

Modular Construction System

Field of Invention

The invention relates to the construction of buildings. Specifically, the invention relates to prefabricated volumetric construction modules.

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Background

Prefabricated volumetric construction (PPVC) is frequently used in the construction industry to speed up the construction process. Currently, PPVC involves constructing individual modules in factories before transporting these modules on site for assembly.

10 However, the transportation of individual modules from the factories to the construction site tends to be very slow and expensive, particularly for remote sites. In particular, current PPVC systems require expensive handling and erection equipment to transport and erect the prefabricated modules.

15 It would therefore be desirable to provide a modular construction system which overcomes or alleviates the above disadvantages, or which at least provides a useful alternative.

Summary of Invention

20 In a first aspect of the present invention, there is provided a modular structure, comprising a first module and a second module, said first and second modules moveably coupled to each other by an engagement assembly, wherein the first

module is arranged to be nested within the second module when the modular structure is in an unextended position, and wherein the engagement assembly further comprises a guide mechanism arranged to allow translation of the first or second module relative to each other from the unextended position to an extended position.

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Accordingly, the collapsible nature of the modular structure allows two units of living space to be shipped as one single module. This facilitates easy transportation from the factory to the construction site, thereby reducing the cost of shipping, transportation and logistics handling, while maximizing living space.

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As a result, due to its easy deployment, the modular structures of the present invention is applicable for military or civilian projects of short duration, and also for construction of long-term housing in remote areas where on-site construction is uneconomical.

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In addition, the modular structures of the present invention can also be deployed in copious quantities quickly and efficiently in areas where an urgent need of accommodation may be required. This may include, but is not limited to, disaster areas or refugee camps, both of which may require large scale accommodation so as to avoid a humanitarian crisis in terms of exposure and disease.

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In embodiments of the present invention, the guide mechanism is arranged to allow vertical translation of the second module relative to the first module. This is to effect the translation of the second module relative to the first module, and vice versa.

- 5 In embodiments of the present invention, the modular structure further comprises at least one external column positioned adjacent the guide mechanism, the external column arranged to support the second module when the modular structure is in the extended position. Accordingly, this arrangement will enhance the safety of the modular structure.

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In embodiments of the present invention, the engagement assembly further comprises at least one binding member arranged to secure the first and second modules in either the unextended position or the extended position. Accordingly, this allows the modular structure to be easily transported in the unextended position. Furthermore,

15 the safety of the modular structure in the extended position will also be ensured.

In embodiments of the present invention, the first and/or second module is arranged to be of the same dimensions as a standard shipping container. Accordingly, such an arrangement is advantageous for transportation to the construction site. In particular,

20 the modular structure may be transported through normal shipping methods.

Furthermore, if transportation to a remote location is required, shipping carriers and/or international ports can also use standard equipment and trailers to lift, shift

and transport these modules. All these will lead to a reduction in transportation costs, thereby reducing the overall building costs.

In a second aspect of the present invention, there is provided a building structure,
5 comprising a plurality of modular structures arranged to be adjacent to each other;
and at least one binding member arranged to span across and couple adjacent
modules, wherein each of the plurality of modular structures comprises a first module,
and a second module moveably coupled to the first module by an engagement
assembly, the first module is arranged to be nested within the second module when
10 the modular structure is in an unextended position, the engagement assembly further
comprises a guide mechanism arranged to allow translation of the first or second
module relative to each other from the unextended position to an extended position,
and wherein at least one edge of one modular structure is aligned with a
corresponding edge of the adjacent modular structure.

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Accordingly, the present invention allows for the easy deployment of modular
structures in copious quantities quickly and efficiently in areas where an urgent need
of accommodation may be required.

20 **Brief Description of Drawings**

It will be convenient to further describe the present invention with respect to the
accompanying drawings that illustrate possible arrangements of the invention. Other

arrangements of the invention are possible, and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

- 5 Figure 1 shows a perspective view of a modular structure in an unextended position according to one embodiment of the present invention;
- Figure 2 shows a perspective view of a modular structure in an extended position according to one embodiment of the present invention;
- Figure 3 shows a perspective view of a modular structure in an extended position that
- 10 is secured in position according to one embodiment of the present invention;
- Figure 4 shows a perspective view of a first module for the modular structure according to one embodiment of the present invention;
- Figure 5 shows a perspective view of a second module for the modular structure according to one embodiment of the present invention;
- 15 Figures 6A and 6B show views of the upper corner casting according to one embodiment of the present invention;
- Figures 6C and 6D show views of the lower corner casting according to one embodiment of the present invention;
- Figures 7A to 7E shows the process of transformation of the modular structure from
- 20 the unextended position to the extended position according to one embodiment of the present invention;

Figures 8A to 8C shows various examples of building structures constructed from more than one modular structures;

Figure 9 shows a perspective view of a binding member according to one embodiment of the present invention;

5 Figures 10A to 10C show views of another binding member according to one embodiment of the present invention;

Figure 11 shows cross-sectional view of a binding member according to a further embodiment of the present invention; and

Figures 11 to 16 show perspective views of a modular structure according to
10 embodiments of the present invention.

Detailed Description

Broadly, embodiments of the present invention generally provide a modular structure having at least one internal occupiable space comprising at least a first module and a
15 second module, said first and second modules moveably coupled to each other by an engagement assembly. The first module is arranged to be nested within the second module when the modular structure is in an unextended position, and extend out of the second module when the modular structure is in an extended position. To arrive at the extended position from the unextended position, either the first module or the
20 second module is arranged to undergo a translation relative to each other.

It will also be appreciated that embodiments of the present invention as will be described below may be constructed using a variety of accepted construction materials including, but not limited to: (i) masonry materials; (ii) reinforced, prestressed, poststressed and fibre reinforced concrete; (iii) construction metals including steel and aluminum; (iv) non-combustible, non-ferrous materials such as PVC; and (v) plasterboard.

In one embodiment of the present invention as shown in Figs 1 to 5, there is provided a modular structure 1 having a first module 2 and a second module 3 moveably engaged to the first module 2 by an engagement assembly. In an embodiment, the first module 2 is smaller than the second module 3, and is nested in the second module 3 when the modular structure 1 is in an unextended position.

As shown in Figure 4, the first module 2 includes a first plurality of columns and beams interjoined to form a self-supporting structure. In this exemplary embodiment, a first plurality of bottom rails 2B are interconnected to form a first base of the first module 2, while a first plurality of top rails 2C are interconnected to form a top of the first module 2. The top and the first base of the first module 2 are connected to each other by a first plurality of columns 2A. In some embodiments, the first base of the first module 2 may further comprise a plurality of floor purlins 2E, and the top of the first module 2 may also comprise a plurality of roof purlins 2F. In further embodiments of

the present invention, the first module 2 may comprise wall panels, a roof panel and a floor panel coupled to the sides, top and first base of the first module 2 respectively.

Referring now to Figure 5, like the first module 2, the second module 3 includes a

5 second plurality of column and beams interjoined to form a self-supporting structure.

In this exemplary embodiment, a second plurality of bottom rails 3B is interconnected to form a second base of the second module 3, while a second plurality of top rails 3C are interconnected to form a roof of the second module 3. The roof and the second base of the second module 3 are connected to each other by means of corner columns

10 3A, wherein the corner columns 3A are hollow so as to provide a passageway therethrough. In an embodiment, the second module 3 may further comprise wall panels and a roof panel coupled to the sides and the roof of the second module 3 respectively, while the second base of the second module 3 is arranged to be hollow so as to allow encasement of the first module 2 within the second module 3.

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The second module 3 further comprises a plurality of pairs of corner castings arranged at the edges of the second module 3. Each pair of corner castings comprises a lower corner casting 3D and an upper corner casting 3E. In an embodiment, the lower corner casting 3D and the upper corner casting 3E are arranged at distal ends of one corner

20 column 3A.

An embodiment of the upper corner casting 3E is shown in Figures 6A and 6B. In this embodiment, the upper corner casting 3C comprises a first top plate, a first bottom plate and four first side plates interjoined or casted together to form the upper corner casting 3C. A first top opening 6, a first bottom opening 7 and four first side openings 8
5 are provided on the first top plate, the first bottom plate and the four first side plates, respectively. As shown in Figure 6A, the first top opening 6 is arranged to be larger than the first bottom opening 7.

Figures 6C and 6D further show an embodiment of the lower corner casting 3D in
10 further detail. Like the upper corner casting 3C, the lower corner casting 3D comprises a second top plate, a second bottom plate and four second side plates interjoined or casted together to form the lower corner casting 3D. A second top opening 9, a second bottom opening 10 and four second side openings 11 are provided on the second top plate, the second bottom plate and the four second side plates, respectively. As shown
15 in Figure 6C, the second top opening 9 is arranged to be smaller than the second bottom opening 10.

The engagement assembly on the first and second modules will now be described in further detail. In the illustrated embodiment as shown in Figures 4 and 5, each of the
20 first plurality of columns 2A further comprises at least one guide mechanism 2F arranged to be moveably engaged with a corresponding lower corner casting 3D of the second module 3. A base corner casting 2D is further provided at one end of each

guide mechanism 2F, and arranged to be adjacent to the first plurality of bottom rails 2B. In one embodiment, the base corner casting 2D is the same as the lower corner casting 3D of the second module.

5 Referring now to Figures 7A to 7E, the method of setting up the modular structure 1 will now be described. In an embodiment, the second module 3 of the modular structure 1 is first lifted from an unextended position as shown in Figure 7A to an extended position as shown in Figure 7C. This can be done using a crane or forklift or any other standard lifting equipment. External columns 4 are installed in between the
10 lower corner casting 3D of the second module 3 and the base corner casting 2D of the first module 2, such that the second module 3 is at least partially supported by the external columns 4. To secure the modular structure 1 in the extended position, binding members 5 are threaded through the upper corner castings 3E, into the passageway of the corner columns 3A and the lower corner casting 3D, before entering
15 the external columns 4 and finally being secured at the base corner castings 2D. It will be understood that one or more binding elements 5 may be used for securing each edge of the modular structure 1.

Accordingly, such an arrangement allows for an efficient method of erecting a housing
20 block. In particular, the modular structure 1 can be prefabricated and prefinished in the factory, before being sent on site for assembly. To this end, the collapsible nature of the modular structure 1 of the present invention allows a two-storey building to be

shipped as one. This facilitates easy transportation from the factory to the construction site, thereby reduces shipping and transportation costs while maximizing living space.

- 5 To this end, due to its easy deployment, the modular structure 1 of the present invention has several applications, such as erecting temporary structures for military or commercial purposes, or even for construction of long-term housing in remote areas where on-site construction is uneconomical.
- 10 Furthermore, the present invention also allows the modular structure 1 to be secured when it is in the unextended position. In particular, when the modular structure 1 is in the unextended position as shown in Figure 1, binding members may be threaded through the passageways of the corner columns 3A and secured at the base corner castings 2D. This further increases the ease of transportation of the modular structure
- 15 1 while it is in the unextended position.

In embodiments of the present invention and as shown in Figures 8A to 8C, two or more of the modular structure 1 can be stacked together or positioned adjacent to each other so as to construct a low-rise apartment block with several adjoining units.

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In an embodiment of the present invention, adjacent units that are arranged beside each other may be secured by an interlocking plate as shown in Figure 9. In this

embodiment, the interlocking plate 12 is placed over the upper corner castings 3E of adjacent second modules such that each of the plate apertures 14 is aligned with the opening of the upper corner casting 3E. The plate apertures 14 are arranged to allow the binding members 5 to penetrate through so as to secure the interlocking plate 12 and the modular structures in place.

For vertical securement, the binding members 5 may extend across two modular structures so as to secure vertically adjoining modules. In an embodiment, the binding members 5 may be a connection rod 25 as shown in Figures 10A to 10C. In this embodiment, the connection rod 25 comprises an internally threaded socket head 30 and an externally threaded tail 35, the threads of the externally threaded tail 35 and the internally threaded socket head 30 are complementary. The socket head 30 is arranged to have a larger external diameter than the diameter of the shaft 40, the first top opening 6 of the upper corner casting 3C and the second bottom opening 10 of the lower corner casting 3D. Further, the socket head 30 is also arranged to have a smaller external diameter than the first bottom opening 7 of the upper corner casting 3C.

In operation, a first connection rod 25 will be inserted into the edge of a first modular structure. The socket head will go through the first top opening 6 of the upper corner casting and abut the first bottom plate of the upper corner casting. The externally threaded tail will in turn engage the base corner casting 2D, therefore securing the first modular structure in place. A second modular structure is then stacked on top of the

first modular structure, and a second connection rod 25 is inserted into the edge of the second modular structure. As with the first connection rod, the socket head of the second connection rod will also abut the first bottom plate of the upper corner casting of the second modular structure. At the same time, the externally threaded tail of the second connection rod 25 will penetrate through the first bottom opening 7 of the upper corner casting and the second top opening 9 of the lower corner casting so as to engage with the internally threaded socket head of the first connection rod, thereby securing the second modular structure to the first modular structure.

- Other types of binding members may also be used to secure adjacent modular structures together. This will include, but is not limited to, at least one tension cable and at least a pair of anchors.

As an alternative arrangement the binding member may comprise a series of anchor blocks and post-stressing cables locating at the peripheral edges of the modules, with anchor blocks positioned at the connections portions of the modules. For instance the corner castings may comprise end anchors arranged to resist a post-stressed cable connecting adjacent modules and binding said modules into a building structure. Such an arrangement is shown in Figure 11, which is alternative to the use of connecting rods as the binding member, as shown in Figures 10A to 10C. For this alternative embodiment, the end connections 72 are modified to receive an anchor 71, which act to resist the post-stressing of the cable 70. Thus when the various modules have been

placed and aligned, the cable is stressed so as to couple the placed discrete modules to form a unitary building structure.

Accordingly, such an arrangement allows a multi-storey apartment block to be constructed quickly and efficiently, thereby increasing construction productivity and as
5 a result reduces the cost of construction.

Whilst the first and second modules of the present invention are described to comprise corner castings, it will be appreciated that the corner castings are not required for the invention to work. In particular, as described earlier, one of the main
10 functions of the corner castings is to aid in the securement of the modules using the binding members of Figures 10A to 10C. Hence, a skilled person will naturally understand that any mechanism that allows any binding members to secure the modules may be used for the purposes of this invention.

15 While the second module of the present invention is illustrated to translate relative to the first module, it will be appreciated that the first module may also translate relative to the second module. Furthermore, in other embodiments of the present invention, the second module may be smaller than the first module, and arranged to be nested within the first module when the modular structure is in the unextended position.

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In embodiments of the present invention, the modular structures of the present invention may be stacked up to a height of 10 storeys. Nevertheless, it will be

appreciated that depending on the building codes and regulations, the modular structures may be stacked to a height of more than 10 storeys.

In embodiments of the present invention, the modular structure 1 has dimensions
5 equal to that of a standard shipping container when it is in the unextended position.
For example, the modular structure 1 may have the same dimensions as a standard 20-
footer or 40-footer shipping container. In other embodiments, the modular structure
of the present invention may have dimensions corresponding to the requirements of
the construction site.

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Accordingly, such an arrangement is advantageous for transportation to the
construction site. In particular, the modular structure may be transported through
normal shipping methods, such as cranes and forklifts using twistlock devices to
engage, lift and disengage the modular structure. Furthermore, if transportation to a
15 remote location is required, shipping carriers and/or international ports can also use
standard equipment and trailers to lift, shift, load and transport these modules. All
these will lead to a reduction in transportation costs, thereby reducing the overall
building costs.

20 In yet another embodiment of the present invention as shown in Figures 12 to 17, the
modular structure 101 further comprises a third module 104 rotatably engaged to the
first module 102 by a rotating mechanism (not shown). The rotating mechanism may

include ball bearings, ball transfer units, a ball bearing swivel plate, or any mechanism that allow smooth rotation of the third module 104 relative to the first module 102.

Furthermore, the third module 104 is arranged to be nested within the first module 102 when the modular structure is in an unextended position, and extend out of the

5 first module when the modular structure is in an extended position. To arrive at the extended position from the unextended position, the third module 104 is arranged to undergo a rotation relative to the first module 102.

The method of setting up the modular structure 101 will now be described. In an

10 embodiment, the second module 103 of the modular structure 101 is first lifted from

an unextended position as shown in Figure 12 to an extended position as shown in

Figure 13. This can be done using a crane or forklift or any other standard lifting

equipment. Detachable walls 102A of the first module 102 will then be opened (as

shown in Figure 14), thereby exposing the third module 104 that is nested within the

15 first module 102. As shown in Figures 15 and 16, the third module 104 can then rotate

out of the first module 102 so as to reach the extended position. Once the third

module 104 is in the extended position, the detachable walls 103A can then be closed,

thereby securing the modular structure 101 in place (as shown in Figure 17).

20 Accordingly, one modular structure will have more internal occupiable space available.

This allows a large multi-storey building to be prefabricated and prefinished in the

factory, before being transported out to the construction site for assembly.

Although the illustrated embodiment only shows one module being nested in the first module when the modular structure is in the unextended position, it will be appreciated that two or more modules may be nested in the first module as well.

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While the invention has been described with reference to specific embodiments, modifications and variations in design and/or detail may be made without departing from the spirit and scope of the invention.

Claims

1. A modular building structure, comprising:

a first module, and

a second module, said first and second modules moveably coupled to

5 each other by an engagement assembly;

wherein the first module is arranged to be nested within the second module when the modular structure is in an unextended position, and;

the first and second modules are positioned adjacent to each other in an extended position;

10 wherein the engagement assembly further comprises

a guide mechanism arranged to allow relative translation of the first and second modules from the unextended position to an extended position;

at least one binding member configured to extend through an upper corner of the second module to a base corner of the first module, such that the binding member is arranged to span across at least one edge of the first module and couple to the second module, said at least one binding member arranged to secure the first and second modules in a secured position; and

15 wherein at least one edge of one modular building structure is aligned with a corresponding edge of an adjacent modular building structure.

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2. The modular building structure according to claim 1, wherein the first module is further arranged to extend out of the second module when the modular building structure is in the extended position.
- 5 3. The modular building structure according to claim 1, wherein the second module is further arranged to extend out of the first module when the modular building structure is in the extended position.
- 10 4. The modular building structure according to claim 1, wherein the guide mechanism is further arranged to allow vertical translation of the second module relative to the first module.
5. The modular building structure according to claim 4, further comprising at least
15 one external column positioned adjacent the guide mechanism, the external column is arranged to support the second module when the modular building structure is in the extended position.
6. The modular building structure according to claim 1, wherein the secured
20 position is either the unextended position or the extended position.

7. The modular building structure according to claim 1, wherein the binding member comprises at least one connection rod arranged to be inserted through at least one edge of the second module, the connection rod comprises an internally threaded end and an externally threaded end, the externally threaded end of at least one connection rod is arranged to be secured to a base of the first module.
8. The modular building structure according to claim 1, wherein the binding member comprises an assembly of at least one tension cable and at least one pair of end anchors.
9. The modular building structure according to any of the preceding claims, wherein the second module further comprises a plurality of pairs of corner castings.
10. The modular building structure according to claim 9, wherein the binding member is arranged to engage the pair corner castings.
11. The modular building structure according to any of the preceding claims, wherein the second module is arranged to be of the same dimensions as a standard shipping container.

12. A building structure, comprising:

a plurality of modular building structures arranged to be adjacent to each other;

5 wherein each of the plurality of modular building structures comprise a first module, and a second module moveably coupled to the first module by an engagement assembly, the first module is arranged to be nested within the second module when the modular building structure is in an unextended position, the engagement assembly further comprises a guide mechanism arranged to allow translation of the first or second module relative to each
10 other from the unextended position to an extended position;

each of the plurality of modular building structures further including at least one binding member configured to extend through an upper corner of the first module to a base corner of the second module, such that the binding member is arranged to span across and couple the first and second modules,
15 said at least one binding member arranged to secure the first and second modules in a secured position; and

wherein at least one edge of one modular building structure is aligned with a corresponding edge of the adjacent modular structure and secured together with an interlocking plate placed over upper corner castings of the
20 adjacent modular structures.

13. The building structure according to claim 12, wherein the first module is arranged to extend out of the second module when the modular structure is in the extended position.
- 5 14. The building structure according to claim 13, the second module is arranged to extend out of the first module when the modular building structure is in the extended position.
- 10 15. The building structure according to any one of claims 12 to 14, wherein the first module is adjacent to the second module when the modular building structure is in the extended position.