

PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION MODULE

[0001] The present application claims an earlier priority date of Singapore patent application 10201608260Q that was filed with IPOS (Intellectual Property Office of Singapore) on 03 October 2016. Contents or subject matter of the priority application is hereby incorporated entirely by reference.

[0002] The present application relates to a prefabricated prefinished volumetric construction module, which is also known as PPVC module, PPVC modular room or PPVC unit. The application also relates methods for making, manufacturing, assembling, installing, configuring, maintaining, using the prefabricated prefinished volumetric construction module.

[0003] This application further relates to building construction industry, with application of new technology by using prefabricated and prefinished concrete modular rooms for the design and construction of low-rise or high-rise buildings.

[0004] Conventional building construction involves labour intensive construction work such as formwork, scaffolding, rebar binding, concrete casting, mechanical and electrical works, water supply and sanitary services, architectural finishes, etc. The conventional building construction work also requires a lot of coordination of workers of different trades to cooperate. Thus, the emergence of technique on manufacturing pre-fabricated modular rooms has largely resolved or reduced issues of complicated site construction and site coordination between numerous construction trades. A prefabricated building (informally known as prefab) can be divided into several types of standard modular rooms, prefabricated off-site, preinstalled with mechanical and electrical works, water supply and sanitary services, and prefinished with majority of architectural features at a factory off-site. The modular rooms (known as modules) are manufactured and constructed, which comprises factory-made components or units, subsequently transported and assembled on-site to form the complete prefabricated building. Since the modular rooms are prefabricated in the factory by controlled assembly lines, checked with stringent quality criteria before delivery to construction sites for installation, the PPVC technique extensively reduces the need

for skilled workers on site, saves time, and provides great productivity and high quality products.

[0005] This technique of construction prefabricated prefinished modular rooms (PPVC modules) is proposed for low or high rise building development that incorporates prefabricated or precast volumetric system. This technique comprises a normal-weight or lightweight reinforced concrete base floor slab, staggered concrete or steel/concrete composite columns/walls at one or more corners, and in-filled with lightweight panels or dry walls, lightweight frame at ceiling level as bracing and to hold ceilings. The concrete base slab 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.

[0006] 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 prefabricated off-site and pre-assembled at the fabrication yard and delivered to construction site for installation. The prefabricated prefinished volumetric 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.

[0007] A typical intermediate prefabricated module comprises of columns/walls along two or more sides of the modules. The two side by side modules will have columns/walls positioned in a staggered 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, which adopted double column/wall method. Thus, this innovation will create more space for

the end users. The system is versatile to accommodate different 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 volumetric modular room will be reduced greatly to facilitate easier assembly, transportation, handling, lifting and installation. These non-structural walls can be 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.

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[0008] 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.

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[0009] 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

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[0010] Although existing prefabricated prefinished modular room systems have already been widely used in various applications. All of the above system share a common double wall or double column arrangement. There are also respective constraints and limitations of each system, which can be summarized as below.

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[0011] 1. For Steel Systems

[0012] The steel system requires a very stringent fire protection to suite higher requirements in certain building usages.

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[0013] 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.

[0014] Building maintenance and inspection will require high skilled and trained technical personnel for the steel elements fully concealed in fire protection materials or embedded in cement board walls.

- 5 [0015] 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 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.

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[0016] 2. Conventional concrete system:

- [0017] Conventional concrete modular room system all used similar concept to the steel system. It generally comprised of a reinforced concrete base slab with four or
15 more columns/walls at corners of the module. Thus, after two modules are assembled on site, there will be unavoidable double columns/walls.

[0018] 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.

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[0019] 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:

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[0020] 1. Weight: By utilising the innovative PPVC modular 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.

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[0021] 2. Durability: The concrete volumetric modular room system can achieve very good durability against floor deformation, impact forces, corrosion, fire and other incidental stresses.

[0022] 3. Rigidity and Robustness: Sufficient rigidity and robustness of the reinforced concrete system to withstand various handling stresses of lifting, transportation, and installation etc.

- 5 [0023] 4. Quality and Workmanship: Stringent quality control in factory ensures uniform and superior quality product.

[0024] 5. Productivity: Production of prefabricated prefinished modular room unit in factory proceeds in parallel while other site activities at construction site run
10 concurrently.

[0025] 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.

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[0026] 7. Elimination of Double Column/wall: The innovative system resolved the conventional double columns/walls and increased the usable spaces of the rooms. When it comes to high-rise buildings, the double column/wall system will require much bigger column/wall thickness to withstand higher gravity and lateral forces and avoid
20 lateral buckling. For this application, the columns/walls will be assembled in staggered manner, and each of the columns/walls will be constructed in a staggered manner, and the thickness of the columns/walls will be just equivalent to conventional building columns/walls.

- 25 [0027] 8. Wider Applications: The innovative reinforced concrete modular room system can be adopted in multi-user residential buildings and other various low rise or high rise buildings.

[0028] The present application pertains to a novel structural system and relevant
30 connections for prefabricated prefinished volumetric modular room construction method.

[0029] An end module of the application comprises a reinforced concrete base slab (with or without steel section encasement), gable end wall at one side, structural

columns/walls at the other side(s) of the module. The structural columns/walls for the end module will be located in staggered location to fit in the empty space of next intermediate module. The staggered columns/walls will then fit into the empty space of the neighbouring module, and will finally form a uniform thick column/wall after the two modules are assembled. The conventional way of construction will only allow side by side column/wall connections and will result in a much thicker column/wall.

[0030] An intermediate module of the application comprised of a reinforced concrete base slab (with or without steel section encasement), structural columns/walls at two (or more) sides of the module. Between two side by side modules, the columns/walls will be located in a staggered manner. After two side by side modules are assembled, the column/wall of neighbouring unit finally form a uniform thickness of column/wall after they are assembled. These columns/walls can either behave independently or can be grouted to form a uniform column/wall finally. While the conventional way of construction will only allow side by side column/wall connections and will result in a much thicker column/wall.

[0031] The present invention aims to provide one or more new and useful PPVC modules. The invention also aims to present new and useful methods for making, manufacturing, assembling, installing, configuring, maintaining, using the prefabricated prefinished volumetric construction module. Essential features of the invention are provided by one or more independent claims, whilst advantageous features are presented by their dependent claims.

[0032] According to a first aspect, the present application provides a first PPVC (Prefabricated Prefinished Volumetric Construction) module for building construction. The First PPVC module comprises structural base floor slab for defining a habitable room; and a first pillar connected to one or more of the structural base floor slab for supporting weight of another PPVC module on top of the first PPVC module. The first pillar further comprises a first elongated interior wall surface for the First PPVC module and a second elongated interior wall surface for a neighbouring PPVC module. The first elongated interior wall surface is opposite to the second elongated interior wall surface.

[0033] Hence, the First PPVC module includes the first pillar that can also act as interior walls of the First PPVC module and its neighbouring PPVC module. Two contiguously neighbouring PPVC modules can share the same first pillar that provides their respective interior walls or interior wall surfaces. The shared first pillar eliminates the requirement of providing two separate walls, interior walls or partition walls for the two contiguously neighbouring PPVC modules. In practice, the shared first pillar is thinner and lighter than two pillars joined side by side.

[0034] The first PPVC module can further comprise a first non-structural skin wall extending from a lateral side of the first pillar for covering one or more a lateral side of the PPVC module, such that the first pillar and the first non-structural skin wall can be unitarily formed. Since the first non-structural skin wall does not provide substantial structural support in its vertical or upright direction, the first non-structural skin wall can be made thinner than the first pillar, especially without including reinforcing elements or bars. Accordingly, the first pillar can be economically made by making a slim and low cost partition wall attached to a pillar, whilst both the pillar and the partition wall jointly provide a large interior wall surface. When required, partition walls of neighbouring PPVC modules are adhered together, whether with filler in-between or not, offers two opposite interior surfaces for the neighbouring PPVC modules. In practice, the first non-structural skin wall has many types, which include partition wall, partition, infill wall, concrete wall, moveable partition and other types of non-load bearing walls. The non-loading bearing wall is alternatively known as a non-structural wall.

[0035] Optionally, the first PPVC module provides the first pillar or a first set of pillars that have non-structural skin walls (i.e. skin walls) extending from opposite sides of the first set of pillars. Two or more of the first pillar and its extended skin walls share one common flat surface, which can serve as an interior wall surface. The extended skin wall and the first pillar together provide a lateral side of the first PPVC module, noting thickness directions of the extending walls and the first pillar are substantially parallel to each other.

[0036] The first set of pillar and the skin wall may have the same height, or their longitudinal ends may be levelled. For example, the first pillar and the skin wall stand

on the same floor base slab, and terminate at the same ceiling. Instead of a full-sized partition wall, the first set of pillar and skin wall jointly presents a side wall of the first PPVC module, whether partially or fully cover a lateral side of the first PPVC module. Double partition walls of two joined PPVC modules are eliminated.

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[0037] The first set of pillar can comprise reinforcing components for supporting weight of one or more PPVC modules on top of the first PPVC module. For example, the reinforcing elements include reinforcing bars or rebars that extend vertically along a longitudinal direction of the first pillar. The reinforcing bars can have different lengths, thickness or diameters. The reinforcing elements can further comprise composite or other materials that are heat insulating, sound-proof, moisture resistant or fire retardant.

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[0038] The first set of pillar and skin wall may have different thickness. For example, the pillar is thicker whilst the skin wall is thinner and non-structural in nature, such that the skin wall possesses less weight and requires less materials.

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[0039] The first pillar or the first skin wall can be located at a corner of the first PPVC module. Multiple pieces of the first pillar and the first non-structural skin wall are able to provide side walls of the first PPVC module depending on the structural load transfer requirements and architectural layout requirements.

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[0040] The first set of pillar and skin wall may be levelled at their lateral sides respectively, which is to have a common flat surface as an interior wall finished surface or share a levelled surface. The interior wall surface offers a broad, even and aesthetically appealing interior wall surface that is jointly provided by the first set of pillar and skin wall (i.e. first non-structural skin wall).

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[0041] The first set of pillar, the skin wall (i.e. first non-structural skin wall) or both can be connected to a bottom or top edge of the first PPVC module in order to provide a side wall of the first PPVC module. For example, the first pillar and the first non-structural skin wall together covers an entire lateral side of the first PPVC module. Alternatively, the first pillar and the first non-structural skin wall are united to partially conceal the lateral side of the first PPVC module.

[0042] The first pillar further may comprise lateral connectors at its lateral side for joining another pillar from neighbouring module laterally together. The lateral connector can comprise one or more loops for receiving (e.g. inserting) a rod into the one or more loops at a construction site.

[0043] The first pillar further can comprise vertical connectors for linking upper PPVC module. The vertical connector can join two or more PPVC modules together when they are stacked on top of each other. In practice, the vertical connector often include threaded or grouted rebar couplers. The vertical connector is alternatively known as a longitudinal connector, which is usually installed in an upright position.

[0044] The first PPVC module may comprise multiple sets of pillars to form a structurally stable system for stacking and connecting side by side PPVC modules as well as upper and lower PPVC modules. Hence, the first PPVC module may include multiple pillars that have broad lateral surfaces as interior wall surfaces. The multiple pillars may be independently constructed or supported, or mutually connected. For example, the multiple pillars are positioned at opposite sides of the first PPVC module and connected together by a side wall having a window. Optionally, the subsequent pillars and skin wall may have sizes, materials, structures, shapes or dimensions similar to those of the first set of pillar and the skin wall (first non-structural skin wall).

[0045] All the pillars and skin walls may be levelled at their lateral sides respectively, having one common flat surface as the interior wall finished surface or share a substantially levelled surface. In other words, the four parts (i.e. the first pillar, the first non-structural skin wall, the second pillar and the second wall) may conceal a single lateral side of the first PPVC module, providing a complete interior wall surface.

[0046] The first PPVC module can further comprise a beam that is connected to the first set of pillar / skin wall and the second set pillar / skin wall having their sides at the same level as an interior wall finished surface. The beam can be levelled with top edges of the first and second set of pillars, or even with bottom surfaces of the first and second set of pillars. The can additionally have thickness similar to that of the first pillar and first non-structural skin wall.

[0047] The first PPVC module may further comprise a first peripheral side connector (i.e. first side connector) at a side or an edge of the first PPVC module for connecting the first PPVC module to another PPVC module horizontally or laterally at perimeter of the building, which is known as peripheral ties. For example, the side connector includes a rectangular steel plate having bolt holes evenly distributed. Two or four neighbouring PPVC modules may be connected to the through holes for coupling together.

10 [0048] The side connector can comprise one or more bolts. The one or more bolts can be connected to their respective PPVC modules and inserted into the through holes. The bolts are commonly, cheaply, widely and reliably available such that the side connector is easily and securely constructed.

15 [0049] The first PPVC module may further comprise a second side peripheral connector at the same side or edge of the first PPVC module for connecting the first PPVC module to the other neighbouring PPVC module laterally at the same side or edge. The first and second side connectors may be located at opposite ends of the first PPVC module so that the first PPVC module may be locked to a neighbouring
20 PPVC module robustly over an entire lifetime of the first PPVC module.

[0050] The first set pillar and skin wall can be symmetrical to the second set pillar and skin wall with respect to the first PPVC module or a centreline of the first PPVC module. Two laterally joined PPVC modules have a panel with uniform thickness as
25 their common partition, termed as pillar-wall partition. Since the first PPVC module becomes symmetrical, many PPVC modules can be tessellated laterally over a large area. Similarly, a lot of first PPVC modules can be stacked together for constructing a high-rise building with high speed, good quality and excellent efficiency.

30 [0051] The PPVC module may further comprise a brace aligned to a beam of the first PPVC module. The brace sometimes includes steel bars or frames that are strong for providing structural integrity and sturdiness. For example, a frame of angle bar or angle strap provides a ledge for holding a ceiling and/or floor panel and/or weatherproof protection layer.

[0052] The application may provide a PPVC building that comprise of many PPVC modules, which are manufactured or prefabricated in off-site factories. On-site construction time and total construction cost may be greatly reduced, benefiting both consumers and building constructors. The off-site factories further facilitate efficient processes, standard procedures and environmentally friendly operations, which is beneficial to society at large. The PPVC building has multiple PPVC modules that are inter-locked to each other by side connectors, vertical connectors and lateral connectors, the PPVC building simple and reliable to construct, and easy to be taken apart.

[0053] The second layer of PPVC modules or second PPVC module can be stacked on top of the first layer of PPVC module. For example, a high-rise building of fifty storeys includes fifty layers or less number of PPVC modules laid on top of each other. Workers of the building construction site only need to align PPVC modules vertically, instead of building a residential unit by laying bricks piece by piece. Time and cost of building construction is greatly reduced.

[0054] The present application provides a method for designing and manufacturing a PPVC (prefabricated prefinished volumetric construction) module. The method comprises a first step of providing structural floor base of the PPVC module; a second step of forming (e.g. erecting) multiple sets of pillar that is connected to the structural floor base, the positioning of a first elongated interior wall surface for the PPVC module and a second elongated interior wall surface for a neighbouring PPVC module along an edge or side of the first PPVC module. The first elongated interior wall surface is opposite to the second elongated interior wall surface. Some of these steps can be changed in sequence or combined. The method is efficient and cost effective in constructing a building because the first PPVC module is standard unit, which can be manufactured offsite with speed and quality.

[0055] The method can further comprise a step of extending a non-structural skin wall from a lateral side of the first pillar for covering a lateral side of the first PPVC module. The method may further comprise a step of aligning the first pillar and the first skin wall possibly along the edge or side such that the first pillar and first skin wall have a

common interior wall surface. The first pillar not only provides structural support vertically, but also offers interior wall surfaces of the first PPVC module and its contiguously neighbouring PPVC module.

- 5 [0056] The method can further comprise a step of positioning the first pillar or the first non-structural skin wall at a corner of the first PPVC module. The first pillar or first non-structural skin wall is able to render structural fulcrum to the first PPVC module.

- 10 [0057] The method may further comprise a step of connecting the first set pillar and skin wall or both to an edge or a floor of the first PPVC module. For example, opposite ends of the first set pillar and skin wall reach both ceiling and floor of the first PPVC module. No additional partition is required for enclosing sides of the first PPVC module.

- 15 [0058] The method can further comprise a step of joining the first set pillar and the second pillar with a beam. Since the first pillar and the second pillar are vertically standing (i.e. upright), the beam offers mutual support between the pillar in their lateral directions.

- 20 [0059] The method may further comprise a step of linking the first pillar and the second pillar with a frame. The frame is light and strong, providing an anchor for holding other parts of the first PPVC module.

- 25 [0060] The method can further comprise a step of providing another subsequent pillar (i.e. third pillar) on an edge opposite to the first pillar. Construction of the multiple pillars reduce requirement or reliance of independent partition walls.

- 30 [0061] The method may further comprise a step of presenting a floor that is connected to the first pillar, the second pillar, the third pillar, the fourth pillar or a combination of any of these pillars. The method can further comprise a step of presenting a ceiling that is connected to the first pillar, the second pillar, the third pillar, the fourth pillar or a combination of any of these pillars. Accordingly, the pillars provide interior walls of the first and neighbouring PPVC units, reducing demand to partition walls to PPVC modules or PPVC buildings.

[0062] According to a third aspect, the present application presents a method for manufacturing a first PPVC (prefabricated prefinished volumetric construction) building. The method comprises a first step of providing the first PPVC module; a second step of attaching a second PPVC module to a lateral side of the first PPVC module; and a third step of aligning a pillar of the first PPVC module with another pillar of the second PPVC module in their longitudinal directions. Two PPVC modules are seamlessly and neatly joined together laterally, which requires less time and labour on constructing two rooms with traditional methods. Multiple PPVC modules are further able to be tessellated for covering a floor, greatly enhancing manufacturing efficiency and quality of the PPVC modules or buildings.

[0063] The method can further comprise a step of adhering a pillar of the first PPVC module to a pillar of the second PPVC module.

[0064] The method may further comprise a step of linking the first PPVC module and the second PPVC module with a lateral connector. The lateral connector provides additional coupling to PPVC modules, whether they are adjacent or spaced part.

[0065] The present application can moreover provide a method for constructing a PPVC (prefabricated prefinished volumetric construction) building. The method comprises a step of providing the first layer PPVC module; and another step of stacking a second layer PPVC module on top of the of the first layer PPVC module. A high-rise building can be constructed efficiently according to this method by stacking and combining multiple layers of PPVC modules.

[0066] The method may further comprise a step of linking the first PPVC module and the second PPVC module with a vertical connector. A stack of PPVC modules is made secure and robust by the method.

[0067] 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 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 slab 3, end wall or end units 4, pillars with non-structural skin walls (the pillars between two immediate modules will be a manner of staggered arrangement to avoid double pillars) 5, beams 6 as basic key structural elements, and other optional supplementary outfitting such as: façade 7, partition, ceiling, painting, tiling, water supply, electrical services, air conditioning services, drainage, plumbing services, gas services, etc.

[0068] The base of the prefabricated prefinished modular room unit consists of a floor base slab 3 constructed with normal weight reinforced concrete or lightweight reinforced concrete fabricated in the factory. The reinforcement of the concrete floor slab 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.

[0069] The reinforced concrete base floor slab 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 pillar connections, loop connectors between pillars 11 to connect two side by side pillars, 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 slab with starter bars.

[0070] The concrete or composite pillars will be constructed on top of the concrete floor slab at the starter bar locations at designated locations required by structural layout arrangement. Each will have a thicker structural pillar 5a and connected with a thinner non-structural skin wall 5b to create a flat surface for the finishing works. The right side of the pillar will be arranged in a staggered location from the left side of the pillar from neighbouring module. Thus, when the two modules are combined together, the staggered pillars will not be clashing each other and can form as a uniform pillar in thickness. Each staggered pillar 5 shall have a recess groove with wire loop connectors 11 for grouting during site installation.

[0071] 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 pillars 5 (Fig 2). Fig. 4 illustrates a plan view at a bottom of one module structure;

[0072] There shall be a beam 6 connecting two staggered pillars 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.

[0073] 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 slab . 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.

[0074] 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 floor slab and structural frame system for the receiving of the in-filled wall panels.

[0075] 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.

[0076] 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 pillars to form a uniform final pillars at construction site. By adopting this staggered pillar method, there will be no need for double pillar, 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).

[0077] After the modules are installed on site, there will be a vertical joint between the two neighbouring modules at the place of the staggered pillars. 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 pillar. Fig. 12 illustrates a plan view of vertical connection between staggered pillars 5; Fig. 13 illustrates a 3D view of vertical connection between staggered pillars 5;

[0078] 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.

[0079] 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 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.

[0080] There will be pre-embedded connectors 10 on top of each pillar. Before upper module is to be installed, the connectors will be grouted with designated 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 pillars, 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;

[0081] Fig. 18 illustrates typical site installation sequence of multiple prefabricated modules on a conceptual floor layout.

[0082] Fig. 19 illustrates a 3D module with optional temporary working platform 19, and the module will be protected with temporary weatherproof membranes 20.

[0083] Fig. 20, 21, 22, 23, 24 illustrates typical installation 3D module site installation.

5 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 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.

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[0084] 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 pillars 5. Fig. 25 illustrates beams between staggered pillars 5.

15 [0085] The described system shall not be restrained to the shape of the staggered pillars 5. The staggered pillars can comprise of a few numbers of structural portion and non-structural skin wall. Fig. 26 illustrates other possible types of the staggered pillar but not limited to these types of alternatives.

20 [0086] Compared with the prior applications, this innovative prefabricated prefinished modular room system has its technical advantages and uniqueness:

1. This application used staggered pillar to reduce the size of the pillar and formed a uniform thickness of the pillar aligned with partitions.

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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 the overall weight of the module.

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4. The rigid base floor slab and staggered framing system are wholly designed with sufficient robustness and rigidity to withstand the various handling stresses of lifting, transportation and installation.

5 5. It is common for home users to replace or change the interior finishes, fitting out, as well as maintenance of services over time. Cement or concrete based materials for base slab and in-filled panels can be selected in this application, which are adaptive for future changes of the interior finishes, fitting out, and replacement of services using common renovation methods.

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6. This application is a fully pre-assembled prefabricated room unit system with 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
15 installation to achieve better productivity and quality product using market available materials.

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[0087] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or
20 "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

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[0088] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and
25 should not be construed as an inflexible limitation on the scope of the disclosed ranges. 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,
30 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, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

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[0089] 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 intended that all such modifications and adaptations come within the scope of the appended claims.

[0090] List of Figures

- Fig. 1 illustrates an overall 3D view for the modular unit;
- Fig. 2 illustrates another overall 3D view for the modular unit;
- 10 Fig. 3 illustrates a bottom floor slab with starter bars and connectors;
- Fig. 4 illustrates a plan view of one module structure at bottom;
- Fig. 5 illustrates a top framing plan view of one module structure;
- Fig. 6 illustrates a long direction elevation view of structure from left side;
- Fig. 7 illustrates a long direction elevation view of structure from right side;
- 15 Fig. 8 illustrates a short direction elevation view of structure from façade side;
- Fig. 9 illustrates a 3D structural module when it is combined;
- 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);
- Fig. 12 illustrates a plan view of vertical connection between staggered pillars;
- 20 Fig. 13 illustrates a 3D view of vertical connection between staggered pillars;
- Fig. 14 illustrates a plan view of internal floor tie connection between one module to another module on floor slab;
- Fig. 15 illustrates a section view of internal floor tie connection between one module to another module on floor slab;
- 25 Fig. 16 illustrates a 3D view of internal floor tie connection between one module to another module on floor slab;
- Fig. 17 illustrates the vertical dowel and grouting connector between an upper module and a lower module;
- Fig. 18 illustrates installation sequence of multiple modules on a conceptual layout plan;
- 30 Fig. 19 illustrates a 3D module with weather protections membrane and temporary working deck;
- Fig. 20 illustrates the 3D modules installed on the construction site waiting for another two modules to be installed;

- Fig. 21 illustrates the removal of the temporary working deck before installation of the upper intermediate module;
- Fig. 22 illustrates the installation of the upper intermediate module;
- 5 Fig. 23 illustrates the removal of the temporary working deck before installation of the upper end module;
- Fig. 24 illustrates the installation of the upper end module;
- Fig. 25 illustrates an alternative option of the proposed application with beams located on the base floor slab level instead of upper level between pillars;
- 10 Fig. 26 illustrates an alternative connection between staggered columns/walls; and
- Fig. 27 illustrates a further alternative connection between staggered columns/walls.

Claims

1. A first PPVC (Prefabricated Prefinished Volumetric Construction) module for building construction, the PPVC module comprising:
 - structural base floor slab for defining a habitable room; and
 - a first pillar connected to the structural floor slab, wherein the first pillar further comprises a first interior wall surface and a second interior wall surface, the first interior wall surface being opposite to the second interior wall surface.
2. The first PPVC module of claim 1 further comprising a first non-structural skin wall extending from the first pillar for covering a lateral side of the PPVC module.
3. The first PPVC module of claim 1 or 2, wherein the first pillar comprises reinforcing components for supporting structural loads.
4. The first PPVC module of any of the preceding claims, wherein the first pillar and the first non-structural skin wall have different thickness.
5. The first PPVC module of any of the preceding claims, wherein the first pillar or the first non-structural skin wall is located at a corner of the PPVC module.
6. The first PPVC module of any of the preceding claims, wherein the first pillar and the first non-structural skin wall are levelled at their lateral sides respectively.
7. The first PPVC module of any of the preceding claims, wherein the first pillar, the first non-structural skin wall or both are connected to an edge or a base floor slab of the first PPVC module.
8. The first PPVC module of any of the preceding claims, wherein the first pillar further comprises a lateral connector for joining another pillar.

9. The first PPVC module of claim 8, wherein
the lateral connector comprises at least one loop for receiving a rod into the at
least one loop.
- 5
10. The first PPVC module of any of the preceding claims, wherein
the first pillar further comprises one or more vertical connectors for linking
another PPVC module.
- 10 11. The first PPVC module of any of the preceding claims further comprising
➤ a second pillar further connected to the base floor slab with or without
beams (for supporting loads of another PPVC module on top of the first
PPVC module),
wherein the second pillar further comprises a third interior wall surface
and a fourth interior wall surface, the third interior wall surface being
15 opposite to the fourth interior wall surface.
12. The first PPVC module of claim 11 further comprising
a second wall extending from the second pillar for covering a lateral side of the
20 PPVC module.
13. The first PPVC module of claim 12, wherein
the first pillar, the first non-structural skin wall extension, the second pillar and
the second wall are levelled at their lateral sides respectively.
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14. The first PPVC module of any of the preceding claims further comprising
a beam connected to the first pillar and the second pillar having sides at the
same level.
- 30 15. The first PPVC module of any of the preceding claims further comprising
a first side connector at a side of the first PPVC module for connecting the first
PPVC module to another PPVC module laterally.

16. The first PPVC module of claim 15, wherein
the side connector comprises at least one bolt or other types of anchors or ties.
17. The first PPVC module of claim 15 or 16 further comprising:
5 a second side connector at the same side of the first PPVC module for
connecting the first PPVC module to the other PPVC module laterally.
18. The first PPVC module of any of the preceding claims 12 to 17, wherein
the first pillar and the first non-structural skin wall are symmetrical to the
10 second pillar and the second wall.
19. The first PPVC module of any of the preceding claims 11 to 18, wherein
the first pillar is located at a corner of the first PPVC module; and
the second pillar is located at another corner of the first PPVC module.
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20. The first PPVC module of any of the preceding claims 11 to 19 further
comprising
a third pillar connected to (at least one of) the structural base floor slab,
wherein the first pillar further comprises a first interior wall surface and
20 a second interior wall surface, the first interior wall surface being
opposite to the second interior wall surface.
21. A PPVC building comprising
the first PPVC module according to any of the preceding claims; and
25 a second PPVC module next to the first PPVC module;
wherein the second PPVC module comprises
- structural floor slab (with or without beams) for defining another
habitable room;
 - a third pillar connected to the structural floor slab, and
 - 30 ➤ a third wall extending from the third pillar for covering a lateral side of
the second PPVC module.

22. The PPVC building of claim 21, wherein
- the second PPVC module is stacked on top of the first PPVC module, and
 - the first pillar is aligned to the third pillar vertically.
23. The PPVC building of claim 21 or 22, wherein the second PPVC module is annexed to the first PPVC module laterally.
24. The PPVC building of any of the preceding claims 21 to 23, wherein
- the third pillar is attached to the first non-structural skin wall; and
 - the third wall is attached to the first pillar.
25. The PPVC building of any of the preceding claims 21 to 24, wherein the second PPVC module comprises a brace aligned to a beam of the first PPVC module.
26. A method for manufacturing a first PPVC (prefabricated prefinished volumetric construction) module, the method comprising:
- providing structural base floor slab (with or without beams);
 - forming a first pillar that is connected to the structural base floor slab;
 - positioning a first interior wall surface and a second interior wall surface along an edge of the first PPVC module, the first interior wall surface being opposite to the second interior wall surface.
27. The method of claim 26 further comprising extending a first non-structural skin wall from the first pillar for covering a lateral side of the first PPVC module.
28. The method of claim 26 or 27 further comprising aligning the first pillar and the first non-structural skin wall such that the first pillar and the first non-structural skin wall have a common interior wall surface.

29. The method of any of the preceding claims 26 to 28 further comprising:
positioning the first pillar or the first non-structural skin wall at a corner of the
first PPVC module.
- 5 30. The method of any of the preceding claims 26 to 29 further comprising
connecting the first pillar, the first non-structural skin wall or both to a floor of
the first PPVC module.
- 10 31. The method of any of the preceding claims 26 to 30 further comprising
joining the first pillar and the second pillar with a beam.
32. The method of any of the preceding claims 26 to 31 further comprising
linking the first pillar and the second pillar with a frame.
- 15 33. The method of any of the preceding claims 26 to 32 further comprising
providing a third pillar on an edge opposite to the first pillar.
34. The method of any of the preceding claims 26 to 33 further comprising
adding a fourth pillar on the same edge of the third pillar.
- 20 35. The method of any of the preceding claims 26 to 34 further comprising
presenting a floor that is connected to the first pillar, the second pillar, the third
pillar, the fourth pillar or a combination of any of these pillars.
- 25 36. The method of any of the preceding claims 26 to 35 further comprising
presenting a ceiling that is connected to the first pillar, the second pillar, the
third pillar, the fourth pillar or a combination of any of these pillars.

37. A method for manufacturing a first PPVC (prefabricated prefinished volumetric construction) building, the method comprising:
- providing the first PPVC module according to any of the preceding claims 1 to 20;
 - 5 ➤ attaching a second PPVC module to a lateral side of the first PPVC module;
 - aligning a pillar of the first PPVC module with another pillar of the second PPVC module in their longitudinal directions.
- 10 38. The method of claim 37 further comprising:
adhering a wall of the first PPVC module to a wall of the second PPVC module.
39. The method of claim 37 or 38 further comprising:
linking the first PPVC module and the second PPVC module with a lateral
15 connector.
40. A method for manufacturing a second PPVC (prefabricated prefinished volumetric construction) building, the method comprising
- providing the first PPVC module according to any of the preceding
20 claims 1 to 20; and
 - stacking a second PPVC module on top of the of the first PPVC module.
41. The method of claim 40 further comprising:
linking the first PPVC module and the second PPVC module with a longitudinal
25 or peripheral connector.