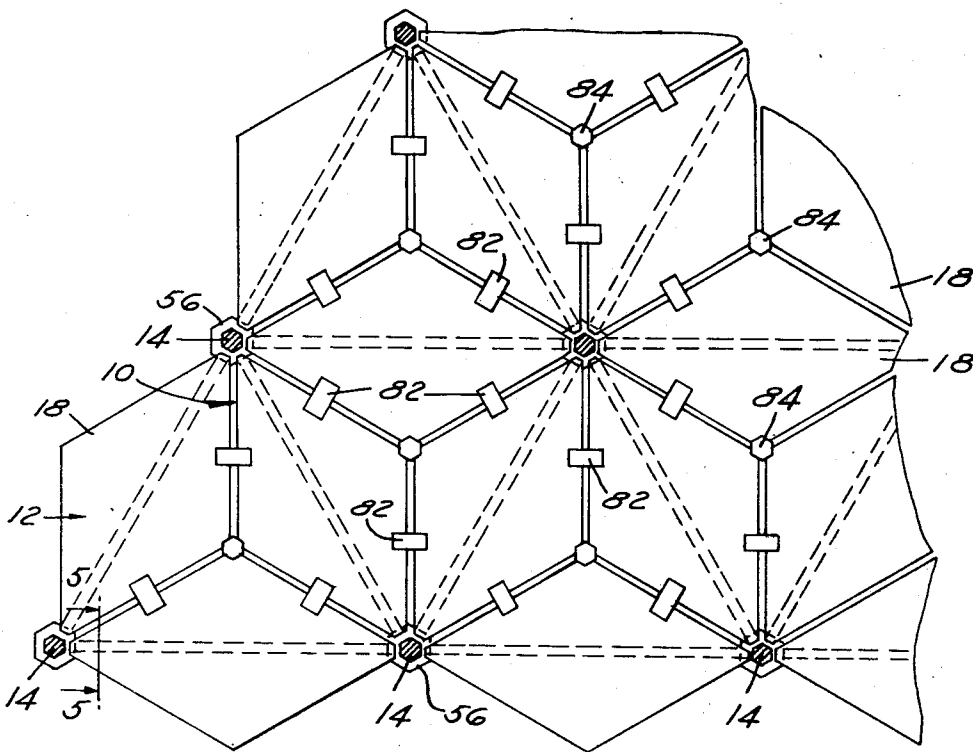


FIG. 1

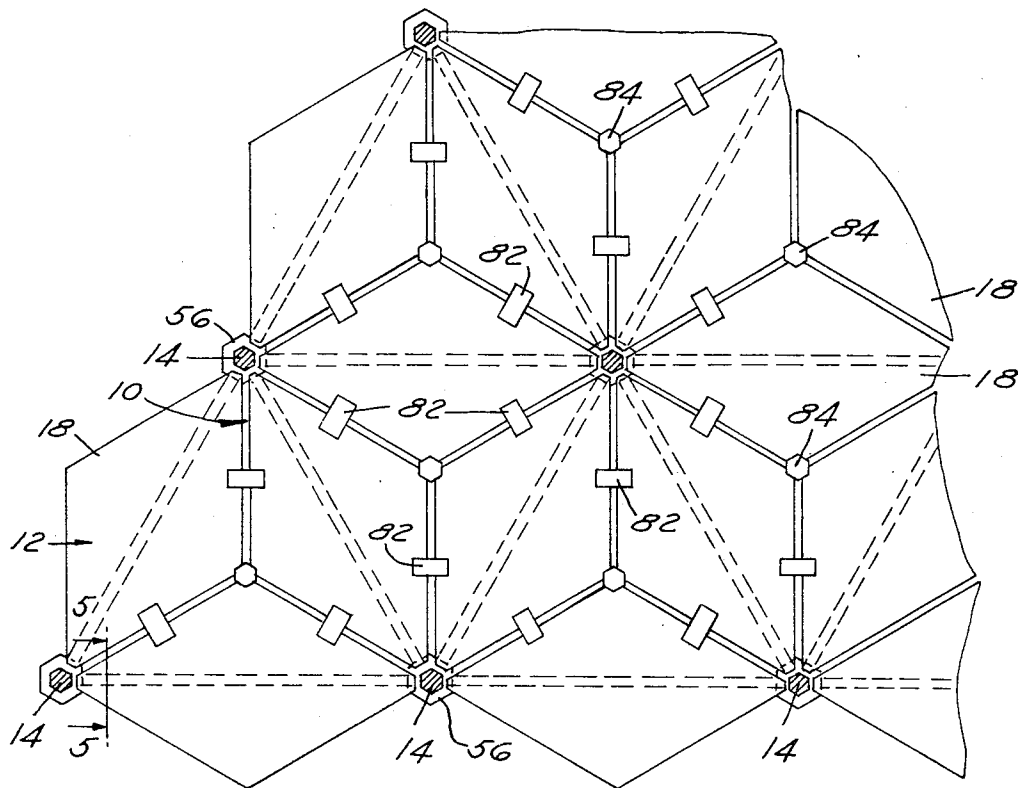


FIG. 5

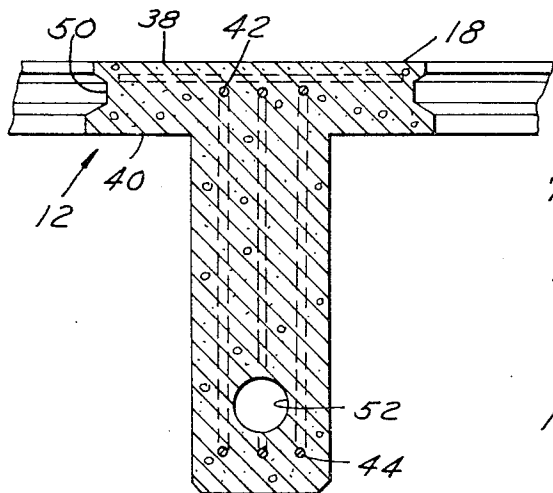


FIG. 6

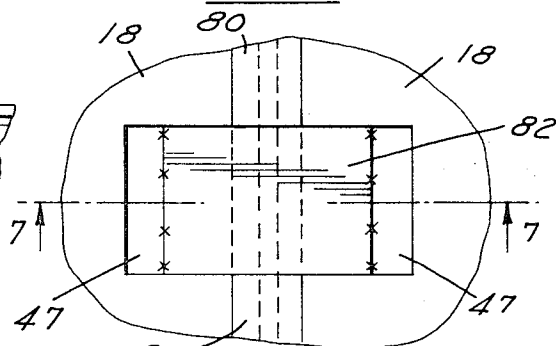
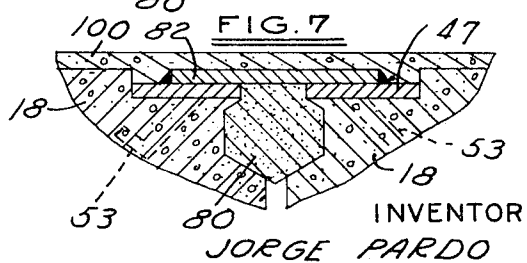
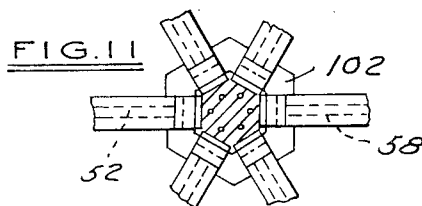
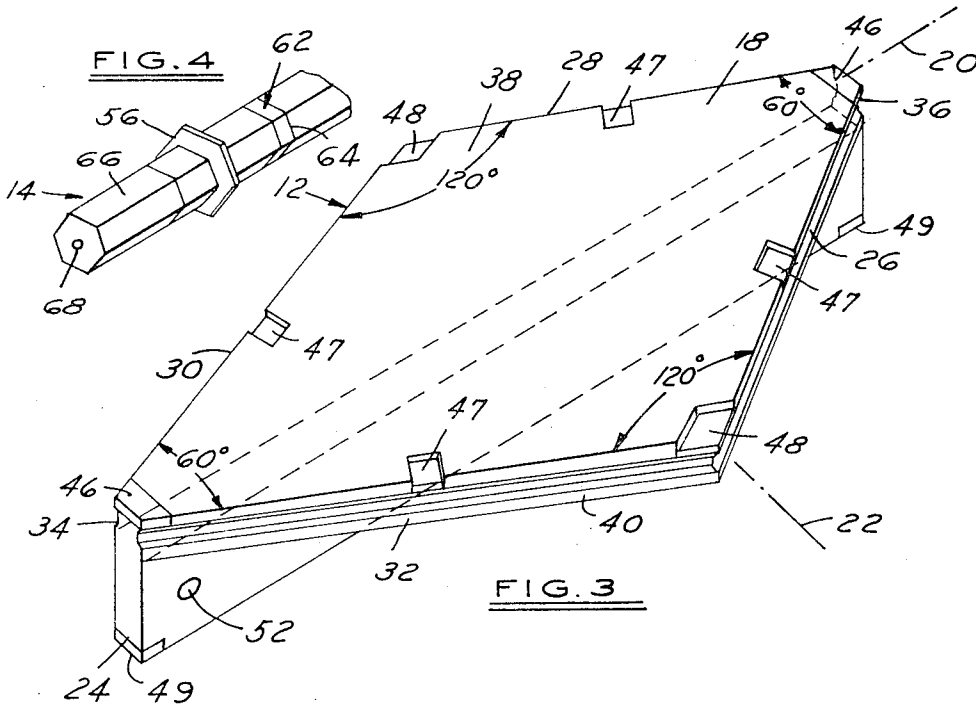
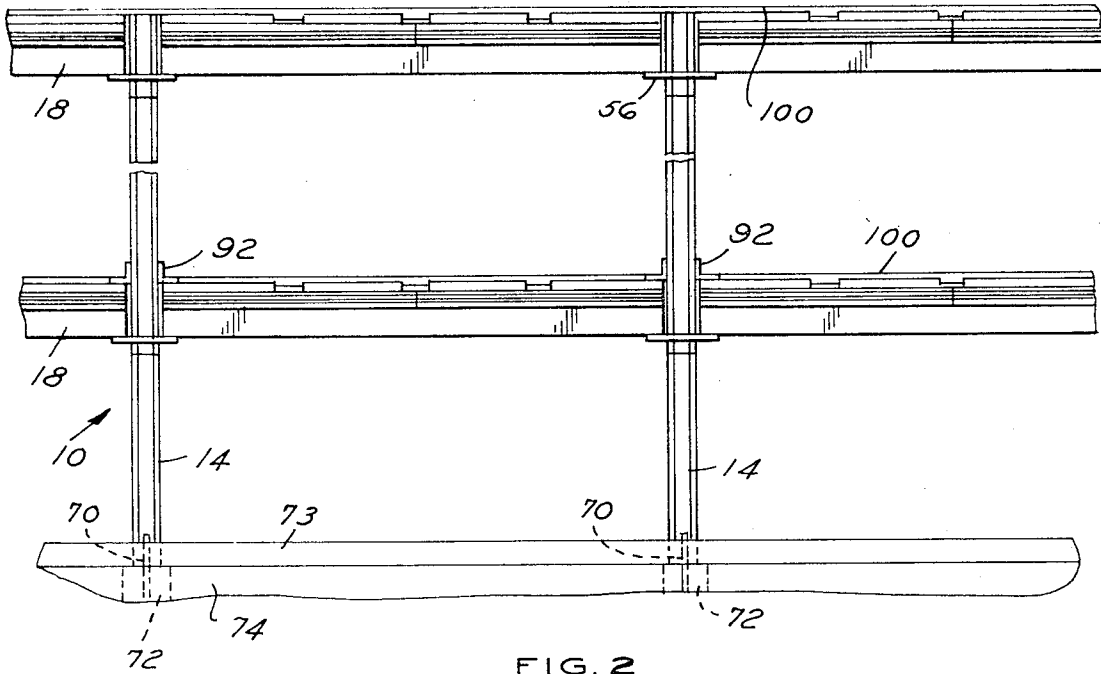


FIG. 7



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FIG. 8

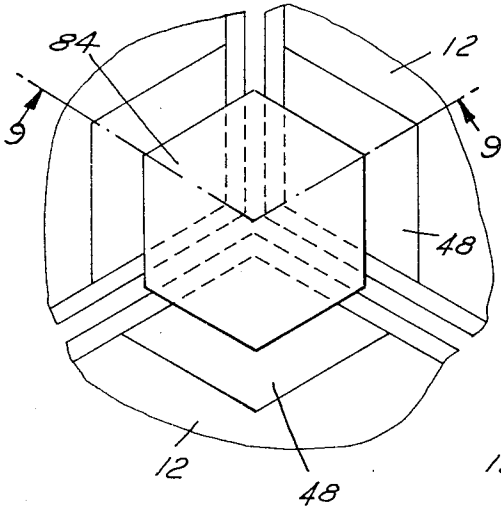


FIG. 12

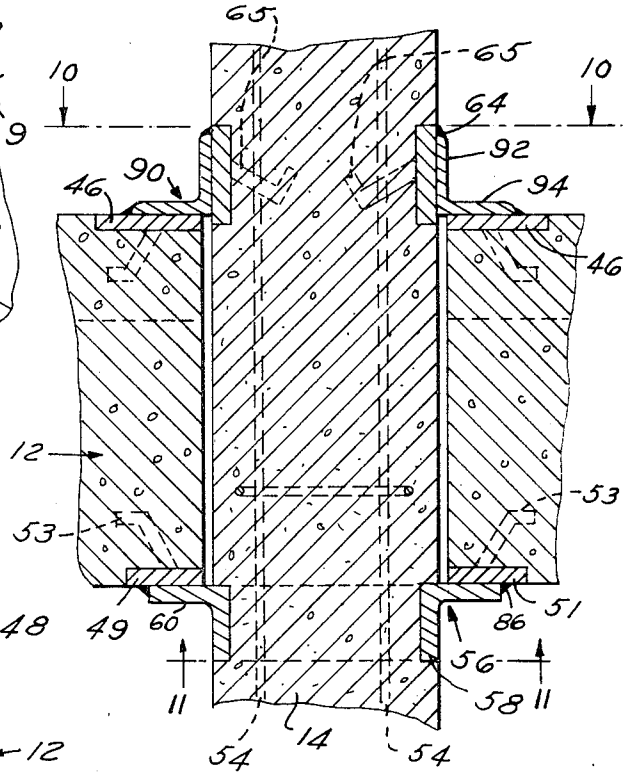


FIG. 9

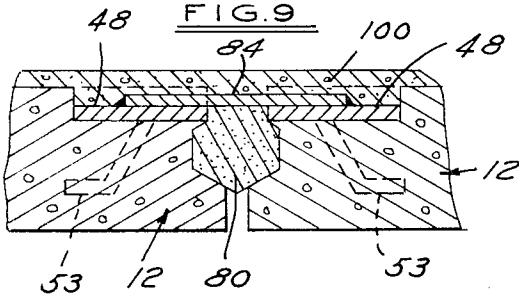
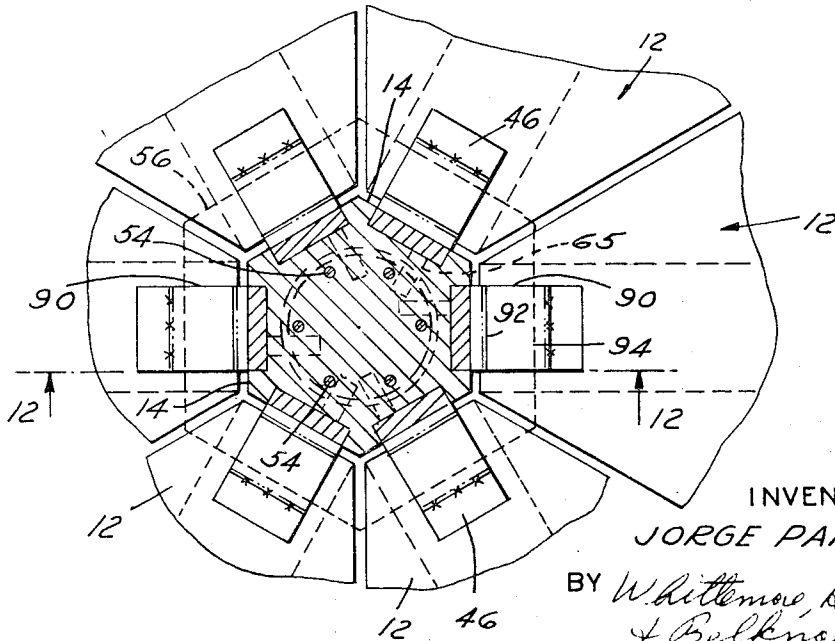


FIG. 10



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BINARY PRECAST CONCRETE TRIANGULATED BUILDING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The construction industry is in the midst of a process of re-evaluation and re-discovery and can be described or defined as being a collection of trades bypassed by the so-called "industrial revolution" at the beginning of the century. The construction industry only recently adopted or attempted to adopt the mass production techniques already familiar in the manufacture of many consumer-oriented products. The principal factor for the delayed industrialization of a heretofore medieval-in-approach building situation has been the population increase and the inability of conventional construction to provide housing at such an unprecedented rate. In Europe, the crisis arrived earlier than in the United States, as a result of the large devastation caused by two world wars; and as a result, volume production and standardization have been developed to a far greater degree than in the United States.

In the construction industry, two different structural systems are in use: (a) post & beam; and (b) bearing panels. Each of these systems has innumerable variations according to degree of fabrication, materials used and country of origin. All variations, in turn are based on rectangular modules, which is another way of expressing the fact that all their angles are 90°. Post & beam systems, whether steel or concrete, necessitate floor (roof) diaphragms for their realization. Panel systems include floor elements, but their "deck-of-cards" assembly makes them prone to failures such as the "Ronan Point" disaster in England; while limiting their vertical scope.

It is the general practice in the construction industry that the floor and ceiling of a building structure be constructed of building elements in the shape of flat, rectangular bodies which have been prefabricated by moulding and which are joined together in situ to form said floor and ceiling. The conventional shape of the building element limits the scope of design of the structure and frequently makes it impossible to adapt the structure to the landscape or other environment, with the result that aesthetic considerations must be foregone. Furthermore, the handling on the building site of the conventional building element requires a large labor force, use of large mechanical lifting appliances, scaffolding, and wooden framework.

The present invention reduces the labor force required to handle the building elements for erection of building structures; eliminates the intrinsic disadvantages of prior art systems; and provides a greater flexibility of design of such structures than has been achieved heretofore with conventional building elements, particularly with regard to subsequent vertical extension causing minimum inconvenience to the occupants of the building, and the provision of a wide variety of shapes for the building structure.

2. Description of the Prior Art.

The Hamill U.S. Pat. No. 3,500,601 of March 17, 1970, the Camoletti et al U.S. Pat. No. 3,363,370 of Jan. 16, 1968, the Deam U.S. Pat. No. 2,959,256 of Nov. 8, 1960, and the Deam U.S. Pat. No. 2,922,299 of Jan. 26, 1960 each discloses a prefabricated building structure as does the present invention; however the building structure disclosed herein is structurally dis-

similar from the prior art building structures in the geometrical shape of the T-shaped building elements and columns employed and in the manner in which the components are assembled. The Hirschthal U.S. Pat. No. 1,301,561 of Apr. 22, 1919, the Moore U.S. Pat. No. 1,376,152 of Apr. 26, 1921, the Winston U.S. Pat. No. 1,745,880 of Feb. 4, 1930, the Henderson U.S. Pat. No. 2,569,669 of Oct. 2, 1951 and the Richmond U.S. Pat. No. 3,239,913 of Mar. 15, 1966 each relate generally to component parts of building structures through being structurally dissimilar from the present invention.

SUMMARY OF THE INVENTION

The present invention relates to a structural framing system utilizing precast concrete steel reinforced T-shaped building elements and precast concrete steel reinforced hexagonal shaped columns. Each T-shaped building element comprises a diamond shaped slab and an integral beam extending along the major axis of the slab on the under side thereof. With such a construction the slab includes four sides of equal length, with the two 60° corners being located on the major axis of the slab and the two 120° corners being located on the minor axis of the slab.

The prefabricated T-shaped building elements are provided during the manufacture thereof with insert plates at the four corners thereof and with at least one insert plate along the edge of each side of the slab intermediate the corners. The insert plates are provided with anchoring rods which are embedded in the slab during fabrication. Moment connectors or elements are welded to the insert plates in the field between adjacent slabs and between the T-shaped building elements and columns to provide a strong framework capable of withstanding the conditions of load.

Each precast concrete steel hexagonal shaped column is provided with a plurality of vertically spaced annular shelves. Each shelf includes a rim portion extending laterally from the column and upon which an end of a T-shaped beam rests. Each shelf is adapted to support the ends of six adjacent T-shaped building units. Each column is further provided with a plurality of annular bands corresponding in number to the number of shelves. Each band consists of an insert plate embedded in each side of the six sided column during the fabrication of the column. Moment connecting plates are welded to the column insert plates in the field during the erection of the framework of the building structure.

A purpose of the present invention is to standardize the T-shaped building elements and hexagonal shaped columns thus permitting such units to be mass produced so as to reduce costs, obtain a superior structure at a permissible cost and to further obtain uniformity of construction.

A further purpose of the present invention is to provide a prefabricated building structure wherein a plurality of the T-shaped building elements are arranged in a unit to form a floor, ceiling or roof and a plurality of such units are vertically aligned and spaced apart by means of the precast concrete reinforced columns.

Another purpose is to provide a structural framing system of such configuration that it contains inherent fabrication, erection, cost and engineering advantages over conventional systems of comparable range and performance.

The binary triangulated system of the present invention is an open system in the sense that it can accom-

moderate elements from other systems for its walls and finish; while avoiding the excessive weight and area of bearing walls. The geometry of the system is such that floor layout and facade variations equal in number snowflake configurations. Dimensions of system members are calibrated to make full utilization of existing building material and to accommodate virtually any type of available curtain wall. Construction of the T-shaped building elements and columns allows rapid set-up construction by local precasters without requiring the expensive, elaborate equipment and locale required by paneled systems.

IN THE DRAWINGS

FIG. 1 is a fragmentary plan view of a typical floor or roof of the framework of the building structure;

FIG. 2 is a fragmentary elevational view of the framework of the building structure;

FIG. 3 is a perspective view of the precast T-shaped building element;

FIG. 4 is a perspective view of the precast hexagonal shaped column.

FIG. 5 is a sectional view, with parts broken away, showing a T-shaped building element taken on the line 5-5 of FIG. 1.

FIG. 6 is an enlarged view of part of FIG. 1, illustrating a typical moment connection between a pair of adjacent slabs;

FIG. 7 is a sectional view of a typical moment connection taken on the line 7-7 of FIG. 6;

FIG. 8 is an enlarged view of part of FIG. 1, illustrating a typical moment connection between the 120° corners of three adjacent slabs;

FIG. 9 is a sectional view taken on the line 9-9 of FIG. 8;

FIG. 10 is an enlarged sectional view through a column taken on the line 10-10 of FIG. 12 and showing the six moment connector plates between the slabs and column;

FIG. 11 is a sectional view through a column taken on the line 11-11 of FIG. 12 and showing the bottom view of the T-shaped building elements and the utility voids therein; and

FIG. 12 is a vertical sectional view through the column and building elements, taken on the line 12-12 of FIG. 10.

Referring now to the drawings, FIGS. 1 and 2 illustrate the framework of a building structure 10 which uses a plurality of identical precast concrete steel reinforced T-shaped building elements 12 and a plurality of identical precast concrete steel reinforced hexagonal shaped columns 15. The T-shaped building elements 12 are arranged in side by side relationship, as shown in FIG. 1, to form a plurality of building units 16 for each floor and roof of a one or multistory building structure. The T-shaped building elements or units 12 are joined together to form the floors, ceilings and roof of the building structure. The building units 16 for each floor 18 are aligned vertically and spaced apart, as shown in FIG. 2, and together with the structural supporting columns 14 aforesaid provide the framework for the building structure 10.

FIG. 3 illustrates a typical T-shaped building element 12 which comprises a diamond shaped slab 18 having a major axis 20 and a minor axis 22 and an integral concrete beam 24 extending along the major axis 20 of the slab 18 on the under side thereof. The four sides 26, 28,

30 and 32 of the diamond shaped slab 18 are equal in length, with the sides being so arranged as to provide two corners of 120° each, arranged on the minor axis 22 of the slab 18, and two corners of 60° each, arranged on the major axis 20 of the slab 18. The intersections of the sides 28, 30 and 26, 32 of the slab 18 defining the 120° corners are sharp or pointed, while the intersections of the sides 30, 32 and 26, 28 defining the 60° corners are formed flat as best illustrated in FIG. 3 to provide end surfaces 34, 36 each having a width approximately equal to the width of the beam 24. The slab 18 has a flat generally smooth upper surface 38 and a flat generally smooth lower surface 40.

The concrete building element 12 is prefabricated in the factory. The pressure-vacuum extraction method of casting may be employed as an alternative to the conventional type of metal framework usually employed. As best illustrated in FIG. 5, the slab 18 and beam 24 of the T-shaped building element 12 are reinforced with steel rods 42 and 44 respectively. The concrete slab 18 may also be reinforced with steel mesh, glass fiber or matting, or synthetic fibers or matting, as is conventional in the art. The beam 24 of the T-shaped building element 12 may be manufactured from conventional reinforced concrete, as illustrated in FIG. 5 by rods 44 or the beam 24 may be made by methods utilizing prestressed concrete or post tension concrete as is well known in the art.

During the manufacture of the T-shaped building element 12 steel insert plates 46 are embedded in the upper surface of the concrete slab 18 at the 60° corners as shown in FIG. 3 with the upper surface of plates 46 flush with the upper slab surface 38. Steel insert plates 48 are embedded in the upper surface of the slab at the 120° corners as shown in FIG. 3 with the upper surfaces of plates 48 recessed inwardly from surface 38. Each of the sides or edges of slab 18 is provided with a steel insert plate 47 intermediate the corners. The top surfaces of plates 47 are recessed inwardly from surface 38 of the slab 18. The lower surfaces of the beam 24 which rest on the annular shelf of the column 14, to be subsequently described, are provided with metal insert plates 49 and 51 (FIG. 12). The outer surfaces of insert plates 49 and 51 are flush with the bottom surface of beam 24. All of the metal insert plates 46, 47, 48, 49 and 51 embedded in the T-shaped element during the manufacture thereof are each provided with one or more anchors or reinforcing rods 53 as shown in FIGS. 7, 9 and 12 to secure the insert plates to the building element 12.

The side edges of the slab 18 are provided with an elongated groove or grout key 50 which is used for a purpose to be subsequently described. It will be noted when referring to FIG. 5 that the width of the lower rib or flange of the groove 50 is greater than the width of the upper rib or flange.

Each T-shaped building element 12 is provided with a utility void or a cast-in aperture 52 (FIGS. 3, 5 and 11) which extends substantially the entire length of the beam 24 and has right angled ends thereof opening through the side walls of the beam 24 as best illustrated in FIGS. 3 and 11. Electrical or other utility type conduits or elements, not shown, may be inserted into the voids 52 of the T-shaped building elements 12 after the erection of the building structure 10. Thus, the T-shaped building element 12 is designed to provide a comprehensive conglomerate system which includes

structural, architectural, electrical and mechanical functions.

The building structure 10 further includes standardized precast vertical support members or columns 14 each in the form of a hexagonal shaped precast concrete steel reinforced elongated member. The column 14 may be manufactured by utilizing conventional types of metal formwork or by other commercially known methods of casting. The concrete column 14 includes a plurality of reinforcing rods 54. In addition, the column 14 includes one or more annular shelves 56 of hexagonal configuration corresponding in number to the number of floors in the building structure 10. The shelf 56 consists of a vertically extending annular portion 58 which is embedded in the concrete, as illustrated in FIG. 12, and of a laterally extending annular rim portion 60, perpendicular to the vertical portion 58, which extends laterally from the column 14 as best illustrated in FIG. 12. The ends of the T-shaped building elements 12 on the major axes thereof, which are provided with the metal insert plates 49 and 51, rest upon the shelves 56 as shown in FIG. 12.

Spaced vertically upward from each annular shelf 56 is an annular band 62 of metal inserts or plates 64, one insert 64 for each side 66 of the hexagonal shaped column 14 as shown in FIG. 4. Each insert plate 64 is provided with one or more anchors or reinforcing rods 65, as shown in FIG. 12, to secure the insert plates 64 to the column 14. The outer surfaces of the metal inserts 64 are flush with the outer surface of the column 14 as best illustrated in FIG. 12. Thus each shelf 56 has a corresponding metal band 62.

The lower end of the column 14 during the manufacture thereof is provided with an internally threaded insert 68 which is adapted to be connected to an anchor bolt 70 provided in the site poured concrete footings 72 of the foundation 74 of the building structure 10 as best illustrated in FIG. 2.

In erecting the building structure 10, the anchor bolts 70 and other structural steel members, not shown, are placed in the foundation. The bolts 70 are located at a predetermined column spacing, there being one anchor bolt 70 for each column 14. The concrete foundation 74 and footings 72 are poured in a conventional manner well known in the art. After the concrete has set the vertically extending precast columns 14 are appropriately secured to the anchor bolts 70 as shown in FIG. 2. As an example, the columns 14 are arranged in horizontally and vertically extending rows as shown in the plan view in FIG. 1. With such a construction it should be noted that three adjacent columns are located at the apexes of a triangle. The first floor 73 is then superimposed over the foundation 74. The first floor 73 may be concrete or made from prefabricated building elements.

Once the vertically extending columns 14 have been erected and appropriately anchored, the second floor of the building structure 10 is installed, with each T-shaped building element 12 having the ends of the beam 24 supported on the annular shelves 56 of adjacent columns 14. Once the plurality of T-shaped building elements 12 have been appropriately installed on the columns 14 to form the second floor of the building structure 10, it is necessary to field weld the slabs 18 and columns 14 together to form moment connections. Thereafter, it is necessary to place or insert concrete

grouting 80 in the grout key 50 formed by the side edges of adjacent slabs 18.

A moment connector plate 82 is placed over opposing insert plates 47 of adjacent slabs 18 and then is field welded on the ends thereof to the insert plates 47 as illustrated in FIGS. 6 and 7. As illustrated in FIG. 1 the inner T-shaped building elements 12 will have four moment connector plates 82 securing one slab 18 to the four adjacent slabs 18.

A hexagonal shaped moment connector plate 84, illustrated in FIGS. 8 and 9, is placed over opposing insert plates 48 of three adjacent slabs 18 and is then field welded on the edges thereof the insert plates 48. FIG. 1 illustrates typical moment connector 84 on the minor axes 22 of slabs 18.

In addition, moment connections are also provided at each column 14 as illustrated in FIGS. 10 and 12. The annular shelf 56 is welded at 86 throughout the periphery thereof to the insert plates 49 and 51 provided on the bottom side of the beams 24 of the T-shaped building elements 12. In addition, angle shaped moment connectors 90 are provided each having a vertical web 92 and a horizontal web 94. One moment connector 90 is provided for each end of the slab on the major axis 20. The horizontal web 94 is welded to the metal insert 46 provided in the slab 18 while the vertical flange or web 92 is welded to the corresponding metal insert plate 46 located in the column 14. As shown in FIG. 10, the column 14 supports the ends of six T-shaped building elements 12 and six angle shaped moment connectors 90 tie the elements 12 to the column 14.

After the second floor of the building structure 10 is constructed in the manner described heretofore the process is continued up to the highest part of the building structure 10 where the last floor simultaneously forms the roof part of the structure.

The construction of the walls and facing of the building structure 10 may be effected in any conventional manner, and the invention is not concerned with this aspect of the building structure. In addition to the unlimited possibilities of extending the construction horizontally in all directions, the prefabricated building elements 12 and columns 14 according to the invention allow a similar development in height. The T-shaped building elements provide for added flexibility of plan shape layout in the overall building structure.

If it is necessary at a later date to disassemble the structure 10, the floors and roof can simply be removed after first removing the various connector plates aforesaid and the grout keys 80. Thereafter the slab units 12 can be lifted by a crane and treated as interchangeable units to be employed in a new building.

Once the building elements 12 have been installed and the plurality of moment connections field welded in place to complete the floor, a cement field topping 100 is placed on the slabs 18 to cover same including the various connector plates as shown in FIGS. 2, 7 and 9.

Once the floors and roof of the building structure 10 have been completed, the walls and facing are installed. The air and electrical conduits may then be installed in the beams 24 via the utility voids 52. Thereafter asbestos cement may be applied between the webs or sides of the beams 24 as shown in FIG. 11 to form a typical utility connecting closure 102.

It will further be evident that the columns 14 and building elements 12 will desirably be produced under

mass production conditions, and merely shipped to the location of use. However, if the job is large enough to warrant it, the columns 14 and building elements 12 can be produced on the job.

What I claim as my invention is:

1. A building structure comprising a plurality of building units which are vertically aligned and spaced apart by means of vertical columns, each building unit comprising at least three substantially identical T-shaped building elements, each element having a diamond shaped slab provided with a smooth upper surface and a lower surface and an integral beam engaging and arranged perpendicular to the lower surface of the slab, each slab having four sides of equal length arranged to form two oppositely facing angles of 60° on a major axis of the slab and two oppositely facing angles of 120° on the minor axis of the slab, the integral beam of each T-shaped building element extending along the major axis thereof, said T-shaped building elements being joined together, with each slab having one of its sides opposite and in close proximity to a side of one of the remaining slabs and each slab having a second side which intersects said one side opposite and in close proximity to a side of another of the remaining slabs, said vertical columns engaging the ends of the T-shaped building elements along the major axes thereof of each of said building units.

2. The building structure of claim 1 wherein said columns are of hexagonal cross section.

3. The building structure of claim 1 wherein said columns are precast and are of concrete reinforced with steel reinforcing elements.

4. The building structure of claim 3 wherein vertically spaced annular shelves are precast with each column, the ends of each building element on the major axis thereof being supported by the shelves on said columns.

5. The building structure of claim 4 wherein each of

said annular shelves is provided with anchoring rod means embedded in the corresponding concrete column.

6. The building structure of claim 1 wherein the 60° corners of each of said slabs are provided with insert plates embedded in the upper surface of the slab, and a moment connector plate spanning the insert plates of adjacent slabs and being welded thereto.

7. The building structure of claim 1 wherein at least one insert plate is embedded in the upper surface of the slab along the edge of each side thereof intermediate said corners, and moment connector plates spanning the sides of adjacent slabs and being welded to the corresponding insert plates.

8. The building structure of claim 7 wherein the four corners of each of said slabs are provided with insert plates embedded in the upper surface of the slab, first moment connector means spanning the insert plates on the minor axes of adjacent slabs and being welded thereto, and second moment connector means welded between the insert plates on the major axes of adjacent slabs and steel elements embedded in said columns.

9. The building structure of claim 8 wherein vertically spaced annular shelves are precast with each column, the ends of each building element on the major axis thereof being supported by the shelves on said columns.

10. The building structure of claim 9 wherein all of said insert plates are provided with anchoring rods embedded in the corresponding slab.

11. The building structure of claim 1 wherein the 120° corners of each of said slabs are provided with insert plates embedded in the upper surface of the slab, and moment connector plates welded between said insert plates and steel elements embedded in said columns.

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