ABSTRACT OF THE DISCLOSURE

A modular building system which utilizes a plurality of column supported, preformed box-shaped modular units, which are cast as a single unit, adapted for interconnected assembly, and include a factory installation of all kitchens, bathrooms, closets, interior partitions, stairs needed for the proper functioning of the enclosed spaces.

The modular units are stacked in a predetermined manner to form a variety of efficient, easily planned multi-level residential buildings which maximize the advantages of both overlapped and staggered modular assembly.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to multi-level residential buildings of modular design and more particularly to buildings formed of factory produced box-shaped modular units which are stacked in a predetermined manner in order to maximize the advantages of both overlapped and staggered modular assembly.

Description of the prior art

The advantages of constructing multi-level buildings from factory produced modular units has long been recognized. Quality control, speed of erection, and lower material and labor costs can be obtained when mass produced industrialized techniques are used in place of conventional construction procedures.

However, while these advantages have been achieved in the prior art applications of stacked box-shaped modules, many disadvantages have become apparent concerning the size and weight of these modules, the transportation to the building site, the method of stacking, and how efficiently they satisfy the planning and functional requirements of the multi-level buildings they form.

In particular, when these modules are stacked adjacent to and over other modules, the disadvantages of wall and floor duplication are quickly apparent.

When these modules are stacked in staggered or checkerboard relationship to other modules, as in U.S. Pats. No. 3,430,398 and No. 3,503,170, the purpose is to avoid the duplication of floor and walls and to employ the least number of individual units in forming a building. The results, and the disadvantage however, is that the overall length of these modules is equal to the overall width of the building it forms. When used for the conventional double loaded corridor type building, these modules are excessive in size and weight and therefore increase the factory, transportation, and erection costs.

In addition, any cost savings gained by installing all utilities in the constructed modules at the factory are limited by the nature of the staggered placement of the modules which restricts the normal economies to be gained when kitchens and bathrooms are grouped together and share a common mechanical shaft.

Also, the staggered placement of the modules as in Pat. No. 3,503,170 predetermines the location of the vertical mechanical shafts and therefore makes apartment planning inflexible, with bathrooms and kitchens following a set location and living areas of one apartment being located over bedrooms of a lower apartment. Further, the interior partitions, fixtures, closets, and stairs that are located between the modules must be field installed without the benefits of factory cost and quality control procedures.

OBJECTS

In view of the above indicated and other important deficiencies of the prior art constructions, it is a primary object of the present invention to provide a novel, economical, and improved building system comprised of a plurality of factory produced box-shaped modules.

Another object is to provide a modular system which allows the length of its modules to be less than the width of the building they form and therefore permits these modules to be more easily fabricated, transported and stacked.

A further object is to provide a modular system that reduces costly field work by allowing all bathroom and kitchen utilities, stairs, closets, interior partitions to be installed and finished in the constructed modules at the factory.

A further object is to provide a modular system in which the modular units are, in width, acceptable for over-the-highway transportation, and in length, always less than the forty (40') foot maximum limit for conventional trucking.

A further object is to provide a modular system which allows full apartment plan flexibility, since there is no constriction of mechanical shaft size or location.

A further object is to provide a modular system which reduces the cost of construction by allowing kitchens and bathrooms to be grouped together and share common vertically matched mechanical shafts.

A further object is to provide a modular system which avoids locating living-room areas over bedrooms and therefore eliminates the need for expensive soundproofing.

A further object is to provide a modular system which can adjust to a wide variety of building types in which the modules alone form the support structure during erection and in the final building.

Other objects, advantages, and applications of the present invention will be made apparent by the following detailed description of the invention.

SUMMARY OF THE INVENTION

Briefly, the foregoing objects are accomplished by employing a plurality of column supported box-shaped modular units which are preformed in two stages with side walls, columns, roof slab and beams being cast first as a partial unit and then cast to a floor slab to form a single unitary modular unit.

These modular units include a factory installation of all kitchen and bathroom utilities, closets, interior partitions and stairs needed for the proper functioning of the enclosed public and private spaces.

The units are always less than the width of the building they form and when shipped from factory to building site
are acceptable for over-the-highway transportation with lengths less than the forty (40') foot maximum for conventional trucking.

In forming a building structure these modular units are placed on a concrete foundation in a "partial by-pass" relationship to adjacent and similar units on the same level, and are stacked in a "partial overlap" and "partial staggered" relationship to similar units on the adjacent lower and upper levels. The "partial by-pass" and "partial overlap" would occur in an interior area or zone of the building structure where kitchens, bathrooms, closets, interior corridors and stairs are located. This allows mechanical shafts to be freely located with substantial cost savings since apartments can be flexibly planned with kitchen and bathroom utilities grouped on both sides of a common vertically matched mechanical shaft.

The "partial staggered" areas would occur in the outward or perimeter side areas of the building structure where the open habitable spaces are located and therefore obtain the advantages of spaces created in which the walls, floors, and ceilings are formed from adjacent modular units.

Any additional material costs developed by this system in the "partial overlap" and "partial by-pass" areas would be easily offset by the economies gained in the workability of a shortened module, efficient apartment planning and reduced field labor.

These modular units are structurally related to each other by support columns which are cast with the side walls of the unit. In the area of the "partial overlap" units, a plurality of vertically aligned interior columns permits the stacking of one modular unit directly over a lower and adjacent unit. In the area of the "partial staggered" units, two (2) exterior perimeter columns of the upper level unit stack directly over the corner exterior perimeter columns of the adjacent units on the lower level.

All columns are vertically aligned from one level to another by means of bearing plates with alignment prongs. These prongs are inserted into preformed sleeves which are cast into the upper and lower bearing surfaces of the support columns.

The interior columns of adjacent modules are horizontally aligned and tied to each other by the same bearing plates which are double-width to interlock the adjacent pair of interior columns and act as shear plates for the "partial by-pass" and "partial overlap" area of the building structure.

In the event of the building structure being located in a high earthquake zone, the vertically aligned exterior perimeter columns would be post-tensioned from the uppermost unit level to the foundation structure by either bolting each perimeter column to its lower level perimeter column or by continuous tension rods placed in sleeves cast within each perimeter column.

In addition, the system permits the floors of the formed building structure to be level and contiguous by means of depressed roof slabs in the area of the "partial overlap" units, and recessed perimeter column bearing seats in the area of the "partial staggered" units.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a perspective diagrammatic view of the preformed A modular units and sub-components of the modular building system in accordance with the present invention.

FIG. 2 is a transverse diagrammatic sectional view along line 2-2 in FIG. 1 showing the relationship of three (3) vertically stacked preformed A modular units.

FIG. 3 is a part plan of a motel or dormitory type building with exterior corridors utilizing "A" modular units.

FIG. 4 is a diagrammatic sectional view along line 4-4 in FIG. 3 showing the vertical relationship of the A modular units.

FIG. 5 is a diagrammatic sectional view along line 5-5 in FIG. 3 showing the vertical relationship of the A modular units.

FIG. 6 is a part plan of the lower duplex level of a residential type building with exterior corridors utilizing A modular units.

FIG. 7 is a part plan of the upper duplex level of the residential type building in FIG. 6 utilizing A modular units.

FIG. 8 is a part plan of a residential type building with a double loaded interior corridor utilizing A modular units.

FIG. 9 is a part plan of a residential type building with a double loaded interior corridor utilizing B and C modular units.

FIG. 10 is a transverse diagrammatic sectional view along line 10-10 in FIG. 9 showing the relationship of three (3) vertically stacked preformed B modular units.

FIG. 11 is a transverse diagrammatic sectional view along line 11-11 in FIG. 9 showing the relationship of three (3) vertically stacked preformed C modular units.

FIG. 12 is a part of one half of a residential type building with a double loaded interior corridor utilizing A modular units.

FIG. 13 is a vertical section detail view along line 13-13 in FIG. 3 showing the vertical alignment of the interior columns of four (4) modular units in the area of the partial by-pass and partial overlap.

FIG. 14 is a vertical section detail view along line 14-14 in FIG. 3 showing the vertical alignment of the exterior perimeter columns of two (2) modules in the area of the partially staggered units.

FIG. 15 is a perspective diagrammatic view of a prefabricated modular unit in accordance with the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to the drawings wherein similar characters of reference represent corresponding parts in each of the several views and cross diagonal lines are used in the drawn plan and part plan views to differentiate the horizontally interconnected modular units:

Referring to FIG. 1, a perspective diagrammatic view is shown of the preferred relationship of the performed A modular units to each other when they are stacked to form a building structure. In this relationship the A modules moving in either direction partially by-pass other A modules on the same level moving in the opposite direction. Further, the A modules of upper levels are placed in a partially overlapped and partially staggered relationship to A modules on the lower and adjacent level. In the areas where these modules are partially staggered, spaces 10 are created in which the walls, floors and ceilings are formed from adjacent A modules.

FIG. 1 also shows the field installed roof 11, side wall 12 and end wall 13 sub-components which are required to enclose the perimeter of the building structure at the points of the created spaces 10. The end wall enclosure panel required to enclose the habitable space of the A modular unit is not shown here and would be factory installed in the constructed module. The side wall sub-components 12 are located at the ends of the building structure and are positioned with A modules of the same level to allow the placement of the first and last A modular units of the upper and adjacent level.

Referring to FIG. 2, a transverse diagrammatic sectional view is shown indicating the vertical alignment of the preformed A modular units when they are stacked to form a building structure as in FIG. 1. In this vertical alignment the A modules partially overlap each other at the central part of the formed building. Shown, also, is the depressed roof slab 14 formed in each A module.
at the area of the partial overlap and approximately equal in depth to the thickness of the floor slab. This depressed area allows the floor of the created space 10 between modules to have a level and contiguous floor alignment to adjacent A modules.

Referring now to FIG. 3, a part plan of a modular or dormitory type building is shown indicating the horizontal alignment of the preformed A modular units and the functional use of the building they form. Shown, also, is the plan location of the support columns which are cast with the side walls of the modular unit and transmit the reaction of the module to the columns of the adjacent A modules on the level below.

The partial by-pass of the A modules on the same level is shown and the location of the vertically aligned interior columns 22, 23, 24, 25 which frame and define the area of the partial unit overlap. Shown, also, in FIG. 3 are the vertically aligned perimeter columns 20, 21 in the partially staggered unit areas. These perimeter columns 20, 21 are cast so that their center-line is slightly to the outside of the outside face of the side wall of the modular unit. This permits the floor corner of the upper unit to slightly by-pass the roof corner of the adjacent units in the partially staggered unit area. (See FIG. 4.) The perimeter columns 20, 21 are stacked directly over and are vertically aligned with the adjacent and lower corner columns of the units below. These perimeter columns 20, 21 have recessed column bearing seats 44 of a combined depth approximately equal to the thickness of the floor slab and along with the depressed roof area 14 noted in FIG. 2 allow the units to have a level and contiguous floor alignment with the floor of the areas created 10 by the staggered units. (See FIG. 14.)

FIG. 3 shows the functional grouping of the factory installed bathroom utilities 16, 17, in-unit mechanical shafts 19, closets 18 and interior partitions needed for the proper functioning of the apartments they comprise in the area of the partial unit overlap.

This allows the efficient planning of plumbing utilities with a shared freely located mechanical shaft 19 and the factory installation of substantially all interior work needed for the apartment spaces.

In this particular design the access to the apartment would be from an outside corridor 26, which is cast as a cantilever slab with the floor and roof of the modular units, and would connect with an exterior placed stair and/or elevator facility.

Referring to FIG. 4 and FIG. 5. Both embodiments are diagrammatical sectional views taken along lines 4—4 and 5—5 in FIG. 3. FIG. 4 shows the vertical relationship of the preformed A modular units in the area of the partially staggered modules. FIG. 5 shows the vertical relationship of the preformed A modular units in the area of the partially by-passed and partially overlapped modules.

Referring to FIG. 6 and FIG. 7. FIG. 6 is a part plan of the lower or entrance level of a duplex apartment that would be located in a multi-level duplex type residential building. Access to the apartment would be from an outside corridor 26 similar to the corridor in FIG. 3. FIG. 7 indicates the part plan of the upper or bedroom level. Shown here is the method of incorporating the factory installed stairs 27, kitchens 28, bathrooms 29, closets 18 in the partial by-pass and partial overlap areas.

Referring now to FIG. 8, a part plan of a one-bedroom type apartment building is shown using the similar horizontally aligned A modules. This plan indicates the method of incorporating the interior public double loaded corridor 30 within the areas of the partial unit overlap.

In this particular design, kitchens 28 and bathrooms 29 are grouped in the same unit overlap area and share common vertically aligned mechanical shafts 31 which are located between the modular units. In the erection sequence those plumbing utilities which are in separate units would be connected to each other in the field through access panels in the side walls once the units are positioned.

Since the public corridor 30 is included in the cast module, all of the corridor partitions, fixtures, doors, finishes and light can be factory installed along with all interior work needed for the proper functioning of the adjacent one-bedroom apartments.

The circulation along the public corridor 30 and within the apartment would be provided by openings in the side walls of the cast modules which are achieved by blocking out that portion of the mold prior to casting. Structural framing around such openings could be achieved in any number of ways and apparent to those skilled in the art.

Shown, also, in FIGS. 3, 6, 7, and 8 are the field installed end wall sub-components 13 which enclose the perimeter of the building at the points of the created spaces 10.

Referring now to FIG. 9, a part plan of another one-bedroom double loaded corridor type apartment building is shown, comprised of types B and C preformed modular units, and includes the mechanical utility areas of these modules and the functional use of the building they form. FIG. 9 also shows a variation on the location of the vertically aligned interior columns 32, 33, 34, 35 which frame and define only the area of an interior public corridor 30. Most likely, on the outside perimeter of these modular units only at the area where the interior public corridor 30 is located. Module B is similar to Module A in its overlap of the lower and adjacent unit, but its vertically aligned interior columns 32, 33, 34, 35 move closer together and frame and define only the area where the interior public corridor is located 30. This is done since this particular design does not require any utilities, partitions or closets in Module C beyond the public corridor enclosure. Also, the horizontal column alignment and interlock connection of the bearing plates (see FIG. 13) is needed for the structural continuity of the internal partial by-pass areas of the building structure.

Referring now to FIG. 10 and FIG. 11. Both embodiments are transverse diagrammatical sectional views taken along lines 10—10 and 11—11 in FIG. 9. Module B is shown in FIG. 10 and indicates the degree of the partially overlapped unit area and the center-line location of the interior columns 34, 35, and 32, 33. Module C is shown in FIG. 11 and indicates the degree of the partially overlapped unit area and the center-line location of the interior columns 34, 35, and 32, 33.

Referring now to FIG. 12, a plan is shown which represents one half of an apartment building consisting of one 0 bedroom, 1 bedroom, and 2 bedroom apartments. FIG. 12 illustrates the method of planning a typical apartment building of A modules which incorporates interior public areas for corridor 30, stairs 36, elevators 37, and other spaces needed for the proper functioning of the building structure. Module A—1 incorporates the elevator 37 and incinerator 38 and space 38, while Module A—8 incorporates the public fire stair 36. The floor and ceiling openings in the cast module needed for these facilities would be achieved by blocking out that portion of the mold prior to casting. Module A—9 indicates the method of utilizing the space that would have been given to the public corridor 30, but now is used for bathroom utilities 29 sharing a common in-unit mechanical shaft 19. The side wall sub-component 12 is shown in this plan and indicates its function in enclosing the end building created space 10 and the support position it takes to allow the placement of the partially staggered A module on the upper level.

Referring now to FIG. 13, a vertical section detail view along line 13—13 in FIG. 3 is shown and indicates the vertical column alignment of the four (4) modular units in the area of the partial by-pass and partial overlap. The
double-width steel bearing plates 39 with alignment prongs 40 and the preformed sleeves 41 are shown and these indicate the method by which the modular units are adapted for interconnected assembly and vertically aligned to each other. Shown, also, are the neoprene pads 42 and grout filler 43 which is poured in by means of grout holes not shown.

Referring now to FIG. 14, a vertical section detail view along line 14—14 in FIG. 3 is shown, and it indicates the vertical column alignment of the two (2) modular units in the area of the partially staggered units. In addition to the alignment method shown in FIG. 13, this detail illustrates the recessed column bearing seats 44 which allow a level and contiguous floor alignment between the modular unit and the floor of the created space 10.

Referring now to FIG. 15, a perspective diagrammatic view of a prefabricated modular unit is shown and indicates one possibility of constructing a modular unit in accordance with the present invention from a framework of horizontal and vertical structural members 45 with enclosure and infill panels 46. FIG. 15 also shows the option of eliminating the roof of the modular unit at the area of the partial overlap with the use of tie beams 47. While the preferred embodiments of the present invention have been described, it is to be understood that various modifications can be made thereto without departing from the spirit and scope of the present invention. For example, while the invention is shown and described herein with reference to residential type buildings, it will be understood that it may be used for the construction of any type of multi-level building.

Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation. Having thus described my invention, I claim:

1. A modular building system employing a plurality of preformed box-shaped modular units, of a similar shape, adapted for interconnected assembly to form a habitable multi-level structure;
- each of said units comprising a roof, floor, side walls and columns cast as a single unit;
- said units being positioned to form a building structure in a partial by-pass relationship to similar and adjacent units on the same level, and stacked in a partial overlap and partial staggered relationship to similar units on the adjacent lower and upper levels;
- said units being vertically stacked over each other and supported by means of a plurality of vertically and horizontally aligned interior columns which frame and define the area of the partial unit overlap, and by vertically aligned exterior perimeter columns in the partially staggered unit areas;
- said columns being vertically aligned from one level to another by means of bearing plates with vertically positioned alignment prongs or shafts being inserted into vertical preformed recess sleeves which are cast into the upper and lower bearing surfaces of each column;
- said columns being horizontally aligned from one module to another by means of double-width bearing plates which interlock the common and adjacent interior columns of the horizontally placed modular units in the area of the partial by-pass;
- said units having a level and contiguous floor alignment with the floor of the area created by the staggered units, by means of a depressed roof slab in the area of the unit overlap, of a depth approximately equal to the thickness of the floor slab, and recessed column bearing seats for each exterior perimeter column of a combined depth approximately equal to the thickness of the floor slab.

2. A modular building structure in accordance with claim 1 wherein the areas of the said partial unit overlap would be comprised of the apartment kitchens, bathrooms, interior stairs, closets, storage and circulation spaces and would include a factory installation of substantially all partitions, fixtures, utilities, stairs and finishes needed for the proper functioning of said apartment spaces.

3. A modular building structure in accordance with claim 2 wherein the areas of the said partial unit overlap would be comprised, also, of space designated for an interior public corridor in a double loaded corridor type building and would include a factory installation of substantially all fixtures, partitions, and finishes needed for the proper functioning of said public space.

4. A modular building structure in accordance with claim 3 wherein the areas of the said partial unit overlap would be comprised, also, of spaces designated for interior public stairs and elevators in a double loaded corridor type building.

5. A modular building structure in accordance with claim 1 wherein the said plurality of vertically aligned interior columns frame and define only the area of an interior or public corridor of a double loaded corridor type building;
- said modular units being of two (2) types in which one unit type would overlap the similar lower and adjacent unit only at the area where the interior public corridor space is located and would include a factory installation of substantially all fixtures, partitions, and finishes needed for the proper functioning of that part of the said public space, and the other unit type would overlap the similar lower and adjacent unit at the areas in which the interior public corridor space is located and the areas comprised of the apartment kitchens, bathrooms, interior stairs, closets, storage and circulation spaces, and would include a factory installation of substantially all partitions, fixtures, utilities, stairs and finishes needed for the proper functioning of said apartment and public spaces.

6. A modular building system in accordance with claim 1 wherein the said plurality of box-shaped units of a similar shape would be prefabricated of a framework of horizontal and vertical structural members with enclosure and infill panels of a variety of materials acceptable to fireproof multi-level building construction.

7. A modular building system in accordance with claim 1 wherein the said vertically aligned exterior perimeter columns in the partially staggered unit areas would be post-tensioned from the uppermost unit level to the foundation structure by either bolting each said perimeter column to its lower level perimeter column or by continuous tension rods placed in sleeves cast vertically within each said perimeter column.

8. A modular building system employing a plurality of preformed box-shaped modular units, of a similar shape, adapted for interconnected assembly to form a habitable multi-level structure;
- each of said units comprising a roof, floor, side walls, tie beams and columns cast as a single unit;
- said units being positioned to form a building structure in a partial by-pass relationship to similar and adjacent units on the same level, and stacked in a partial overlap and partial staggered relationship to similar units on the adjacent lower and upper levels;
- said units being vertically stacked over each other and supported by means of a plurality of vertically and horizontally aligned interior columns which frame and define the area of the partial unit overlap, and by vertically aligned exterior perimeter columns in the partially staggered unit areas;
- said units being vertically stacked over each other and supported by means of a plurality of vertically and horizontally aligned interior columns which frame and define the area of the partial unit overlap, and by vertically aligned exterior perimeter columns in the partially staggered unit areas;
- said columns being vertically aligned from one level to another by means of bearing plates with vertically positioned alignment prongs or shafts being inserted
into vertical preformed recess sleeves which are cast into the upper and lower bearing surfaces of each column;
said columns being horizontally aligned from one module to another by means of double-width bearing plates which interlock the common and adjacent interior columns of the horizontally placed modular units in the area of the partial by-pass;
said units having a level and contiguous floor alignment with the floor of the areas created by the staggered units, by means of depressed tie beams in the area of the unit overlap, of a depth approximately equal to the thickness of the floor slab, and recessed column bearing seats for each exterior perimeter column, of a combined depth approximately equal to the thickness of the floor slab.