

PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION MODULE

[0001] The present application relates to a prefabricated prefinished volumetric construction module. The application also relates methods of making, assembling,
5 disassembling, installing, configuring, maintaining and using the prefabricated prefinished volumetric modular construction module.

[0002] This application further relates to building and construction industry, with special application of new technology by using total prefabricated and prefinished concrete
10 modular room for the design and construction of low-rise or high-rise buildings.

[0003] The conventional method of contracting the construction of a large building can involve innumerable subcontractors, with added tiers of sub-subcontractors, most of whom are working together for the first time and who have competing needs for time
15 and space to perform their work. Each subcontractor is responsible for hundreds if not thousands of bits and pieces of work, some of those pieces constructed in the field at the building site. Even medium-size buildings can entail hundreds of thousands of man-hours of construction and coordination among contractors, subcontractors, consultants, and clients. Thus, pre-fabricated modular room resolved complicated site construction
20 and site coordination between numerous construction trades. The building can be divided into several types of standard modular rooms prefabricated in a factory controlled assembly lines with majority of the building elements preinstalled and transported to the construction site for final installation.

[0004] This novel prefabricated prefinished modular room system is proposed for low or high rise building development that incorporates prefabricated or precast volumetric system. This innovative system comprises a normal-weight or lightweight reinforced concrete base floor slab, staggered male/female concrete or steel/concrete composite columns/walls at four corners, and in-filled with lightweight panels or dry walls,
30 lightweight frame at ceiling level as bracing and to hold ceilings. The concrete base tray and integrated column/wall and ceiling bracings will form a rigid and robust structure will be a free-standing system by itself, prefabricated off-site with or without architectural finishes and building services. The modules will be transported to the construction site for installations. The prefabricated system will be installed and

connected at construction site between each other with floor ties and peripheral ties and connected to core walls by mechanical or cast-in-situ slab to form a final building structures.

5 [0005] The advantage of this unique prefabricated prefinished modular room system using dry installation method and assembly at factory can eliminate most of the labour intensive elements such as formwork, scaffolding, shoring, brick wall, waterproofing, architectural finishes, fitting out, mechanical and electrical works, water supply, sanitary works, and air conditioning works. Virtually most of the components can be
10 prefabricated off-site and pre-assembled at the fabrication yard and delivered to construction site for installation. The prefabricated prefinished modular room system extensively reduces the need for various trades of skilled workers on site, save time, improve productivity, and maintain a high quality factory controlled product.

15 [0006] The prefabricated concrete module comprises of four columns or walls, each side are staggered in a male-female manner to allow for connections with the neighbouring module without creating double column/wall scenario. This will greatly reduce the thickness of the column/wall in conventional modular system design, and create more space for the users. The system is versatile to accommodate different
20 types of dry-wall or precast lightweight panel, aerated concrete panel, foam concrete panel, hollow core panel, aerated hollow core panel, sandwich panel, lightweight aggregate panel, etc. as in-filled wall. By usage of lightweight in-filled panels, the weight of the prefabricated concrete room will be reduced greatly to facilitate easier assembly, transportation, handling, lifting and installation. These non-structural walls can be
25 dismantled to create a larger room at the desire of the users. Thus, the system is also adaptive to home user's future renovation changes using market available conventional methods with no special skill.

[0007] This application relates to building and construction industry, with special
30 application of new technology by using total prefabricated and prefinished concrete modular room for the design and construction of low-rise or high-rise buildings.

[0008] Conventional building construction involves labour intensive constructions such as formwork, scaffolding, rebar binding, concrete casting, mechanical and electrical

works, water supply and sanitary services, architectural finishes, etc. It also requires a lot of coordination for different trades to work together. The proposed application will prefabricate the concrete modular room off-site at factory, and preinstalled with mechanical and electrical works, water supply and sanitary services, prefinished with majority of architectural features. The modular room will be checked with stringent quality checks systems before delivery to construction site for installation. The application extensively reduces the need for skilled workers on site, save time, improve productivity, and maintain a high quality factory controlled product.

- 10 [0009] The prefabricated modular room system is not new. This application is innovative as it adopted a staggered male – female columns or walls system to eliminate the conventional modular construction with double columns or walls. It reduced the thickness of the columns or walls by utilizing staggered one-side structural columns/walls to match the non-structural columns/walls on the neighbouring module.
- 15 It significantly reduced the width of double columns/walls in conventional modular room construction, and created more usable spaces for the end users. The system also utilized various methods to minimize the in-situ wet works to avoid disturbance to the preinstalled interior finishes.
- 20 [0010] There are various types of prefabricated modular room systems invented with its respective application fields or restrictions. This new application of prefabricated prefinished concrete modular room system provides a totally new concept which is different from the existing types of available or patented systems.
- 25 [0011] The common types of existing modular room system available are:
1. Steel frame with cement board as floor and walls
 2. Steel or metal sheet container system
 3. Full solid precast concrete in double wall or double column system
- 30 [0012] These prefabricated bathrooms can either be pre-assembled as a complete modular room or partially finished in factory delivered to site for installation or assembled on site. All of the above system share a common double wall or double column arrangement.

[0013] In summary, although existing prefabricated prefinished modular room systems have already been widely used in various applications, there are respective constraints and limitations of each system, which can be summarized as below.

- 5 [0014] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of relevant applications.
- 10 [0015] Fig. 1 illustrates an overall 3D view for the modular unit;
[0016] Fig. 2 illustrates another overall 3D view for the modular unit;
[0017] Fig. 3 illustrates a bottom floor tray with starter bars and connectors;
[0018] Fig. 4 illustrates a plan view of one module structure at bottom;
[0019] Fig. 5 illustrates a top framing plan view of one module structure;
- 15 [0020] Fig. 6 illustrates a long direction elevation view of structure from left side;
[0021] Fig. 7 illustrates a long direction elevation view of structure from right side;
[0022] Fig. 8 illustrates a short direction elevation view of structure from façade side;
[0023] Fig. 9 illustrates a 3D structural module when it is combined;
[0024] Fig. 10 illustrates a 3D structural module when it is finished (without ceiling);
- 20 [0025] Fig. 11 illustrates a 3D structural module when it is finished (with ceiling);
[0026] Fig. 12 illustrates a plan view of vertical connection between staggered columns or walls;
[0027] Fig. 13 illustrates a 3D view of vertical connection between staggered columns or walls;
- 25 [0028] Fig. 14 illustrates a plan view of internal floor tie connection between one module to another module on floor slab;
[0029] Fig. 15 illustrates a section view of internal floor tie connection between one module to another module on floor slab;
[0030] Fig. 16 illustrates a 3D view of internal floor tie connection between one module
- 30 to another module on floor slab;
[0031] Fig. 17 illustrates the vertical dowel and grouting connector between an upper module and a lower module;
[0032] Fig. 18 illustrates installation sequence of multiple modules on a conceptual layout plan;

[0033] Fig. 19 illustrates a 3D module with weather protections membrane and temporary working deck;

[0034] Fig. 20 illustrates the 3D modules installed on the construction site waiting for another two modules to be installed;

5 [0035] Fig. 21 illustrates the removal of the temporary working deck before installation of the upper intermediate module;

[0036] Fig. 22 illustrates the installation of the upper intermediate module;

[0037] Fig. 23 illustrates the removal of the temporary working deck before installation of the upper end module;

10 [0038] Fig. 24 illustrates the installation of the upper end module;

[0039] Fig. 25 illustrates an alternative option of the proposed invention with beams located on the floor tray level instead of upper level between columns or walls.

15 [0040] 1. For Steel Systems

[0041] The steel system requires a very stringent fire protection to suite higher requirements in certain building usages.

20 [0042] Corrosion may be of a concern and require high skill of the treatment of the steel elements. It may cause subsequent maintenance problems if there is corrosion over the long service life, normally 50 years.

[0043] Building maintenance and inspection will require high skilled and trained
25 technical personnel for the steel elements fully concealed in fire protection materials or embedded in cement board walls.

[0044] Thus, with the above constraints, the steel prefabricated modular room were mostly applied in single owner or operator, such as hotel, hostel, nursing home, worker
30 quarter, small office, roof extensions, etc. However, if it is applied in the multi-user, the maintenance and inspection will be very troublesome and shall be well coordinated between different tenants and end users.

[0045] 2. Conventional concrete system:

[0046] Conventional concrete modular room system all used similar concept to the steel system. It generally comprised of a reinforced concrete base slab with 4 or more columns/walls at corners of the module. Thus, after 2 modules are assembled on site, there will be unavoidable double columns/walls.

[0047] For some of the wall modular room system, the partition wall cannot be hacked off and not adaptive to home user's future renovation changes.

[0048] The design of this innovative prefabricated prefinished modular room system aims to overcome the constraints and limitations of the existing systems and present a complete new concept that meets the above criterion. The advantages of the systems are as follows:

[0049] 1. Weight: By utilising the innovative column system, the prefabricated prefinished room can be in-filled with light weight partitions and reduced handling and lifting weight requirements in conventional reinforced concrete wall system.

[0050] 2. Durability: The concrete volumetric modular room system can achieve very good durability against floor deformation, impact forces, corrosion, fire and other incidental stresses.

[0051] 3. Rigidity and Robustness: Sufficient rigidity and robustness of the reinforced concrete system to withstand various handling stresses of lifting, transportation, and installation etc.

[0052] 4. Quality and Workmanship: Stringent quality control in factory ensures uniform and superior quality product.

[0053] 5. Productivity: Production of prefabricated prefinished modular room unit in factory proceeds in parallel while other site activities at construction site run concurrently.

[0054] 6. Adaptive: The system must be adaptive to home users' maintenance and future renovation changes of finishes and fitting out using market available conventional methods.

- 5 [0055] 7. Elimination of Double Column/wall: The innovative system resolved the conventional double columns/walls and increased the usable spaces of the rooms.

[0056] 8. Wider Applications: The innovative reinforced concrete modular room system can be adopted in multi-user residential buildings and other various low rise or
10 high rise buildings.

[0057] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of
15 relevant applications.

[0058] Fig. 1 and Fig. 2 illustrates an overall 3D view with one end unit module 1 and one intermediate unit module 2. Each module can be prefabricated in the factory on a production line with or without architectural, mechanical, electrical, water supply
20 systems. These modules can be transported to the construction site and installed onto the building structure as a large 3D building elements to function as bedroom, study room, living room, etc. Each of the 3D module comprised of base floor tray 3, end wall or end units 4, staggered male-female columns/walls 5, beams 6 as basic key structural elements, and other optional supplementary outfitting such as: façade 7, partition,
25 ceiling, painting, tiling, water supply, electrical services, air conditioning services, drainage, plumbing services, gas services, etc.

[0059] The base of the prefabricated prefinished modular room unit consists of a floor tray 3 constructed with normal weight reinforced concrete or lightweight reinforced
30 concrete fabricated in the factory. The reinforcement of the concrete floor tray shall be designed for both temporary stage (such as demoulding, lifting, storage, transportation, and installation) and permanent stage loading when the modules are joined and combined.

[0060] The reinforced concrete floor tray 3 has the starter rebars 8 for the construction of the columns and walls which comes with the module. There is also pre-embedded dowel at bottom 9 and grouting connectors 10 at top of vertical column/wall connections, loop connectors between male-female columns/walls 11 to connect two side by side columns, and internal floor ties and peripheral floor ties connectors 12 for the future joining on construction site after installation. Fig. 3 illustrates a bottom floor tray with starter bars.

[0061] The concrete or composite columns/walls will be constructed on top of the concrete floor tray at the starter bar locations at designated locations required by structural layout arrangement. Each column/wall will have a thicker structural portion 5a and connected with a thinner non-structural portion 5b to create a flat surface for the finishing works. The right side of the columns/walls will be arranged in a staggered location from the left side of the columns/walls from neighbouring module. Thus, when the two modules are combined together, the staggered columns/walls will not be clashing each other and can form as a uniform column/wall in thickness. Each staggered columns/walls 5 shall have a recess groove with wire loop connectors 11 for grouting during site installation.

[0062] For the gable end module, the end wall 4 may be formed by one long wall with or without openings (Fig 1). However, for intermediate modules, both sides will have the staggered columns/walls 5 (Fig 2). Fig. 4 illustrates a plan view at a bottom of one module structure;

[0063] There shall be a beam 6 connecting two staggered columns/walls 5 on one of the long side of the module. The beam will have protruded corbel for the future seating by neighbouring module. On the other long side of the module, steel framing 13 will be provided as bracings to hang false ceiling 14 and temporary protection working platform. These elements formed the key structural elements for the module.

[0064] The lifting points are fixed to the rigid corners of the framing system so that any lifting or handling stresses will directly transfer to the framing system and base floor tray. Thus, the system depends less on the rigidity and strength of in-filled panels. This

concept allows the user to select a wide variety of the in-filled panel to their preference. Fig. 5 illustrates a plan view at a top framing one module structure.

[0065] The façade 7 and partition wall 15 may be installed onto the prefabricated modules to form a final enclosed room. The partition walls may be formed with either dry wall or lightweight panels such as hollow core wall, aerated concrete wall, lightweight concrete panels, etc. The connections will be installed on to the base tray and structural frame system for the receiving of the in-filled wall panels.

[0066] The module may be pre-installed with architectural finishes, tiling, painting, out-fittings, mechanical and electrical services, etc. depending the required level of finishing for different projects. There shall be weatherproofing covers to protect the finished module from rain. Fig. 6 illustrates an elevation (long direction) structure and partition left side; Fig. 7 illustrates another elevation (long direction) structure and partition right side; Fig. 8 illustrates an elevation (short direction) structure and partition façade side.

[0067] The prefabricated modular rooms will be transported to the construction site for installation. Fig. 9 illustrates a typical end module on the left combined with neighbouring module with staggered columns/walls to form a uniform final column/wall at construction site. By adopting this staggered column/wall method, there will be no need for double column/wall, and reduced the thickness of the column/wall protrusion into the unit. Fig. 10 illustrates a 3D structural module when it is finished (without ceiling); Fig. 11 illustrates a 3D structural module when it is finished (with ceiling).

[0068] After the modules are installed on site, there will be a vertical joint between the two neighbouring modules at the place of the staggered columns. This vertical joint will have pre-embedded starter wire ropes 11 to transfer the tying forces. The connection can be grouted with non-shrink grout to form a final column/wall. Fig. 12 illustrates a plan view of vertical connection between staggered male – female columns or walls; Fig. 13 illustrates a 3D view of vertical connection between staggered male – female columns or walls 5;

[0069] On the floor slab between the two neighbouring modules, connectors will be provided on to the recess holes pre-constructed with the modules. The recess holes will be grouted to form a uniform integrity floor ties 12.

- 5 [0070] At the peripheral location between the two neighbouring modules, connectors will be provided on to the recess holes pre-constructed with the modules. The recess holes will be grouted to form a uniform integrity peripheral ties. Fig. 14 illustrates a plan view of the connection between a slab and another slab known as internal floor ties and peripheral ties; Fig. 15 illustrates section view of the connection between the slab and
10 the other slab known as internal floor ties and peripheral ties; Fig. 16 illustrates a 3D view of the second type of connection between the slab and the other slab.

[0071] There will be pre-embedded connectors 10 on top of each precast column/wall. Before upper module is to be installed, the connectors will be grouted with designated
15 grout to receive the upper module. The upper module shall have dowel bar 9 protruded on the base and inserted into the module for connections. On top of the beams and columns/walls, there will be a layer of non-shrink bedding mortar to be laid to receive the upper modules for structural bearing requirements and fire protection requirements. Fig. 17 illustrates the connection between an upper module and a lower module;

20

[0072] Fig. 18 illustrates typical site installation sequence of multiple prefabricated modules on a conceptual floor layout.

[0073] Fig. 19 illustrates a 3D module with optional temporary working platform 19, and
25 the module will be protected with temporary weatherproof membranes 20.

[0074] Fig. 20, 21, 22, 23, 24 illustrates typical installation 3D module site installation. Fig. 20 shows the lower floor modules are all completely installed. Fig 21 illustrates removal of temporary working deck 19 before installation of upper module. Fig 22
30 shows the upper module installed. Fig 23 shows remove of temporary working deck 19 before installation of another upper neighbouring module. Fig. 24 illustrates the final upper end module is installed.

[0075] As an alternative to the previous described system, the beams 6 can also be located at bottom of the floor instead of on top of the staggered column/walls 5. Fig. 25 illustrates beams between staggered columns or walls 5.

5 [0076] The described system shall not be restrained to the shape of the staggered columns/walls 5. The staggered columns/walls can comprise of a few numbers of structural portion and non-structural portion. Fig. 26 illustrates other possible types of the staggered column/wall but not limited to these types of alternatives.

10 [0077] Compared with the prior inventions, this innovative prefabricated prefinished modular room system has its technical advantages and uniqueness:

1. This invention used staggered column/wall to reduce the size of the column/wall and formed a uniform thickness of the column/wall aligned with partitions.
- 15 2. It allows a five sided or six sided fully finished room interior at factory.
3. The invented module is designed with flexibility to choose different types of prefabricated or precast lightweight concrete or cement based in-filled panel in forms of precast concrete hollow wall panels, lightweight concrete wall panels, aerated concrete wall panels, and other similar lightweight panels which reduce
- 20 the overall weight of the module.
4. The rigid base floor tray and staggered framing system are wholly designed with sufficient robustness and rigidity to withstand the various handling stresses of lifting, transportation and installation.
5. It is common for home users to replace or change the interior finishes, fitting out,
- 25 as well as maintenance of services over time. Cement or concrete based materials for base tray and in-filled panels can be selected in this invention, which are adaptive for future changes of the interior finishes, fitting out, and replacement of services using common renovation methods.
6. This invention is a fully pre-assembled prefabricated room unit system with
- 30 concrete base slab, concrete or composition structural framing system, and lightweight in-filled wall panels. The overall system is designed using simple and convenient methods that focus on ease of fabrication, assembly and installation to achieve better productivity and quality product using market available materials.

[0078] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-
5 explicitly recited elements.

[0079] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges.
10 Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range,
15 for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0080] It will be apparent that various other modifications and adaptations of the application will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is
20 intended that all such modifications and adaptations come within the scope of the appended claims.

Claims

1. A prefabricated prefinished volumetric construction module substantially as
hereinbefore described with reference to or as illustrated in any of the
5 accompanying drawings.
2. A method for making a prefabricated prefinished volumetric construction module
substantially as hereinbefore described with reference to or as illustrated in any
of the accompanying drawings.

10