APPARATUS FOR CONNECTING PREFINISHED PREFABRICATED VOLUMETRIC CONSTRUCTION UNITS

Technical Field of the Invention

The present invention relates to an apparatus for coupling prefinished prefabricated volumetric construction (PPVC) units.

Background of the Invention

Prefinished prefabricated volumetric construction *(PPVC)* units are currently being used to quickly and efficiently construct buildings. This construction technique 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.

When there are multiple rows of modules being coupled together, it is sometimes the case that connections are not be directly accessible to the workers from the outside of the module. PPVC modules are often prefinished with the fire proofing board and finishing material. As such, heavy structural work is difficult to undertake within the module. Therefore connections can often only be achieved working from the top of the modules, which is the only face of the modules from which access can be gained to connections between structural elements not located at the perimeter of the PPVC building.

Current practice for structural connections of steel-framed PPVC units typically consists of bolted plate splices or more sophisticated mechanical system as follows:

1. Bolted splice plates

This type of connection requires access from outside as well as inside the modules. The internal access must be achieved through the finishing and fireproofing material installed within the modules. This system provides neither guidance for final module positioning and nor accurate positioning of the element during its installation. This type of connection provides very little protection with regards to corrosion and is only well suited for open steel sections which allow recesses which can accommodate the

plate sleeves.

2. Container type connection

This system is proven, cheap and efficient; however it requires access in between the modules to operate the lock. This can be done only on the joints adjacent to the PPVC building perimeter. There is also no protection with respect to corrosion. This system provides guidance for the final module positioning during erection work. This system can be implemented with either open or closed sections.

3. Ad Hoc machined connection

These connections are accessed from the top of the modules, through columns that consist of hollow sections. Hence they do not require access panels and can be implemented anywhere along the module sides. This type of connection cannot be protected against corrosion as they are machined, unless they are manufactured of corrosion resistant material. This type of connection also has very little installation tolerance. These pieces are expensive to produce because of the milling and machining required and overall cost can be prohibitive as single project requires a large number of connections. The main functions provided by these mechanical couplers are:

(a) Guidance of the element for the accurate positioning during installation;
(b) Horizontal structural continuity between elements, provided by creating a link between two (or more) adjacent columns; and
(c) Vertical continuity using threaded bars.

It is also important to ensure that when a module is being placed on top of another, that the top module is aligned accurately above of the bottom module. Some existing systems use an apparatus such as a centering pin to guide the top module to align on top of bottom. However, after the top module has been placed on top of the bottom, the centering pin can either be retrieved or left in place after installation. This results in an addition time cost to the construction process. Further, in some retrieval operations, at least a portion of the inner part of the column has to be left completely free of any element protruding within the tube.

Therefore, at present, there is no simple and effective connection system for steel framed PPVC construction that is cost efficient and addresses installation, structural and durability constraints.

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

Summary of the Invention

In accordance with the present invention, there is provided an apparatus for coupling prefinished prefabricated volumetric construction (PPVC) units, including first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective upper sections of columns of first adjacent PPVC units to thereby couple the units together, wherein the first and second inserts each include a plurality of vanes extending radially from a central axis towards respective inner peripheral sections of respective columns.

Preferably, the vanes include chamfered edges for facilitating insertion into respective columns of the units.

Preferably, the bridging member is a plate, including first and second slots separated by a spacing section, wherein the inserts extend normally through respective slots, and wherein the vanes extend radially out to meet and engage with respective inner peripheral sections of the first and second slots.

In accordance with the present invention, there is also provided a method of coupling adjacent PPVC units using the above-mentioned apparatus, including the steps of:

(a) inserting lower ends of the inserts into respective upper sections of columns of first adjacent PPVC units; and

(b) forcing the apparatus downwards with respect to a vertical axis Av of the columns until the bridging member abuts the upper ends of the columns of the units.

In another embodiment, the vanes extend radially out from a central axis to meet and engage with said respective inner peripheral sections of respective upper sections of columns.

Preferably, the bridging member is a parallelepiped plate, with opposed ends being coupled to respective ones of the inserts. Preferably, the bridging member is coupled between apexes defined by neighbouring vanes of respective inserts.

In accordance with the present invention, there is also provided a method of coupling adjacent PPVC units using the apparatus claimed in any one of claims 9 to 17, including the steps of:

(a) cutting slots in opposed sides of respective upper sections of columns of first adjacent PPVC units;

(b) inserting lower ends of the inserts into respective upper sections of columns of first adjacent PPVC units; and

(c) forcing the apparatus downwards with respect to a vertical axis Av of the columns until the bridging member is seated in the slots of opposed columns.

Brief Description of the Drawings

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

Figure 1 is a top perspective view of the apparatus for connecting prefinished prefabricated volumetric construction units;

Figure 2 is a bottom perspective view of the apparatus shown in Figure 1;

Figure 3 is a front view of the apparatus shown in Figure 1;

Figure 4 is a left side view of the apparatus shown in Figure 1;

Figure 5 is a top view of the apparatus shown in Figure 1;

Figure 6 is a side perspective view of prefinished prefabricated volumetric construction units arranged side by side;

Figure 7 is an enlarged view of detail "A" of the units shown in Figure 6;

Figure 8a is a front perspective view of the apparatus shown in Figure 1 to be coupled together with the units as shown in Figure 6 during a stage of assembly;

Figure 8b is a front perspective view of the apparatus shown in Figure 1 to be coupled together with the units as shown in Figure 6 during another stage of assembly;

Figure 9 is a section view of the apparatus of Figure 1 coupled with the units as shown in Figure 6;

Figure 10 is a top view of the apparatus of Figure 1 coupled with the units as shown in Figure 6;

Figure 11a is a side perspective view showing the apparatus of Figure 1 with reinforcement bars, also known as rebar, coupled to the apparatus shown in Figure 1 at a stage of assembly;

Figure 11b is a side perspective view showing the apparatus of Figure 1 with rebar coupled to the apparatus shown in Figure 1 at another stage of assembly;

Figure 11c is a side perspective view showing the apparatus of Figure 1 with rebar coupled to the apparatus shown in Figure 1 at yet another stage of assembly;

Figure 12 is a front view of the apparatus of Figure 1 with rebar coupled with the units as shown in Figure 6;

Figure 13 is a top view of the apparatus of Figure 1 with rebar coupled with the units as shown in Figure 6;

Figure 14a is a cross-section view through the line A-A shown in Figure 7 during a stage of assembly;

Figure 14b is a cross-section view through the line A-A shown in Figure 7 during another stage of assembly;

Figure 15 is a top perspective view of an apparatus for connecting prefinished prefabricated volumetric construction units;

Figure 16 is a bottom perspective view of the apparatus as shown in Figure 15;

Figure 17 is a front view of the apparatus shown in Figure 15;

Figure 18 is a left side view of the apparatus shown in Figure 15;

Figure 19 is a top view of the apparatus shown in Figure 15;

Figure 20 is an enlarged view of detail "A" of the units shown in Figure 6;

Figure 21 is a front perspective view of the apparatus shown in Figure 15 to be coupled together with the units as shown in Figure 6 during a stage of assembly;

Figure 22 is a front view of the apparatus of Figure 15 coupled with the units as shown in Figure 6;

Figure 23 is a top view of the apparatus of Figure 15 coupled with the units as shown in Figure 6;

Figure 24 is a front view of the apparatus of Figure 15 with rebar coupled with the units as shown in Figure 6;

Figure 25 is a top view of the apparatus of Figure 15 with rebar coupled with the units as shown in Figure 6;

Figure 26a is a cross-section view through the line B-B shown in Figure 20 during a stage of assembly; and

Figure 26b is a cross-section view through the line B-B shown in Figure 20 during another stage of assembly.

Detailed Description of Preferred Embodiments of the Invention

The apparatus 10 shown in Figures 1 to 5 is used for coupling prefinished prefabricated volumetric construction (PPVC) units 50 arranged in the manner shown in Figure 6, for example. Each PPVC unit 50 includes four vertical columns 52. As particularly shown in Figure 6, two units 50 are placed adjacent to each other with opposing columns 52 of respective units and apparatus 10 is used to couple the units together.

The apparatus 10 including first and second parallel inserts 12, 14 laterally displaced by a bridging member 16, the first 12 and second inserts 14 being coupleable to respective upper sections of columns 52 of first adjacent PPVC units 50a to thereby couple the units together, wherein the first and second inserts 12, 14 each include a plurality of vanes 18 extending radially from a central axis towards respective inner peripheral sections 54 of respective columns 52. The inserts 12, 14 are shaped to be at least partially received within the respective upper sections of columns 52.

As particularly shown in Figure 7, showing detail A of Figure 6, inner peripheral sections 54 of respective columns 52 are tubular and substantially square. Of course the columns 52 may be of a different shape. For example, the cross-section of the columns 52 may be circular or rectangular and as such, the inserts 12, 14 will be shaped accordingly.

As particularly shown in Figure 1, first insert 12 includes four vanes 18 extending radially from a central axis A_{v1} and second insert 14 includes four vanes 18 extending radially from a central axis A_{v2}. Of course, the inserts 12, 14 may have any number of vanes. Preferably, the inserts 12, 14 have at least two vanes.

In some embodiments, the bridging member 16 is a plate, including first and second

slots 22, 24 separated by a spacing section 13, wherein the inserts 12, 14 extend normally through respective slots 22, 24, and wherein the vanes 18 extend radially out to meet and engage with respective inner peripheral sections 26 of the first and second slots 22, 24 as shown in Figure 5. The slots 22, 24 are preferably shaped to receive the inserts 12, 14.

The inserts 12, 14 are coupled to the bridging member 16. For example, the parts are joined by fastener 31 between the vanes 18 and the inner peripheral sections 26 of the first and second slots 22, 24. For example, fastener 31 is a welded joint. In other embodiments, the inserts 12, 14 are coupled to the bridging member 16 by frictional engagement between the vanes 18 and the inner peripheral sections 26 of the first and second slots 22, 24. Of course, the inserts 12, 14 can be coupled to the bridging member 16 by any other suitable means.

In some embodiments, the shape of the bridging member 16 is substantially rectangular.

For example, the inserts 12, 14, bridging member 16 and column 52 has the following dimensions, as particularly shown in Figure 3, Figure 4, Figure 9 and 10:

- H_I = 150 mm to 300 mm
- H_{BM} = 15 mm to 25 mm
- W_I = 120 mm
- W_C = 150mm
- W_{BM} = 330 mm
- T_C = 15 mm
- T_I = 5 to 10mm
- D_I = 120 mm
- D_c = 150 mm
- D_{BM} = 160 mm

Of course the dimensions of apparatus 10 can vary to suit the dimensions of the columns 52. The height of the vanes 18 may vary with the characteristics of the grout 58, for example. The dimensions of the apparatus 10 can be varied for use with any other particular application.

The first and second parallel inserts 12, 14 are laterally displaced by the spacing section 13 of the bridging member 16. The distal ends of the vanes 18 are coupled to respective internal peripheral sections 26 of the first and second slots 22, 24. In some embodiments, the inserts 12, 14 extend normally through respective slots 22, 24 so as to couple with respective columns 52 of PPVC units 50 located above and below the plate.

The apparatus 10 is assembled by performing the following steps:

1. cutting sections of metal to form a plurality of vanes 18 for the inserts 12, 14;
2. coupling the plurality of vanes 18 substantially along a central axis A_{v1}, A_{v2} to form inserts 12, 14 using a fastener 30;
3. cutting a section of metal for the bridging member 16;
4. cutting slots 22, 24 in the bridging member each slot being shaped to at least partially receive a section of the inserts 12, 14; and
5. coupling the inserts 12,14 with the bridging member 16 by coupling the inner peripheral sections 26 of slots 22, 24 with sections of the inserts 12, 14 by using a fastener 31 or frictional engagement.

Preferably, the inserts 12, 14 are coupled to the bridging member 16 between the upper 18b and lower sections 18a of the vanes 18.

The fastener 30, 31 is preferably a welded joint. Alternatively, the fastener 30, 31 can be any other suitable means for coupling.

The components of the apparatus 10 have been above described as being made from metal such as weathering steel (COR-TEN) so as to protect against corrosion if corrosion protection is an issue, overwise, painted or galvanised steel can be used.

The inserts 12, 14 are shaped to be at least partially received within the respective upper sections of columns 52 of first adjacent PPVC units 50a as shown in Figure 8a. That is, the inserts 12, 14 are configured for at least partial insertion into columns 52 of the units 50. Lower sections 18a of inserts 12, 14 are received with the upper sections of columns 52. In this arrangement, one or more outer peripheral sides of the inserts 12, 14 abut corresponding inner peripheral sides of the columns 52. Further, the width of the bridging member 16 is dictated by the gap between the

columns 52 of the units 50. The bridging member 16 is shaped to overlie open ends of respective upper sections of columns when the inserts 12, 14 are partially inserted into respective columns 52 as shown in Figure 8a.

In some embodiments, the vanes 18 include chamfered edges 20, as shown in Figure 8b, for facilitating insertion into respective columns 52 of the units 50.

With reference to Figure 8a, the apparatus 10 is used to couple adjacent PPVC units 50 together by performing the following steps:

(a) inserting lower ends of the inserts 12,14 into respective upper sections of columns 52 of first adjacent PPVC units 50a; and

(b) forcing the apparatus 10 downwards with respect to a vertical axis Av of the columns 52 until the bridging member 16 abuts the upper ends of the columns of the units.

The apparatus 10 has been above described with reference to coupling neighbouring units 50 that are arranged side by side. In addition, the apparatus 10 can be used to couple PPVC units 50 that are stacked on top of one another. This usage of the apparatus 10 is below described, by way of non-limiting example, with reference to the apparatus 10 shown in Figure 1a. However, this operation can be used with any one of the above-described configurations of the apparatus 10.

In some embodiments, the inserts 12, 14 of apparatus 10 are also coupleable to respective lower sections of columns of superiorly mounted second adjacent PPVC units 50b to thereby couple the units 50 together, wherein vanes 18 of the inserts 12, 14 extend radially from the central axis A_{v1} and A_{v2} towards respective inner peripheral sections 54 of respective columns 52 of the second adjacent PPVC units 50b.

The upper sections 18b of inserts 12, 14 preferably include chamfered edges 20 designed to guide the columns 52 of a unit 50 being lowered thereon into a locking position. Apparatus 10 facilitates the positioning of the units 50 and ensures that the units 50 are aligned correctly.

As particularly shown in Figure 9, the inserts 12, 14 are preferably shaped to be at

least partially received within the respective columns 52 of the second adjacent PPVC units 50b. As particularly shown in Figure 10, the vanes 18 extend radially out to meet and engage with said respective inner peripheral sections of respective columns 52 of the second adjacent PPVC units 50b. The inserts 12, 14 are coupled to columns 52 of respective second adjacent PPVC units 50 by frictional engagement between the vanes 18 and said respective inner peripheral sections 54 of respective columns 52 of the second adjacent PPVC units 50b.

With reference to Figure 8b, the apparatus 10 is used to couple second adjacent PPVC units 50b with the first adjacent PPVC units 50a by lowering respective lower sections of columns 52 of superiorly mounted second adjacent PPVC units 50b on the inserts 12, 14 to thereby couple the units 50 together.

The apparatus 10 is preferably secured in position by frictional engagement with the posts 52 of the units 50. The adjacent columns 52 of the PPVC units 50 are thereby coupled together.

With reference to Figures 11a, 11b, 11c, 12 and 13, to complete the coupling of the PPVC units 50, reinforcement bars 56 coupled to apparatus 10 with fastener 33. For example, fastener 33 is a welded joint and the rebar 56 are welded to the apparatus 10 as particularly shown in Figure 11a. The fastener 33 is preferably a welded joint. Alternatively, the fastener 33 can be any other suitable means for coupling.

The apparatus 10 with coupled rebar 56 is then placed within column 52 of lower module of unit 50 as particularly shown in Figure 11b. As particularly shown in Figure 11c, lower sections of column 52 of superiorly mounted second adjacent PPVC units 50b are then placed on the inserts 12, 14 to thereby couple the units 50 together. Figures 12 and 13 show section views of the apparatus 10, rebar 52 and units 50 in use i.e. after coupling lower and upper units 50 together. Grout 58 is then filled into the columns 52 for allowing the connector to transfer loads between the elements.

Figure 14a and 14b show an alternate embodiment where rebar continuity along the entire columns is ensured. Apparatus 10 and rebars 52 are placed in the columns 52 before grouting. The internal volume of columns 52 is then filled with concrete 58, or other form of grout, such as non shrink cementitious grout, through a hose 60 as particularly shown in Figures 14 a and b. Vertical continuity is achieved by:

(a) inserting overlapping reinforcement bars 56 within the hollow section of column 52;

(b) filling, at least partially, the internal volume of the column 52 is with non shrink grout 58, for example, with a hose 60.

Preferably, at the end of assembly of the units 50, the entire inner volume of the columns 52 is filled with grout 58 for allowing load transfer between the elements.

The above steps ensure rebar continuity, provide corrosion resistance to the inner face of the column 52, and to enhance both the fire resistance and load bearing capacity of the column 52.

The apparatus 10 has been developed in order to address the following points:

(a) Installation guidance of the module to an accurate final position and ease of use resulting in time and cost savings;
(b) Simplification of fabrication and cost effectiveness;
(c) Horizontal and vertical continuity of structural members;
(d) Corrosion resistance;
(e) Avoidance of the expense of milling or machining;
(f) Access to structural connections from the top of the modules;
(g) Provision of adjustment to accommodate manufacturing and construction tolerances; and
(h) Ease of procurement and fabrication.

The apparatus 10 simplifies site work, improves durability and reduces the overall cost of construction. The apparatus 10 provides a concealed connection without any protrusion on the outside of the column assembly.

The apparatus 10 has been above described with reference to use with connecting two columns 52 of adjacent PPVC units 50. However, the apparatus 10 can be configured for use in connecting:

(a) one column 52 of a PPVC unit 50;
(b) two neighbouring corner columns 52 of two PPVC units 50;

(c) three neighbouring corner columns 52 of three PPVC units; and

(d) four neighbouring corner columns 52 of four PPVC units 50.

Apparatus 100

The apparatus 100 shown in Figures 15 and 16 is used for coupling prefinished prefabricated volumetric construction (***PPVC***) units 50 arranged side by side in the manner shown in Figure 6, for example. The apparatus 100 functions in an analogous way to that of the apparatus 10 and, as such, like parts are referenced with like reference numerals.

The apparatus 100 including first and second parallel inserts 12, 14 laterally displaced by a bridging member 16, the first and second inserts 12, 14 being coupleable to respective upper sections of columns 52 of first adjacent PPVC units 50a to thereby couple the units 50 together, wherein the first and second inserts 12, 14 each include a plurality of vanes 18 extending radially from a central axis towards respective inner peripheral sections 54 of respective columns 52. The inserts 12, 14 are shaped to be at least partially received within the respective upper sections of columns 52.

As particularly shown in Figure 15, first insert 12 includes four vanes 18 extending radially from a central axis A_{v1} and second insert 14 includes four vanes 18 extending radially from a central axis A_{v2}. Of course, the inserts 12, 14 may have any number of vanes. In some embodiments, the shape of the bridging member 16 is substantially rectangular.

Preferably, the bridging member 16 is a parallelepiped plate, with opposed ends being coupled to respective ones of the inserts 12, 14. As particularly shown in Figure 19, the bridging member 16 is coupled between apexes 28 defined by neighbouring vanes 18 of respective inserts 12, 14. Of course, the bridging member 16 may be of any shape to facilitate coupling between the two inserts 12, 14.

The dimensions for the apparatus 100 is chosen for use with the columns 52 of the PPVC units 50. That is, the lower sections 18a and upper sections 18b inserts 12, 14 are configured for at least partial insertion into columns 52 of the units 50. In this arrangement, one or more outer peripheral sides of the inserts 12, 14 abut corresponding inner peripheral sides of the posts 52. Further, the width of the

bridging member 16 is dictated by the gap between the columns 52 of the units 50. Of course, the dimensions of the apparatus 100 can be varied for use with any other particular application.

For example, the inserts 12, 14, bridging member 16 and column 52 has the following dimensions, as particularly shown in Figure 17, Figure 19, Figure 22 and 23:

- H_I = 150 to 300 mm
- H_{BM} = 80 mm to 120 mm
- W_I = 120 mm
- W_C = 150 mm
- W_{BM} = 170 mm
- T_C = 15 mm
- T_I = 5 mm to 10 mm
- D_I = 120 mm
- D_C = 150 mm
- D_{BM} = 15 mm to 25 mm

Of course the dimensions of apparatus 10 can vary to suit the dimensions of the columns 52. The height of the vanes 18 may vary with the characteristics of the grout 58, for example. The dimensions of the apparatus 10 can be varied for use with any other particular application.

The apparatus 100 is assembled by performing the following steps:

1. cutting sections of metal to form a plurality of vanes 18 for the inserts 12, 14;
2. coupling the plurality of vanes 18 to form inserts 12 and 14 using a fastener 30;
3. cutting a section of metal for the bridging member 16; and
4. coupling the inserts 12,14 with the bridging member 16 using a fastener 31.

For example, fastener 30, 31 is a welded joint. Inserts 12, 14 is preferably coupled to bridging member by welding the surfaces of respective parts together. Alternatively, the fastener 30, 31 can be any other suitable means for coupling.

With reference to Figures 20 and 21, the apparatus 100 is used to couple adjacent PPVC units 50 together by performing the following steps:

(a) cutting slots 32 in opposed sides of respective upper sections of columns 52 of first adjacent PPVC units 50a;

(b) inserting lower ends 18a of the inserts 12, 14 into respective upper sections of columns 52 of first adjacent PPVC units 50a; and

(c) forcing the apparatus 100 downwards with respect to a vertical axis Av of the columns 52 until the bridging member is seated in the slots 52 of opposed columns.

As particularly shown in Figures 22 and 23, the neighbouring columns 52 of the PPVC units 50 are thereby coupled together.

At least part of the bridging member 16 is preferably shaped to sit in slots 32 of opposed columns 52. The lower sections 18a of inserts 12, 14 preferably include chamfered edges 20 designed to facilitate insertion of the inserts into the columns 52.

Preferably, the vanes 18 extend radially out from a central axis to meet and engage with said respective inner peripheral sections of respective upper sections 54 of columns 52 as particularly shown in Figures 22 and 23. Preferably, the apparatus 100 is coupled to the columns 52 by frictional engagement between the vanes 18 and respective inner peripheral sections 54 of respective columns 52.

The components of the apparatus 100 are preferably made from metal such as weathering steel (COR-TEN) so as to protect against corrosion if corrosion protection is an issue, overwise, painted or galvanised steel can be used. The components are manufactured out of plates by a laser cutting machine in order to ensure clean and accurate fabrication. The pieces will be assembled together by gas metal arc welding.

So as to ease fabrication in case out-of-tolerance construction, made-to-measure apparatus components can be readily fabricated to conform to the specific column arrangement required. Variation in height can also be obtained by varying the plate thicknesses.

The apparatus 100 has been above described with reference to coupling neighbouring units 50 that are arranged side by side. In addition, the apparatus 100 can be used to couple PPVC units 50 that are stacked on top of one another. In some embodiments,

the inserts 12, 14 of apparatus 100 are also coupleable to respective lower sections of columns 52 of superiorly mounted second adjacent PPVC units 50b to thereby couple the units 50 together, wherein vanes 18 of the inserts 12, 14 extend radially from the central axis A_{v1} and A_{v2} towards respective inner peripheral sections 54 of respective columns 52 of the second adjacent PPVC units 50b.

The upper sections 18b of inserts 12, 14 preferably include chamfered edges 20 designed to guide the columns 52 of a unit 50 being lowered thereon into a locking position. Apparatus 100 facilitates the positioning of the units 50 and ensures that the units 50 are aligned correctly.

As particularly shown in Figure 22, the inserts 12, 14 are preferably shaped to be at least partially received within the respective columns 52 of the second adjacent PPVC units 50b. As particularly shown in Figure 23, the vanes 18 extend radially out to meet and engage with said respective inner peripheral sections of respective columns 52 of the second adjacent PPVC units 50b. The upper sections 18b of inserts 12, 14 are coupled to columns 52 of respective second adjacent PPVC units 50b by frictional engagement between the vanes 18 and said respective inner peripheral sections 54 of respective columns 52 of the second adjacent PPVC units 50b. The apparatus 100 is preferably secured in position by frictional engagement with the columns 52 of the units 50. The adjacent columns 52 of the PPVC units 50 are thereby coupled together.

To complete the coupling of the PPVC units 50, reinforcement bars are preferably 56 coupled to apparatus 100 with fastener 33. For example, fastener 33 is a welded joint and the rebar 56 are welded to the apparatus 100 as particularly shown in Figures 24 and 25. The fastener 33 is preferably a welded joint. Alternatively, the fastener 33 can be any other suitable means for coupling.

The apparatus 100 with coupled rebar 56 is then placed within column 52 of lower module of unit 50. Lower sections of column 52 of superiorly mounted second adjacent PPVC units 50b are then placed on the inserts 12, 14 to thereby couple the units 50 together. Grout 58 is then filled into the columns 52 for allowing the connector to transfer loads between the elements.

In an alternate embodiment, to complete the coupling of the PPVC units 50, reinforcement bars 56 are secured in the columns 52 as particularly shown in Figure

26a. Apparatus 100 and rebars 52 are placed in the columns 52 before the grouting process. The internal volume of columns 52 is then at least partially filled with concrete 58, or other form of grout, for example non shrink cementitious grout, through hose 60. This process is above described with reference to the apparatus 10. Analogous steps also apply here.

As shown in Figures 26a and 26b, vertical continuity is achieved by:

(a) inserting overlapping reinforcement bars 56 within the hollow section of column 52;

(b) filling, at least partially, the internal volume of the column 52 is with non shrink grout 58, for example, with a hose 60.

Preferably, at the end of assembly of the units 50, the entire inner volume of the columns 52 is filled with grout 58 for allowing load transfer between the elements.

The grout 58 ensures rebar 56 continuity, provides corrosion resistance to the inner face of the column 52, and enhances both the fire resistance and load bearing capacity of the column 52.

The rebars 56 are preferably 32mm. Of course, any other suitable rebars 56 can be used.

The apparatus 100 has been above described with reference to use with connecting two columns of neighbouring PPVC units 50. However, the apparatus 100 can be configured for use in connecting neighbouring corner columns 52 of one, two, three or four PPVC units 50, the latter being shown in Figure 11. Alternative embodiments of the apparatus 100 have the following configurations:

(a) the apparatus 100 for use with one column 52 of a PPVC unit 50;

(b) the apparatus 100 for use with two neighbouring corner columns 52 of two PPVC units 50;

(c) the apparatus 100 for use with three neighbouring corner columns 52 of three PPVC units 50; and

(d) the apparatus 100 for use with four neighbouring corner columns 52 of four PPVC units 50.

For case (a) above, the apparatus 100 includes a single insert 12 and does not include a bridging member 16. In this embodiment, the apparatus 100 is coupled to the column 52 with fastener 30.

The apparatus 100 has been developed in order to address the following points:

(a) Installation guidance of the module to an accurate final position and ease of use resulting in time and cost savings;
(b) Simplification of fabrication and cost effectiveness;
(c) Horizontal and vertical continuity of structural members;
(d) Corrosion resistance;
(e) Avoidance of the expense of milling or machining;
(f) Access to structural connections from the top of the modules;
(g) Provision of adjustment to accommodate manufacturing and construction tolerances; and
(h) Ease of procurement.

The apparatus 100 simplifies site work, improves durability and reduces the overall cost of construction. The apparatus 100 provides a concealed connection without any protrusion on the outside of the column assembly.

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

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 this specification and the claims that follow, unless stated otherwise, the word "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 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.

Claims Defining the Invention

1. An apparatus for coupling prefinished prefabricated volumetric construction (PPVC) units, including first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective upper sections of columns of first adjacent PPVC units to thereby couple the units together, wherein the first and second inserts each include a plurality of vanes extending radially from a central axis towards respective inner peripheral sections of respective columns, wherein the bridging member is a plate, including first and second slots separated by a spacing section, wherein the inserts extend normally through respective slots, and wherein the vanes extend radially out to meet and engage with respective inner peripheral sections of the first and second slots.

2. The apparatus claimed in claim 1, wherein the inserts are shaped to be at least partially received within the respective upper sections of columns.

3. The apparatus claimed in claim 1 or 2, wherein the vanes include chamfered edges for facilitating insertion into respective columns of the units.

4. The apparatus claimed in any one of claims 1 to 3, ~~wherein the bridging member is a plate, including first and second slots separated by a spacing section, wherein the inserts extend normally through respective slots, and wherein the vanes extend radially out to meet and engage with respective inner peripheral sections of the first and second slots~~ wherein the vanes extend towards corners of the respective inner peripheral sections of the respective columns.

5. The apparatus claimed in claim 4, wherein the first and second parallel inserts are laterally displaced by the spacing section of the bridging member.

6. The apparatus claimed in claim 4 or claim 5, wherein the inserts extend normally through respective slots so as to couple with respective columns of PPVC units located above and below the plate.

7. The apparatus claimed in any one of claims 4 to 6, wherein distal ends of the vanes are coupled to respective internal peripheral sections of the first and second slots.

8. The apparatus claimed in any one of claims 4 to 7, wherein the bridging member is shaped to overlie open ends of respective upper sections of columns when the inserts are partially inserted into respective columns.

9. The apparatus claimed in any one of claims 1 to 3, wherein the vanes extend radially out from a central axis to meet and engage with said respective inner peripheral sections of respective upper sections of columns.

10. The apparatus claimed in claim 9, wherein the inserts are coupled to the columns by frictional engagement between the vanes and said respective inner peripheral sections of respective columns.

11. The apparatus claimed in claim 9 or 10, wherein the bridging member is a parallelepiped plate, with opposed ends being coupled to respective ones of the inserts.

12. The apparatus claimed in any one of claims 9 to 11, wherein the bridging member is coupled between apexes defined by neighbouring vanes of respective inserts.

13. The apparatus claimed in any one of claims 9 to 12, wherein at least part of the bridging member is shaped to sit in slots of opposed columns.

14. The apparatus claimed in any one of claims 1 to 13, wherein the inserts are also coupleable to respective lower sections of columns of superiorly mounted second adjacent PPVC units to thereby couple the units together, wherein vanes of the inserts extend radially from the central axis towards respective inner peripheral sections of respective columns of the second adjacent PPVC units.

15. The apparatus claimed in claim 14, wherein the inserts are shaped to be at least partially received within the respective columns of the second adjacent PPVC units.

16. The apparatus claimed in claim 14 or claim 15, wherein the vanes extend radially out to meet and engage with said respective inner peripheral sections of

respective columns of the second adjacent PPVC units.

17. The apparatus claimed in claim 16, wherein the inserts are coupled to columns of respective second adjacent PPVC units by frictional engagement between the vanes and said respective inner peripheral sections of respective columns of the second adjacent PPVC units.

18. The apparatus of any one of claims 1 to 17, further comprising, in use, grout at least partially filling the columns.

19. The apparatus of claim 18, further comprising reinforcement bar in use in the grout.

~~18. A method of coupling adjacent PPVC units using the apparatus claimed in any one of claims 1 to 8, including the steps of:~~

~~(a) inserting lower ends of the inserts into respective upper sections of columns of first adjacent PPVC units; and~~

~~(b) forcing the apparatus downwards with respect to a vertical axis Av of the columns until the bridging member abuts the upper ends of the columns of the units.~~

~~19. The method claimed in claim 18, further including the step of lowering respective lower sections of columns of superiorly mounted second adjacent PPVC units on the inserts to thereby couple the units together.~~

~~20. A method of coupling adjacent PPVC units using the apparatus claimed in any one of claims 9 to 17, including the steps of:~~

~~(a) cutting slots in opposed sides of respective upper sections of columns of first adjacent PPVC units;~~

~~(b) inserting lower ends of the inserts into respective upper sections of columns of first adjacent PPVC units; and~~

~~(c) forcing the apparatus downwards with respect to a vertical axis Av of the columns until the bridging member is seated in the slots of opposed columns.~~

~~21. The method claimed in claim 20, further including the step of lowering~~

respective lower sections of columns of superiorly mounted second adjacent PPVC units on the inserts to thereby couple the units together.

22. The methods claimed in any one of claim 18 to 21, further including the step of inserting one or more reinforcement bars into the columns and at least partially filling the columns with grout.