

**METHOD OF MANUFACTURING AND ASSEMBLY of A SERIES OF
PREFABRICATED PREFINISHED VOLUMETRIC
CONSTRUCTION (PPVC) MODULES**

5 Technical Field of the Invention

The present invention relates to a method of manufacturing a series of prefabricated prefinished volumetric construction (PPVC) modules; and to a method of assembling the same.

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Background of the Invention

Prefinished-Prefabricated-Volumetric-Construction (**PPVC**) units are currently being used to quickly and efficiently construct buildings. This construction technique
15 requires neighbouring units to be coupled together. Any such couplings need to ensure adequate structural continuity between adjacent modules. It is generally desirable to provide an effective and cost efficient module connection system.

It is desirable to construct PPVC modules such that the modules can be assembled
20 with very small tolerances. It is also desirable to ensure that joined modules provide vertical and horizontal structural continuity.

It is generally desirable to overcome or ameliorate one or more of the above mentioned difficulties, or at least provide a useful alternative.

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Summary of the Invention

According to the present invention, there is provided a method of manufacturing a series of prefabricated prefinished volumetric construction (PPVC) modules, including
30 the steps of:

- (a) casting a slab of a new module in the series of modules against an adjoining slab of a previous module in the series of modules;
- (b) casting opposed walls of the new module on opposed sides of the slab, wherein one of said walls is cast against an adjoining wall of said
35 previous module;

- (c) casting a roof slab on said opposed walls of the new module, the roof slab being cast against an adjoining roof slab of said previous module;
 - (d) separating the new module from the previous module;
 - (e) repeating steps (a) to (d) for each successive module in the series,
- 5 wherein the side walls of each module in the series of modules are matched to side walls of neighbouring modules in the series of modules.

Preferably, the method also includes the steps of:

- 10 (a) casting a slab of a first module in the series of modules;
- (b) casting opposed walls of the first module on opposed sides of the slab; and
- (c) casting a roof slab on said opposed walls of the first module.

- 15 Preferably, one or more vertically extending locking channels are cast into outer articular surfaces of the side walls of each module. The locking channels span an entire wall height of the walls of each module. The locking channels of each module are lipped. The lipped channels are coupled to studs of reinforcement bars installed in the walls of the modules during the casting step.

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According to the present invention, there is also provided a method of assembling a plurality of prefabricated prefinished volumetric construction (PPVC) modules, each being formed in accordance with the above described method, including the steps of:

- (a) positioning a module in the series of modules against a matched
- 25 previous module in the series;
- (b) coupling the module and the previous module together; and
- (c) repeating steps (a) and (b) for each successive module in the series.

- Preferably, the step of positioning includes arranging corresponding locking channels
- 30 to overly one another to form combined locking conduits of vertical locks. The step of coupling includes the steps of pouring grout into the vertical locks. The locks ensure the horizontal mechanical continuity of the slabs of the modules to transfer horizontal forces to the various resisting members.

- 35 Preferably, the method includes the step of applying a compression force between the modules. The step of applying the compression force is achieved through installing a pre-stressing cable through the modules.

The above described methods preferably provide an effective and cost efficient module connection system.

- 5 The above described methods allow assembly of PPVC modules with very small tolerances. The joined modules preferably provide vertical and horizontal structural continuity.

Brief Description of the Drawings

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Preferred embodiments of the present invention are hereafter described, by way of non-limiting example only, with reference to the accompanying drawing in which:

- 15 Figure 1 is an exploded view of modules formed and assembled in accordance with preferred embodiments of the invention;

Figures 2a to 2h are diagrammatic illustrations showing the steps involved in constructing the modules shown in Figure 1;

Figure 3a is a side perspective view of a module formed in accordance with the steps shown in Figures 2a to 2h;

- 20 Figure 3b is a side view of the module shown in Figure 3a;

Figure 4a is a section view through the line A-A of the modules shown in Figure 2f;

Figure 4b is a plan view of the modules shown in Figure 2f including an alternative lock arrangement;

Figure 4c is an enlarged view of detail B shown in Figure 4b;

- 25 Figure 4d is an enlarged view of the grouted lock shown in Figure 4c showing compression stress lines formed when a force is applied to separate the walls of the module;

Figure 4e is an enlarged view of detail A shown in Figure 4b;

Figure 5a is a diagrammatic illustration of an intersection of the four modules shown in

- 30 Figure 1;

Figure 5b is another diagrammatic illustration of the intersection of the four modules shown in Figure 5a featuring different couplers and rebar cage arrangement;

Figure 6 is a section view of the of the intersection of the four modules shown in Figure 1;

- 35 Figure 7 is a side perspective view of one of the modules shown in Figure 1;

Figure 8 is a section view through the line B-B of the modules shown in Figure 2f;

Figure 9 is a plan view of the modules shown in Figure 2f;

Figure 10a is a side perspective view of separation apparatus;

Figure 10b is a section view through the line A-A of the modules shown in Figure 2f with the separation apparatus of Figure 10a seated in the channels of the abutting modules;

5 Figure 11a is a side perspective view of alternative separation apparatus; and

Figure 11b is a section view through the line A-A of the modules shown in Figure 2f with the alternative separation apparatus of Figure 11a seated in the channels of the abutting modules.

10 Detailed Description of Preferred Embodiments of the Invention

The series of prefabricated prefinished volumetric construction (PPVC) modules 10 shown in Figure 1 is manufactured in accordance with the steps set out in Figures 2a to 2h. The method involves manufacturing a first module 10a in the series 10 by

15 performing the steps of:

- (a) casting a slab 12 of a first module 10a in the series of modules 10;
- (b) casting opposed walls 14a, 14b of the first module 10a on opposed sides 18a, 18b of the slab; and
- 20 (c) casting a roof slab 16 on the opposed walls 14a, 14b of the first module 10a.

With reference to Figure 2a, the step of casting the slab 12 of the first module 10a includes the steps of:

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- (a) positioning two steel plates 18a, 18b in spaced apart positions on the casting rig 20, the plates 18a, 18b defining end sections of formwork for the slab 12;
- (b) securing the steel plates 18a, 18b in position using stopper 22;
- 30 (c) setting reinforcement bars into the formwork;
- (d) pouring concrete into the formwork; and
- (e) allowing the slab 12 set.

The casting rig 20 includes any suitable configuration that facilitates soft fit of each
35 module such that they can slide to allow for removal (positioning key 66 needs to be disengaged). To reduce friction, the casting rig 20 is either fitted with rollers or sitting on Teflon™ pads. For illustrative purposes, the casting rig is below described with

reference to the rig 20 including a metal plate 24 separated from a base section 26 by a plurality of angle bar members 28.

5 The plate 24 and the angle bar members 28 are preferably 8mm thick. The casting rig 20 also includes a raised section 30 that sits on top of the metal plate 24. The raised section 30 is defined by additional metal plate 32 separated from the plate 24 by additional angled bar members 24. The raised section 30 acts to create a recess in a bottom section of the slab 12 so as to reduce the weight of the slab 12 and the amount of concrete needed to be used.

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The metal plates 18a, 18b are preferably 3000mm apart. Alternatively, the plates 18a, 18b can be separated by any suitable distance to meet the requirements of a particular project. The plates 18a, 18b are preferably 8mm thick and have a height of 15 230mm. Again, any other suitable dimensions are anticipated to suit the needs of a particular project.

The resultant slab 12 has a thickness of 230mm at its edges and a thickness of 120mm at its centre. Any other thicknesses can also be achieved to meet any 20 particular requirement.

With reference to Figure 2b, the walls 14a, 14b are constructed on opposed sides 34a, 34b of the slab 12. For each wall 14a, 14b, formwork 36 is set up using standard equipment and using known techniques. The close wall formwork panels are 25 separated by a gap of 100mm. This is for a 200mm thick wall 14a, 14b. For a 250mm wall 14a, 14b the setup will be with 125mm (half of the wall thickness). This will be the resultant thickness of the walls. Of course, any other suitable thickness for the walls can be used. Reinforcement bars are included in the formwork to strengthen the walls 14a, 14b. The concrete is poured into the formwork 36 of each wall 14a, 30 14b to a height of 3200mm, for example. Alternatively, any suitable alternative height for the walls 14a, 14b can be used. The formwork 36 remains in place whilst the concrete sets.

With reference to Figure 2c, to create the roof slab 16, a metal plate 38 is suspended 35 over the slab 12 by scaffold equipment 40. The plate 38 is positioned such that it creates a bottom surface for the formwork for the roof slab 16 and is bookended by top sections 42a, 42b of the walls 14a, 14b. Reinforcement bars are included in the

formwork to strengthen the roof slab. Concrete is poured into the formwork to create the roof slab 16. The roof slab is preferably 130mm. Alternatively, the roof can be of any other suitable thickness, or by using precast planks or any other suitable roofing system. The formwork remains in place whilst the concrete sets.

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Following manufacture of the first module 10a in the series, the subsequent modules 10b, ... are manufactured by following the steps set out below:

- 10 (a) casting a slab 12 of a new module 10b in the series of modules 10 against a slab 12 of the previous module 10a in the series of modules 10;
- (b) casting opposed walls 14a, 14b of the new module 10b on opposed sides 18a, 18b of the slab 12, wherein one of the walls 14a is cast against a wall 14b of the previous module 10a;
- 15 (c) casting a roof slab 16 on the opposed walls 14a, 14b of the new module 10b, the roof slab 16 being cast against the roof slab 16 of the previous module 10a;
- (d) separating the new module 10b from the previous module 10a;
- (e) repeating steps (a) to (d) for each successive module in the series 10.

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The side walls 14a, 14b of each module in the series 10 of modules are matched to corresponding side walls 14a, 14b of neighbouring modules in the series of modules 10.

- 25 As particularly shown in Figure 2d, the step of casting the slab 12 of the next successive module 10b in the series includes the steps of:

- (a) positioning a steel plate 18 in a position on the casting rig 20 spaced apart from the slab 12 of the previous module 10a in the series, the end of the slab 12 of the previous module and the plate define formwork for the slab 12;
- 30 (b) securing the steel plate 18 in position using a stopper 22;
- (c) setting reinforcement bars into the formwork;
- (d) pouring concrete into the formwork; and
- 35 (e) allowing the slab 12 set.

The casting rig 20 includes an additional raised section 30 that sits on top of the metal plate 24. The raised section 30 is defined by additional metal plate 32 separated from the plate 24 by additional angled bar members 24. The additional raised section 30 acts to create a recess in a bottom section of the slab 12 so as to reduce the weight of the slab 12 and the amount of concrete needed to be used. Any other thicknesses can also be achieved to meet any particular requirement.

The resultant slab 12 has a thickness of 230mm at its edges and a thickness of 120mm at its centre.

With reference to Figure 2e, the walls 14a, 14b are constructed on opposed sides 34a, 34b of the slab 12. For each wall 14a, 14b, formwork 36 is set up using standard equipment and using known techniques. As shown, one of the walls 14a is cast against a wall 14b of the previous module 10a.

The close wall formwork panels are separated by a gap of 100mm. This will be the resultant thickness of the walls. For a 250mm wall 14a, 14b, the setup will be with 125mm (half of the wall thickness).

Of course, any other suitable thickness for the walls can be used. Reinforcement bars are included in the formwork to strengthen the walls 14a, 14b. The concrete is poured into the formwork 36 of each wall 14a, 14b to a height of 3200mm, for example. Alternatively, any suitable alternative height for the walls 14a, 14b can be used. The formwork 36 remains in place whilst the concrete sets.

With reference to Figure 2f, to create the roof slab 16, a metal plate 38 is suspended over the slab 12 by scaffold equipment 40. The plate 38 is positioned such that it creates a bottom surface for the formwork for the roof slab 16 and is bookended by top sections 42a, 42b of the walls 14a, 14b. Reinforcement bars are included in the formwork to strengthen the roof slab. Concrete is poured into the formwork to create the roof slab 16. The roof slab is preferably 130mm. Alternatively, the roof can be of any other suitable thickness, or by using precast plank or any other suitable roofing system. The formwork remains in place whilst the concrete sets.

Finally, as shown in Figure 2g, the modules 10a, 10b are separated on the Teflon coated track of the casting rig 20. Alternatively, the casting rig 20 includes any other

suitable surface with a reduced co-efficient of friction so as to facilitate easy lateral translation of the modules thereacross.

5 In order to reduce the force required to separate the modules 10a, 10b, and in particular at the 100mm thick wall area, the modules 10a, 10b preferably include polyethylene sheets 43. In this embodiment, the match cast surface for the walls 14b, 14a does not need to extend across the entire surface. Match cast is chiefly required at base 12 and top slab area 16, the vertical edges of the module 10 and around the vertical locks 50.

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The first module 10a is taken away by a lifting module in the manner shown in Figure 2h for installation at the construction site where the following steps are performed:

- 15
- (a) positioning a first module in the series against a second module in e the series; and
 - (b) coupling the first module and the second module together.

20 The above-described method improves upon issues relating to construction tolerance between elements by providing a perfect match when the elements are put back together. Furthermore, the above-described method ensures accurate finishing material continuity after erection.

25 The formwork is not described in detail. However, it is understood to include sophisticated formwork techniques, such as tunnel forms in which the walls and the ceiling slabs are poured simultaneously, could be used to speed up the fabrication process.

Assembly

30 The method of assembling the plurality of PPVC modules 10, includes the steps of:

- (a) positioning a module 10b in the series of modules 10 against a matched previous module 10a in the series;
- (b) coupling the module 10b and the previous module 10a together; and
- 35 (c) repeating steps (a) and (b) for each successive module in the series 10.

It is desirable for the two half-walls 14b, 14a of adjoining modules 10a, 10b to be a monolithic member with a width equal to the sum of the thickness of the single elements. The vertical locks 50 on adjoining modules 10a, 10b facilitate this function in the manner shown in Figures 3 to 8.

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As particularly shown in Figures 4a and 7, the locks 50 are formed using a lipped locking channel 52 positioned in the concrete walls 14a, 14b, on either side of the construction joint. The locking channels 52 are arranged to overly one another to form a combined locking conduit for the lock 50.

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Studs 54 welded onto the steel section 56 forming the locks ensure the lock 50 is tied to the reinforcement bars 58a, 58b in each half wall 14a, 14b. To ensure the mechanical continuity of these locks 50, "C" channels 60 are inserted in the locks 50 and cement slurry 62 is poured into the internal volume to seal the various elements.

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The lock 50 can also been formed using other types of steel sections 56 working in conjunction with grout 62. The grout 62 has the additional benefit of protecting the steel section against corrosion to ensure the system durability.

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The locks 50 preferably span the entire wall height and form a mechanical connection between the two half-walls 14b, 14a of adjoining modules. The locks 50 replace the links or stirrups found in conventional reinforced concrete construction. The locks 50 also ensure the horizontal mechanical continuity of the slab 12 (diaphragm) that is required to transfer the horizontal forces to the various resisting members.

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As shown in Figures 4b to 4d, the "U" shaped channels can alternatively include a flat bar 70. For this solution the U channel 56 is welded to the rebar cage 58a, 58b.

The tying force required to keep the two sections of the wall 14b, 14a monolithic depends on:

30

- (a) the wall thickness;
- (b) free length; and
- (c) the gravity force applied onto it.

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In the following calculation note, in order to assess the performance of the lock 50, this effort is taken as 40 t/m^2 (the magnitude of this effort is greatly overestimated).

It is also assumed that locks 50 are spaced 1 m center to center, giving a pulling effort of 0.4 MN / m.

- **Estimation of the stress in the flat bar (for 1m length of lock)**

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Considering:

- A_s as the sectional area of the bar 70:

- o $A_s = 0.004 \cdot 1$
 - o $m = 0.004 \text{ m}^2$

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- N as the pulling force applied on the lock:

- o $N = 0.4 \text{ MN}$

We get a tension stress in the steel member of:

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$$\sigma_s = \frac{N}{A_s} = \frac{0.4}{0.004} = 100 \text{ MPa}$$

This is to be compared to $\bar{\sigma}_s$ tensile resistance of the steel:

$$\bar{\sigma}_s = 235 \text{ MPa}$$

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- **Calculation of the compressive stress in the grout struts**

25 We consider that the tension effort is transferred between the flat bar 70 and the U channel 56 by struts that are developing in the grout orientated with a 45° angle as shown in Figure 4d.

Considering a pulling effort N of 0.4 MN, we can define the compressive stress in the grout as:

30

- Compressive force in the strut:

$$N_s = \frac{N}{2} \cdot \frac{1}{\cos 45^\circ} = \frac{0.4}{2} \cdot \frac{2}{\sqrt{2}} = 0.28 \text{ MN}$$

- Stress in the grout strut

$$\sigma_g = \frac{N_s}{A_g} = \frac{0.28}{0.0226} = 12.51 \text{ MPa}$$

Where A_g is the strut sectional area:

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$$A_g = 0.032 \cdot \cos 45^\circ = 0.0226 \text{ m}^2$$

This is to be compared to the compressive resistance to the grout 62 that we take as:

10 $\bar{\sigma}_g = 80 \text{ MPa}$

- **Friction of between the bar/U channel and the grout strut**

The friction stress between the steel surface and the grout is given by:

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$$\tau = \frac{N}{2} \cdot \frac{1}{A} = \frac{0.40}{2} \cdot \frac{1}{0.032} = 6.25 \text{ MPa}$$

Where:

N is the pulling strength $N = 0.4 \text{ MN}$

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A is the contact area between the strut and the steel surface $A = 0.032 \text{ m}^2$

This is to be compared to the allowable shear stress:

25 $\bar{\tau} = 0.6 \cdot \psi^2 \cdot f_t + 0.4 \sigma_c = 0.6 \cdot 7.65 + 0.4 \cdot 6.25 = 7.09 \text{ MPa}$

Where:

ψ is a coefficient depending on the steel roughness. $\psi = 1$ when no roughness

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f_t is the traction resistance of the grout taken as $f_t = 7.65 \text{ MPa}$

σ_c is the compression stress " σ_s " applied at the interface steel / grout resulting from the 45° strut angle. It is equal to:

$$\sigma_s = \frac{N}{2} \cdot \frac{1}{A} = \frac{0.4}{2} \cdot \frac{1}{0.032} = 6.25 \text{ MPa}$$

As shown in Figures 4c and 4e, the modules 10a, 10b include T20-500 (Dowel Bars) 63 extending therethrough. This provides additional structural integrity to the modules 10.

As shown in Figures 5a, 5b and 6, grouted connectors 57 provide continuity of vertical bars 58a between vertically stacked modules 10a, 10c. The grouted connectors 57 are interconnected by conduits 59. The grouted connector sleeves 57 are spaced at 150mm c/c or any distance meeting the structural design requirement.

The connector 57 are pre-positioned in the formwork before the module pouring. This sleeve 57 consist of a steel tube in which vertical rebars 58a from the upper and lower modules 10a, 10c are located and are abutting. The continuity is achieved by pouring grout that will transfer a load from the rebar 58a, to the sleeve 57, and then from the sleeve 57 to the other rebar 58a. The grouting is achieved by pumping grout in the injection port 61 that is located at the base of the connector, until it escape from the venting port that is located at the top of the connector. In our case, as the grouting will be performed for a series of connectors, we will connect the venting port to the injection port of the next connector.

Epoxy glue will be preferably be applied to the match cast surface. This has at least the following benefits:

- (a) Gluing of the modules;
- (b) Lubricate the element to ease the accurate positioning when applying the prestressing force; and
- (c) Ensure tightness for the grouting operation of the vertical locks.

With reference to Figure 6, the transfer of vertical forces between modules 10 is done through a 20mm thick metal plate 64 that is also used to ensure the leveling of the module. This steel plate 64 is accurately positioned on top of the modules 10 that have been installed at the lower floor by grouting. This plate 64 works in conjunction with a 4mm metal plate 65 embedded in the lower part of the upper module so as to have steel to steel bearing during installation. This 4mm thick plate 65 is also used to

accurately position the connectors during the module fabrication by tack welding them on the steel member. This thickness may vary depending on the application.

AS shown in Figures 8 and 9, during installation, to ensure proper relative positioning of the elements, centering keys 66 are provided on the lateral faces of the modules
5 10.

To ensure key 66 effectiveness for the accurate positioning of modules 10 in relation to one another, a compression force must be applied between the modules 10. This is achieved through a pre-stressing cable positioned in a duct 68 installed in the slab 12
10 of the module floor. Other methods can also be used to apply the force, such as using hydraulic jacks fixed on the roof of the modules already installed. This operation is done in order to achieve very accurate positioning of a module 10b in relation to an adjacent module 10a that is already placed. To be efficient, this compression force needs to be applied in order for the positioning key 66 to engage and displace the
15 module 10b sideways if not align satisfactorily.

To facilitate easier separation of matched modules during the module construction phase, separation apparatus 100 can be inserted into the locking channels 52. As shown in Figures 10a and 10b, the apparatus 100 includes an elongate shaft 102
20 which is generally rectangular in cross-section. Short sides of the shaft include opposed "U" shaped recesses 104a, 104b which each include seated therein inflatable balloons (also referred to as seals) 106a, 106b.

The balloons 106a, 106b are connected to a pneumatic or fluid pump which, when
25 activated, cause the balloons 106a, 106b to inflate outwardly in opposite directions from their respective recesses 104a, 104b. The inflating balloons 106a, 106b abut respective channels 52 and apply a force thereto in the direction in which they are inflating (i.e. away from their recesses 104a, 104b). Continued inflation thereby causes the channels 52 of the two modules 10a, 10b to move in opposite directions
30 and separate.

An alternative embodiment of the separation apparatus 100 is shown in Figures 11a and 11b. The apparatus 100 includes an elongate shaft 112 which is generally rectangular in cross-section. The apparatus 100 includes pairs of hydraulic jacks 114
35 located in spaced apart positions along the length of the shaft 112.

The pairs of jacks 114 are connected to a pump which, when activated, cause the jacks to expand outwardly in opposite directions. The expanding jacks 114 abut respective channels 52 and apply a force thereto in the direction in which they are expanding (i.e. away from the shaft 112). Continued expansion thereby causes the
5 channels 52 of the two modules 10a, 10b to move in opposite directions and separate.

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention

10 The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that the prior art forms part of the common general knowledge in Australia, Singapore or any other jurisdiction.

In this specification and the claims that follow, unless stated otherwise, the word
15 "comprise" and its variations, such as "comprises" and "comprising", imply the inclusion of a stated integer, step, or group of integers or steps, but not the exclusion of any other integer or step or group of integers or steps.

References in this specification to any prior publication, information derived from any
20 said prior publication, or any known matter are not and should not be taken as an acknowledgement, admission or suggestion that said prior publication, or any information derived from this prior publication or known matter forms part of the common general knowledge in the field of endeavour to which the specification relates.

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Claims Defining the Invention

1. A method of manufacturing a series of prefabricated prefinished volumetric construction (PPVC) modules, including the steps of:
 - 5 (a) casting a slab of a new module in the series of modules against an adjoining slab of a previous module in the series of modules;
 - (b) casting opposed walls of the new module on opposed sides of the slab, wherein one of said walls is cast against an adjoining wall of said previous module;
 - 10 (c) casting a roof slab on said opposed walls of the new module, the roof slab being cast against an adjoining roof slab of said previous module;
 - (d) separating the new module from the previous module;
 - (e) repeating steps (a) to (d) for each successive module in the series, wherein the side walls of each module in the series of modules are matched to
 - 15 side walls of neighbouring modules in the series of modules.
2. The method claimed in claim 1, including the steps of:
 - (a) casting a slab of a first module in the series of modules;
 - (b) casting opposed walls of the first module on opposed sides of the slab;
 - 20 and
 - (c) casting a roof slab on said opposed walls of the first module.
3. The method claimed in claim 1 or claim 2, wherein one or more vertically extending locking channels are cast into outer articular surfaces of the side walls of
- 25 each module.
4. The method claimed in claim 3, wherein the locking channels span an entire wall height of the walls of each module.
- 30 5. The method claimed in claim 3 or claim 4, wherein the locking channels of each module are lipped.
6. The method claimed in claim 5, wherein the lipped channels are coupled to studs of reinforcement bars installed in the walls of the modules during the casting
- 35 step.

7. The method claimed in any one of claims 1 to 6, wherein the walls of the modules are keyed to assist in accurate positioning of modules in relation to one another.
- 5 8. The method claimed in any one of claims 1 to 7, wherein the modules each include a lateral duct for carrying a pre-stressing cable therethrough that is used to apply horizontal mating forces.
9. The method claimed in claim 8, wherein the duct of each module is positioned
10 in the slab.
10. The method claimed in any one of claims 1 to 9, wherein the step of casting the slab is performed on a casting rig.
- 15 11. The method claimed in claim 10, wherein the casting rig includes an upper surface with a reduced co-efficient of friction so that the modules can laterally translate thereacross.
12. The method claimed in claim 11, wherein the upper surface is coated with
20 PTFE.
13. The method claimed in any one of claims 3 to 12, wherein the step of separating includes the step of actuating separation apparatus seated in channels between the new module and the previous module.
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14. The method claimed in claim 13, wherein the separation apparatus includes inflatable balloons coupled to opposed sides of an elongate shaft.
15. The method claimed in claim 13, wherein the separation apparatus includes
30 hydraulic jacks coupled to opposed sides of an elongate shaft.
16. The method claimed in any one claims 1 to 15, wherein the step of casting opposed side walls of the new module includes the step of coupling sheets of material to outer peripheral sides of the walls to facilitate easier separation of the new module
35 from the previous module.

17. The method claimed in claim 16, wherein the sheet of material is a polyethylene sheet.
18. A method of assembling a plurality of prefabricated prefinished volumetric construction (PPVC) modules, each being formed in accordance with the method claimed in any one of claims 3 to 17, including the steps of:
- (a) positioning a module in the series of modules against a matched previous module in the series;
 - (b) coupling the module and the previous module together; and
 - (c) repeating steps (a) and (b) for each successive module in the series.
19. The method claimed in claim 18, wherein the step of positioning includes arranging corresponding locking channels to overlie one another to form combined locking conduits of vertical locks.
20. The method claimed in claim 19 including the step of inserting "C" channels into the locking channels.
21. The method claimed in claim 19 or claim 20, wherein the step of coupling includes the steps of pouring grout into the vertical locks.
22. The method claimed in any one of claims 19 to 21, wherein the locks ensure the horizontal mechanical continuity of the slabs of the modules to transfer horizontal forces to various resisting members.
23. The method claimed in any one of claims 18 to 22, including the step of applying a compression force between the modules.
24. The method claimed in claim 23, wherein the step of applying the compression force is achieved through installing a pre-stressing cable through the modules.