

## **APPARATUS FOR CONNECTING PREFINISHED PREFABRICATED VOLUMETRIC CONSTRUCTION UNITS**

### Technical Field of the Invention

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The present invention relates to an apparatus for connecting prefinished prefabricated volumetric construction units.

### Background of the Invention

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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  
15 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  
20 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.

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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  
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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  
35 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

5 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.

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## 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  
15 implemented anywhere in the floor plate. 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 a single project requires a large number of  
20 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
- 25 (c) Vertical continuity using threaded bars.

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

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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 apparatus for connecting prefinished prefabricated volumetric construction units, including:

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- (a) first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective open ends of columns of neighbouring units to thereby connect the units together,

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wherein the inserts vertically engage the open ends of the columns, and

wherein the bridging member is generally rectangular plate, with opposed ends being welded to respective opposed sides of the inserts, so that, as the apparatus is forced downwards with respect to a vertical axis  $A_v$  of the columns, the bridging member is forced into slots in opposed sides of the open ends of the columns until the

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bridging member is seated in slots.

Preferably, the inserts are shaped to be received within said upper ends of the columns. Preferably, the inserts are secured to the upper ends of the columns by frictional engagement.

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Preferably, the bridging section is a plate, the inserts extending normally therethrough. Each one of said inserts is formed in upper and lower parts coupled to respective sides of the plate.

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Preferably, the apparatus also includes first and second centering pins for guiding respective ones of the inserts into columns of prefinished prefabricated volumetric construction units being above mounted, each one of said centering pins including:

- (a) an elongate body section shaped for insertion into one of said inserts;
- (b) a chamfer mating section coupled to a top end of the body section for
- 30 guiding the columns of a unit being lowered thereon into a locking position;
- (c) one or more locking members coupled between the elongate body and the mating section, the locking members project outwardly from the vertical axis so as to engage an open end of an insert as the centering
- 35 pin is being fitted thereto; and
- (d) a hollow shaft extending through the pin along the vertical axis  $A_v$ .

Preferably, the body section includes a series flutes along the vertical axis  $A_v$ .

In accordance with the invention, there is also provided a method of connecting two prefinished prefabricated volumetric construction units using an apparatus, including:

- 5           (a) first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective open ends of columns of neighbouring units to thereby connect the units together,

wherein the inserts vertically engage the open ends of the columns, and

- 10           wherein the bridging member is generally rectangular plate, with opposed ends being welded to respective opposed sides of the inserts, so that, as the apparatus is forced downwards with respect to a vertical axis  $A_v$  of the columns, the bridging member is forced into slots in opposed sides of the open ends of the columns until the bridging member is seated in slots,

- 15           including the steps of:

(a) cutting slots in opposed sides of open ends of neighbouring columns of the units;

(b) inserting lower ends of the inserts into respective ones of said open ends of neighbouring columns of the units; and

- 20           (c) forcing the apparatus downwards with respect to a vertical axis  $A_v$  of the columns until the bridging member is seated in the slots.

Preferably, the method further includes the steps of inserting reinforcement bars into the columns and at least partially filling the columns with cementitious grout.

- 25           Preferably, the apparatus further includes:

first and second centering pins for guiding respective ones of the first and second inserts into columns of prefinished prefabricated volumetric construction units being above mounted, each one of said centering pins including:

(a) an elongate body section shaped for insertion into one of said inserts;

- 30           (b) a chamfer mating section coupled to a top end of the body section for guiding the columns a unit being lowered thereon into a locking position;

(c) one or more locking members coupled between the elongate body and the mating section, the locking members project outwardly from the vertical axis so as to engage an open end of an insert as the centering pin is being fitted thereto; and

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(d) a hollow shaft extending through the pin along the vertical axis  $A_v$ ,  
including the steps of:

- (a) inserting the centering pins into the top of said inserts; and
- (b) lowering an additional upper unit over one of the two neighbouring units  
5 such that a bottom end of one of the columns of the upper unit receives  
one of said centering pins.

#### Brief Description of the Drawings

- 10 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 1a is a front perspective view of apparatus for connecting prefabricated  
prefabricated volumetric construction units;

- 15 Figure 1b is a front view of the apparatus shown in Figure 1a;

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

Figure 1d is a cross-section view through the line A-A of the apparatus shown in  
Figure 1c;

- 20 Figure 2a is a side perspective view of prefabricated prefabricated volumetric  
construction units arranged side by side;

Figure 2b is an enlarged view of detail "B" of the units shown in Figure 2a;

Figure 2c is a further view of detail "B" of the units shown in Figure 2a coupled  
together with the apparatus shown in Figure 1a;

Figure 2d is a cross-section view through the line C-C of the units shown in detail B;

- 25 Figure 2e is a cross-section view through the line C-C of the units shown in detail B at  
a different stage of assembly;

Figure 3 is a front perspective view of component parts of the apparatus shown in  
Figure 1a during a stage of fabrication;

Figures 4a to 4f are views of alternative embodiments of the apparatus shown in  
30 Figure 1a;

Figure 5a is a further view of detail "B" of the units shown in Figure 2a during a  
further stage of assembly with centering pin inserted;

Figure 5b is a further view of detail "B" of the units shown in Figure 2a during still  
another stage of assembly;

- 35 Figure 6a is a bottom perspective view of a centering pin of the apparatus shown in  
Figure 1a;

Figure 6b is a top perspective view of a centering pin shown in Figure 6a;

Figure 6c is a top view of the centering pin shown in Figure 6a;

Figure 6d is a cross-section view through the line D-D of the centering pin shown in Figure 6c;

- 5 Figure 7a is a front perspective view of the apparatus shown in Figure 1a fitted with the centering pin shown in Figure 6a;

Figure 7b is a top view of the apparatus shown in Figure 7a;

Figure 7c is a cross-section view through the line E-E of the apparatus shown in Figure 7a;

- 10 Figures 8a and 8b are section views through the line C-C of the units shown in detail B;

Figure 9a is a front perspective view of apparatus for connecting prefabricated volumetric construction units;

Figure 9b is a top view of the apparatus shown in Figure 9a;

- 15 Figure 9c is a cross-section view through the line G-G of the apparatus shown in Figure 9b;

Figure 9d is a cross-section view through the line F-F of the apparatus shown in Figure 9b;

- 20 Figure 10a is a further view of detail "B" of the units shown in Figure 2a coupled together with the apparatus shown in Figure 9a;

Figure 10b is a cross-section view through the line H-H of the apparatus shown in Figure 10a coupled to two prefabricated volumetric construction units;

Figure 11 is a top perspective view of an alternative embodiment of the apparatus shown in Figure 9a;

- 25 Figures 12a to 12h are views of alternative embodiments of the apparatus shown in Figure 9a;

Figure 13a is a top perspective view of a centering pin of the apparatus shown in Figure 9a;

Figure 13b is a bottom perspective view of the centering pin shown in Figure 13a;

- 30 Figure 14a is a top perspective view of an alternative embodiment of the centering pin shown in Figure 13a;

Figure 14b is a cross-section view through the line I-I of the centering pin shown in Figure 14a;

Figure 14c is a bottom perspective view of the centering pin shown in Figure 14a;

- 35 Figures 15a to 15c are section views through the line C-C of the units shown in detail B.

Detailed Description of Preferred Embodiments of the Invention

5 The apparatus 10 shown in Figures 1a to 1d is used for connecting prefabricated volumetric construction (**PPVC**) units 50 arranged in the manner shown in Figures 2a to 2c, for example.

The apparatus includes first and second parallel inserts 12, 14 laterally displaced by a  
10 bridging member 16. As shown, the inserts 12, 14 are tubular, each have a generally square cross-section taken through a vertical axis  $A_v$ .

The apparatus 10 preferably has the following dimensions:

|    |          |   |       |
|----|----------|---|-------|
| 15 | $W_I$    | = | 134mm |
|    | $W_{BM}$ | = | 43mm  |
|    | $W_A$    | = | 290mm |
|    | $D_A$    | = | 134mm |
|    | $D_I$    | = | 134mm |
| 20 | $G$      | = | 22mm  |
|    | $H_A$    | = | 300mm |
|    | $H_{BM}$ | = | 150mm |

The above-dimensions for the apparatus 10 have been chosen for use with the posts  
25 52 of the PPVC units 50 shown in Figure 2a. That is, the inserts 12, 14 are configured for at least partial insertion into posts 52 of the units 50. In this arrangement, one or more outer peripheral sides of the inserts 12, 14 overlie and abut corresponding inner peripheral sides of the posts 52. Further, the width of the bridging member 16  $W_{BM}$  is dictated by the gap between the posts 52 of the units 50.

30 Of course, the dimensions of the apparatus 10 can be varied for use with any other particular application.

In an alternative embodiment, the inserts 12, 14 may not be completely tubular.  
35 Rather, they may be "U" shaped, with the bridging member 16 extending between opposed ends 20 of the inserts 12, 14.

With reference to Figure 3, the apparatus 10 is assembled by performing the following steps:

- 5 1. cutting two sections of tubular metal with the above dimensions for the inserts;
2. cutting a section of metal having the above dimensions for the bridging member;
3. cutting a slot 18 on the opposed sides 20 of each insert 12, 14, each slot being shaped to at least partially receive an end section 22 of the bridging member
- 10 16; and
4. coupling the end sections 22 of the bridging member 16 to respective short sides 20 of the inserts 12, 14 using a fastener 24.

The fastener 24 is preferably a welded joint. Alternatively, the fastener can be any  
15 other suitable means for coupling the bridging member to respective inserts.

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.

20 With reference to Figure 2b and 2c, the apparatus 10 is used to couple two PPVC units 50 together by performing the following steps:

1. inserting first end of the inserts 12, 14 into respective open ends 54 of neighbouring posts 52 of the units 50; and
- 25 2. forcing the apparatus 10 downwards with respect to a vertical axis  $A_v$  of the posts 52 until the bridging member 16 slides into and abuts a bottom section of the slot 18 in member 52.

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

To ensure horizontal structural continuity, the inserts 12, 14 are preferably no more than 2mm smaller than the inner face of the hollow section posts 52.

35 As particularly shown in Figures 2d and 2e, to complete the coupling of the PPVC units

50, reinforcement bars 56 are secured in the posts 52 and then the posts are filled with concrete 58, or other form of non shrink cementitious grout with a hose 60.

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

- (a) one column 52 of a PPVC unit 50, as shown in Figures 4a and 4b;
- (b) two neighbouring corner columns 52 of two PPVC units 50, as shown in  
10 Figure 1a;
- (c) three neighbouring corner columns 52 of three PPVC units, as shown in  
Figures 4c and 4d; and
- (d) four neighbouring corner columns 52 of four PPVC units 50, as shown in  
Figures 4e and 4f.

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#### Coupling Stacked PPVC Units 50 with Apparatus 10

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  
20 coupled PPVC units 50 that are stacked on top of one another by used of the centering  
pin 26 in the manner shown in Figures 5a and 5b. This usage of the apparatus 10 is  
below described, by way of non-limiting example, with reference to the apparatus  
shown in Figure 1a. However, this operation can be used with any one of the above-  
described configurations of the apparatus 10.

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The centering pin 26 shown in Figures 6a to 6d is used in combination with the  
apparatus 10 in the manner shown in Figures 7a to 7c.

The centring pin 26 includes an elongate body section 28 that is shaped for insertion  
30 into an open end 30 of an insert 12, 14. The body section 28 is generally square in  
cross-section taken through a vertical axis  $A_v$ . The outer peripheral sides of the body  
section 28 abut corresponding internal sides of the insert 12, 14 when so fitted.

The body section 28 includes a series flutes 32 along the vertical axis  $A_v$  such that  
35 there are less contact points between the inserts 12, 14 and the centring pins 26  
when inserted therein. As shown, there are four flutes, one for each side of the body

section 28. Alternatively, the centering pins 26 can include any suitable number of flutes 32.

5 A first end of the centring pin 26 also includes locking members 34 that project outwardly from the vertical axis of the body member 28. The locking members 34 are shaped to engage the open end 30 of the insert 12, 14 as the centering pin 26 is being fitted into the insert 12, 14. The locking members 34 inhibit the centering pin 26 from being further moved into the insert 12, 14.

10 As particularly shown in Figures 6d, the centering pin 26 includes a hollow shaft 36 extending therethrough along the vertical axis  $A_v$ . The shaft 36 is arranged to facilitate removal of the centering pin 26 from the insert. For example, a rod (not shown) can be extended through the centering pin 26 and a flange or a boss attached to the shaft can engage a bottom section of the pin 26 and pull it vertically out of the  
15 insert 12, 14. The retrieval can be either done by manpower pulling on the Fishing Rod recovery tool or with the assistance of the crane used for module installation

Further, the first end of the centering pin 26 includes a chamfer mating surface 38 designed to guide the posts 52 of a module 50 being lowered thereon into a locking  
20 position. The centering pin 26 is preferably constructed of steel and will be retrieved upon installation of each module 50 in order that it can be re-used for the installation of the subsequent modules 50.

The top end 40 of the shaft 36 is wider than the main section of the shaft 36. The  
25 wider open end 40 facilitates easier entry of the recovery tool (not shown) into the centering pin 26.

The centering pin 26 preferably has the following dimensions:

30  $W_{CP} = 118\text{mm}$   
 $W_S = 50\text{mm}$   
 $W_{OS} = 80\text{mm}$   
 $H_{BS} = 300\text{mm}$   
 $H_{MS} = 50\text{mm}$

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With reference to Figures 8a and 8b, vertical continuity is achieved by:

- (a) overlapping reinforcement bars 56 within the steel hollow section module column 52;
- (b) filling the internal volume of the steel hollow section column 52 with concrete 58 or non shrink grout.

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.

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Insertion of the reinforcement bar 56 in the hollow steel section module column. Checking should preferably be done to ensure it has been lowered to the prescribed height, and it is sitting on the grout poured during the installation of the lower module. Filling up of the column 52 using non shrink cementitious grout.

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

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

The apparatus 10 simplifies site work, improves durability and reduces the overall cost of construction.

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#### Apparatus 100

The apparatus 100 shown in Figures 9a to 9d is used for connecting prefabricated volumetric construction (**PPVC**) units 50 arranged side by side in the manner shown in Figure 2a, 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 includes first and second parallel inserts 12, 14 laterally displaced by a bridging member 16. The apparatus 100 preferably has the following dimensions:

|    |          |   |       |
|----|----------|---|-------|
|    | $W_I$    | = | 136mm |
|    | $W_{BM}$ | = | 320mm |
|    | $W_A$    | = | 320mm |
| 10 | $W_S$    | = | 7mm   |
|    | $D_A$    | = | 150mm |
|    | $D_{BM}$ | = | 150mm |
|    | $D_I$    | = | 136mm |
|    | $G$      | = | 34mm  |
| 15 | $H_A$    | = | 120mm |
|    | $H_{BM}$ | = | 20mm  |

The above-dimensions for the apparatus 100 have been chosen for use with the posts 52 of the PPVC units 50 shown in Figure 2a. That is, the inserts 12, 14 are configured for at least partial insertion into posts 52 of the units 50. In this arrangement, one or more outer peripheral sides of the inserts 12, 14 overlie and abut corresponding inner peripheral sides of the posts 52. Further, the width of the bridging member 16  $W_{BM}$  is dictated by the gap between the posts 52 of the units 50.

Of course, the dimensions of the apparatus 100 can be varied for use with any other particular application.

As particularly shown in Figures 9c and 9d, the bridging member 16 is a generally rectangular plate 16 and the inserts 12, 14 are tubular, each have a generally square cross-section taken through a vertical axis  $A_v$ . Each insert 12, 14 is formed in coaxial upper and lower parts 12a, 12b, 14a, 14b fastened to respective sides of the bridging member 16. The parts 12a, 12b, 14a, 14b are preferably secured to the bridging member 16 with a welded joint 24. Alternatively, the parts 12a, 12b, 14a, 14b are fastened to the bridging member 16 by any other suitable means.

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The components of the apparatus 100 have are preferably made from metal such as

weathering steel (COR-TEN) so as to protect against corrosion. 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.

- 5 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.
- 10 With reference to Figure 10a and 10b, the apparatus 100 is used to couple two PPVC units 50 together by performing the following steps:
  1. inserting first end of the inserts 12, 14 into respective open ends 54 of neighbouring posts 52 of the units 50; and
  - 15 2. forcing the apparatus 100 downwards with respect to a vertical axis  $A_v$  of the posts until the bridging member 16 abuts a top section of the posts 52.

The apparatus 100 is secured in position by frictional engagement with the posts 52 of the units 50. The neighbouring corner posts of the PPVC units 50 are thereby coupled  
20 together.

To ensure horizontal structural continuity, the inserts 12, 14 are preferably no more than 2mm smaller than the inner face of the hollow section posts 52.

- 25 To complete the coupling of the PPVC units 50, reinforcement bars 56 are secured in the posts 52 and then the posts can be filled with concrete 58, or other form of non shrink cementitious grout. This process is above described with reference to the apparatus 10. Analogous steps also apply here.
- 30 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.
- 35 Alternative embodiments of the apparatus 100 have the following configurations:

- (a) the apparatus 100 shown in Figures 12a and 12b for use with one column 52 of a PPVC unit 50;
- (b) the apparatus 100 shown in Figures 12c and 12d for use with two neighbouring corner columns 52 of two PPVC units 50;
- 5 (c) the apparatus 100 shown in Figures 12e and 12f for use with three neighbouring corner columns 52 of three PPVC units; and
- (d) the apparatus 100 shown in Figures 12g and 12h for use with four neighbouring corner columns 52 of four PPVC units 50.

#### 10 Coupling Stacked PPVC Units 50 with Apparatus 100

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 coupled PPVC units 50 that are stacked on top of one another by used of the centering  
15 pin 200 shown in Figures 13a and 13b. The centring pin 200 operates in an analogous manner to that of the centering pin 26 and, as such, like parts are referenced with like reference numerals.

The centering pin 200 includes an elongate body section 28 that is shaped for  
20 insertion into an open end 30 of an insert 12, 14. The body section 28 is generally square in cross-section taken through a vertical axis  $A_v$ . The outer peripheral sides of the body section 28 abut corresponding internal sides of the insert 12, 14 when so fitted.

25 A first end of the centring pin 200 also includes locking members 34 that project outwardly from the vertical axis of the body member 28. The locking members 34 are shaped to engage the open end 30 of the insert 12, 14 as the centering pin 200 is being fitted into the insert 12, 14. The locking members 34 inhibit the centering pin 200 from being further moved into the insert 12, 14.

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The centering pin 200 includes a hollow shaft 36 extending therethrough along the vertical axis  $A_v$ . The shaft 36 is arranged to facilitate removal of the centering pin 200 from the insert 12, 14. For example, a rod (not shown) can be extended through the centering pin 200 and a flange or a boss attached to the rod can engage a bottom  
35 section of the pin 200 and pull it vertically out of the insert 12, 14. The retrieval can be either done by manpower pulling on the fishing rod recovery tool or with the

assistance of the crane used for module installation

Further, the first end of the centering pin 200 includes a chamfer mating surface 38 designed to guide the posts 52 of a module 50 being lowered thereon into a locking position. The centering pin 200 is preferably constructed of steel and will be retrieved upon installation of each module 50 in order that it can be re-used for the installation of the subsequent modules 50.

The top end 40 of the shaft 36 is wider than the main section of the shaft 36. The wider open end 40 facilitates easier entry of the recovery tool (not shown) into the centering pin 200.

The centering pin 200 includes a step 48 in the elongate body 28. The step abuts the bridging member 16 of the apparatus 100 when the centering pin 200 is seated in a corresponding insert 12, 14.

The centering pin 200 preferably has the following dimensions:

$$\begin{array}{lcl} W_{CP} & = & 130\text{mm} \\ H_{CP} & = & 180\text{mm} \end{array}$$

The centering pin 200 can take many different forms depending on the size and shape of the insert 12, 14 in which it is to be inserted. For example, the centering pin 26 shown in Figures 14a to 14c.

As shown in Figures 15a to 15c, vertical continuity is achieved by:

- (a) inserting overlapping reinforcement bars 56 within the steel hollow section module column 52;
- (b) filling the internal volume of the steel hollow section column 52 is with non shrink grout 58 with a hose 60.

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.

5 Checking should preferably be done to ensure the overlapping rebar 56 has been lowered till the prescribed height, and it is sitting on the grout 58 poured during the installation of the lower module 50.

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

- 10 (a) Installation guidance of the module to an accurate final position;
  - (b) Horizontal and vertical continuity of structural members;
  - (c) Corrosion resistance;
  - (d) Avoidance of the expense of milling or machining;
  - (e) Access to structural connections from the top of the modules;
  - 15 (f) Provision of adjustment to accommodate manufacturing and construction tolerances;
  - (g) Cost effectiveness; and
  - (h) Ease of procurement.
- 20 The apparatus 100 simplifies site work, improves durability and reduces the overall cost of construction.

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

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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.

30 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.

35 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. Apparatus for connecting prefinished prefabricated volumetric construction units, including:
  - 5 (a) first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective open ends of columns of neighbouring units to thereby connect the units together,  
wherein the inserts vertically engage the open ends of the columns, and  
10 wherein the bridging member is generally rectangular plate, with opposed ends being welded to respective opposed sides of the inserts, so that, as the apparatus is forced downwards with respect to a vertical axis  $A_v$  of the columns, the bridging member is forced into slots in opposed sides of the open ends of the columns until the bridging member is seated in slots.
- 15 2. The apparatus claimed in claim 1, wherein the inserts are shaped to be received within said open ends of the columns.
3. The apparatus claimed in claim 2, wherein the inserts are secured to the open  
20 ends of the columns by frictional engagement.
4. The apparatus claimed in any one of claims 1 to 3, wherein the inserts are tubular.
- 25 5. The apparatus claimed in any one of claims 1 to 4, including first and second centering pins for guiding respective ones the first and second inserts into columns of prefinished prefabricated volumetric construction units being above mounted, each one of said centering pins including:
  - (a) an elongate body section shaped for insertion into one of said inserts;
  - 30 (b) a chamfer mating section coupled to a top end of the body section for guiding the columns of a unit being lowered thereon into a locking position;
  - (c) one or more locking members coupled between the elongate body and the mating section, the locking members project outwardly from the  
35 vertical axis so as to engage an open end of an insert as the centering pin is being fitted thereto; and

- (d) a hollow shaft extending through the pin along the vertical axis  $A_v$ .
6. The apparatus claimed in claim 5, wherein the body section includes a series of flutes along the vertical axis  $A_v$ .
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7. The apparatus claimed in claim 5 or 6, wherein the hollow shaft is arranged to facilitate removal of the centering pin from the insert.
8. A method of connecting two prefinished prefabricated volumetric construction units using an apparatus, including:
- 10
- (a) first and second parallel inserts laterally displaced by a bridging member, the first and second inserts being coupleable to respective open ends of columns of neighbouring units to thereby connect the units together,
- 15
- wherein the inserts vertically engage the open ends of the columns, and wherein the bridging member is generally rectangular plate, with opposed ends being welded to respective opposed sides of the inserts, so that, as the apparatus is forced downwards with respect to a vertical axis  $A_v$  of the columns, the bridging member is forced into slots in opposed sides of the open ends of the columns until the
- 20
- bridging member is seated in slots, including the steps of:
- (a) cutting slots in opposed sides of open ends of neighbouring columns of the units;
- (b) inserting lower ends of the inserts into respective ones of said open ends of neighbouring columns of the units; and
- 25
- (c) forcing the apparatus downwards with respect to a vertical axis  $A_v$  of the columns until the bridging member is seated in the slots.
9. The method claimed in claim 8, including the steps of inserting reinforcement bars into the columns and at least partially filling the columns with cementitious grout.
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10. The method claimed in claim 8 or claim 9, wherein the apparatus further includes:
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- first and second centering pins for guiding respective ones of the first and second inserts into columns of prefinished prefabricated volumetric construction units

being above mounted, each one of said centering pins including:

- (a) an elongate body section shaped for insertion into one of said inserts;
  - (b) a chamfer mating section coupled to a top end of the body section for guiding the columns a unit being lowered thereon into a locking position;
  - (c) one or more locking members coupled between the elongate body and the mating section, the locking members project outwardly from the vertical axis so as to engage an open end of an insert as the centering pin is being fitted thereto; and
  - (d) a hollow shaft extending through the pin along the vertical axis  $A_v$ ,
- including the steps of:
- (a) inserting the centering pins into the top of said inserts; and
  - (b) lowering an additional upper unit over one of the two neighbouring units such that a bottom end of one of the columns of the upper unit receives one of said centering pins.

11. The method claimed in claim 10, including the step of retrieving the centering pin by drawing it from said one of said columns of the upper unit.

12. The method claimed in claim 11, including the step of inserting reinforcement bars and filling the columns with cementitious grout.