

PPVC CONNECTOR

Field of the Invention

5 The present application relates to one or more PPVC (Prefabricated Prefinished Volumetric Construction) connectors for coupling PPVC modules together. The application also relates to one or more methods for making, assembling, disassembling, installing, configuring, maintaining, repairing and using the one or more PPVC connectors in order to couple the PPVC modules.

Background

10 To raise construction productivity and fundamentally improve design and construction processes, Building and Construction Authority of Singapore (BCA) encourages construction industry to embrace a concept of Design for Manufacturing and Assembly (DfMA), whereby construction may be done off-site in a controlled manufacturing environment as much as possible.

15 PPVC is one of the game changing technologies that support the DfMA concept to significantly speed up building construction. PPVC can potentially achieve a productivity improvement of up to 50% in terms of manpower and time savings, depending on complexity of relevant projects. Furthermore, dust and noise pollution can be minimised as more activities are done off-site (i.e. away from building construction site). With the bulk of installation activities and manpower moved
20 off-site to a factory controlled environment, building construction site safety is also improved.

Though important, known connection between PPVC modules is inherently weak because walls, floors or side panels of different PPVC modules are prefabricated separately in factories, instead of constructed or cured together onsite continuously. Hence, those skilled in the art are striving
25 to provide an improved method and connectors to improve the coupling building elements or PPVC modules

Summary of the Invention

The above and other problems are solved and an advance in the state of the art is made by a
30 PPVC connector in accordance with this invention. The present application of the invention aims to provide one or more new and useful PPVC connectors for coupling multiple PPVC modules, which are known as building elements as well. Particularly, the PPVC connector of the present application has a rigid nature and can provide confined space for inducing confinement effect between the PPVC connector and the fillers. By filling and curing fillers into the confined space,
35 the PPVC connector makes two or more PPVC modules into a monolithic assembly by forming a continuous reinforced structure in-between the PPVC modules. The present application further aims to provide one or more new and useful methods for making, assembling, disassembling,

installing, configuring, maintaining, repairing and using the PPVC connector for coupling building elements or PPVC modules.

A first aspect of the disclosure describes a PPVC connector comprising: a connecting element;
5 a plurality of first anchors anchored to a first PPVC module; a plurality of second anchors anchored to a second PPVC module arranged apart from the plurality of first anchors wherein the PPVC connector is adapted to be installed to the first and second PPVC modules such that the connecting element engages the first and second anchors preventing the first and second PPVC modules from moving apart from each other.

10 In an embodiment of the first aspect of the disclosure, a part of each first anchor is embedded into the first PPVC module with another part of the first anchor exposed at the recess of the first PPVC module and a part of each second anchor is embedded into the second PPVC module with another part of the second anchor exposed at the recess of the second PPVC module.

15 In an embodiment of the first aspect of the disclosure, the recess of the first PPVC module is provided on a grouting surface of the first PPVC module and the recess of the second PPVC module is provided on a grouting surface of the second PPVC module.

20 In an embodiment of the first aspect of the disclosure, each of the first and second PPVC modules comprises a thin half-leaf wall with thickness of at least 80mm measured between opposing surfaces of each of the first and second PPVC modules.

25 In an embodiment of the first aspect of the disclosure, the connecting element comprises: a rebar having a length; and a plurality of hook anchor coupled to the rebar, the plurality of hook anchor are spaced apart from each other.

In an embodiment of the first aspect of the disclosure, each hook anchor has a base having a length that determines a grouting width between the first and second PPVC modules.

30 In an embodiment of the first aspect of the disclosure, each hook anchor has a pair of extensions extending from both ends of the base to form a hook-like grip for engaging the first and second anchors.

35 A second aspect of the disclosure describes a composite PPVC wall comprising: a first PPVC module and a second PPVC module, each comprising a thin half-leaf wall having a grouting surface and an external surface and at least one recess defined on the grouting surface; a PPVC connector comprising: a connecting element; a plurality of first anchors anchored to the recess

of the first PPVC module; a plurality of second anchors anchored to the recess of the second PPVC module and arranged apart from the plurality of first anchors wherein the connecting element is adapted to engage the first and second anchors preventing the first and second PPVC modules from moving apart from each other.

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In an embodiment of the second aspect of the disclosure, a part of each first anchor is embedded into the first PPVC module with another part of the first anchor exposed at the recess of the first PPVC module and a part of each second anchor is embedded into the second PPVC module with another part of the second anchor exposed at the recess of the second PPVC module.

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In an embodiment of the second aspect of the disclosure, the connecting element comprises: a rebar having a length; and a plurality of hook anchor coupled to the rebar, the plurality of hook anchor are spaced apart from each other.

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In an embodiment of the second aspect of the disclosure, each hook anchor has a base having a length that determines a grouting width between the first and second PPVC modules.

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In an embodiment of the second aspect of the disclosure, each hook anchor has a pair of extensions extending from both ends of the base to form a hook-like grip for engaging the first and second anchors.

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A third aspect of the disclosure describes a method of constructing the composite PPVC wall according to the second aspect of the disclosure comprising: arranging the first and second PPVC modules such that the respective recesses are facing each other; inserting the rebar through an opening formed by the respective recesses; rotating the rebar by approximately 90 degrees; lowering the rebar until the hook anchor engage the first and second anchors; and filling a gap defined between the grouting surfaces with grout.

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In an embodiment of the first, second and third aspects of the disclosure, the hook anchor is a U shaped fork.

Brief Description of the Drawings

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

Figure 1 illustrates a plan of two facing half-leaf wall being connected by a connecting element in accordance with an embodiment of this invention with 1st step, 2nd step and 3rd step during installation;

Figure 2 illustrates a plan of full length of two typical PPVC half-leaf wall being connected being connected by the connecting element in accordance with an embodiment of this invention with step 1 and step 2 and step 3;

Figure 3 illustrates a plan of full length of two typical PPVC half-leaf wall being connected by the another connecting element in accordance with another embodiment of this invention with step 1 and step 2 and step 3;

Figure 4 illustrates a perspective of PPVC thin half-leaf wall before forming a composite PPVC wall. The connection element installed in sequence of Step 1, Step 2, and Step 3;

Figure 5 illustrates a perspective of two side by side PPVC thin half-leaf wall having 3 indentations/recesses, the connection element installed in sequence of Step 1, Step 2, and Step 3;

Figure 6 illustrates another perspective of PPVC wall with the assembly of connection element;

Figure 7 illustrates a side view of two walls stack on top of each other of a first embodiment;

Figure 8 illustrates a section view and a plan view of the frame of the connecting element in accordance with an embodiment of this disclosure;

Figure 9 illustrates a front view of the frame of the connecting element in accordance with an embodiment of this disclosure;

Figure 10 illustrates a top view of the frame of the connecting element in accordance with an embodiment of this disclosure;

Figure 11 illustrates a process of constructing a composite PPVC wall in accordance with an embodiment of this disclosure;

Figure 12 illustrates a perspective view of the composite PPVC walls adjacently connecting each other on the same level in accordance with an embodiment of this disclosure;

Figure 13 illustrates a perspective view of the composite PPVC walls connecting to upper composite PPVC walls in accordance with an embodiment of this disclosure; and

Figure 14 illustrates a perspective view of the composite PPVC walls as shown in figure 13 with connecting elements (where first and second PPVC modules are omitted) extending further for connecting to subsequent upper composite PPVC walls in accordance with an embodiment of this disclosure.

Detailed Description

The present application relates to one or more PPVC (Prefabricated Prefinished Volumetric Construction) connectors for coupling PPVC modules together. The application also relates to

one or more methods for making, assembling, disassembling, installing, configuring, maintaining, repairing and using the one or more PPVC connectors in order to couple the PPVC modules.

According to an aspect, the present application provides a PPVC (Prefabricated Prefinished Volumetric Construction) connector that is typically fabricated before installation in order to couple, join, bind or fix a first PPVC module 100 and a second PPVC module 200 together permanently or temporarily.

As shown in figures 1-3, the PPVC connector 300 comprises a first PPVC module 100, a second PPVC module 200 and a connecting element 350.

The PPVC connector 300, either rigid or flexible, is used for coupling or joining a first PPVC module 100 and a second PPVC module 200 together. The first PPVC module 100 of the PPVC connector 300 comprises the first anchor 110 for being attached to or embedded into/onto a wall (e.g. ceiling, floor, sidewall) of the first PPVC module 100. The first anchor 110 is provided such that part of the first anchor is attached to or embedded into/onto a wall with another part of the first anchor exposed at the recess 120. The recess 120 is provided on the grouting surface of the first PPVC module 100. The second PPVC module 200 of the PPVC connector 300 also comprises the second anchor 210 for being attached to or embedded into/onto the second PPVC module wall (e.g. ceiling, floor, sidewall) 200. The second anchor 210 is provided such that part of the second anchor 210 is attached to or embedded into/onto a wall with another part of the second anchor 210 exposed at the recess 220. The recess 220 is provided on the grouting surface of the second PPVC module 200.

The PPVC connector 300 further comprises the connecting element 350 (also known as a frame) either rigid or flexible operable for coupling the first anchor 110 and the second anchor 210 together. The connecting element 350 is one or a combination of the following components: metal rod, rebar, plate or sheet. The connecting element 350 is usually a hard, tough, strong structural component or structure, although the connecting element 350 is optionally resilient or springy. The connecting element 350 comprises a vertical rebar 351, a few numbers of hook anchor 352 which are made of rigid steel plate or rigid rebar or similar type. The hook anchor 352 may be a U shaped fork or similar configuration adapted to hook and anchor the first and second anchors preventing the first and second PPVC modules 100 and 200 from moving apart from each other.

The hook anchor 352 are been spaced approximately 500-800mm vertically apart from each other. The length of the vertical rebar 351 is longer than the length of the recess of a PPVC module so that it extends into a recess of the connecting top or bottom PPVC modules.

The hook anchor 352 has a base 3521 having a length that determines the grouting width between the first and second PPVC modules. The hook anchor 352 further comprises a pair of extension 3522 extending from both ends of the base 3532 to form the hook anchor 352. The hook anchor 352 is coupled to the vertical rebar 351 via tack weld 3511. Specifically, the hook anchor 352 is coupled approximately at the middle of the length of the base 3522 to the vertical rebar 351.

Figures 9 and 10 shows one embodiment of the hook anchor 352 where the length of the base is approximately 100mm and the middle of the base 3521 is coupled to the rebar 351. A pair of extension 3522, each with a length of approximately 70mm, extends from both ends of the base 3532 to form the hook anchor 352. One skilled in the art will recognise that other length of the base 3521 and extensions 3522 may be implemented without departing from the invention. Further, while the vertical rebar 351 and hook anchor 352 shown in figures 9-10 appear to be two separate pieces welded together, one skilled in the art will recognise that the vertical rebar 351 and hook anchor 352 may be manufactured as a one piece connecting element 350. Still further, the pair of extension 3522 extending from both ends of the base 3532 are to form a hook-like grip for engaging the first and second anchors. Hence, while the figures in the drawings show that the extensions 3522 are perpendicular to the base 3521, one skilled in the art will recognise that the base 3521 and extension 3522 only needs to form a grip to engage the first and second anchors. In short, the hook anchor 352 is adapted to engage the first and second anchors, which are arranged apart from with each other, preventing the first and second PPVC modules from moving apart from each other.

The first anchor 110 and the second anchor 210 are made of rigid steel plate or rigid rebar or similar type. Figures 2 and 3 illustrate the plan view of the PPVC connector 300 with two embodiments of the first anchor 110 and second anchor 210. Referring to figure 2, the first PPVC module 100 comprises a number left first anchors, a number right first anchors and a number of intermediate first anchors. Each first anchor 110 has a length with the middle portion folded to form a trough which is partially exposed on the recess 120 of the first PPVC module 100. The left and right first anchors have edges proximate the respective sides of the first PPVC module 100 folded to form a C shape end. The second anchors 210 provided on the second PPVC module 200 is a mirror image of the first anchors 110.

Figure 3 illustrates another embodiment of the first and second anchors 110 and 210 where the troughs are deeper. The frame 350 comprises one number of vertical rebar 351, a few numbers of horizontal hook anchor 352 (made of rigid steel plate or rigid rebar or similar type) in a form of fork shape. The hook anchor 352 will be spaced around 500-800mm vertically apart from each

other, and the vertical rebar 351 will be anchoring into lower module with tension lapping length typically equals to 50 times of the diameter of the vertical rebar. The hook anchor 352 are coupled to the vertical rebar 351 via tack weld 3511 (as shown in figure 10) or other welding methods. Alternatively, the hook anchor 352 and vertical rebar 351 may be a one piece frame.

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Each PPVC module 100 and 200 has a length 610, width 620 and depth 630 and actual dimension for the length 610, width 620 and depth 630 is left as a design choice to one skilled in the art. Each PPVC module 100 and 200 has an external surface and a grouting surface. In one embodiment, the external surface is a smooth skin facing room side and the grouting surface is a roughened surface. At least one recess 120 or 220 is provided on the grouting surface that runs across the length 610 of the PPVC module 100. The number of recesses for each PPVC module is determined by the dimension of the width 620. In the embodiments shown in figures 2-7, three recesses are provided on the grouting surface. However, if the width 620 has a smaller dimension, two recesses may be used instead.

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The first PPVC module 100 and the second PPVC module 200 are laterally arranged, being next to each other with respective grouting surfaces facing each other. For example, the first PPVC module 100 and the second PPVC module 200 are substantially at the same level or on the same floor. After the first PPVC module 100 and the second PPVC module 200 are lateralled arranged to final position on site with respective grouting surfaces facing each other, the frame 350 are inserted into a through opening (i.e. Step 1) formed by the recesses 120 and 220 between the first PPVC module wall 100 and second PPVC module wall 200. The frame 350 will be rotated (i.e. Step 2) ninety degree and lower down (i.e. Step 3) to connect the first anchor 110 in PPVC wall 100 with the second anchor 210 in PPVC wall 200. The frame 350 will also be anchoring to the recesses at lower pair of PPVC modules 100 and PPVC 200 as shown in figure 7. The gap between the grouting surfaces and the through opening formed by the recesses 120 and 220 between the two PPVC modules will be grouted to connect the two PPVC modules to form a composite PPVC wall 500.

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Figures 2-7 show three sets of PPVC connector 300 being implemented to couple, join, bind or fix a first PPVC module 100 and a second PPVC module 200 together permanently or temporarily. The three sets of PPVC connector 300 are spaced apart from each other on the grouting surface and are arranged based on structural integrity considerations. Hence, one skilled in the art will recognise that the number of sets of PPVC connector 300 to be implemented is dependent on the dimension of the first and second PPVC modules 100 and 200, and the exact number of sets of PPVC connector 300 to be implemented is left to those skilled in the art.

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In accordance with an embodiment of this invention, the PPVC connector 300 system is able to produce a composite PPVC wall 500 with minimum thickness of 80mm + 20mm grout + 80mm to achieve a monolithic wall of 180mm as shown in figures 1 and 2 or alternatively with larger thickness to achieve a monolithic wall with larger thickness. In short, each of the first and second PPVC modules comprises a thin half-leaf wall with thickness of at least 80mm measured between opposing surfaces of each of the first and second PPVC modules. One skilled in the art will recognise that other thickness may be implemented without departing from the invention.

Figure 11 illustrates a process 1100 of constructing a composite PPVC wall 500. Process 1100 beings with step 1105 by arranging the first and second PPVC modules where the grouting surfaces are facing each other. In one embodiment, the PPVC modules are arranged apart from each other such that there will be a grouting gap to allow for grouting. Preferably, the grouting gap is between 15mm and 25mm. More preferably, the grouting gap is approximately 20mm. The recess gap defined between the recesses will be approximately 115 to 125mm. This means that each recess 120, 220 has a depth of about 50mm.

In step 1110, process 1100 positions the connection element 350 such that the hook anchor 352 are parallel to the thin half-leaf wall in the recess gap.

In step 1115, process 1100 inserts the connecting element 350 at Step 1 into the recess gap.

In step 1120, process 1100 rotates the connecting element 350 by 90 degrees at Step 2 so that the hook anchor 352 are perpendicular the exposed first and second anchors.

In step 1125, process 1100 lowers connecting element 350 until the hook anchor 352 engage the first and second anchors forming a rigid tying connection and preventing the first and second PPVC modules to move apart from each other. Additional metal wire tie may be implemented to secure the hook anchor 352 to the first and second anchors.

In step 1130, process 1100 fill the grouting gap and recess gap with grout to complete the connection of the two PPVC modules to form the composite PPVC wall 500. In this step, a top portion of the recess gap may not be filled with grout in order to form an adjacent upper composite PPVC wall 520. For example, the connecting element 350 of the adjacent upper composite PPVC wall 520 will extend into the unfilled top portion of the recess gap of the lower composite PPVC wall 510 to form vertical connection by lapping action between upper and lower composite PPVC walls as shown in figure 7.

Process 1100 ends after step 1130.

Process 1100 illustrates a process of constructing a composite PPVC wall 500 as shown in figures 5 and 6 and extending further by connecting adjacent upper composite PPVC wall 520 as shown in figure 7. One skilled in the art will recognise that the composite PPVC wall 500 may also extend further by connecting adjacent side composite PPVC walls 511-516 as shown in figure 12. While figure 12 shows the adjacent side composite PPVC walls 511-516 are connected to each other via linking walls, one skilled in the art will recognise that adjacent side composite PPVC walls 511-516 may be directly connected to each other without departing from the invention. Further, as shown in figures 13 and 14, the adjacent side composite PPVC walls 511-516 may form adjacent lower composite PPVC walls of adjacent upper composite PPVC walls 521-516. This allows the upward construction from the composite PPVC walls 511-516.

The new invented connection will achieve much higher strength and simulating the conventional horizontal links in wall elements.

The above is a description of exemplary embodiments of a PPVC connector and method of using the PPVC connector to construct composite PPVC walls in accordance with this disclosure. It is foreseeable that those skilled in the art can and will design alternatives based on this disclosure.

Claims

1. A Prefabricated Prefinished Volumetric Construction (PPVC) connector comprising:

a connecting element;

5 a plurality of first anchors anchored to a first PPVC module;

a plurality of second anchors anchored to a second PPVC module arranged apart from the plurality of first anchors wherein the PPVC connector is adapted to be installed to the first and second PPVC modules such that the connecting element engages the first and second anchors preventing the first and second PPVC modules from moving
10 apart from each other.

2. The PPVC connector according to claim 1 wherein a part of each first anchor is embedded into the first PPVC module with another part of the first anchor exposed at the recess of the first PPVC module and a part of each second anchor is embedded into the
15 second PPVC module with another part of the second anchor exposed at the recess of the second PPVC module.

3. The PPVC connector according to claim 1 wherein the recess of the first PPVC module is provided on a grouting surface of the first PPVC module and the recess of the
20 second PPVC module is provided on a grouting surface of the second PPVC module.

4. The PPVC connector according to claim 1 wherein each of the first and second PPVC modules comprises a thin half-leaf wall with thickness of at least 80mm measured between opposing surfaces of each of the first and second PPVC modules.
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5. The PPVC connector according to claim 1 wherein the connecting element comprises:

a rebar having a length; and

a plurality of hook anchor coupled to the rebar, the plurality of hook anchor are
30 spared apart from each other.

6. The PPVC connector according to claim 1 wherein each hook anchor has a base having a length that determines a grouting width between the first and second PPVC modules.
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7. The PPVC connector according to claim 1 wherein each hook anchor has a pair of extensions extending from both ends of the base to form a hook-like grip for engaging the first and second anchors.
- 5 8. The PPVC connector according to anyone of claims 5-7 wherein the hook anchor is a U shaped fork.
9. A composite Prefabricated Prefinished Volumetric Construction (PPVC) wall comprising:
- 10 a first PPVC module and a second PPVC module, each comprising a thin half-leaf wall having a grouting surface and an external surface and at least one recess defined on the grouting surface;
- a PPVC connector comprising:
- a connecting element;
- 15 a plurality of first anchors anchored to the recess of the first PPVC module;
- a plurality of second anchors anchored to the recess of the second PPVC module and arranged apart from the plurality of first anchors wherein the connecting element is adapted to engage the first and second anchors preventing the first and second PPVC modules from moving apart from each other.
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10. The composite PPVC wall according to claim 8 wherein a part of each first anchor is embedded into the first PPVC module with another part of the first anchor exposed at the recess of the first PPVC module and a part of each second anchor is embedded into the second PPVC module with another part of the second anchor exposed at the recess
- 25 of the second PPVC module.
11. The composite PPVC wall according to any one of claims 9-10 wherein the connecting element comprises:
- a rebar having a length; and
- 30 a plurality of hook anchor coupled to the rebar, the plurality of hook anchor are spaced apart from each other.
12. The composite PPVC wall according to claim 11 wherein each hook anchor has a base having a length that determines a grouting width between the first and second
- 35 PPVC modules.

13. The composite PPVC wall according to claim 12 wherein each hook anchor has a pair of extensions extending from both ends of the base to form a hook-like grip for engaging the first and second anchors.

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14. The composite PPVC wall according to anyone of claims 11-13 wherein the hook anchor is a U shaped fork.

10 15. A method of constructing the composite PPVC wall of any one of claims 9-14 comprising:

arranging the first and second PPVC modules such that the respective recesses are facing each other;

inserting the rebar through an opening formed by the respective recesses;

rotating the rebar by approximately 90 degrees;

15 lowering the rebar until the hook anchor engage the first and second anchors; and filling a gap defined between the grouting surfaces with grout.