A pre-fabricated building module containing components of a typical multi-story housing project and a corresponding method of installation. Each module is configurable to provide one of a variety of room and dual-room layouts. The module's design allows for road transportation and installation by a tower crane typically found in most multi-story construction projects. Module embodiments are provided for enabling drop-in, stack-in, or slide-in installation in most buildings. Each module is preferably stackable with another module of the same type and configured to provide a predetermined amount of support for loads in the surrounding structure. Each module preferably provides all necessary mechanical and electrical components including their section of risers and ventilation shaft, as well as fixtures, fittings, appliances, cabinets, etc. except for the exterior cladding of perimeter walls which are designed for on-site installation. Each module preferably includes panelized interior cladding for built-in room items enabling sub-assembly prefabrication.
PRE-FABRICATED BUILDING MODULES AND METHOD OF INSTALLATION
CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 60/525,250 filed Nov. 25, 2003.

FIELD OF INVENTION

[0002] The present invention relates in general to modular building construction systems and, more particularly, to an apparatus and method for pre-fabricated building modules for use in the construction of building structures.

BACKGROUND OF INVENTION

[0003] The cost of construction of a typical multi-story housing project includes significant material and labor costs. The labor costs are increased by the need for the use of specialized workers of many trades on site. The time spent by these specialized workers and the specialization required is heightened by the need for construction to be done on site. Costs and specialization are enhanced by the need for on-site construction to be done in confined spaces. Typically, due to the confined spaces and location of the work site, on-site construction is not performed using the most current fabrication technologies. Thus, on-site construction does not present the most advantageous industrial environment.

[0004] On-site housing construction has the drawback of not taking full advantage of the benefit of economies of scale experienced by other industries operating in a modern automated factory setting. As a result, the inefficiencies inherent in on-site construction result in wasted time and effort thereby increasing the cost of construction. A need therefore exists for a building module that is pre-fabricated in the most advantageous industrial environment using the most modern fabrication technologies.

[0005] The bathrooms and kitchens are typically the most expensive components of a housing project because these rooms require more construction time due to the confined spaces and features of these rooms. What is also needed therefore is a pre-fabricated finished building modules and corresponding method of installation for reducing construction time, especially as compared with on-site construction.

[0006] Pre-fabricated building modules must be transported to the construction site for installation. Public regulations generally limit the dimensions of loads that can be transported via the public roads. A need therefore exists for a lightweight manufactured building module that can be transported on public roads. Building modules which are bulky can require specialized cranes or similar equipment for installation. A need therefore also exists for a lightweight manufactured building module that can be readily installed via a tower crane of the type typically used in most multi-story construction projects. Housing projects vary in their size and layout. A need therefore exists for building modules that are readily configurable off site into various preselected room components.

[0007] Many housing projects such as condominiums, hotels, apartments, etc. have multiple stories, each configured similarly. For example, a component such as a bathroom on one floor of the building is often located above and below an identical bathroom on another floor. Typically, each room of the project is constructed on site. A more efficient and less costly means is needed for construction of components of such buildings. A need therefore exists for pre-fabricated building modules and a corresponding method of installation for efficiently placing the modules in a suitable building. A need also exists for pre-fabricated stackable building modules (SBMs) and a corresponding method of installation that enables stacking of the pre-fabricated modules for efficiently placing the units in a suitable building.

SUMMARY OF THE INVENTION

[0008] The present invention overcomes the drawbacks of known building modules and methods by providing lightweight pre-fabricated building modules containing components of a typical multi-story housing project. The modules are configurable for most components of a typical housing unit including the bathroom and kitchen, typically the most expensive components in a housing project. The building modules are configurable to provide other building components such as powder rooms, laundries, other specialized facilities, and floor-to-floor sections of completed stair and elevator shafts. The building module can be used in various applications such as, hotels, dormitories, barracks, hospitals, etc.

[0009] An advantage of the present invention is that it provides building modules for production in an industrial environment using modern fabrication technologies. The use of industrialized production has the benefit of providing large economies of cost of construction and in construction time when compared with on-site conventional construction involving many trades working in rather confined spaces.

[0010] Another advantage of the present invention is that the building modules lightweight design allows for road transportation and installation by a tower crane of the type usually found in most multi-story construction projects.

[0011] Another advantage of the present invention is that the building modules are finished units. Typically each module contains the necessary mechanical and electrical components including their section of risers and ventilation shaft, as well as sanitary fixtures and fittings, appliances, cabinetwork, interior finishes, etc. One exception to complete pre-fabrication off site is that the perimeter walls outside cladding is to be installed in-situ in order to allow for the completion of the electrical installation of the adjacent rooms.

[0012] Still another advantage of the present invention is that the use of panelized interior cladding, which includes built-in items such as medicine cabinets, paper holders, etc., allows for sub-assembly fabrication and contracting, as well as simplifying maintenance and future renovation.

[0013] Another advantage of the present invention is that the building modules can be designed in many varied designs, combinations, and configurations, e.g., dual-bathroom, dual kitchen, bathroom-kitchen combination to suit most building conditions.

[0014] Another advantage of the present invention is that the building modules are compatible with different types of construction such as wood frame, light gauge steel, hot rolled steel, pour-in-place concrete, pre-stressed concrete, etc.
Another advantage of the present invention is that it provides for integration within stackable modules of overhead air conditioning equipment.

Another advantage of the present invention is that it provides various methods of installing the building modules of a given design layout in order to conform to different building conditions, such as a “stack-in”, “drop-in” and “slide-in” installation types.

Another advantage of the present invention is that it provides the ability to structurally connect the concrete floor topping of the module with the adjacent floor’s (or roofs) concrete structural floor (or roof) by means of steel dowels inserted at the perimeter of the module floor. Thus, the module has the advantage of allowing for a continuous floor diaphragm so as to aid in resisting lateral loads, e.g., seismic and wind.

Broadly stated, the present invention provides a stackable prefabricated building module for forming one or more rooms of a multi-story building located at a first location and configured for stacking with other stackable prefabricated building modules, said module comprising a floor frame for supporting a floor assembly; a ceiling frame for supporting a ceiling assembly, wherein stacking of said module with one of said other modules forms a ceiling cavity between a ceiling assembly of said module and the floor assembly of said other module, said ceiling cavity providing space for housing ventilation ducting and utility equipment therewithin; a plurality of columns extending vertically from below said floor frame to above said ceiling frame, one of said columns located at each corner of said module, each of said columns extending below said floor assembly for providing a leg for connecting to an adjacent level of said building beneath said module, wherein said columns support the weight of a predetermined number of stacked modules as a function of the size and number of said columns; a plurality of floor edge connectors, each of said floor edge connectors for coupling said floor assembly to an adjacent portion of the same floor level of said building; and a plurality of column connectors, each of said column connectors installed at the top of a corresponding column for connection to a leg of one of said other modules positioned adjacent to and above said module.

According to another embodiment, broadly stated, the present invention provides a prefabricated building module for forming one or more rooms of a building located at a first location and configured to be slideable into an opening of said building for installation, said module comprising a floor frame for supporting a floor assembly; a ceiling frame for supporting a ceiling assembly; a plurality of columns extending vertically from below said floor frame to above said ceiling frame, one of said columns located at each corner of said module; a plurality of floor edge connectors, each of said floor edge connectors for coupling said floor assembly to an adjacent portion of the same floor level of said building; and a plurality of column connectors, each of said column connectors installed at the top of a corresponding column; wherein said module enables connection to the risers of said building used for coupling utilities to each said module.

According to another embodiment, broadly stated, the present invention provides a method of installation of a prefabricated stackable building module into a building at a first location, said module having a vertical shaft section for providing ventilation and for enclosing a vertical section of a plurality of risers, comprising the steps of fabricating said module at a second location a distance away from said first location; transporting said module to said first location; inserting said module from a top of said building into a cavity in said building via a crane; and operatively connecting said shaft section to a shaft section of one or more adjacent stackable modules; each said shaft section including a seal such that said shaft sections of adjoining building modules are automatically sealed during installation of said module.

According to another embodiment, broadly stated, the present invention provides a method of installation of a prefabricated building module into a building at a first location comprising the steps of fabricating said module at a second location a distance away from said first location; transporting said module to said first location; sliding said building module into an opening of said building; and coupling said module to a plurality of risers housed within a shaft of said building for connecting said module to utilities and ventilation systems therein.

According to another embodiment, broadly stated, the present invention provides a method for storage and transport of a prefabricated building module, said module to be installed in a building at a first location comprising the steps of providing at least one upper connecting steel plate for lifting said module during fabrication at a second location; attaching wood members to each said plate; installing a temporary roof cover supported by said wood members; installing tubular steel legs extending from the bottom of said module at each corner; attaching wood sleepers via threaded rods at the bottom of said tubular legs so that said module is suitable for transportation; and after fabrication, with said temporary roof cover in place, wrapping said module with a tear-resistance waterproof protective membrane secured by wood strips at the bottom of the module.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and the attendant advantages of the present invention will become more readily appreciated by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 illustrates a top view floor plan of a preferred embodiment of the module according to the present invention that includes two bathrooms in a back-to-back, dual bathroom, configuration.

FIG. 2 illustrates an enlarged area of FIG. 1 covering the common vertical shaft;

FIG. 3 illustrates a side sectional view of the dual bathroom module in FIG. 1.

FIG. 4 illustrates a side sectional view of the dual bathroom module 10 in FIG. 1 shown with its storage and transportation trim.

FIG. 5 illustrates a side sectional view of an embodiment of an exemplary stack of “stack-in” installation type of building modules containing four dual bathroom modules within a building.
FIG. 6 is a detail view illustrating the typical connection of a module stack in FIG. 5 with the adjacent supported floors of light gauge steel construction.

FIG. 7 is a detail view illustrating the typical connection of a module stack in FIG. 5 wherein the adjacent supported floors are comprised of standard wood construction.

FIG. 8 is a detail view illustrating the typical connection of a module stack in FIG. 5 wherein the adjacent supported floors are comprised of standard steel construction using hot rolled sections.

FIG. 9 is a detail view illustrating the typical connection of a module stack in FIG. 5 wherein the adjacent supported floors include a concrete slab.

FIG. 10 illustrates a side sectional view of an alternate embodiment according to present invention of an exemplary stack of “drop-in” installation type of building modules containing four dual bathroom modules within a building.

FIG. 11 illustrates a detail view of the embodiment in FIG. 10 showing the connection of a typical module stack with the adjacent floors of concrete construction.

FIG. 11 a is a cross section of area 11 a of FIG. 11 showing additional details of the removable channel and removable guide.

FIG. 11 b is a detail view taken along section line 11 b of FIG. 11 a.

FIG. 12 is a detail view similar to FIG. 11 for an alternative embodiment wherein the surrounding non-supported structure is of standard steel construction using hot rolled sections.

FIG. 13 illustrates a side cross section view of a “slide-in” installation type embodiment of the module according to present invention.

FIG. 14 a-14 b illustrates exemplary alternate embodiments of the module according to the present invention for use as bathrooms, kitchens, powder rooms, laundries, and other types of specialized facilities.

FIG. 15 illustrates a fragmentary view of an exemplary apartment floor plan showing exemplary paired kitchens and bathrooms modules and their location within the floor layouts.

FIG. 16 a illustrates an exemplary “stack-in” method of installing the building modules according to an embodiment of the present invention.

FIG. 16 b illustrates an exemplary “drop-in” method of installing the building modules according to an embodiment of the present invention.

FIG. 16 c illustrates an exemplary “slide-in” method of installing the building modules according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a top view floor plan of a preferred embodiment of the module 100 according to the present invention that includes two bathrooms in a back-to-back, dual bathroom, configuration. The module 100 is also referred to herein as a dual-bath or dual-bathroom module. Bathrooms 12, 14 in dual bathroom module 10 preferably have identical bathroom elements and are shown as mirror images of each other in FIG. 1. As a result, the description of elements in one bathroom also applies to the other bathroom in module 10. A tubular steel frame forms the basic structure of dual bathroom module 10 and includes corner columns 101 and connecting beams 102 at top and bottom. Light gauge metal stud insert panels 103 are attached to the tubular frame to support the perimeter wall finishes. The intermediate wall separating the individual bathrooms 12, 14 contains most of the plumbing installation as a sub-assembly 104.

The dual bathroom module 10 includes a common vertical shaft 4 formed by fire rated walls 105. FIG. 2 illustrates a detail view of the area 2 in FIG. 1 including details for the common vertical shaft 4. The vertical shaft 4 includes a floor grille 106 for allowing the vertical flow of exhaust air and a fire-rated access door/panel 107. The vertical shaft 4 contains the floor-to-floor segments of a riser 108 for waste, sanitary vent 109, hot and cold water supply 110, air-conditioning lines 111, and condensate water drain 112. The vertical shaft preferably contains a riser 108 a for the electrical system and a riser 108 b for the fire sprinkler systems. Module 10 includes a wall mounted exhaust grille 113 preferably having fire-rated shutters.

For stackable buildings modules 10, the present invention integrates accessible ventilation shafts containing floor to floor sections of risers, as shown in FIGS. 1 and 2. The horizontal joint between shaft sections of adjacent modules 10 is preferably sealed by a rated fire resistant resilient tape adhered to the top of the shaft walls of the lower module. Once a stack of building modules is installed, the integrated vertical shaft 4 offers continuous fire protection throughout its entire height, in conformance to U.S. and international building codes. Access to the mechanical and electrical risers is provided by means of fire-rated doors, or through provisional wall openings to be field clad in fire rated materials such as gypsum board.

As shown in FIG. 1, dual bathroom module 10 includes the standard bathroom fixtures and fittings installed for each bathroom 12, 14 including a tub 114, a water closet (toilet) 115, and a lavatory portion 117. Alternatively, the water closet 115 includes a tank 116 built into the wall. The lavatory portion 117 preferably includes a counter 118 and a medicine cabinet 119 built into a finished wall panel assembly 121. Air conditioning units 136 (shown in FIG. 3) are preferably included in module 10 and located above a ceiling 135 (shown in side view in FIG. 3). A ceiling access panel 120 is included for enabling access to the air conditioning unit 136. The dual bathroom module 10 includes a finish wall panel assembly 121 and a towel rack 122. Module 10 preferably includes an installed toilet paper dispenser 123. Module 10 includes a bathroom access door and frame assembly 124. Module 10 preferably includes a floor finish 125. An outside cladding 126 for the perimeter walls is installed on-site in order to allow for the completion of the electrical installation of adjacent rooms.

FIG. 3 illustrates a side sectional view of the dual bathroom module 10 of FIG. 1. As seen in FIG. 3, the module 10 preferably includes tubular steel columns 101 at
each corner sized to support the weight of a full stack of bathrooms and resist lateral loads when required. Module 10 includes steel beams 102, of tubular or W sections, connecting the columns 101 at the floor and ceiling levels. The columns 101 project below the floor level thereby functioning as “legs” 129 for connecting to the lower module. The tubular steel legs 129 have a welded steel plate end cover and a threaded steel bar 130 (shown in FIG. 4) serving as a leveling device. At each corner, at the ceiling level, module 10 includes connecting steel plates 131 welded to the top of each corner columns 101 to receive the legs 129 of the module above. The legs 129 and the connecting steel plates 131 are attached by means of high strength bolts 132 and/or welding. In a preferred embodiment, module 10 includes bolts 132 and welding. Steel joists 127 and a corrugated steel deck 128 of module 10 form the floor support for a concrete topping 133 and finish floor 125 (above a waterproof membrane).

As shown in FIG. 3, module 10 includes light gauge steel channels 134 supporting a finish ceiling 135. A ceiling access panel 120 is included to allow access for maintenance of the air conditioning unit 136. Light gauge steel studs 103 preferably frame the perimeter (exterior) wall spaces between the corner columns 101 and a cavity between the bathrooms which contain the plumbing assembly 104 (shown in FIG. 1). FIG. 3 also shows the tub 114 and the water closet 115. A water closet tank 116 is concealed between the wall cavity. Module 10 includes a glass-tub enclosure 138. Compressible fire-seal tapes 140 are included at the top of the wall cavity studs. Module 10 includes acoustical batt insulation 140 at the wall cavity. As shown in FIG. 3, adjacent floors 141 are supported by the bathroom module stack.

FIG. 3 also shows the perimeter wall outside cladding 120 that is field installed. In an alternate embodiment, diagonal bracing 137 (shown in phantom in FIG. 3) is provided at the perimeter walls. The diagonal bracing 137 between the perimeter steel members aids in resisting lateral forces. The diagonal bracing is preferably the same thickness as the perimeter steel members, and thus is concealed and fire protected by the perimeter wall cladding.

FIG. 4 illustrates a side sectional view of the dual bathroom module 10 in FIG. 1 shown with its storage and transportation trim. Upper connecting steel plates 131 are provided for lifting module 10 during fabrication, transportation, and erection to its permanent location within a building structure. Plates 131 also serve to attach wood members 142 for supporting a temporary roof cover structure 143. Tubular steel legs 129 project from the bottom of the module at each corner. Threaded rods 130 at the bottom of the tubular steel legs 129 enable attachment of wood sleepers 144 suitable for transportation and casters 145, as required, to facilitate moving during fabrication. After fabrication, with the temporary roof framing in place, the module assembly is wrapped tightly with a tear-resistance waterproof protective membrane 146 kept tight in place by wood strips 147 at the bottom of the module. The membrane 146 and wood and temporary “roof” framing 143 are to be removed just before the installation of the module in a building. The wood sleepers 144 are to be removed once the module is lifted by a crane for permanent installation.

FIG. 5 illustrates a side sectional view of an embodiment of an exemplary stack 20 of “stack-in” installation type of building modules containing four dual bathroom modules 10 within a building. The stack 20 is not only self-supporting but, as shown, also supports part of the adjacent floors. The bottom legs 148 of the module 10 on the 1st floor are customizable to suit the conditions of a specific project. Stack 20 includes a floor or foundation cavity 149 required to accommodate the floor of the lowest module and its attachment to the base structure or foundation. Although shown in FIG. 5 on the 1st floor, the lowest module in the stack 20 need not be on the 1st floor depending on the building arrangement. For installation, the bottom legs 148 of the lowest module 10 are welded to a base steel plate 150 anchored into the base structure/foundation 151. The uppermost module 10 is to be covered by a cap 152 of similar type construction. The configuration of the cap structure is adjustable to meet the conditions of the adjacent roof structure 153. The construction of the roof cap 152 is preferably similar to the floor of the module (tubular steel frame, light gauge steel joist, and corrugated steel deck) including legs at each corner. Once the erection of a module stack is completed, the riser sections contained in the vertical shaft, shown best in FIG. 2, are connected to each other, and the electrical lines and air conditioning system of the module will be connected with those of the adjacent structure.

FIG. 6 is a detail view illustrating the typical connection of a module stack in FIG. 5 with the adjacent supported floors of light gauge steel construction. A threaded bar 130 at the end of the upper module legs 129 serves primarily as a leveling device and secondarily as an attachment for wood sleepers 144 and casters 145 shown in FIG. 4. High strength steel bolts 132 attach the lower module to the “leg” of the module above, through slotted holes in a connecting steel plate 131. Preferably, fillet welding, identified as 6 in FIG. 6, is included around the connecting steel plate 131 for providing greater load bearing capacity. The use of fillet welding 6 enables the module stack to be higher than it otherwise could be when using high strength bolts 132 alone. In an alternative embodiment (not shown), the fillet welding is used in place of the bolts 132. The modules stacks such as shown in FIG. 5 are able to be structural self-supporting and also able to support the loads of a portion of the adjacent floor structure including vertical and lateral loads, e.g., seismic and wind. The stack capacity varies with the size and number of perimeter steel columns 101 and the use of high strength bolts 132 and/or fillet welding 6 at the column connections. For example, for an exemplary dual bathroom module 10 as shown in FIG. 1, having four 6”x6” tubular ½” thick steel columns, a stack 12 modules high will be self-supporting by using four ¾” x 490 high strength bolts 132 at each attachment. If welded connections 6 are used, a self-supporting stack of approximately 40 modules high is possible with 4”x½” steel plate connectors and 27” of ½” fillet welding at each connector plate. Self-supporting herein refers to gravity loads. The bolt holes at the connecting steel plate 131 are also useable as lifting points during the erection of the stack. One bolt at each connecting steel plate 131 can be used temporarily until field welding is effected.

As seen in FIG. 6, bent steel plates hangers 154 are welded to the lower tubular steel beams 102 of the upper module for serving as support for the adjacent floor assemblies. The supported floor assemblies include light gauge steel joists 155 supporting a corrugated steel deck 156. Coiled steel bar inserts 157 embedded into the concrete
topping 133 of the module floor allow the attachment of threaded steel bar dowels 158 prior to the pouring of a concrete topping 159 on the adjacent supported floor. The structure has a cladding 160 of the exterior surface of the perimeter walls of the module 10 and a finished ceiling 161 attached to the bottom of the steel joists of the adjacent floors. As a result, the capability is provided by the present invention to structural connect the concrete floor topping of the module with the adjacent floor’s (or roof) concrete structural floor (or roof) by means of steel dowels inserted at the perimeter of the module floor. This structure allows for a continuous floor diaphragm which aids in resisting lateral loads, e.g., seismic and wind.

[0055] FIG. 7 is a detail view illustrating the typical connection of a module stack in FIG. 5 wherein the adjacent supported floors are comprised of standard wood construction. Bent steel plate hangers 154 are welded to the bottom tubular steel beam 102 of the module above, for providing support for the adjacent wood floors. Each of the adjacent supported steel floors includes a wood joist 162, a plywood deck 163, a sound barrier sheet 164, and a topping 165 of gypsum or alternatively, lightweight concrete.

[0056] FIG. 8 is a detail view illustrating the typical connection of a module stack in FIG. 5 wherein the adjacent supported floors are comprised of standard steel construction using hot rolled sections. For this embodiment, continuous steel angles 167 are welded to the lower tubular steel beam 102 of the upper module for providing support to the adjacent floor of standard steel construction. Each of the adjacent supported steel floors includes a corrugated steel deck 168, and a concrete topping 169.

[0057] FIG. 9 is a detail view illustrating the typical connection of a module stack in FIG. 5 with the adjacent supported floors of concrete construction.

[0058] FIG. 10 illustrates a side sectional view of an alternate embodiment according to present invention of an exemplary stack of “drop-in” installation type of building modules containing four dual bathroom modules within a building. In this embodiment, the modules are similar to the module stack in FIGS. 1 and 5, except, in FIG. 10 the stack of modules, although self-supporting, does not support any part of the adjacent structure. The modules are inserted from the top of the building structure through a vertical shaft of appropriate dimensions.

[0059] FIG. 11 illustrates a detail view of the embodiment in FIG. 10 showing the connection of a typical module stack with the adjacent floors of concrete construction. The embodiment in FIG. 11 includes an edge of an opening 170 in a concrete structure. The opening 170 allows the modules to be lowered into position so as to form the module stack. Removable steel channels 171 are attached to the edge of the opening 170, two each at opposite sides, to further facilitate the lowering of the modules. Removable steel guides 172 are attached to the tubular steel columns 101, shown in FIGS. 1 and 3, located at each corner of the module, one guide towards the top of each module, and other towards the bottom.

[0060] FIG. 11a is a cross section of area 1a in FIG. 11 showing additional details of the removable channel 171 and removable guide 172. FIG. 11b is a detail view taken along section line 11b of FIG. 11a. As shown for the embodiment in FIG. 11, once the modules are leveled and attached to each other, cement grout 173 is poured in the joint between the module and the surrounding concrete structure. The grout 173 is contained by a cement board skirt 174 and a removable board at the bottom attached to the concrete structure by a bolted insert 176 used to attach the removable channels 171 to the structure.

[0061] FIG. 12 is a detail view of an alternative embodiment of FIG. 11 wherein the surrounding non-supported structure is made of standard steel construction using hot rolled sections. In this alternative embodiment, the space between the module stack and the surrounding steel structure is to be filled with cement grout 173. The grout 173 is to be contained by a cement board skirt 174 attached to the module and a removable steel plate 177. The steel plate 177 is attached by means of threaded bolts 176 welded to the bottom of a steel member 166 at the edge of the opening.

[0062] FIG. 13 illustrates a side cross section view of a “slide-in” installation type embodiment of the module according to present invention. The “slide-in” module 40 is for use in installations within an individual floor of a building where there is no stacking requirement. The “slide-in” module 40 requires connection to the building plumbing and ventilation risers since it lacks its own risers and ventilation shaft section. The “slide-in” module 40 also lacks the air conditioning equipment found at the top of other embodiments of the module so as to facilitate their installation between two existing floor assemblies. The installation of the “slide-in” module requires a floor depression or an opening in the supporting floor structure. The “slide-in” module is attached to the existing supporting structure via a steel angle 179 as shown, or by other suitable means. The “slide-in” module can receive the same storage and transportation trim protection as shown in FIG. 4, and described above.

[0063] The smaller dimension of the module is generally limited for transport by road regulations, typically 10 feet for unescorted transport and 12 feet for escorted ones. The module length is generally limited to the length of the truck bed, typically 40 feet. Other restraints may exist for specific construction sites. The building modules of the present invention can be transported using standard size shipping containers. In this case, the module overall dimensions are to be limited to 88” in width and in height, with a maximum length of 230” for 20 feet long containers and 460” for 40 feet containers. When using shipping containers, the legs and connector plates are attached at the destination point, as well as the completion of the installation of overhead air conditioning equipment. In the case of container transport, the clear floor the ceiling height within the module is to be 7’-0”, which is acceptable for such small spaces and by the US building codes. For example, a 40 feet container can be used to transport two sets of dual bathrooms or dual kitchens or two sets of kitchen/bathroom modules, or a combination of two of those types. The total weight of an exemplary pair of such modules is about 24,000 pounds, which is below the 45,000 pound capacity of the typical 40 feet container.

[0064] FIG. 14a-14h illustrates exemplary alternate embodiments of the module according to the present invention for use as bathrooms, kitchens, powder rooms, laundries, and other types of specialized facilities. FIG. 14a shows an embodiment of a dual-bathroom module, such as
shown in FIG. 1, that includes a pair of bathrooms in a back-to-back arrangement. FIG. 14a shows an embodiment of a dual-kitchen module including a pair of kitchens in a back-to-back arrangement. FIG. 14c shows an embodiment of a module including a kitchen and a bath in a back-to-back arrangement. FIG. 14f shows an embodiment of a module including a combination of a kitchen and two bathrooms. FIG. 14e shows an embodiment of a module including an individual bathroom. FIG. 14g shows an embodiment of a module including an individual kitchen. FIG. 14h shows an embodiment of a floor-to-floor module including a stair shaft. FIG. 14i shows an embodiment of a floor-to-floor module including an elevator shaft.

FIG. 15 illustrates a fragmentary view of an exemplary apartment floor plan showing exemplary paired kitchens and bathrooms module embodiments and their location within the floor layouts. It will be recognized by those skilled in the art that the module of the present invention is also adaptable for use in hotels, dormitories, hospitals, barracks, etc.

The building modules can also be produced in a wide variety of design layouts and combinations to suit most building conditions. A variety of installation methods are provided for a given design layout in order to conform to different building conditions, such as a “stack-in”, “drop-in” and “slide-in” installation types of modules, as will now be described in further detail.

For the various module configuration described above there are three installation types of building modules. A given module according to the present invention is adaptable to the different methods of installation by relatively simple modifications. A first installation type of building module is a “stack-in” building module. A stack of this first type of building modules is self-supporting as well as able to support a certain amount of tributary floor loads from the surrounding structure. This type of modules is intended to be installed concurrently with the surrounding structure. FIG. 16a illustrates an exemplary “stack-in” module and method of installing the building modules according to an embodiment of the present invention. As seen in FIG. 16a, a structure 180 is in the process of being built around a module stack 50. In this condition, the module stack 50 is self-supporting and, if properly designed, capable to support adjacent floors. Each module 182 is installed by means of a crane 183 to create the stack.

A second installation type building module (and corresponding method) is a “drop-in” building module. A stack of this type is self-supporting, but is not intended to carry loads from the surrounding structures. As its name implies, this second type of module is intended for installation through floor openings within an existing building being remodeled or converted into housing, or a new structure being completed. FIG. 16b illustrates an exemplary “drop-in” type module and method of installing the building modules according to an embodiment of the present invention. For the “drop-in” type and method, a structure 181 is built with aligned floor openings able to receive the module stack. Each module 182 is descended to its floor position by means of the crane 183 through a vertical shaft in the structure.

The different module configurations e.g., dual-bathroom, according to the present invention are usable in a non-stackable configuration for single family homes and other similar types of small buildings. A third installation type of building module (and corresponding method) is a “slide-in” building module. This type of module is a simplified version of those described in the first two types. Typically, modules of this third type lack mechanical/electrical risers and the integrated vertical shafts since the modules are intended for random locations within a building structure where stacking is not a requirement. These modules require to be individually supported at each floor. As their name implies, their installation is by sliding over a given floor until reaching their intended location. A floor cavity or opening is required, as well as connection to field-installed mechanical/electrical risers and ventilation ducts or shafts. Similar to the “drop-in” type, the “slide-in” modules are suitable for installation in existing buildings being renovated or new structures in the process of being completed. FIG. 16c illustrates an exemplary “slide-in” installation type module and method of installing the building modules according to an embodiment of the present invention. A structure 186 is built with floor cavities ready to receive a module 182. The module 282 is lifted to its destination floor by means of a cradle. The module 282 is slid or rolled on a bottom module portion 184 into its final position. This “slide-in” installation method is suitable for use in small buildings such as single family residences.

The design of the module of the present invention allows the floor of the module to be level with the adjacent floor areas. This is an important comfort feature as well as conforming to U.S. and international regulations regarding access for the disabled. This is achieved by lowering the module ceiling with respect to the adjacent floor structure and lowering the module to module stack connection at a level below the adjacent floor levels. This allows clearance for the module floor depth and also for the installation of air conditioning equipment in the resulting cavity. The design of the building modules of the present invention also complies with applicable U.S. and International building codes with regards to structural, mechanical, electrical, fire-protection, sound insulation, etc.

Having disclosed exemplary embodiments, modifications and variations may be made to the disclosed embodiments while remaining within the scope of the invention as described by the following claims.

What is claimed is:

1. A stackable prefabricated building module for forming one or more rooms of a multi-story building located at a first location and configured for stacking with other stackable prefabricated building modules, said module comprising:

   a floor frame for supporting a floor assembly;

   a ceiling frame for supporting a ceiling assembly, wherein stacking of said module with one of said other modules forms a module cavity between a ceiling assembly of said module and the floor assembly of said other module, said ceiling cavity providing space for housing ventilation ducting and utility equipment therewithin;

   a plurality of columns extending vertically from below said floor frame to above said ceiling frame, one of said columns located at each corner of said module, each of said columns extending below said floor assembly for providing a leg for connecting to an adjacent level of
said building beneath said module, wherein said columns support the weight of a predetermined number of stacked modules as a function of the size and number of said columns;

a plurality of floor edge connectors, each of said floor edge connectors for coupling said floor assembly to an adjacent portion of the same floor level of said building; and

a plurality of column connectors, each of said column connectors installed at the top of a corresponding column for connection to a leg of one of said other modules positioned adjacent to and above said module.

2. The module of claim 1, further comprising a vertical shaft section for providing ventilation and for enclosing a vertical section of a plurality of risers used for coupling utilities to each said module, said shaft section including a seal to seal said shaft section to the shaft sections of any adjoining building modules above and below said module.

3. The module of claim 1, further comprising a plurality of metal stud insert panels for framing perimeter wall spaces between said columns.

4. The module of claim 1, further comprising a plurality of beams coupling said columns to said ceiling frame and floor frame.

5. The module of claim 1, wherein said module is comprised of tubular light gauge steel members.

6. The module of claim 1, wherein said adjacent portion is comprised of wood.

7. The module of claim 1, wherein said adjacent portion is comprised of steel.

8. The module of claim 1, wherein each of said column connectors includes one or more plates welded at the top of each column and having one or more holes therein, said module further comprising one or more high strength bolts, each said bolt for fastening the plates of each said column to the adjacent leg of another said module positioned adjacent to and above said module.

9. The module of claim 8, wherein said holes further provide lifting points during installation of said module at said first location.

10. The module of claim 8, wherein each said plate enables the further coupling of said each said column via welding to the adjacent leg of another said module positioned adjacent to and above said module.

11. The module of claim 1, wherein said column connector comprises one or more plates welded at the top of each column, each said plate for enabling the coupling of said each said column via welding to the adjacent leg of another said module positioned adjacent to and above said module.

12. The module of claim 1, further comprising an air conditioning unit located in said ceiling cavity and a ceiling access panel for enabling access to said air conditioning unit.

13. The module of claim 1, further comprising a plurality of casters disposed to said legs for facilitating movement of said module during fabrication.

14. The module of claim 1, wherein said floor assembly includes a concrete topping disposed on a steel deck supported by steel joists.

15. The module of claim 14, wherein a coiled steel bar insert is embedded into said concrete topping for enabling attachment of threaded steel bar dowels at the perimeter of said floor assembly of said module, to enable said concrete floor topping to be structurally connected to the concrete structural floor of an adjacent level of said building so as to provide further resistance to lateral loads.

16. The module of claim 1, wherein said module is the lowest module of said stack and for installation on the lowest floor of said building, said module forming a foundation cavity for accommodating said floor assembly and its attachment to a foundation of said building, the legs of said module sized to be welded to a base steel plate anchored into a base foundation of said building when said module is installed at said first location.

17. The module of claim 1, further comprising bent steel plate hangers welded to said floor frame of said module for providing support for an adjacent floor assembly.

18. The module of claim 1, further comprising a threaded bar coupled to an end of said leg to enable leveling with adjacent levels.

19. The module of claim 1, wherein perimeter walls are formed on said module, said perimeter walls having an exterior surface and a cladding thereon.

20. The module of claim 15, further comprising diagonal steel bracing member positioned between said columns at said perimeter walls for providing increased resistance to lateral loads.

21. The module of claim 16, wherein said diagonal steel bracing is about the same thickness as said columns such that said bracing is concealed and fire-protected by said perimeter wall cladding.

22. The module of claim 1, wherein said module is fabricated at a second location and is adapted to be handled and transported on a vehicle on a public road for transporting said module from said second location to said first location.

23. The module of claim 2, wherein each shaft section includes an access door for enabling connection to said risers and a grating to enable air flow.

24. The module of claim 15, wherein said building is a pre-existing building having one or more other stacked modules and said module is installed at said first location by stacking said module with said other stacked modules in said building, said module providing a predetermined amount of support for loads of the surrounding structure of said building.

25. The module of claim 1, wherein said module is inserted from a top of said building and does not support for the loads of the surrounding structure of said building.

26. A prefabricated building module for forming one or more rooms of a building located at a first location and configured to be slidable into an opening of said building for installation, said module comprising:

a floor frame for supporting a floor assembly;

a ceiling frame for supporting a ceiling assembly;

a plurality of columns extending vertically from below said floor frame to above said ceiling frame, one of said columns located at each corner of said module;

a plurality of floor edge connectors, each of said floor edge connectors for coupling said floor assembly to an adjacent portion of the same floor level of said building; and

a plurality of column connectors, each of said column connectors installed at the top of a corresponding column;
wherein said module enables connection to the risers of said building used for coupling utilities to each said module.

27. The module of claim 26, wherein said module is attached to said building via a plurality of steel angles.

28. A method for storage and transport of a prefabricated building module, said module to be installed in a building at a first location comprising the steps of:

- providing at least one upper connecting steel plate for lifting said module during fabrication at a second location;
- attaching wood members to each said plate;
- installing a temporary roof cover supported by said wood members;
- installing tubular steel legs extending from the bottom of said module at each corner;
- attaching wood sleepers via threaded rods at the bottom of said tubular steel legs so that said module is suitable for transportation; and
- after fabrication, with said temporary roof cover in place, wrapping said module with a tear-resistance waterproof protective membrane secured by wood strips at the bottom of the module.

29. The method of claim 28, further comprising the steps of removing said membrane, said wood strips, and said temporary roof cover before installation of said module in said building; and

removing said wood sleepers once said module is lifted by a crane for permanent installation in said building.

30. The method of claim 28, further comprising the step of attaching a plurality of casters to said tubular steel legs to facilitate movement of said module during fabrication, said casters being removed prior to transport of said module.

31. The method of claim 28, wherein said legs and said at least one upper connecting steel plate are attached to said module at said first location.

32. A method of installation of a prefabricated building module into a building at a first location comprising the steps of:

- fabricating said module at a second location a distance away from said first location; transporting said module to said first location;
- sliding said building module into an opening of said building; and
- coupling said module to a plurality of risers housed within a shaft of said building for connecting said module to utilities and ventilation systems therein.

33. A method of installation of a prefabricated stackable building module into a building at a first location, said module having a vertical shaft section for providing ventilation and for enclosing a vertical section of a plurality of risers, comprising the steps of:

- fabricating said module at a second location a distance away from said first location;
- transporting said module to said first location;
- inserting said module from a top of said building into a cavity in said building via a crane; and
- operatively connecting said shaft section to a shaft section of one or more adjacent stackable modules; each said shaft section including a seal such that said shaft sections of adjoining building modules are automatically sealed during installation of said module.

34. The method of claim 33, wherein said inserting step comprises stacking said module onto a stack of one or more other prefabricated stackable building modules via a crane; said module providing a predetermined amount of support for loads of the surrounding structure of said building, and further comprising the step of connecting said module to said building such that said module provides a predetermined amount of support for loads in the surrounding structure of said building.

35. The module of claim 1, further comprising panelized interior cladding for built-in room items enabling subassembly fabrication thereof.