

PREFABRICATED PREFINISHED VOLUMETRIC CONSTRUCTION MODULE

[0001] The present application claims a priority date of Singapore patent application number 10201608260Q that was filed with IPOS (Intellectual Property Office of Singapore) on 03 October 2016. The present application also claims another priority date of Singapore patent application number 10201609258R that was filed with IPOS on 04 November 2016. All contents or relevant subject matter of the two priority applications are hereby incorporated entirely or wherever appropriate 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, maintaining, using the prefabricated prefinished volumetric construction (PPVC) module. 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.

[0003] 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 great deal of resources allocation especially manpower which demand different specialisations for different construction works. Quality of the finished work or building is often inconsistent due to the individual workmanship. Time spent on a construction site of a builder is frequently longer than projected time, which may be a result of an unexpected bad weather like torrential rain or other unforeseen circumstances.

[0004] 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.

[0005] The present application aims to provide one or more new and useful Prefabricated Prefinished Volumetric Construction (PPVC) modules or combined walls. A combined wall is also known as a column wall or pillar wall. The application also
5 aims to present new and useful methods for making, manufacturing, assembling, installing, configuring, maintaining, using the one or more PPVC modules or combined walls. Essential features of the invention are provided by one or more independent claims, whilst advantageous features are presented by their dependent claims.

[0006] According to a first aspect, the present application provides a PPVC module or first PPVC module for constructing a building, an architecture, a house, a home, an apartment, a tower, a domicile, a building unit, a residential unit or an office unit. The PPVC module comprises a structural wall for bearing weight or load in a longitudinal or vertical direction of the structural wall when standing upright in the longitudinal
15 direction. The structural wall is also known as a load-bearing wall, a bearing wall, a column or a pillar. The PPVC module further comprises a non-structural wall (e.g. curtain wall, partition wall, skin wall) extending from and connected to a side or lateral side of the structural wall in forming a first combined, stepped or column wall, which is a wall of uneven thickness in a transverse direction of the PPVC module, the structural
20 or non-structural wall. The structural wall has a structural thickness or thickness in a transverse direction of the structural wall, which is thicker or larger than a non-structural thickness or the thickness of the non-structural wall in a transverse direction of the structural wall. The structural wall and the non-structural wall are optionally aligned such that their transverse directions or thickness directions become parallel,
25 identical or coincide. The structural wall and the non-structural wall are further optionally aligned such that their lateral directions or thickness direction are parallel or identical. In the present application, both the structural wall and the non-structural wall are known as wall, which further include column, pillar or any other solid and flat structure.

[0007] The structural wall and the non-structural wall may be collectively known as a first combined wall, a combined wall, a first column wall, a column wall, a first pillar wall or a pillar wall. The first combined wall or neighbouring sides of the first combined wall are aligned to three axes of a Cartesian coordinate system for illustration.

Particularly, the longitudinal direction, the lateral direction and the transverse direction of the first combined wall are perpendicular to each other such that these three directions are aligned with three axes of a Cartesian coordinate system respectively. For example, the longitudinal direction of the first combined wall is aligned with Z-axis, the lateral direction is aligned with Y-axis and the transverse direction is aligned with X-axis of a right-handed Cartesian coordinate system. Accordingly, the transverse direction is also known as a thickness direction of the structural wall or the non-structural wall; the longitudinal direction of the first combined wall is also known as a height or vertical direction; and the lateral direction of the first combined wall is also known as a sidewise direction or length direction. The first combined wall has multiple sides, which include ends of narrower sides and surfaces of wider sides. If the first combined wall is erected upright, a higher side of the first combined wall is termed as a top combined end, a top side, a top end; whilst a lower side of the first combined wall is termed as a bottom combined end, a bottom side, a bottom end. To differentiate, the structural wall, the non-structural wall, the combined wall and the PPVC module are alternatively known as a first structural wall, a first non-structural wall, a first combined wall and first PPVC module respectively.

[0008] The combined wall optionally has one structural wall and two non-structural wall, whilst the two non-structural walls extend from lateral ends of the structural wall at opposite sides. Alternatively, the combined wall has one non-structural wall and two structural walls, whilst the two structural walls extend from lateral ends of the non-structural wall respectively. Multiple combined walls are further possible to be connected laterally, providing an elongated wall of partition and support. Since two non-structural walls of neighbouring or joined combined walls are able to match a thickness of a structural wall, whether having adhesive in-between or not, two joined combined walls provide a unitary wall when matching non-structural walls and structural walls of the neighbouring or joined combined walls.

[0009] To provide the building or residential unit, the PPVC module sometimes further comprises a floor, a ceiling, a partition wall, a façade or a combination of any of these walls, which are adjoined to the structural wall, the non-structural wall or the first combined wall.

[0010] The structural wall or non-structural wall optionally comprises reinforce elements including wire mesh, fibres, bars or layer, whether exposed out of or buried inside the structural wall. The reinforce elements are optionally interconnected made of steel, alloy, composite materials.

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[0011] Integration of the structural wall and the non-structural wall forms a unitary body, which is known as a first PPVC wall, a first combined wall, a first stepped wall or a first column wall. The non-structural wall extends laterally from the structural wall or the non-structural wall such that lateral directions of the structural wall and the non-structural wall are aligned or parallel to each other. The first PPVC wall, the first combined wall, the first stepped wall or the first column wall provides both support in its longitudinal direction and partition in its transverse direction such that the structural wall is possible to be used as a partition wall as well, avoid introducing an extra step of joining two non-structural wall to provide a partition wall. The structural wall of the combined wall also provides robust support to the first PPVC module or the first combined wall in the longitudinal direction.

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[0012] The PPVC module or the combined wall provides a unique structure or solution to building construction, which is faced by traditional prefabricated buildings (also known as prefab). Instead of providing structural walls (e.g. pillar or column) and non-structural walls separately to a PPVC module, the present PPVC module integrate the structural wall and the non-structural wall as a single piece possibly mounted at an edge or side of the PPVC module (e.g. residential unit), a step of joining two opposite non-structural walls is possibly eliminated, whilst the structural wall provides both vertical support and transverse partition to the PPVC module.

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[0013] The structural wall and the non-structural wall have or share a common surface or levelled exterior in traverse or thickness directions of the structural wall and the non-structural wall, which are together known as first combined wall or combined wall.

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[0014] For example, a structural surface of the structural wall in the transverse direction is aligned or levelled with a non-structural surface of the non-structural wall such that the structural surface and the non-structural surface join together, becoming a broad and flat wall surface at a transverse side of the first combined wall.

[0015] Moreover, a transverse side of the non-structural wall and a transverse side of the structural wall can be levelled or share a single transverse surface such that the first combined wall has a combined transverse surface or a combined surface, which is common to both the non-structural wall and the structural wall. Preferably, the combined surface or the combined wall is straight in their lateral directions. Alternatively, the structural wall and the non-structural wall are at an angle (e.g. 30°, 60°, 75°) with respect to each other, such as having 90° in their lateral directions substantially. The combined surface provides a broad partition between two neighbouring or contiguous PPVC modules, obviating the necessity of an additional partition wall. Since the combined surface is held by the structural wall, the PPVC module, the combined wall and the non-structural wall become sturdy for transport and building construction.

[0016] Alternatively speaking, the present application provides a prefabricated prefinished volumetric construction (PPVC) module which forms a six-sided polygonal unit comprises one or more slabs, one or more frames, a plurality of combined walls, one or more façades, walls, a ceiling and floor. The PPVC module is constructed in a manufacturing plant and assembled at a remote site. The PPVC module is equipped with internal fittings comprising partition walls, bathroom fittings, electrical wiring and water piping.

[0017] The PPVC module may further comprise a connector on a side (e.g. surface, end) of the combined wall or the structural wall for joining another structural wall, combined wall or PPVC module, whether longitudinally, laterally or in the transverse direction. The connector may further include one or more detachable connectors or permanent connectors. The connector may additionally comprise parts that are attached to opposing PPVC modules or combined walls so that the opposing PPVC modules or combined walls are possibly joined together with resilience or endurance by coupling the parts.

[0018] The connector can comprise one or more loop connectors (e.g. wire loop connector), possibly at a lateral end on the structural wall for connecting the other PPVC module or combined wall. The loop connector includes a hook, whether closed

or open, which is capable of receiving a rod passing through a centre of the hook. Two loop connectors can be stacked on top of each other so that the rod is able to pass through their common hole or centre in their longitudinal directions for joining the two loop connectors. The one or more loop connectors are simple and cheap to manufacture, and yet provide reliable connection in lateral or transverse directions.

[0019] The loop connector may comprise a prefabricated frame for attaching a lateral end of the structural wall or combined wall to of another wall having a plurality of loops with predetermined distances in-between the plurality of loops, possibly extending in a longitudinal direction of the structural wall. The prefabricated frame is made from metal, plastic, composite material or a combination of any of these materials. Since the prefabricated frame is possibly mass produced with precision, robustness and low cost, the prefabricated frame may be distributed to factories or construction sites of diverse geographical locations. Moreover, the loop connector may be supplied with standard sizes, shapes or materials so that building contractors are able to select suitable product ranges of the prefabricated frames for building construction.

[0020] Embodiments of the connector comprise a splice connector having an elongated through hole for receiving a dowel, a shaft or a continuity bar in the longitudinal direction of the first structural wall or the connector for connecting a wall (e.g. structural wall, combined wall) of the another PPVC module on top or at bottom of the present PPVC module (i.e. first PPVC module). The splice connector possibly includes an elongated through hole that extends between two longitudinal ends of the combined wall (i.e. first combined wall) or structural wall (i.e. first structural wall). An adhesive material (e.g. cement or concrete), a rod (e.g. dowel, shaft, wires) or both are optionally inserted into elongated through holes of two PPVC modules, combined walls or structural walls on top of each other so that the two PPVC modules, combined walls or structural walls are both aligned and united. Of course, a PPVC module, combined wall or structural wall is possible to have multiple splice connectors that are spaced apart and/or parallel to each other. Especially, a plurality of splice connectors that are located at opposite ends of a PPVC module ensures reliable fixture between neighbouring stacking PPVC modules, combined walls or structural walls.

[0021] The splice connector can comprise a grouting tube opening at a longitudinal end of the first structural wall or combined wall, and partly parallel as well as connected to the thorough hole of the splice connector for infilling adhesive materials (e.g. grout) into the splice connector. Instead of infilling the adhesive materials directly into the
5 through hole, the grout tube provides a side channel to fill the adhesive materials and avoid trapping gases or air when infilling.

[0022] The PPVC module, also known as first PPVC module, may further comprise a second structural wall (also known as load-bearing wall, bearing wall, column, pillar)
10 for bearing weight or load in a longitudinal direction of the second structural wall. The PPVC module additionally include a second non-structural wall (e.g. curtain wall, partition wall, skin wall) extending from and connected to a lateral side or end of the second structural wall and contiguous to the second structural wall in forming a second combined wall. The second structural wall has a second structural thickness in a
15 transverse direction of the second structural wall larger, greater or bigger than a second non-structural thickness in a transverse direction of the second non-structural wall of the second non-first structural wall. The second structural wall and the second non-structural wall also form a unitary body, which is known as a second PPVC wall, a second combined wall, a second stepped wall or a second column wall. The second
20 combined wall has structures, sizes or shapes that are substantially similar or different to those of the first combined wall (i.e. combined wall, column wall, stepped wall, first wall, first column wall, first stepped wall). The first combined wall and the second combined wall may be positioned on a same side, neighbouring sides or opposite sides of the PPVC module. For example, a combined surface or first combined surface
25 of the combined wall is aligned or levelled with a combined surface of the second combined wall. The first combined wall (i.e. combined wall) and the second combined wall provide both structural support and partitions to the PPVC module (i.e. first PPVC module). In fact, any side of the PPVC module is possible made of one or more combined walls, which are joined or separately.

[0023] The first structural wall (i.e. structural wall), the first non-structural wall (i.e. non-structural wall), the second structural wall and the second non-structural wall can have a common transverse or levelled surface in thickness directions of the structural wall, the non-structural wall, the second structural wall and the second non-structural wall,
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which optionally provide or define a side wall of the PPVC module, whether connected or disconnected. The common transverse surface that is shared by the structural wall and non-structural wall is also known as a combined surface. The structural wall and the non-structural wall are also able to be levelled at a common end or combined end in lateral directions of the structural wall and the non-structural wall. The common transverse surface, levelled surface or combined surface sometimes have good surface finish quality and is flat so that the combined surface obviates the requirement of secondary proves when offering an interior wall surface of the PPVC module or residential room.

[0024] Particularly, when attaching a non-structural wall of a first combined wall (also known as combined wall) with another non-structural wall of a second combined wall (also known as another combined wall), a length of the non-structural wall of the first combined wall is desired to be substantially similar to another length of the other non-structural wall of the second combined wall so that no visible or perceptible gap will exist on transverse sides of the two joined combined walls. Additionally, a sum of the thickness of the first non-structural wall (also known as non-structural wall) and the thickness of the second non-structural wall (alternatively known as non-structural wall) is preferred to be substantially the same as a thickness of the first structural wall, the second structural wall or both the first structural wall and the second structural wall. The first combined wall and the second combined wall form a wall with substantially uniform thickness when attaching the non-structural walls together, if the first structural wall and the second structural wall have substantially the same thickness as the two non-structural walls stacked.

[0025] The PPVC module may further comprise a beam connecting the first structural wall or first combined wall to the second structural wall or second combined wall. The structural walls at opposite ends of the beam give good support to the beam, precludes additional construction work or pillar support. The beam optionally has a rectangular cross section, an "I" or a "H" section, which provides increased stiffness in the longitudinal direction of the PPVC module, the combined wall or the structural wall. The beam optionally has hollow structure at its core so that overall weight of the beam is greatly reduced.

[0026] The beam can have a beam thickness in the transverse direction of the combined walls that is substantially equal or slightly larger to a sum of a structural thickness of a structural wall and a non-structural thickness of a non-structural wall. Particularly, if a first PPVC module and a second PPVC module are contiguously joined together, an overall thickness of a structural wall of a first combined wall of the first PPVC module, an adhesive and a non-structural wall of a combined wall of the second PPVC module can be substantially identical to the beam thickness. Once the two PPVC modules are adhered together, the beam is levelled with walls of the two PPVC modules at opposite sides, having no ugly protrusion or corner. Hence, the beam and the combined walls are elegantly united with both sturdiness and beauty.

[0027] The beam may comprise one or more joints or mechanical joints (e.g. tie-plate, prefabricated anchor, steel plate) for joining another PPVC module laterally, transversely or longitudinally. Since the beam has a broad thickness or width, the beam possibly offers a larger area of support or connection so that two PPVC modules are able to be reliably joined, whether by the beam alone or together with other walls (e.g. between structural walls, between a non-structural wall and a structural wall).

[0028] The PPVC module sometimes comprises one or more angle bars for joining a first wall (e.g. structural wall, non-structural wall, first structural wall, first non-structural wall) to a second wall (structural wall, non-structural wall, second structural wall, second non-structural wall) at a side (e.g. at a longitudinal end or lateral end). The angle bars are widely and cheaply available so that building contractors are able to introduce the angle bars as reinforcement wherever necessary, offering building design or construction flexibility.

[0029] The PPVC module (also known as first PPVC module) can further comprise one or more peripheral joints (e.g. tie-plate) for joining another PPVC module, whether laterally, vertically or in a thickness direction of the structural or non-structural walls. The peripheral joints can be prepared in advance and completed at a construction site so that the PPVC module has the option of being mounted or adhered to a previously installed PPVC module at the construction site, giving building contractors freedom at the construction site.

[0030] The PPVC module may further comprise a side wall or simply a wall, whether structural or non-structural, extending from the combined wall, whether parallel or perpendicular to the combined surface of the combined wall. The PPVC module may additionally have anchors (e.g. at opposite ends of the PPVC module) for lifting the PPVC module onto a lorry, a platform or a building, such as another PPVC module. A crane or hoist may lift the PPVC module by the anchor so that other parts of the PPVC are prevented from damage during lifting.

[0031] Embodiments of the application provides a building for human occupation. The building can comprise a first PPVC module (also known as PPVC module) and a second PPVC module (also known as a PPVC module or another PPVC module), which optionally are respectively similar to the PPVC module, but are distinctive PPVC modules. The building additionally includes a joint (e.g. connector, splice connector, seal, sealant, grout, bedding mortar, water proofing strip, concrete, gasket such as omega gasket, fibre mesh, skim coat, filler) between a first wall (e.g. structural wall, non-structural wall, floor, ceiling) of the first PPVC module and a second wall (e.g. structural wall, non-structural wall, floor, ceiling) for joining the first PPVC module and the second PPVC module together. Hence, the building adopts multiple PPVC modules for construction so that cost and time of constructing the building can be greatly reduced. Since both the first PPVC module and the second PPVC module can be built offsite (e.g. at a factory), the first PPVC model and the second PPVC module are able to be made with precision and quality with low cost. A building contractor (also known as builder) only needs to assemble the first PPVC model and the second PPVC module onsite (e.g. at a construction site). Time, cost and pollution can be drastically reduced, benefitting future occupants or users of the building greatly. When joining the two PPVC modules, a combined wall of the first PPVC module can be fully attached to a combined wall of the second PPVC module. For example, a combined bottom end of the first combined wall of the first PPVC module is fully aligned with a combined top end of the of the first combined wall of the second PPVC module. Hence, the first PPVC module is stacked on top of the second PPVC module steadily. Alternatively, a non-structural surface and a structural surface of the combined wall of first PPVC module can be attached to a structural surface and a non-structural surface of the combined wall of the second PPVC module respectively. Accordingly, the combined wall of the first PPVC module and the combined wall of the second PPVC model jointly

provide a wall with uniform thickness in their transverse directions. The first combined wall and the second combined wall may have similar sizes, structures, material compositions or shapes. The first PPVC module and the second PPVC module may also have similar sizes, structures, material compositions or shapes.

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[0032] Referring to the combined wall or the first combined wall, a length of the combined wall (also known as combined length) in the lateral direction includes a structural length of the structural wall and a non-structural length of the non-structural wall in their respective lateral directions. For example, a length of the structural wall is substantially similar to a length of the non-structural wall. A thickness of the combined wall (also known as combined length) in the transverse direction includes a structural thickness of the structural wall and a non-structural thickness of the non-structural wall in their respective transverse directions. Preferably, the combined thickness or structural thickness is substantially twice the value or amount of the thickness of the non-structure wall. More preferably, the thickness of the combined wall (also known as thickness of the structural wall) is slightly larger than twice the value, amount, dimension or size of the thickness of the non-structure wall. If attaching a first combined wall and a second combined wall at their non-structural surfaces and at their structural ends, a binder or sealant is able to be filled between their contacting sides (e.g. respective non-structural surfaces, structural ends) so that a consolidated wall or joint wall of the two combined walls (also known as column walls) is possible provide a uniform thickness and has no gap on exposed sides, whilst a thickness of the two combined walls is substantially the same as the thickness of any of the single combined wall or structural wall.

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[0033] Similarly, if a first combined wall and a second combined wall are attached together at their non-structural surfaces respectively, a non-structural length of the first combined wall is preferably to be substantially the same as a non-structural length of the second combined wall. Moreover, a non-structural length of the non-structural wall of a combined wall (e.g. first combined wall) is preferably to be substantially the same as a structural length of the structural wall of the combined wall (e.g. first combined wall). In other words, a combined wall (e.g. second combined wall) is desired to have its structural wall and non-structural wall having substantially the same or equal lengths respectively such that the combined wall has a length or combined length in

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its lateral direction substantially the twice the value or amount of the non-structural wall's length or structural wall's length.

[0034] Two PPVC modules are possibly to be joined at their respective combined walls with excellent surface finishing, even including the binder or sealant between the non-structural surfaces.

[0035] A structural surface of a combined wall of a first PPVC module may be joined to a non-structural surface of another combined wall of another PPVC module (e.g. second PPVC module) by one or more adhesive materials (also known binders). The one or more adhesive materials optionally comprise a fire resistant or retardant sealant, an acoustic insulation material, a glue, a water sealant, a skin wall, a detachable wall, a party wall, an air gap (e.g. hollow section), a window frame, a door frame or a combination of any of these between two neighbouring PPVC modules or two neighbouring combined walls.

[0036] The building can further comprise a straight, curved, bent or zigzagged groove at the joint for draining rainwater between two joining PPVC modules. Additionally, the building or PPVC module can comprise a temporary roofing (e.g. metal sheet or lightweight concrete) with safety barricade at a peripheral edge of the building or PPVC module. Furthermore, the building or PPVC module can comprise a permanent roofing that is possibly waterproof. For example, the permanent roofing comprises a concrete layer with reinforce elements (e.g. steel wire mesh or net) or a PC roof facia at or around an edge of the building or PPVC module.

[0037] According to a second aspect, the present application provides a method for manufacturing a first PPVC (prefabricated prefinished volumetric construction) module. The first PPVC module is also known as a PPVC module. The method comprises a first step of providing a first structural wall (i.e. load-bearing wall, bearing wall, column, pillar) for bearing weight or load in a longitudinal direction of the first structural wall. The method also comprises a second step of constructing a first non-structural wall (e.g. curtain wall, partition wall, skin wall) extending from and connected to a lateral side of the first structural wall and contiguous to the first structural wall, which provides a first combined wall. The method further comprises a third step of making a first

structural thickness of the first structural wall thicker than a first non-structural thickness of the first non-first structural wall in forming a first combined or stepped wall. The first structural wall, first non-structural wall, first structural thickness, first non-structural thickness and first combined wall are alternatively known as a structural wall, a non-structural wall, a structural thickness, a non-structural thickness and a combined wall respectively. Some of these steps may be changed in sequence or combined, such as by moulding the first structural wall and the first non-structural wall together in a mould. Once joined, the first structural wall (also known as structural wall) and the first non-structural wall (also known as non-structural wall) are called a first combined wall, first column wall, first stepped wall, combined wall, column wall or stepped wall.

[0038] The present method provides a wall having sections of different thickness. A thicker section of the wall offers a structural wall or structural support as a pillar, whilst a thinner section of the wall provides a non-structural wall as a partition. Both sections are joined or integrated together so that the wall precludes the need to having a pillar for joining a partition wall. The PPVC module having the combined wall or simply wall does not require an additional column or step of making the column. Since all these three steps can be performed by a single manufacturing action, such as moulding or casting, the method provides a fast, reliable and low solution for building construction. If the first PPVC module or PPVC module is produced in a factory away from a construction site (e.g. city centre or Central Business District of a city), onsite construction time, labour and cost will be substantially reduced.

[0039] The method can further comprise a step of levelling or aligning a side (e.g. first structural surface, transverse surface or structural surface) of the first structural wall and a side (e.g. first non-structural surface, transverse surface or non-structural surface) of the first non-structural wall in forming a combined surface (e.g. in transverse directions of the first structural wall and the first non-structural wall), a top end or a bottom end of the combined wall or first combined wall. In other words, the structural wall and non-structural wall of the combined wall are lined up at their respective sides (e.g. end, surface), although the structural wall and non-structural wall optionally have different thickness. The present step offers a wall with even sides for connecting other walls (e.g. ceiling, floor) or further PPVC modules.

[0040] The levelling of the side of the first structural wall and the side of the first non-structural (e.g. skin wall) may comprise aligning a first non-structural surface (i.e. non-structural surface) and a first structural surface (i.e. structural surface) of the first PPVC module or first combined wall. Joined surfaces of the structural and non-structural walls offer a board surface as an interior wall or partition wall, which may be termed as a combined surface. The levelling of the side of the first structural wall and the side of the non-structural skin wall may further comprise a step of lining up a longitudinal side (e.g. end, top end or bottom end) of the first structural wall and a longitudinal side (e.g. end, top end or bottom end) of the first non-structural wall for joining a common ceiling or floor of the first PPVC module.

[0041] The method optionally further comprises a step of making (e.g. moulding or fixing) the first structural wall and the first non-structural wall along an edge of the PPVC module (e.g. joining a floor or ceiling edge, as a building unit). The PPVC module (also known as first PPVC module) optionally comprises one or more frames, struts, rails, shafts, fasteners, joints, connectors, adhesive materials or couplings that support the first combined wall (also known as a combined wall or column wall). The PPVC module becomes a robust or rigid assembly for transportation or stacking.

[0042] The method can further comprise a step of providing a second structural wall (load-bearing wall, bearing wall, column, pillar) for bearing weight (or load) in a longitudinal direction of the second structural wall; another step of constructing a second non-structural wall (e.g. curtain wall, partition wall, skin wall) extending from and connected to a lateral side of the second structural wall and contiguous to the second structural wall; an additional step of making a second structural thickness of the second structural wall thicker than a second non-structural thickness (i.e. the thickness) of the second non-first structural wall in forming a second combined wall. Hence, the method presents another PPVC module, which is optionally similar or different from the earlier PPVC module (also known as first PPVC module or PPVC module). Two PPVC modules are optionally stacked on top of each other, or connected at their lateral or transverse sides, making a building of multiple rooms.

[0043] The method may further comprise another step of aligning the first combined wall with the second combined wall at their sides, which include surfaces or ends. For

example, a non-structural surface of the first combined wall becomes substantially parallel or at the same level as a non-structural surface of the second combined wall. For instance, a longitudinal end (e.g. top end, bottom end) of the first combined wall is substantially parallel or at the same level as a longitudinal end (e.g. top end, bottom end) of the second combined wall. Within a single PPVC module, two aligned combined walls are able to be aligned at a side, edge or end of the PPVC module possibly with a gap in-between the two combined walls. When joining two PPVC modules, two aligned combined walls are further able to be aligned their common side, edge or end of the PPVC modules, possibly with or without a gap in-between the two combined walls. A beam or overhead beam may join the two combined walls together, optionally supported by their structural walls.

[0044] The method can further comprise a step of attaching the first combined wall of the first PPVC module with a first combined wall of another or second PPVC module.

For example, a first structural surface (i.e. structural surface) and a first non-structural surface (i.e. non-structural surface) of the first combined wall (i.e. combined wall) are attached to a non-structural surface and a structural surface of the second combined wall such that a combined surface of the first combined wall and a combined surface of the second combined wall are at opposite sides, in their transverse directions. Two joined combined walls optionally provide uniform thickness having no gap on their exposed sides, surfaces or ends.

[0045] The method may further comprise a step of joining a structural surface and non-structural surface by a middle piece, a joint, a sealant or adhesive for permanent or temporary fixture. For example, the middle piece includes honeycomb structure filled one or more composite materials (i.e. composites) so that two joined combined walls has excellent quality of sound proof, water proof and fireproof. Similarly, the structural wall may include reinforcement elements (e.g. wire mesh, rebar, fibres) and/or composites.

[0046] The method can further comprise a step of transporting one or more PPVC modules (also known as first PPVC module, second PPVC module, PPVC module) or a combined wall from a manufacturing site to a construction site for aligning or attaching the first combined wall to the second combined wall. The method optionally

includes an additional step of covering, surrounding or enclosing the one or more PPVC modules in order to prevent damage or degradation by rainwater, snow, frost, mist, sunlight, ice or knock. The method moreover can include a step of installing one or more fences, frames and/or protective structures around the one or more PPVC modules. The one or more PPVC modules can thus be protected before their installation or assembling into a building.

[0047] The method may further comprise a step of connecting or securing the first PPVC module or first combined wall with the second PPVC module or second combined wall in their lateral, transverse or longitudinal direction for providing a building. For example, when aligned vertically or stacked, weight of a top PPVC module or combined wall is carried or supported by a bottom PPVC module or combined wall.

[0048] The method sometimes further comprises a step of sealing one or more joints between the first PPVC module and the second PPVC module in a lateral direction, a longitudinal direction or both directions for providing a building. The sealing is optionally executed by providing one or more sealants, joints or fillings.

[0049] The method possibly further comprises a step of moving (e.g. transporting, lifting, lowering) the first PPVC module from a place (e.g. factory as a manufacturing site) to another place (e.g. a building construction site). The method plausibly further comprises a step of constructing electrical GI conduits (i.e. conduits or tubes for electrical connections or cables) in the PPVC module or multiple PPVC modules of the building. The method probably further comprises a step of installing fluid pipes (e.g. cold water pipes, hot water pipes, drainage pipes, gas pipes, air-conditioning pipes, sanitary pipes) in the PPVC module, multiple PPVC modules or the building, which is also known as piping and plumbing fitting. The method further preferably comprises a step of installing facilities (e.g. hotel amenity, toilet, sanitation fixture, bidet) in the first PPVC module or building. The method sometimes further comprises a step of connecting the PPVC module to a building lift or a well of a building lift.

[0050] 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 inventions.

- Fig. 1 illustrates an erected building using a plurality of PPVC modules;
- Fig. 2 illustrates an installation order of the plurality of PPVC modules;
- 5 Fig. 3 illustrates a section of PPVC modules;
- Fig. 4 illustrates an exploded view of parts of a PPVC module;
- Fig. 5 illustrates an assembly view of the PPVC module with a safety platform thereon;
- Fig. 6 illustrates the two PPVC modules adjoining to each other transversely;
- 10 Fig. 7 illustrates the two PPVC modules adjoining without a ceiling;
- Fig. 8 illustrates the two PPVC modules separated as seen from a left rear side;
- Fig. 9 illustrates a terminal PPVC module separated from an intermediate PPVC module as seen from a right rear side;
- Fig. 10 illustrates the terminal PPVC module adjoining the intermediate PPVC module as seen from a left rear side;
- 15 Fig. 11 illustrates a left side view of the intermediate PPVC module;
- Fig. 12 illustrates a right side view of the intermediate PPVC module;
- Fig. 13 illustrates a top second combined wall mounted on a lower second combined wall of the two PPVC modules;
- 20 Fig. 14 illustrates a view of internal parts in the second combined wall;
- Fig. 15 illustrates two wire loop connectors that are joined together;
- Fig. 16 illustrates a section of an upper PPVC module above a section of a lower PPVC module;
- Fig. 17 illustrates a completed connection of two adjoining PPVC modules;
- 25 Fig. 18 illustrates the parts of a slab connection;
- Fig. 19 illustrates a close up view of the connection between two adjoining slabs;
- Fig. 20 illustrates the connection (i.e. slab connection) as seen from a side;
- Fig. 21 illustrates a plan view of two adjoining combined walls;
- Fig. 22 illustrates a weather-proofing means (e.g. sealant, gasket, or backer rod) along the PPVC module;
- 30 Fig. 23 illustrates a section of a horizontal joint as seen from a side;
- Fig. 24 illustrates a section of a vertical joint as seen from a top side;
- Fig. 25 illustrates a plurality of vertical gasket seal along the combined wall;
- Fig. 26 illustrates two combined walls placed side by side in a plan view;

- Fig. 27 illustrates the two second combined walls in an isometric view;
- Fig. 28 illustrates a C-shaped combined wall and a conforming T-shaped combined wall in a plan view;
- Fig. 29 illustrates the C-shaped combined wall and the corresponding T-shaped combined wall in an isometric view;
- Fig. 30 illustrates two overlapping double L-shaped combined walls in a plan view; and
- Fig. 31 illustrates two matching double L-shaped combined walls in an isometric view.

[0051] Exemplary, non-limiting embodiments of the present application will now be described with references to the above-mentioned figures. Particularly, Fig. 1 illustrates an erected building 10 using a plurality of PPVC module 12 comprising nineteenth storeys of residential units, a first storey 14 and a rooftop 16. The first storey 14 and the rooftop 16 of the erected building 10 are constructed using conventional precast. A height 22 of the first storey 14 is a distance from a ground floor to a first floor which is three point one-five metres (3.15 m). The ground floor is also known as the first storey 14. The first floor is a floor of a second storey. The residential units start from the second storey to the twentieth storey. The height between each storey is also three point one-five metres (3.15 m). Therefore, the estimated total height 20 of the erected building 10 from the first storey 14 to the rooftop 16 is about sixty-three metres (63 m). The foundation of the erected building 10 is laid underground (not shown). A plurality of pillar 18 is erected onsite. The plurality of pillar 18 is positioned strategically to support the plurality of PPVC module 12 above.

[0052] Fig. 2 illustrates an installation order of the plurality of PPVC module 12 as seen from a plan view. The plurality of PPVC modules 12 is installed following the Roman numerals I, II, III, IV, V, VI beginning from a right side and ends at a left side.

[0053] Fig. 3 illustrates a section of the installed PPVC module 12 having two storeys as seen in an isometric view from a front side. The PPVC modules 12 are arranged according to the installation order as shown in Fig. 2 and repeated for the subsequent storey (i.e. story). At a top side of the one PPVC module 12 is a safety platform 24 with metal deck and peripheral barricade surrounding thereon.

[0054] Fig. 4 illustrates an exploded view as seen from the front side of an internal fitting of the PPVC module 12 specifically PPVC module V 12 according to Fig. 2 and 3. A bathroom fitting 26, a partition wall 28, a timber flooring 30, a plurality of tile 32, a railing 34, a door frame 36 and a ceiling 38 are installed in and along the periphery of the PPVC module 12. Fig. 4 further offers a Cartesian coordinate system 172 having three axes (i.e. X-axis, Y-axis & Z-axis) that are perpendicular to each other. The Cartesian coordinate system 172 is aligned with the first combined wall 43 (also known as combined wall) and the first PPVC module 12 (also known as PPVC module) such that the Z-axis provides a longitudinal direction or height direction of the first combined wall or the first PPVC module; the Y-axis indicates a lateral direction or sideways direction of the of the first combined wall or the first PPVC module; and the X-axis represents a thickness direction or transverse direction of the of the first combined wall or the first PPVC module.

[0055] The PPVC module 12 has a height of about three point one five metres (i.e. 3.15 m), a length of about ten metres (i.e. 10m) and a width of three metres (3 m) forming a hollow rectangular cuboid. The PPVC module 12 has a horizontal rectangular slab 40 with four vertically erected combined walls 43,44 comprising a first combined wall 43 and a second combined wall 44. The slab 40 has a thickness of a hundred and fifty millimetres (150 mm). A first length of the slab 40 has the first combined wall 43 and the second combined wall 44 positioned at the two edges thereof. A second length of the slab 40 has the first combined wall 43 and the second combined wall 44 positioned at the two edges thereof.

[0056] The configuration of the first combined wall 43 and the second combined wall 44 on the first length are different and so does the two combined walls 43,44 on the second length. An expanded view of the first combined wall 43 is shown in Fig. 4. The first combined wall 43 has a structural wall 134 and a non-structural wall 136. The structural wall 134 is thicker than the non-structural wall 136. The structural wall 134 has a thickness of about two hundred and fifty millimetres (250 mm). The non-structural wall 136 has a thickness of one hundred and seventy-five millimetres (175 mm). The thick end of the structural wall 134 is known as a combined lateral end 140. At a thin end of the non-structural wall 136 is a non-structural lateral end 148.

[0057] A long and flat surface wall which is hidden from view is known as a combined lateral surface 138. The combined lateral surface 138 of the one combined wall 44 is a long and flat wall surface which is formed by having the structural wall 134 and the non-structural wall 136 joined contiguously. On an opposite surface of the combined lateral surface 138, in particular, on the structural wall 134 is known as a structural surface 142. Still on the opposite side, on the non-structural wall 136 is known as a non-structural surface 146. At a junction where the structural wall 134 and the non-structural wall 136 meet is a structural lateral end 144. Along the structural lateral end 144 is a wire loop joint 132 that has a V-shaped metallic valley trimming 62. At the top of the combined wall 44 is known as a combined top end 150. Embedded in the structural wall 134 is a plurality of wire loop connectors 58 spaced evenly along the structural lateral end 144. A one end of the wire loop connector 58 is exposed along the structural lateral end 144 via the metallic valley trimming 62.

[0058] Along the first length of the slab 40, the two combined lateral end 140 of the first combined wall 43 and the second combined wall 44 are facing each other. At a top side of the combined lateral ends 140 is a horizontal beam 46 which is supported by the two combined walls 43,44 which are spaced apart. The beam 46 has a thickness of two hundred and fifty millimetres (250 mm). Along the second length of the slab 40, the two non-structural lateral ends 148 of the first combined wall 43 and the second combined wall 44 are facing each other. At a top side of the non-structural lateral ends 148 are two horizontal braces 45 as seen at the intermediate PPVC module 50 in Fig. 8. The braces 45 are mounted specifically along the combined lateral surfaces 138 of the two combined walls 43,44.

[0059] The ceiling 38 is positioned at a top side of the PPVC module 12 above a plurality of strut that extends across a width of the PPVC module 12. The safety platform 24 is placed above the ceiling 38.

[0060] The door frame 36 is installed at the front side of the PPVC module 12 which demarcates a living space within and a balcony outside. The railing 34 is made of aluminum is erected along the perimeter of the balcony. The plurality of tile 32 is laid on the floor of the balcony. The timber flooring 30 is laid on the slab 40 which is inside

the PPVC module 12. The one partition wall 28 is vertically installed inside the PPVC module 12. There is a number of partition walls 28 within to demarcate different compartments which is not shown. The partition wall 28 has a thickness of a hundred and fifty millimetres (150 mm). The bathroom fitting 26 is installed at the interior rear side of the PPVC module 12.

[0061] Fig. 5 illustrates a final assembly of the one PPVC module 12 with the safety platform 24 positioned at the top side of the one PPVC module 12. Fig. 6 to 10 illustrates the two PPVC modules 12, in particular the PPVC modules 12 with the Roman Numerals V and VI which correspond with the PPVC modules 12 as shown in Fig. 2 and 3. Roman Numeral V is known as an intermediate PPVC module 50. Roman Numeral VI is known as an end PPVC module or a terminal PPVC module 48.

[0062] Fig. 6 illustrates the two PPVC modules 12 adjoining to each other with the safety platform 24 removed revealing the ceiling 38 as seen in an isometric view from the rear side. A wall 42 is seen on the terminal PPVC module 48.

[0063] Fig. 7 illustrates the two PPVC modules 12 adjoining to each other without the ceiling 38 revealing the plurality of partition wall 28 and the door frame 36.

[0064] Fig. 8 illustrates the two PPVC modules 12 separated as seen from the left rear side. The terminal PPVC module 48 is positioned at the corners of the building 10. The at least one intermediate PPVC module 50 is interposed between the two terminal PPVC modules 48. There can be more than one intermediate PPVC module 50 between the two terminal PPVC modules 48. The PPVC modules 12 have a concrete strength of fifty.

[0065] The terminal PPVC module 48 has the slab 40, the wall 42, the first combined wall 43, the second combined wall 44 and the beam 46. The slab 40 is levelly positioned relative to a ground. The wall 42 is vertically erected on a first length of the slab 40. The wall 42 is characterized by a long and flat surfaces on both the external and internal thereof. The wall 42 has a thickness of a hundred and fifty millimetres (150 mm).

[0066] A first combined wall 43 is vertically erected on a first edge of a second length of the slab 40. A second combined wall 44 is vertically erected on a second edge of the second length of the slab 40. The two combined walls 43,44 are spaced apart along the second length of the slab 40. The one combined wall 43,44 thickness ranges from one hundred and seventy-five millimetres (175 mm) to two hundred and fifty millimetres (250 mm). An exterior façade 82 is erected vertically that straddles across the width of the slab 40 which is joined to a one end of the wall 42 and the other end joined to the combined lateral surface 138 of the second combined wall 44, specifically to the end of the non-structural wall 136. The exterior façade 82 as seen has a rectangular aperture like a window. The exterior façade 82 is present at the terminal PPVC module 48 and the intermediate PPVC module 50.

[0067] The beam 46 is positioned at a height between the two combined walls 43,44. The beam 46 is supported by the two combined walls 43,44. The beam 46 has a thickness of two hundred and fifty (250 mm).

[0068] The intermediate PPVC module 50 has an intermediate slab 40. The intermediate slab 40 has two lengths. On a first length of the intermediate slab 40, at each of the two edges thereof is the first combined wall 43 and the second combined wall 44 respectively. At a height of the first combined wall 43 and the second combined wall 44 are two horizontal braces 45 that are mounted on the combined lateral surfaces 138 of the two combined walls 43,44. The one end of the exterior façade 82 is joined to the combined lateral surface 138 of the second combined wall 44, specifically to the end of the structural wall 134 (thicker wall). The second end of the exterior façade 82 is joined to the combined lateral surface 138 of the second combined wall 44 on a second length, specifically to the non-structural wall 136 (thinner wall).

[0069] Fig. 9 illustrates the terminal module 48 separated from the intermediate module 50 as seen from the right rear side. Fig. 10 illustrates the terminal module 48 adjoining the intermediate module 50 as seen from the left rear side without internal fittings.

[0070] Fig. 11 and Fig. 12 illustrates a side view of the one intermediate module 50. The left side view and the right side view are with reference from the rear side. Fig. 11

shows two horizontal bars known as braces 45 that straddles at the top side of the two erecting combined walls 43,44 as seen from the left side. Fig. 12 shows the beam 46 supported by two combined walls 43,44 as seen from the right side. There is a plurality of splice field dowel 60 protruding from the bottom sides of the first combined wall 43 and the second combined wall 44. The first combined wall 43 and the second combined wall 44 are joined to the horizontal slab 40 particularly at the vertical long side.

[0071] Fig. 13 illustrates a top second combined wall 44 mounted on a lower second combined wall 44 of the two PPVC modules 12 exposing a detailed internal parts of the intermediate PPVC module 50 as viewed from the left side. The PPVC modules 12 are stacked on top of each other. A top second combined wall 44 is placed on top of a bottom second combined wall 44.

[0072] Within the top second combined wall 44, specifically the structural wall 134, there is a plurality of splice connector grouting tube 52, a plurality of vertical continuity bar 54, a plurality of splice connector 56, a plurality of wire loop connector 58 and the plurality of splice field dowel 60.

[0073] At the combined top end 150 of the second combined wall 44, the splice connector grouting tube 52 and the splice connector 56 is visible. The one splice connector grouting tube 52 and the one splice connector 56 are hollow cylindrical tubes which is joined with the one vertical continuity bar 54 within the second combined wall 44 forming a lowercase letter "Y"-shaped hollow conduit. The one vertical continuity bar 54 extends vertically downwards to the opposite side of the combined top end of the combined wall 44. The one vertical continuity bar 54 is also a hollow cylindrical tube.

[0074] The one splice connector grouting tube 52, the one splice connector 56 and the one vertical continuity bar 54 forms a unit pair. There are four unit pairs in the one second combined wall 44. Along the structural lateral end 144 of the second combined wall 44 is a plurality of wire loop connector 58. The splice field dowels 60 are positioned at a bottom side of the second combined wall 44 known as the combined bottom end specifically at the bottom of the structural wall 134.

[0075] Fig. 14 illustrates a view of the internal parts in the second combined wall 44 specifically the splice connector grouting tube 52, the vertical continuity bar 54, the splice connector 56 and the wire loop connector 58. The two second combined walls 44 are arranged in a manner in which the structural wall 134 (thick wall) of a preceding second combined wall 44 and the non-structural wall 136 (thin wall) of a subsequent second combined wall 44 are adjoined.

[0076] Fig. 15 illustrates a plurality of wire loop connector 58. Along the one structural lateral end 144 of the one combined wall 43,44 overlays a metallic valley trimming 62. There are five wire loop connectors 58 that are equally spaced along the height of 3.15 metres of the metallic valley trimming 62. The metallic valley trimming 62 has perforations. The one wire loop connector 58 goes through the one perforation. The one wire loop connector 58 is a metallic cable that forms a lasso and the two ends of the lasso is terminated by a metal seal. The metal seal and the part of the metallic cable is embedded in the combined wall 43,44. The part of the exposed metallic cable is exposed on the other side of the metallic valley trimming 62. In order to join the two combined walls 43,44, a rebar 158 is inserted into the wire loop connectors 58 of the two combined walls 43,44.

[0077] Fig. 16 illustrates a section of an upper PPVC module 86 above a section of a lower PPVC module 88. The upper PPVC module 86 which have four vertical continuity bars 54 are inserted into the splice connector 56 of the lower PPVC module 88. The ends of the vertical continuity bars 54 are known as the splice field dowels 60.

[0078] Fig. 17 to 19 illustrates the parts of connecting two adjoining PPVC modules 12 in particular the adjoining slabs 40. Fig. 17 further illustrates a section of a completed connection of two adjoining PPVC modules 12 in particular at the slabs 40.

[0079] Fig. 18 illustrates the parts of the slab 40 connection which comprises four bolts 66 and a steel plate 68. The bolts 66 are made of steel with a hexagonal head and a threaded body. The steel plate 68 is a square having four bored holes at the four corners thereof. At a recess of the one slab 40 are two pre-embedded anchors 70. The four pre-embedded anchors 70 have a corresponding screw thread along the

internal periphery wall. The one slab 40 is a member of the one PPVC module 12. A second slab 40 of the second PPVC module 12 has also a corresponding recess with a two pre-embedded anchors 70. The two slabs 40 are aligned according to the position of the recess where the four bolts form a square.

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[0080] Fig. 19 illustrates a close up view of one connection of the two adjoining slabs whereby the steel plate 68 is mounted into the four pre-embedded anchors 70. The four bolts 66 are then screwed into the four pre-embedded anchors 70 securing the two adjoining slabs 40.

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[0081] Fig. 20 illustrates the slab 40 connection as seen from the side. The steel plate 68 and the four bolts 66 are vertically mounted into the pre-embedded anchors 70 which is vertically embedded in the two slabs 40. Each slab 40 has two vertically mounted pre-embedded anchors 70.

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[0082] Fig. 21 illustrates a plan view of the two adjoining second combined walls 44 of the terminal PPVC module 48 and the intermediate PPVC module 50. The splice connector grouting tube 52, the splice connector 56 are visible on the combined top end 150 of the one second combined wall 44. The one-unit pair (as shown by the broken elliptical line) comprises one splice connector grouting tube 52 and one splice connector 56. There are four unit pairs in one second combined wall 44. Separating the two second combined walls 44 is a fifteen millimetres (millimeters) (i.e. 15mm) grouting channel 72. The grouting channel 72 is formed when the two similar combined walls 44 are adjoined.

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[0083] Figs. 22 to 25 illustrate a means for preventing water seepage in the joints between two PPVC modules 12 in either a side-by-side configuration or a top-bottom configuration.

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[0084] Fig. 22 illustrates a weather-proofing means along the PPVC module 12 particularly at two locations; the exterior façade 82 and the second combined wall 44. For laying water proofing along a top side of an exterior façade 82 horizontally, there is a gasket 74 strip laid along the inner perimeter. A bedding mortar 76 strip is then

interposed between the gasket 74 strip and a water proofing strip 78. The water proofing strip 78 is along the external perimeter of the exterior façade 82.

[0085] For laying water proofing along the vertical sides of the two adjoining second combined walls 44. Referring to the top surface of the two adjoining second combined walls 44, there is a filler non-shrinking grout 118 that is filled into the grouting channel 72. A gasket 74 strip is then inserted that runs vertically downwards to the bottom surface of the second combined wall 44. The remaining area is filled with a filler grout 80 which is completely levelled with the external side. The external side is the combined lateral end 140 and the non-structural lateral end 148. After which a water proofing layer is applied onto the filler grout 80.

[0086] Fig. 23 illustrates a section of a horizontal joint 90 where the upper PPVC module 86 is above the lower PPVC module 88. The façade thickness 84 for both the upper and lower PPVC module 86,88 is a hundred and fifty millimetres (150 mm). The upper PPVC module 86 has a slab 40 that is orthogonally extended inwards from the bottom of the interior façade 83. The horizontal joint 90 has a horizontal joint width 92 of fifteen millimetres (15 mm).

[0087] The top surface of the lower PPVC module 88 has an upward inclined surface that extends inwards from the exterior façade 82 (the upward inclination is with reference to a horizontal ground). The inward extension has a length 96 of fifty-five millimetres (55 mm) from the exterior façade 82 to the first bend point 94. The length from the first bend point to a second bend point is ten millimetres (10 mm). The surface from the first bend point to the second bend point is steeper than the surface from the exterior façade 82 to the first bend point. The length from the second bend point to an interior façade 83 is eighty-five millimetres (85 mm) and is horizontal with reference to the slab 40. At the top surface of the lower PPVC module 88 near the interior façade 83, there is an indentation depth 102 of approximately three millimetres (3 mm) from the top surface of the lower PPVC module 88.

[0088] At the bottom surface of the upper PPVC module 86, a gentle upward gradient surface extends inward from the exterior façade 82 to a first flexion point with a length 104 of fifty millimetres (50 mm). From the first to a second inflexion point is ten

millimetres (10 mm). From the second inflexion point to the interior façade 83 is ninety millimetres (90 mm) 106. Between the first inflexion point and the second inflexion point, the upward gradient is steeper than the gradient from the exterior façade 82 to the first inflexion point. The bottom surface from the second inflexion point to the interior façade is horizontal aligning to the slab 40. The distance from the edge of the exterior façade 82 to the second inflexion point is forty millimetres (40 mm) 108.

[0089] The upper PPVC module 86 is placed above the lower PPVC module 88. In between the two modules 86,88 specifically at the horizontal surface of the lower PPVC module 88 are laid with the self-adhesive water proofing strip 78, the strip of bedding mortar 76 and the strip of gasket 74 in sequence from the second bend point 95 to the interior façade 83. The strip of gasket 74 is specifically laid along the indented recess of three millimetres (3 mm) 102. Hence, there is the horizontal joint width of fifteen millimetres (15 mm) which is unfilled or vacant from the exterior façade 82 to the second bend point 95 of the lower PPVC module 88 or from the exterior façade 82 to the second flexion point of the upper PPVC module 86.

[0090] Fig. 24 illustrates a section of a vertical joint as seen from a plan view where a terminal PPVC module 48 is adjoining the intermediate PPVC module 50. Fig. 24 is a close up view of Fig. 22. The intermediate PPVC module 50 wall has a thickness of two hundred and fifty millimetres (250 mm) 116. The right PPVC module 114 wall is made of two vertical second combined walls 44 placed side by side creating a grouting channel 72. The non-structural wall 136 has a non-structural lateral end thickness 162 of sixty millimetres (60 mm). The structural wall 134 has a combined lateral thickness 160 of a hundred and seventy-five (175 mm). The grouting channel 72 is fifteen millimetres (15 mm) wide 124.

[0091] The terminal PPVC module 48 having the façade 82,83 is orthogonally joined to the non-structural wall 136 thereof. There is a grouting channel 72 along the left side of the splice connector grouting tube 52 and the splice connector 56 which is filled with a non-shrink grout 118. The grouting channel 72 has a cylindrical gasket 74 strip running vertically between the non-structural wall 136 and the structural wall 134. The grouting channel 72 has a three millimetres (3 mm) grout channel gasket recess 120 to install the cylindrical gasket 74 strip. A recess length of twenty millimetres (20 mm)

122 along the grouting channel 72 is filled with a mixture of filler grout 80 and fibre mesh and coated with an external skim coat.

[0092] Fig. 25 illustrates a plurality of vertical gasket seal 130 along the one second combined wall 44 of the intermediate PPVC module 50 as seen from a right rear view. The strip of vertical gasket seal 130 is along a wire loop joint 132 and along two sides of the one second combined wall 44.

[0093] Fig. 26 illustrates two second combined walls 44 placed side by side from a plan view. The two second combined walls 44 are overlapped and secured by the wire loop connector 58. Fig. 27 illustrates the two second combined walls 44 in an isometric view in a vertical position.

[0094] The one combined wall 44 when erected in the vertical position comprises six vertical exposed sides, one exposed top side and one hidden bottom side. The one second combined wall 44 has a thick wall known as a structural wall 134 and a thin wall known as a non-structural wall 136. The structural wall 134 has a shape of a big rectangle and the non-structural wall 136 a small rectangle as seen from the top. The two walls 134,136 are contiguously joined.

[0095] A combined lateral thickness 160 is thicker than a non-structural lateral end thickness 162. A structural wall length 164 and a non-structural wall length 166 can be equal in length or unequal in length. However, the corresponding combined wall 43,44 must have the same structural wall length 164 and the non-structural wall length 166 when joining two combined walls 43,44 together. The two combined walls 43,44 can only be either both be the first combined wall 43 or both be the second combined wall 44. In other words, the length of the combined lateral surfaces 138 of the two adjoining combined walls 43,44 must be identical. A structural wall height 168 and a non-structural wall height 170 is identical.

[0096] The structural wall 134 and the non-structural wall 136 form a contiguous long wall known as a combined lateral surface 138. An isolated side of the structural wall 134 is known as the combined lateral end 140. The isolated side is not joined to the non-structural wall 136. The combined lateral end 140 is the breadth of the structural

wall 134. At an opposite surface of the combined lateral surface 138 is a structural surface 142, a structural lateral end 144 and a non-structural surface 146. Opposite the combined lateral end 140 is a non-structural lateral end 148. The structural surface 142 is a length of the structural wall 134. Thus, the six vertical exposed sides are the combined lateral surface 138, the combined lateral end 140, the structural surface 142, the structural lateral end 144, the non-structural surface 146 and the non-structural lateral end 148 are mentioned. The one exposed top side is known as a combined top end 150. The combined top end 150 takes the shape of the big rectangle 134 and the small rectangle 136 join seamlessly at the structural lateral end 144 as seen from a plan view as shown in Fig. 28. The opposite side of the combined top end 150 is a combined bottom end which is not shown. The combined bottom end has the shape of the combined top end 150 as well. The breadth of the combined lateral end 140 is two hundred and fifty millimetres (250 mm). The breadth of the non-structural lateral end 148 is a hundred and seventy-five millimetres (175 mm).

[0097] Fig. 28 illustrates a C-shaped combined wall 152 and a corresponding T-shaped combined wall 154 in a plan view.

[0098] Fig. 29 illustrates the C-shaped combined wall 152 and the corresponding T-shaped combined wall 154 in an isometric view. The C-shaped combined wall 152 is formed by having the two second combined walls 44 joining seamlessly at the non-structural lateral ends 148 as shown by a broken line. The T-shaped combined wall 154 is formed by having the combined walls 44 joining seamlessly at the two combined lateral ends 140. The C-shaped combined wall 152 and the T-shaped combined wall 154 are then joined together using the wire loop connectors 58. The rebar 158 is inserted at the wire loop joints 132 through the wire loop connectors 58.

[0099] Fig. 30 illustrates two overlapping double L-shaped combined walls 156 in a plan view. Fig. 31 illustrates two overlapping double L-shaped combined walls 156 in an isometric view. A first double L-shaped combined wall 156 is formed by joining the non-structural lateral end 148 of the one second combined wall 44 to the combined lateral end 140 of the another second combined wall 44. A second double L-shaped combined wall 156 is then aligned and placed in the recess. The two double L-shaped

combined wall 156 are then secured by three rebar 158 inserted at the three wire loop joints 132 through the wire loop connectors 58.

[0100] Functionally speaking, the prefabricated prefinished volumetric construction (PPVC) module 12 provides rapid development and manufacturing at a manufacturing floor and assembly at a remote construction site.

[0101] Prior to the transporting of the PPVC module 12 to the remote construction site, the pillars 18 are pile-driven into the ground providing a level and stable foundation.

The pillars 18 are erected according to the architect's specifications which supports the PPVC modules 12 above. The pillars 18 are in contact with the slab 40. The one complete PPVC module 12 comprises the partition wall 28, the ceiling 38, the slab 40, wall 42, the combined wall 44, and the beam 46. To provide a liveable space, other add-on facility like the bathroom fitting 26, the timber flooring 30, the tiles 32, the railing 34 and the door frame 36 are added in the one PPVC module 12.

[0102] The PPVC modules 12 are installed in sequence in a direction to provide systematic installation and efficiency. During installation, the safety of the workers is not compromised, the safety platform 24 with metal deck and peripheral barricade are provided. After a one storey of PPVC modules 12 are installed which is six PPVC modules 12 (I, II, III, IV, V, VI) as described, the safety platform 24 are installed above the ceiling 38 thereof. When the necessary works are completed on the one storey, the safety platform 24 are then removed and allowed further installation of the PPVC modules 12 on the second storey.

[0103] The PPVC modules 12 comprising the intermediate module 50 and the terminal module 48. The terminal module 48 forms the extreme ends of the building which is characterised by the long wall 42 along a long side of the slab 40 as shown in Fig. 8. The intermediate module 50 is used to describe any modules that exists between two terminal modules 48. The intermediate module 50 is characterised by two combined walls 44 along each long side of the slab 40. Along the first long side, is a pair of braces 45 straddling between a first pair of the combined walls 44. Along the second long side, is the beam 46 that extends between a second pair of the combined walls 44. The brace 45 provides a support structure and alignment for the two erected

combined walls 44 along the first long side. The beam 46 provides a stronger support structure for the increased load on top of the PPVC module 12 distributing the load evenly onto the combined walls 44. The combined wall 44 provides the structural support for the load exerted by the load on top of the PPVC module 12.

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[0104] Embedded within the combined wall 44 specifically the thick wall known as the structural wall 134 has a plurality of splice connector grouting tube 52, a plurality of vertical continuity bar 54, a plurality of splice connector 56, a plurality of wire loop connector 58 and a plurality of splice field dowel 60.

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[0105] The plurality of splice connector grouting tube 52 provides the channel for the injection of grout into the continuity bar 54 and the splice connector 56. The splice connector 56 provides a channel for the splice field dowel 60 to be inserted. The splice field dowel 60 exists at the bottom of the combined wall 44 to provide a guide and for

15 holding the upper PPVC module 12 and the lower PPVC module 12 in the right position.

[0106] At the side of the combined wall 44 is a valley. The valley provides a channel for the metallic valley trimming 62 to be installed. The metallic valley trimming provides a metal guard for the side combined wall 44 as there are wire loop connectors 58 protruding out from the side combined wall 44. The wire loop connector 58 is terminated by a metal seal which is embedded within the combined wall 44. The lasso part is exposed so that the adjoining combined wall 44 can be joined together. A rebar is then inserted through the wire loop connectors 58 of the two adjoining combined wall 44 to secure the two combined walls 44 together.

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[0107] In order to join to adjoining slabs 40 together the edge of the one slab 40 provides two pre-embedded anchors 70. The steel plate 68 secures the two adjoining slabs of the PPVC modules 12 together. Four bolts 66 are pneumatically screwed into the pre-embedded anchors 70 to fasten the adjoining slabs. The same technique

25 30 applies for securing the upper PPVC module 86 and the lower PPVC module 88.

[0108] After the PPVC modules 12 are placed in a side-by-side configuration or a top-bottom configuration, adhering and water proofing is done at the joints to prevent the PPVC modules 12 from separating and preventing water seepage respectively.

[0109] In the side-by-side configuration whereby two adjoining combined walls 44 meet, there is a narrow gap about fifteen millimetres (15mm) wide. The narrow gap is known as the grouting channel 72. The grouting channel 72 provides the channel for filling of the filler grout 80. The filler grout 80 is a mortar or a paste for filling crevices and in this case is the gap between two adjoining combined walls 44.

[0110] Approaching the exterior façade 82 and the end of the grouting channel 72 is where the gasket 74 strip is inserted. The gasket 74 is made of a rubber material. The gasket 74 provides a seal between the filler grout 80 in the grouting channel 72 and the filler grout 80 thereafter. A second layer of filler grout 80 is filled after the gasket 74 and levelled with the external side to provide extra layer of protection and adhering between adjoining combined walls 44. Finally, the water proofing layer is applied after the filler grout 80 to provide the last layer of protection against the natural elements like rainwater.

[0111] In the top-bottom configuration where the upper PPVC module 86 is on top of the lower PPVC module 88, there is a horizontal joint width of fifteen millimetres (15 mm). The horizontal joint 90 provides an expansion space. The inclination at the horizontal joint 90 prevents rainwater from entering the horizontal joint 90.

[0112] The rebar 158 is a reinforced steel rod to provide added strength to the structure. The rebar at the slabs 40 as shown in Fig. 26 provides structural strength and guides for the installation of the combined walls 44. The rebar 158 used in the connecting two adjoining combined walls 44,152,154,156 provides a secured arrest of the wire loop connectors 58 that protrudes out from the structural lateral ends 144.

[0113] Operationally speaking, the PPVC module 12 is constructed at a manufacturing plant which is remote from the construction site or the installation site providing safe and efficient assembly at the installation site. The PPVC module 12 is a six-sided unit that is fully prefinished with most of the amenities installed. The columns are joined overlapping which helps to save on column construction cost. The adhering and the water proofing of adjoining PPVC modules 12 are also dealt with accordingly.

[0114] A method of constructing the PPVC module 12 comprising following steps. Firstly, forming the concrete slab 40 in a rectangular slab cast. The cast is made of cast iron. The slab wire frame is installed in the slab cast. Secondly, erecting an inner vertical cast; The inner vertical cast is about 150 mm shorter than the rectangular slab cast along the four sides. In other words, the inner vertical cast has a shorter length and width compare to the rectangular slab cast. Thirdly, erecting the vertical wire frame along the periphery of the inner vertical cast. The vertical wire frame circumscribes the inner vertical cast.

[0115] Fourthly, erecting the vertical continuity bar 54. The vertical continuity bar 54 has the splice connector grouting tubes 52 and the splice connectors 56 join at the top thereof. Fifthly, erecting the metallic valley trimming 62 with the wire loop connectors 58. The fourth and the fifth step is in preparation for forming the combined wall 44. Sixthly, erecting an outer vertical cast circumscribing the slab cast, the vertical wire frame and the inner vertical cast. Seventhly, injecting a cement between the hollow space created by the inner vertical cast and the outer vertical cast. The PPVC module 12 is formed. Eighthly, curing the PPVC module 12. Ninthly, removing the inner vertical cast and the outer vertical cast. Tenthly, relocating the PPVC module 12 to an installation floor for internal fittings.

[0116] Finally, installing the amenities inside the PPVC module 12. The partition wall 28, the bathroom fitting 26, the timber flooring 30, the tiles 32, the railing 34, the door frame 36, the ceiling 38, the braces 45, the electrical wiring and the water piping.

[0117] A method of transporting the PPVC module 12 comprising packaging the PPVC module 12, hoisting the fitted PPVC module 12 onto a mobile transport vehicle and moving the fitted PPVC module 12 to the remote installation site.

[0118] A method of assembling the PPVC module 12 at the installation site comprising subsequent steps. Firstly, positioning the first terminal module 48 above the pillars 18 as shown in Fig. 2. Secondly, positioning the intermediate module 50 adjacent to the terminal module 48. The adjoining combined walls 44 are aligned together with the beam 46 of the terminal module 48 aligning with the braces 45 of the intermediate module 50. Thirdly, positioning the second terminal module 48 adjacent to the

intermediate module 50. Fourthly, inserting the rebar 158 into the wire loop joint 132, arresting the wire loop connectors 58 and this securing the adjoining combined walls 44.

- 5 [0119] Fifthly, erecting the safety platform 24 on the top of the PPVC modules 12. Sixthly, inserting the water proofing strip along the top side of the wall and the combined walls 44. Seventhly, removing the safety platform 24 to provide accessibility to the following steps. Eighthly, pouring the cement into the wire loop joint 132. The cement will fill up the grouting channel 72. The cement continues to pour overlaying
- 10 on the combined top ends 150 of the adjoining combined walls 44. Finally, pouring the cement into the splice connector grouting tube 52. The cement will fill the splice connector 56 that is joined to the splice connector grouting tube 52. The above steps are repeated for more storeys.
- 15 [0120] A method of connecting the adjoining PPVC modules 12 comprising following steps. Firstly, aligning the adjoining PPVC modules 12 particularly at the pre-embedded anchor 70. Secondly, inserting the steel plate 68 into the pre-embedded anchor 70. Thirdly, inserting a plurality of washer into the pre-embedded anchor 70. Finally, screwing the bolts 66 into the pre-embedded anchor 70.
- 20 [0121] Once the desired levels of PPVC modules 12 are installed, the detailed internal fittings like electrical wiring and water piping are performed. Finally, the walls 42 and facades 82 are painted if required.
- 25 [0122] 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-explicitly recited elements.
- 30 [0123] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0124] 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.

5 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,
10 for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0125] 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
15 intended that all such modifications and adaptations come within the scope of the appended claims.

Reference Numerals

	10	erected building
	12	PPVC module
5	14	first storey
	16	rooftop
	18	pillar
	20	total height of the erected building
	22	a height of the first storey
10	24	safety platform
	26	bathroom fitting
	28	partition wall
	30	timber flooring
	32	tiles
15	34	railing
	36	door frame
	38	ceiling
	40	slab
	42	wall
20	43	first combined wall
	44	second combined wall
	45	brace
	46	beam
	48	end PPVC module or terminal PPVC module
25	50	intermediate PPVC module
	52	splice connector grouting tube
	54	vertical continuity bar
	56	splice connector
	58	wire loop connector
30	60	splice field dowel
	62	metallic valley trimming
	64	seal
	66	bolt
	68	steel plate

	70	pre-embedded anchor
	72	grouting channel
	74	gasket
	76	bedding mortar
5	78	water proofing strip
	80	filler grout
	82	exterior façade
	83	interior facade
	84	façade thickness
10	86	upper PPVC module
	88	lower PPVC module
	90	horizontal joint
	92	horizontal joint width
	94	first bend point
15	95	second bend point
	96	exterior façade to a first bend point length
	98	first bend point to a second bend point length
	100	second bend point to interior façade length
	102	indentation depth
20	104	exterior façade to a first flexion point length
	106	second inflexion point to the interior façade length
	108	exterior façade to the second inflexion point distance
	110	vertical joint
	116	right PPVC module thickness
25	118	non-shrink grout
	120	grout channel gasket recess
	122	20 mm recess
	124	grouting channel width
	130	vertical gasket seal
30	132	wire loop joint
	134	structural wall, big rectangle
	136	non-structural wall, small rectangle
	138	combined lateral surface
	140	combined lateral end

	142	structural surface
	144	structural lateral end
	146	non-structural surface
	148	non-structural lateral end
5	150	combined top end
	152	C-shaped combined wall
	154	T-shaped combined wall
	156	double L-shaped combined wall
	158	rebar
10	160	combined lateral thickness
	162	non-structural lateral end thickness
	164	structural wall length
	166	non-structural wall length
	168	structural wall height
15	170	non-structural wall height
	172	Cartesian coordinate system

Claims

1. A PPVC module for building construction, the PPVC module comprising:
a first combined wall that comprises
 - a first structural wall for bearing weight in a longitudinal direction of the first structural wall, and
 - a first non-structural wall extending from a lateral side of the first structural wall in forming the first combined wall together with the first structural wall,wherein the first structural wall has a structural thickness larger than a non-structural thickness of the first non-structural wall in their respective transverse directions.
2. The PPVC module of claim 1, wherein the first structural wall and the first non-structural wall have a common surface in a transverse direction of the first combined wall.
3. The PPVC module of claim 1 or 2 further comprising a connector on a side of the first structural wall for joining another combined wall.
4. The PPVC module of claim 3, wherein the connector comprises a wire loop connector on the first structural wall for connecting another wall.
5. The PPVC module of claim 4, wherein the wire loop connector comprises a prefabricated frame having a plurality of loops for coupling.
6. The PPVC module of claim 3, wherein the connector comprises a splice connector at a longitudinal end of the first structural wall for connecting a wall at the longitudinal end.

7. The PPVC module of any of the preceding claims further comprising
a second combined wall that comprises
- 5 ➤ a second structural wall for bearing weight in a longitudinal
direction of the second structural wall,
- a second non-structural wall extending from a lateral side of the
second structural wall in forming the second combined wall,
wherein the second structural wall has a second structural thickness
larger than a second non-structural thickness of the second non-
10 structural wall in their respective transverse directions.
8. The PPVC module of claim 7, wherein
a combined surface of the first combined wall and another combined surface of
the second combined wall are aligned to a side of the PPVC module.
- 15
9. The PPVC module of claim 7 or 8 further comprising
a beam connecting the first structural wall and the second structural wall
together.
- 20
10. The PPVC module of any of the preceding claims further comprising
at least one peripheral joint for joining the PPVC module to another PPVC
module.
- 25
11. A building for human occupation, the building comprising
a first PPVC module according to any of the preceding claims 1 to 10,
a second PPVC module according to any of the preceding claims 1 to 10, and
a joint between a first wall of the first PPVC module and a second wall of the
second PPVC module for coupling the first PPVC module and the second
PPVC module together.
- 30
12. The building of claim 11, wherein
a combined wall of the first PPVC module is attached to another combined wall
of the second PPVC module.

13. The building of claim 12, wherein
a structural surface of the combined wall of the first PPVC module is joined to
a non-structural surface of the other combined wall of the second PPVC module.

5 14. The building of any of the preceding claims 11 to 13 further comprising
a fire sealant, an acoustic insulation material, an adhesive, a water sealant, a
skin wall, a detachable wall, a party wall, an air gap, a window frame, a door
frame or a combination of any of these between two neighbouring PPVC
modules or two neighbouring combined walls.

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15. The building of any of the preceding claims 11 to 14 further comprising
a groove at the joint for draining rainwater between two PPVC modules.

16. A method of manufacturing a PPVC module, the method comprising:

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- providing a first structural wall for bearing weight in a longitudinal
direction of the first structural wall;
- constructing a first non-structural wall extending from a lateral side of the
first structural wall in forming a first combined wall, and
- making the first structural wall thicker than the first non-structural wall in
respective transverse directions of the first structural wall and the first
non-structural wall for providing a first combined wall.

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17. The method of claim 16 further comprising
aligning a side of the first structural wall and a side of the first non-structural
wall in forming a combined surface.

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18. The method of any of the preceding claims 16 or 17 further comprising:
positioning the first structural wall and the first non-structural wall along an edge
of the PPVC module.

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19. The method of any of the preceding claims 16 to 18 further comprising:

➤ providing a second structural wall for bearing weight in a longitudinal direction of the second structural wall,

5 ➤ constructing a second non-structural wall extending from a lateral side of the second structural wall in forming a second combined wall, and

➤ making a second structural thickness of the second structural wall larger than a second non-structural thickness of the second non-structural wall in respective transverse directions of the first structural wall and the first

10 non-structural wall for providing a second combined wall.

20. The method of claim 19 further comprising

attaching one of the combined walls of the PPVC module with another combined wall of another PPVC module.

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