

A MODULAR BUILDING AND A METHOD OF CONSTRUCTION THEREOF

Field of Invention

- 5 The present invention relates to the field of building construction. In particular, the present invention relates to methods and devices for constructing modular buildings.

Background of the invention

- 10 To overcome shortage of skilled labour and to increase speed of construction, pre-fabricated modular building units that may be assembled into a building have been proposed. These pre-fabricated room modules are often made in a remote factory, and are supplied to construction sites complete with walls, windows, doors, finishes, fixtures and fittings. The room modules are typically transported by trucks. On site,
- 15 the room modules are stacked upon each other vertically. Each room module above is secured mechanically to the room module below, and gaps there between are filled in by concrete and steel bars. The room modules are variously modularized by comprising designs for living rooms, bed rooms, staircase, utility areas and so on. An example of this building method is known as the MIC (Modular Integrated
- 20 Construction) method.

Figure 1A illustrates the schematically the construction of a building 101 using the MIC method, showing a pre-fabricated room module 103 being inserted into the top left hand corner of a building already assembled from other room modules.

Figure 1B illustrates the simple decking approach in which each room module is simply placed on top of another. Figure 1C illustrates the alternative approach in which the space between the room modules on each level is filled with cement concrete grouting and reinforcement bars, which reinforces the entire structure.

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There are three conventional MIC modular construction methods, which are described in the following paragraphs, and each has a significant disadvantage when used in housing construction.

- 10 A) Steel-framed MIC Modules: This method is practical for construction of hotels, hostels, hospitals, offices where occupancy is temporary. However, local building code mandates regular structural inspection of steel joints against corrosion, rendering this method impractical for occupancies where inspectors' access into MIC module may be denied by occupants (such as residents of public housing).

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- B) Stacked-up Concrete MIC Module: This method is practical for mid-rise housing construction. However, in order to satisfy local building codes that safeguard buildings against typhoon wind load and disproportionate collapse, progressively higher structural strength is required of the stacked-up MIC units on the lower floors, rendering their structural members impractically large when the building height is above a certain point (around 40 storeys in Hong Kong's case).
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- C) "Permanent Formwork" Semi-MIC Modules: In this hybrid method, columns and beams are cast *in-situ* using steel formwork built into the MIC modules, thereby freeing the modules from supporting the units above. However, the method requires
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casting of concrete after placement of MIC modules, one floor at a time, and requires more skilled labour on site and more extensive protection against concrete spilling into the finished units' interior, which defeats the speed and cleanliness benefits that MIC construction purports to provide.

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Therefore, it is desirable to propose devices and methods that could provide a possibility of improving the speed, efficiency and reliability during assembly of modular buildings and, preferably, also provide a possibility of raising height limitation.

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Summary of the invention

In a first aspect, the invention proposes a method of constructing a building, comprising the steps of: providing a pair of vertical supports; inserting a pre-fabricated room module into a position between the pair of vertical supports; securing the pre-fabricated room module to the pair of vertical supports; such that the weight of the pre-fabricated room module is borne by the pair of vertical supports; wherein insertion of a pre-fabricated room module into a position between the pair of vertical supports includes moving the pre-fabricated room module horizontally into a space between the pair of vertical supports.

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In the prior art, use of a crane is only in lifting, translating and lowering objects, including room modules. However, this method of top-down lowering of room modules does not allow concurrent Slip-Form construction of vertical supports, as

the lowering of the room modules into the location between the vertical supports would clash with the construction formwork of the vertical support.

“Formwork” refers to moulds into which concrete or similar materials are

5 either precast or cast-in-place.

By moving the room units horizontally, work on extending the vertical supports can be conducted at the same time as pre-fabricated room modules are being installed into the lower parts of the vertical supports.

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Typically, therefore, the invention also comprises the further steps of: extending the pair of vertical supports; inserting a second pre-fabricated room module horizontally into a position between the extended parts of the pair of vertical supports; securing the second pre-fabricated room module to the extended parts of the pair of vertical
15 supports; such that the weight of the second pre-fabricated room module is borne by the extended parts of the pair of vertical supports.

Furthermore, the method typically comprises further steps of: installing a guide on each of the pair of vertical supports, the guide being capable of bearing the weight of
20 the pre-fabricated room module, and the guide capable of guiding movement of the pre-fabricated room module horizontally into the space between the pair of vertical supports; the guide being removable and re-installable on the vertical supports.

Preferably, the guide comprises: an elongate rail capable of being secured on each
25 of the sidewalls such that the length of the rail is parallel to the ground; each rail

having rollers capable of moving in the rail; the rollers being connected with a chain assembly capable of being secured to a room module; the step of insertion of a pre-fabricated room module into a position between the pair of vertical supports includes: moving a room module into the space between the pair of vertical supports using a crane; connected the chain assembly of each rail to a respective side of the room module such that the guide takes over the weight of the room from the crane; moving the pre-fabricated room module using the rollers in the rail.

However, the guide may also be a removable and extended platform that can be secured to the desired height in the channel, upon which a room module may be rolled on and moved into the channel.

In a second aspect, the invention proposes a building under construction comprising a pair of vertical supports defining a channel for being installed with pre-fabricated room module; wherein the pair of vertical supports comprises guides for guiding the insertion of the pre-fabricated room module into the channel horizontally. This is because the invention may relate to a building process which must have such an incomplete building still under construction at some point in time, and provides the possibility of improving and speeding up the completion of the building under construction elegantly.

A non-limiting example of the guides is railings that can take over the load of the room modules, and have rollers for moving the room modules along the railings and into the channel.

Preferably, the guides are removable to be reinstalled on a different height on the pair of vertical supports for receiving another pre-fabricated room module into the channel horizontally.

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Typically, the guide comprises: an elongate rail capable of being secured on each of the sidewalls such that the length of the rail is parallel to the ground; each rail having rollers capable of moving in the rail; the rollers being connected with a chain assembly capable of being secured to a room module.

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However, other methods and devices for providing the guide is possible, such as a mini-crane that can be installed into the relevant height of space between the sidewalls, or a platform that sticks out like a tongue for the room module to be rolled upon into the space between the sidewalls.

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Typically, the pre-fabricated room module is secured to the pair of vertical supports at about the height wherein the railing is installed. Any variation in the height of the pre-fabricated room module along the channel may be provided by devices that can lower or raise the pre-fabricated room module, such as chains or a lift jack.

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Preferably, each of the one or more vertical supports is a reinforced cement concrete wall. Optionally, the walls are arranged in parallel. This provides that the building has a straight and planar façade. Alternatively, the walls are arranged angularly to each other. This provides that the building may be curved by being fitted with

prefabricated room modules having a fan-shape plan. In some embodiments, the entire building may be round from the plan view.

In a further aspect, the invention proposes a pre-fabricated room module for
5 assembly into a building, the building comprising the pre-fabricated room module secured to two vertical supports; wherein the room module has dimensions suitable for being inserted into a space between two vertical supports horizontally.

The manufacture of the room module may be left to a third party and assembled by a
10 property developer. Advantageously, this feature provides the possibility of allowing independent room module manufacturers to design and supply room modules of different designs to fit into a frame of sidewalls proposed by a property developer.

Preferably, the pre-fabricated room module has connecting portions suitable for
15 connecting to a movement guide between the vertical supports; the movement guides being suitable for guiding the insertion of the room module.

Preferably, the pre-fabricated room module has pre-fixed security mechanism for being secured to the vertical supports. Examples of such pre-fixed security
20 mechanism include a fixed bracket that is pre-fixed to the room module in factory, the bracket being capable of being bolted to a corresponding sidewall. Optionally, the connecting portions can be provided and fixed to the pre-fabricated room module on site, in which case the builder or sub-contractor may be allowed to select the most suitable connecting portions on site.

Optionally, the pre-fabricated room module has a fan shape in the plan view. This shape allows the pre-fabricated room module to fit into the angularly arranged walls, which provides the advantage of a building having columns of the pre-fabricated rooms arranged to provide a curve façade

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Brief description of the Figures

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention, in which like integers refer to like parts. 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.

- 15 Figure 1A illustrates a the prior art schematically for comparative purposes;
Figure 1B illustrates the prior art in a three dimensional rendition;
Figure 1C shows how cement concrete grouting is used to fill in the spaces between room modules;
- Figure 2 illustrates an embodiment of the invention;
- 20 Figure 3 is a variation of the embodiment of Figure 2,
Figure 4 illustrates a building schedule of constructing the embodiment of Figure 3;
Figure 5 is a technical drawing illustrating the construction of a building according to embodiments similar to that shown in Figure 3;
- Figure 6 is a perspective drawing of the construction of a building according to
25 embodiment similar to that shown in Figure 3;

Figure 7a to Figure 7c illustrate schematically a method of constructing buildings according to embodiments such that that shown in Figure 3;

Figure 8a to Figure 8c illustrate schematically how cement grout is used to filling spaces in a building built according to embodiments such that that shown in Figure 3;

Figure 9 is a technical drawing corresponding to Figure 8c but showing more details;

Figure 10 shows a bigger building built according to embodiments similar to that shown in Figure 3;

Figure 11 shows another building built according to embodiments similar to that shown in Figure 3;

Figure 12 shows another building built according to embodiments similar to that shown in Figure 3;

Figure 13 shows another building built according to embodiments similar to that shown in Figure 3;

Figure 14 is a plan view of the arrangement of vertical supports for a building similar to that shown in Figure 13;

Figure 15 illustrates how room modules are inserted to form a building having the plan of Figure 14;

Figure 16 is an architectural plan for a building having the plan of Figure 14;

Figure 17 illustrate how two room modules of the embodiment shown in Figure 6 may be arranged;

Figure 18 is an exploded illustration of an apartment unit illustrated in Figure 16;

Figure 19 is another exploded illustration of an apartment unit illustrated in Figure 16;

Figure 20 provides more illustration of some of the variations of the embodiments as shown in the preceding drawings;

Figure 21 shows yet another variation of the embodiments shown in some of the preceding drawings; and

Figure 22 shows the variations of the embodiments of Figure 12 to Figure 16.

5 Detailed description of specific embodiments

Embodiments of the invention are described herein after, which include both buildings and methods of constructing the buildings.

10 Figure 2 is an exaggerated, schematic illustration of one of the simplest embodiment of the invention. The illustration shows a two-unit apartment block 200. Each apartment unit comprises a pre-fabricated room module 205 that is suitable for human habitation.

15 Pre-fabricated room modules 205 have been used in modular buildings, which are known by different terms in different regions. Pre-fabricated room modules 205 are called Permanent Modular Construction (PMC) in the United States, Prefabricated Prefinished Volumetric Construction (PPVC) in Singapore, and Modular Integrated Construction (MIC) in Hong Kong. The room modules 205 are room-sized volumetric
20 modules that are fitted out in the factories by mass production, delivered to construction sites and assembled. These room modules 205 are standardised in size and design, and are capable of being assembled to produce a large apartment block. The fittings and finishing of each apartment in a building are usually completed in the room modules 205 before the room modules 205 are transported to the building site
25 and assembled into the building.

In Figure 2, the bottom room module 203 is placed on the ground, between two vertical supports. The upper room module 205 is affixed between the same two vertical supports 201 but is located at a higher position on the vertical supports 201 than the bottom room module 203. The exaggerated gap 207 between upper room module 205 and the bottom room module 203 demonstrates how the weight of the top room module 205 is not imposed onto the bottom room module 203. The weight of the upper room module 205 is equally borne by the two vertical supports 201 on both sides.

Preferably, the vertical supports 201 are provided in the form of sidewalls 201, although other kinds of vertical support structures may be used in other embodiments, such as column pillars or steel frames. Furthermore, each sidewall 201 is preferably relatively thin, steel-reinforced and planar.

In the present embodiment, the two sidewalls 201 are arranged in parallel, so that a vertical channel is defined there between. The stability of the two sidewalls 201 is reinforced by the straddling of the upper room module 205 across the two sidewalls 201. Therefore, the distance between the two sidewalls 201 is selected such that the width of the channel is able to accommodate the width of a room module 205. However, the distance must not be too great. Ideally, the distance between the two sidewalls 201 provides just the minimal amount of excess space between a room module 205 and the sidewalls 201 for allowing flexibility of movement when installing a room module 205 into the channel. A good size fit with sufficient excess space makes it easier to apply any securing mechanism to join a part of a room module

205 to the corresponding part of the sidewalls 201. If there is too much excess space, and these parts are too far from each other due to a poor size fit, the securing mechanism may have difficulty accommodating the excess distance between the parts.

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Furthermore, a certain amount of cement is always required to fill up spaces between the sidewalls 201 and the room module 205. If there is minimal space between sidewalls 201 and room modules 205 due to a good size fit, the amount of cement required to fill the space would be small, and the space can be filled quickly.

10 This leads to faster production, less cement use and a cleaner worksite on the whole.

Figure 3 shows a more practical variation of the embodiment of Figure 2, having three upper room modules 205 each secured independently to the pair of sidewalls

15 201. No room module 205 is bearing down on the top of any room module 205 beneath. A small gap 207 between every upper room module 205 and the respective lower room module 205 is illustrated to demonstrate that none of the room modules 205 is resting on the room module 205 beneath. In practice, however, any gap 207 between an upper room module 205 and a lower room module 205 has to be filled
20 with cement to avoid collecting rain water and rubbish carried by wind.

The embodiment of Figure 3 provides the possibility of some advantages over conventional stacked-up construction methods of the prior art. The prior art method requires room modules to be stacked upon other room modules. Therefore, the

25 height of the building is limited by the structural strength of the lowest room modules,

which bears the weight of all the room modules above. Also, room modules placed on a room module that becomes damaged are all at risk of collapsing into the damaged room module. This is known as the “domino” effect or a “disproportionate collapse”. A room module may be damaged by cooking gas explosion, fire or corrosion.

The present embodiment overcomes this problem by using the sidewalls 201 to support the room modules 205, so that the room modules 205 are basically non-stacking. There is no progressively increasing weight on the lower room modules that could come with increasing building storeys. Safety concerns of excessive load borne by lower room modules 205, which limit the height of buildings constructed by the prior art method have thereby been addressed by the present embodiment. Buildings made accordingly to the present embodiment may break the height limitation imposed on buildings constructed by the prior art method, such as having seventy storeys or more without structural difficulty even in a place with strong winds like Hong Kong, while benefitting from the efficiency of a modular building method.

Furthermore, the sidewalls 201 are typically strong enough to withstand the heat of cooking fires and the impact of explosions from gas leaks. Every room module is isolated from the other room modules, and the building will not have a structural problem if any of the room modules is damaged by fire or explosion. The room modules 205 being independent of each other do not bear down on the damaged room module.

Furthermore, as there is no need for any room module 205 to bear the weight of another room module 205 placed above, the embodiment also provides a possibility that the room modules 205 may be made of lighter and weaker materials than those room modules made for use in the prior art method, which may lead to improved cost and production efficiency.

While the room modules 205 are best manufactured in a factory remotely, sidewalls 201 are strong structures that may be made by casting cement concrete over steel bars, and are more suitable for being erected on site. The sidewalls 201 are erected storey by storey from the ground up.

Generally, tall sidewalls 201 require a long time to construct. Therefore, it would be expected by conventional wisdom that sidewalls 201 have to be completed before room modules 205 may be inserted, and that a room module 205 has to be lifted using a crane over the top of the sidewalls 201 in order to be lowered into the channel between the sidewalls. However, the present embodiments use the crane in a novel way to produce further advantages.

Instead of lowering the room modules 205 down from the top of the channel, the embodiment uses a crane to move pre-fabricated room modules 205 horizontally, into the desired height position in the channel directly. A set of removable slot-in rails 701 is provided at the installation position on the channel. The slot-in rails 701 is able to take over the load of the room module 205 from the crane, and to guide further horizontal movement of the room module 205 inside the channel and into the exact position for fixing the room module 205 to the sidewalls 201.

Moving the room modules into the channel horizontally does not require lowering room modules down into the channel from the top. Therefore, the top parts of the sidewalls may still be under construction while room modules are filling up the lower
5 part of the channel.

Figure 4 and Figure 5 illustrate the steps of constructing the sidewalls 201 using the Slip-Form method. Specifically, Figure 4 shows a building schedule, which illustrates how two sidewalls 201 are erected on the ground using the Slip-Form method to cast
10 the first batch of cement. The illustration shows only two sidewalls 201 but may apply to all the sidewalls 201 of the entire building. Figure 5, on the other hand, shows the Slip-Form equipment as how it is often seen in a construction site, i.e. two sidewalls 201 are illustrated, each having Slip-Form equipment at the top. A set of slot-in rails 701 can be seen right beneath the Slip-Form equipment 501 in Figure 5.

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The Slip-Form method is a preferable way of constructing walls of tall buildings, and uses specific equipment that includes a casting mould 501 to form a wall. The casting mould 501 can be slipped or moved upwardly on the wall that has just be
20 cast and dried in the same mould 501. Therefore, moving the casting mould 501 up on the wall empties the casting mould 501, which may be filled with a new supply of cement and steel bars to make another wall upon the last wall. The internal shape of the wall-casting mould 501 is therefore the shape of the wall.

At the start of building construction, the positions of the sidewalls 201 have to be
25 marked on the ground. Then the lowest sections of all the sidewalls 201 of the

building must be erected first. A Slip-Form casting mould 501 is provided for every side wall, and is placed on the ground. The lowest sections of all the sidewalls 201 are then cast in all the casting moulds 501. Steel bars may be placed into the casting mould 501 first, to provide wall reinforcement. Subsequently, wet cement is poured
5 into the casting mould 501, over the steel bars and then left to dry.

Once the cement has dried and the wall is formed, the casting mould 501 is raised upwardly on the newly formed wall, but just short of detaching from the wall completely. The wall is now the base in the casting mould 501 and the casting mould
10 501 is empty of content. Another batch of cement and steel bars may then be supplied into the casting mould 501. Again, the cement and steel bars form a new section of wall, but one which is built upon the earlier-made wall beneath. This process is repeated for as many times as the final height of the wall requires.

15 Generally, the Slip-Form process reduces the amount of formwork used compared to other methods of wall construction, such as the Continuous Pour method. The Slip-Form method enables continuous, non-interrupted, joint-less concrete structures to be cast *in-situ*, and may be used to erect walls of very tall structures. Together with the “all-dry” installation of pre-fabricated room modules 205, the presently described
20 method of building construction reduces the amount of formwork used, as well as reducing time and labour cost, and improves cleanliness of worksite.

As explained, the Slip-Form equipment can be moved upwardly on newly hardened wall, and equipment includes the casting mould 501 and more. The Slip-Form
25 concept has been applied to construct walls, bridges and many other big structures,

and the technology is mature and well-documented, and does not require any further elaboration herein.

Figure 4 shows how, starting from a day zero, it takes 4 days for the first batch of cement in the casting mould 501 to dry and become strong enough to form the lowest sections of the sidewalls 201. The casting mould 501 is slipped upwardly on the cured wall on day 4, in order for a new extension of the wall to be cast. Again, steel bars and wet cement are supplied into the casting mould 501 to cast new wall on the last formed wall.

Hence, the first wall extension is dried on day 8, whereupon the second extension is made.

The second extension becomes dry after another four days, i.e. day 12. On this day, the two already dried sections of walls are typically tall enough for a room module 205 to be installed into the channel between the sidewalls 201. Therefore, first pre-fabricated room module 205 is slid horizontally into the channel. This room module 205 is then secured to the sidewalls 201 on both sides by bolts and fix brackets. At the same time, the casting moulds 501 at the top of the sidewalls 201 are moved up on the sidewalls 201 into a higher position to receive steel bars and cement to make a third extensions of the sidewalls 201.

On day 16, a second pre-fabricated room module 205 is lifted by a crane and slid horizontally into the channel at the height for the second storey. The two sides of this room module 205 are then secured to the sidewalls 201 at that height, using bolts

and fix brackets. Note that the ground floor room module 205 has been installed on day 12 already. Furthermore, on day 16, the wall section newly cast on day 12 should be dried. Hence, while the activities related to the second storey room module 205 are going on, the casting mould 501 is raised higher along the top of the
5 sidewalls 201 in order to receive more steel bars and cement to form yet a newer and higher section of the sidewall 201.

On day 20, another pre-fabricated room module 205 is lifted by a crane and slid into the channel horizontally, but at the height for the third storey. The two sides of the
10 room module 205 are secured to the sidewalls 201 with bolts and fix brackets. Furthermore, on day 20, the wall section newly cast on day 16 should be dried. Hence, while the activities related to the third story room module 205 are going on, the casting mould 501 is raised higher along the top of the sidewall 201 in order to receive more steel bars and cement to form yet a newer and higher section of the
15 sidewall 201.

The same steps are repeated until the sidewalls 201 have been erected to the desired height and the room modules 205 have been inserted into the channel to complete the building.

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The skilled reader should note that the above description follow the schedule illustrated in Figure 4 only for clarity of this description. It would seem that there is a common rhythm between the extension of the top of the sidewall 201 and the insertion of room modules 205 into channel. In practice, however, there is no need
25 for Slip-Form activities to wait for any room module installation to complete.

Furthermore, other work such as touching up the finishes in room modules 205, filling spaces with cement, connecting water pipes and electrical wires to the utility mains, do not have to depend on the pace of the extension of the sidewalls 201.

- 5 Figure 6 illustrates how a room module 205 is inserted into a channel horizontally. The advantage of horizontal insertion is that work on extending top of the sidewalls 201 is not disturbed by any lowering of a room module 205 down into the channel. Such horizontal “slot-in” method enables the top of the sidewalls 201 to be constructed at the same time as installation of room modules 205 at the lower
10 storeys.

Figure 7a to Figure 7c illustrate in greater detail the method of Figure 6, showing how a pre-fabricated room module 205 is inserted horizontally into a channel. The sidewalls 201 are not illustrated in Figure 7a to Figure 7c for clarity.

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- In Figure 7a, a room module 205 is shown lifted by chains 705 and moved sideways by a crane. Near the position of the sidewalls 201 where the room module 205 is supposed to be inserted is provided a temporary slot-in rail 701. The slot-in rail 701 can be removed and re-installed on a position higher up on the sidewalls 201 after
20 the current room module 205 has been secured to the sidewalls 201.

- The slot-in rail 701 is mounted with a roller device 703 that can move along the slot-in rail 701 by means of rollers, wheels or any other mechanism. Hanging down from the roller device are two hanging chains 707 which can be hooked or otherwise
25 secured to the room module 205 brought to the channel horizontally by a crane.

When the room module 205 is moved partially into the channel by the crane, a worker can attach the hanging chains 707 to the room module 205. This transfers the load of the room module 205 over to the slot-in rail 701, and the crane may be freed to move off and lift another room module 205.

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Figure 7b shows the room module 205, now hung on the hanging chains 707, being slid in on the slot-in rail 701. The slot-in rail 701 extends deep into the channel, and the room module 205 may be brought to the exact depth in the channel for affixation to the sidewalls 201.

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Figure 7c shows the room module 205 moved into the desired depth in the channel. The room module 205 may now be fixed by securing mechanisms such as bolts and fix brackets to the sidewalls 201. In actual construction, it may be necessary to lift or lower the room module 205 slightly to allow fixtures such as plumbing and wiring to be connected to the room modules 205. This is an operational detail which can be provided by adjusting the hanging chains 707, and does not require more elaboration herein.

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In the preferred configuration, the securing mechanisms are fixtures of steel brackets 709 prefixed on top of the room modules 205. The steel brackets 709 are to be bolted into the load bearing sidewalls 201. After such affixation, the room module 205 is secured permanently in the channel. A steel bracket 709 secured to the sidewalls and to a room module 205 can be seen in Figure 6.

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Once the room module 205 is set in place, the space between the present room module 205 and the room module 205 of the lower storey is filled by concrete grout 711 to prevent ambient moisture and dirt from reaching the securing mechanism that secures the lower room module 205 to the sidewalls 201. Typically, the concrete
5 grout 711 is applied by injection.

Subsequently, the worker releases the slot-in rail 701 from the sidewalls 201, to be fixed into the position on the sidewalls 201 for the next storey, in order to be used again to assist in the installation of the room module 205 above. The skilled reader
10 should appreciate that there are two slot-in rails 701 for moving the room module 205 stably, one on each of the sidewalls 201 defining the channel.

Besides using rails, other methods of assisting the horizontal movement of the room modules are within the contemplation of this description. For example, a removable
15 extended platform that sticks out like a tongue might be secured temporarily in the channel upon which a room module might be rolled into the channel.

Figure 8a, Figure 8b and Figure 8c illustrates the application of concrete grout 711 to fill up spaces between an upper room module and a lower room module. The
20 dimensions of the room modules 205 are exaggerated in Figure 8a to Figure 8c for illustrative purposes. Figure 7a to Figure 7c views the room module 205 is from the side that is lateral to the view shown in Figure 8a to Figure 8c.

The façade of the room module 205 shown is the front façade, i.e. the face that looks
25 away from the building. Two windows are illustrated as a way for the reader to

identify the façade. The two sides of the top of the room module 205 are supplied with a steel bracket each, which are to be bolted to the respective sidewall 201.

Either side of the base of the room module 205 is provided with a dent 801 to accommodate the respective steel bracket of a room module 205 below. Figure 8b

5 illustrates how the steel bracket is secured to the sidewall 201 by a bolt 803, thereby affixing the room module 205 to the sidewall 201.

The skilled reader would appreciate that there is another room module 205 on the left side of the sidewall 201, on the same floor, and that there is another sidewall 201
10 to the right of the room module 205 as illustrated. These are not shown so as not to reduce the clarity of the drawing. The neighbouring room module 205 on the left side of the wall may share the same bolt 803 or may not; this is a worksite variation which does not require elaboration here.

15 It can be seen in Figure 8c that there is a space between two vertically arranged room modules 205. Therefore, the room modules 205 are not stacked on another such that the lower room module 205 bears the weight of the upper room module 205. The bolt and any metal parts in the space between the two room modules 205 are cement-covered to prevent corrosion, as implied by the drawing of the syringe.

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Figure 9 corresponds to the illustration in Figure 8c, and shows the space between the top room modules 205a, 205b, and the bottom room modules 205c, 205d, on both sides of the sidewall 201, in greater detail. The four corners shown are the corners of the respective room modules 205a, 205b, 205c, 205d. The grey shaded

area in the insert of Figure 9 illustrates concrete grout 711 covers over the steel bracket, bolt and a large part of a vent hole.

Figure 10 shows another embodiment 1000, in which each room module 205

5 secured to the sidewalls 201 bears two other room modules 205 that are placed onto the secured room module 205 (after being slid in horizontally into the channel).

These two other room modules 205 are not secured to the sidewalls 201. The stack of room modules 205 is arranged in several sub-columns 401 of three-room modules 205. The weight of each sub-column of room modules 205 is borne by the side-walls

10 through the lowest room module 205 of the sub-column. The advantage of this embodiment is that the building can be constructed faster, since only every other room module 205 in the channel requires securing to the sidewalls 201, instead of every room module. The skilled reader would appreciate that the number of room modules 205 making up a sub-column depends on the weight and size of the room
15 modules 205 bearing down upon the room modules 205 secured to the sidewalls 201, which is typically lowest room module 205 in the sub-column, as well as the type and strength of the securing mechanism connecting that lowest room module 205 to the sidewalls 201.

20 Apartment buildings are often built for mass housing, and it is very unlikely that a single column of room modules 205 would make commercial sense. Accordingly, Figure 11 (and also in the preceding drawings in Figure 5 and Figure 6) shows an example of a multi-column apartment building 1100. In particular, three columns of room modules 205 filling three channels defined by four sidewalls 201 are illustrated
25 in Figure 11. The skilled reader should understand that there could be many more

than three columns of room modules 205 in actual buildings, even up to thirty, fifty or more.

However, multiple columns of room modules 205 arranged into a planar building

5 block would require very strong reinforcement to withstand strong winds. In locations such as Hong Kong where there are seasonal strong typhoons, it may not be practical to build big planar blocks.

Figure 12 illustrates another embodiment 1200, which is a building comprising two

10 planar blocks of the pre-fabricated room modules 205, the two planar blocks connected at a right angle, shown as an inverted letter L 1201, so that the length of each block provides reinforced resistance against wind blowing within the plane of the planar block but onto the façade of the orthogonally connected block. Together, the two orthogonally-arranged planar blocks offer combined strength against wind of
15 any direction buffeting against the whole building. Preferably, the junction of the letter L provides a structural core which can be reinforced to increase wind resistance.

Figure 13 shows another embodiment 1300, which has an even more preferable

20 configuration of a T-shape 1301 arrangement of two planar blocks. Again, the junction of the letter T provides a structural core which can be reinforced to increase wind resistance

Figure 14, Figure 15 and Figure 16 are architectural plans of a building that may be

25 constructed using the described embodiments, corresponding to the T-shaped

configuration of the embodiment of Figure 13. Figure 14 illustrates the location of the sidewalls 201 built on the ground for the embodiment of Figure 13. The junction of the T-shape plan provides a building core structure in which elevators may be provided. The load bearing sidewalls 201 are erected on the ground and extended
5 upwardly over a period of time using the Slip-Form method. Pre-fabricated room modules 205 are installed using cranes and slot-in rails 701 as described while the sidewalls 201 are being extended. The horizontal slot-in method shown in Figure 6 is preferred as there is no disruption to the Slip-Form process at the top of the sidewalls 201. Depending on the design of the building, the time for room modules to
10 be filled into an entire storey of the building might just be the time required for the top of the sidewalls to dry and the Slip-Form moulds to be moved up, making the entire construction highly efficient with little lull time.

So far, the room modules 205 have been described as if they are each an
15 apartment. In reality, however, each room module 205 may comprise parts of two neighbouring apartments. Furthermore, different designs of room modules 205, each comprising parts of the same two neighbouring apartments have to be assembled to provide the two neighbouring apartments.

20 Accordingly, Figure 17 illustrates how two rectangular room modules 205, one inner and one outer on the same level of the sidewalls 201 (sidewalls not illustrated) combined to make up neighbouring apartments, apartment A and apartment B. The rectangular modules are moved into the sidewalls 201 by the long side. This is why each rectangular layout is divided among the two neighbouring modules. This design
25 allows the outer room module 205 to provide both neighbouring apartments a

window and a view. A pre-fabricated and pre-installed wall inside each of the two room modules 205 divides the rectangular layout into two quadrants, one for each of the two apartments.

- 5 In other words, the two room modules 205 are arranged to contact by their long side, in order to make up the two apartments. The corresponding halves of each room module 205 together provide apartment A and apartment B, respectively. That is, A1 and A2 are provided by different room modules 205 but are joined to provide apartment A. Similarly, B1 and B2 are provided by different room modules 205 but
10 are joined to provide apartment B.

- Some room modules 205 provide the quadrants to be used for staircases and other common areas. For example, B1 can be a common utility area of the apartment such as gas and water pipes, and electrical connections. B2 is used to provide staircase
15 module that is connect-able to the corresponding quadrant of the room modules 205 below and above, joining up to provide a staircase for the building. A1 can be the living room and the door of the apartment is provided on the far side of A1, while A2 can be a bedroom.

- 20 The skilled reader would know that the sidewalls may have a dimension such that a corridor can be built to supply access to all the room modules 205. The plans in Figure 15 and Figure 16 show corridors providing access to room modules 205.

- The skilled reader would appreciate that as many room modules 205 as required,
25 even three or more, may be combined to make up one, two, three or even more

apartments. This depends on the design of an actual building that embodies the described methods

Figure 18 is an exploded illustration of a medium size apartment 1801 in the drawing of Figure 16. The whole medium size apartment 1801 is shown on the top part of the drawing. The apartment 1801 is made up of different room modules 205 that may be mass produced and assembled from room modules 205 of different designs, which are shown in the lower part of the drawings.

Figure 19 is an exploded illustration of a small size apartment 1901 in the drawing of Figure 16. The whole small size apartment 1901 is shown in the top part of the drawings, while the bottom part shows the different room modules 205 that may be mass produced and to be assembled as modules of the apartments and of the building. It can be seen that some of the room modules 205 provide staircases or common landings.

Preferably, all structural steel are encased in concrete for optimum fire and corrosion protection. The embodiments provide the possibility of non-stop work for *in-situ* concreting concurrently with modules fixing will be most suitable for extra fast-track construction. Furthermore, individually supported modules are generally slimmer and lighter than stack-up ones, thereby reducing lifting and transportation cost. Since all steelwork are encased, long term liability of inspecting uncovered structural steel work will be eliminated. Also, since the modules are supported by the load bearing walls, messy *in-situ* concrete filling work between modules to achieve structural

stability will be unnecessary. The described methods are applicable to public housing, hotels, dormitories, schools, hospitals, clinics, shops etc.

Figure 20 are technical drawings that illustrate the different types of pre-fabricated room modules 205 that can be manufactured and supplied as modularized configurations, and a variety of ways to secure the room modules 205 to the sidewalls 201.

The upper left drawing in Figure 20 shows room modules 205 that have steel brackets 709 or other securing mechanisms placed on the top of the room modules 205, known as the top hung room modules 2701. These room modules 205 are to be secured to the sidewalls 201 to be hanging from the securing mechanism.

The upper right drawing in Figure 20 shows room modules 205 that have steel brackets 709 or other securing mechanisms placed on the bottom of the room modules 205, known as the bottom hung modules 2703. These room modules 205 are to be secured to the sidewalls 201 to be supported from the securing mechanism.

Figure 20 also shows variations in securing the room modules 205 to the sidewalls 201. For example, the lower left drawings is a technical drawing corresponding to the schematic drawing of Figure 10, showing one lower room module 205 secured to the sidewalls 201 and two other room modules 205 stacked onto that lower room module 205 for support. The two upper room modules 205 are not secured to the sidewalls 201. This is known as the multiple-stacking model 2705.

The lower right drawing in Figure 20 shows a particular configuration corresponding to the schematic drawing of Figure 2, in which there is void in the channel not filled in by any room modules 205. This void may provide a vent hole or may be provided for
5 aesthetic reasons.

The manufacture of the room module 205 may be left to a third party and assembled by a property developer. This may open up the contribution of designs supplied by room module manufacturers to fit into a frame of sidewalls proposed by a property
10 developer.

Preferably, the pre-fabricated room module 205 has connecting portions suitable for connecting to a movement guide between the sidewalls; the movement guides being suitable for guiding the insertion of the room module, such as a rail. This provides
15 that the pre-fabricated room module is ready to be rolled into the channel on the rail once lifted to the correction position in the channel by a crane, as already described, which increases the speed and elegance during construction that a modular approach may tend to provide.

20 Preferably, the pre-fabricated room module has pre-fixed security mechanism for being secured to the vertical supports. Examples of such pre-fixed security mechanism include a fixed bracket that is pre-fixed to the room module in factory, the bracket being capable of being bolted to a corresponding sidewall. Optionally, the connecting portions can be provided and fixed to the pre-fabricated room module

on site, in which case the builder or sub-contractor may be allowed to select the most suitable connecting portions on site.

Furthermore, although whole apartment buildings that are straight and flat across the
5 façade have been illustrated and described, there are embodiments that may provide a curved building façade. Figure 21 shows a completely round building. In this case, the sidewalls 201 are arranged around a point of origin. Every pair of adjacent
sidewalls 201 forms a channel that has the shape of a fan when viewed from the top, which opens up towards the exterior. The room module 205 therefore has also a fan
10 shape that fits into the shape of the channel.

Figure 22 shows the different plans of buildings that may be built using the same approach as described. Some buildings may have a Y-shape arrangement 2201, in which case the intersection point may be reinforced with sidewalls that form the core
15 of the whole structure. Another, arrangement shown is the T-shape structure 2203 or the O-shape structure 2205, which has already been described. Yet another arrangement is a linear block 2207 with different sections of the block facing slightly different directions. The centre part of the block may be provided with a core for structural strength.

20

Therefore, the embodiments described include a building comprising: one or more vertical supports 201; a room module 205 secured to the one or more vertical supports 201 by a securing mechanism; wherein most or all of the weight of the room module 205 is borne by the one or more vertical supports 201. One of the
25 advantages provided by the embodiments is, as mentioned, that the weight of the

room modules 205 are borne by load bearing structures erected on the ground, instead of by other room modules 205 beneath. This leads to the advantage of constructed very tall buildings quickly, which are capable of bearing the wind load in places like Hong Kong.

5

The builds described may be constructed by a method comprise the steps of: providing a pair of vertical supports (e.g. sidewalls); inserting a pre-fabricated room module 205 into a position between the pair of vertical supports; securing the pre-fabricated room module 205 to the pair of vertical supports; such that the weight of the pre-fabricated room module 205 is borne by the pair of vertical supports; wherein insertion of a pre-fabricated room module 205 into a position between the pair of vertical supports includes moving the pre-fabricated room 205 module horizontally into a space between the pair of vertical supports. Therefore, one of the main advantages is best seen during building construction, which allows the two processes of erecting sidewalls and inserting pre-fabricated room modules to run concurrently with little or no need to be paced to each other. Therefore, a building under construction has also been described, which comprises a pair of vertical supports defining a channel for being installed with pre-fabricated room module 205; wherein the pair of vertical supports comprises guides for guiding the insertion of the pre-fabricated room module 205 into the channel horizontally.

The invention opens up the construction business sector to third party manufacturers to provide pre-fabricated room modules 205 that are capable of fitting into standardized sidewalls dimensions. This increase competition and allows better designs to be contributed without need of being part of the main architectural design

under the purview of contractor. Therefore, the embodiments includes a pre-fabricated room module 205 for assembly into a building, the building comprising the pre-fabricated room module secured to two vertical supports; wherein the room module 205 has dimensions suitable for being inserted into a space between two
5 vertical supports horizontally.

While there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design, construction or
10 operation may be made without departing from the scope of the present invention as claimed.

15

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Claims

1. A method of constructing a building, comprising the steps of:
 - providing a pair of vertical supports;
 - inserting a pre-fabricated room module into a position between the pair of vertical supports;
 - securing the pre-fabricated room module to the pair of vertical supports; such that the weight of the pre-fabricated room module is borne by the pair of vertical supports; wherein
 - insertion of a pre-fabricated room module into a position between the pair of vertical supports includes moving the pre-fabricated room module horizontally into a space between the pair of vertical supports.
2. A method of constructing a building as claimed in claim 1, comprising the further steps of:
 - extending the pair of vertical supports;
 - inserting a second pre-fabricated room module horizontally into a position between the extended parts of the pair of vertical supports;
 - securing the second pre-fabricated room module to the extended parts of the pair of vertical supports; such that
 - the weight of the second pre-fabricated room module is borne by the extended parts of the pair of vertical supports.

3. A method of constructing a building as claimed in claim 1, comprising the further steps of:

installing a guide on each of the pair of vertical supports, the guide being capable of bearing the weight of the pre-fabricated room module, and the guide capable of guiding movement of the pre-fabricated room module horizontally into the space between the pair of vertical supports;

the guide being removable and re-installable on the vertical supports.

4. A method of constructing a building as claimed in claim 3, wherein

the guide comprises:

an elongate rail capable of being secured on each of the sidewalls such that the length of the rail is parallel to the ground;

each rail having rollers capable of moving in the rail;

the rollers being connected with a chain assembly capable of being secured to a room module;

the step of insertion of a pre-fabricated room module into a position between the pair of vertical supports includes:

moving a room module into the space between the pair of vertical supports using a crane;

connected the chain assembly of each rail to a respective side of the room module such that the guide takes over the weight of the room from the crane;

moving the pre-fabricated room module using the rollers in the rail.

5. A building under construction comprising
 - a pair of vertical supports defining a channel for being installed with pre-fabricated room module; wherein
 - the pair of vertical supports comprises guides for guiding the insertion of the pre-fabricated room module into the channel horizontally.
6. A building under construction as claimed in claim 5, wherein
 - the guides are removable to be reinstalled on a different height on the pair of vertical supports for receiving another pre-fabricated room module into the channel horizontally.
7. A building under construction as claimed in claim 6, wherein
 - the guide comprises:
 - an elongate rail capable of being secured on each of the sidewalls such that the length of the rail is parallel to the ground;
 - each rail having rollers capable of moving in the rail;
 - the rollers being connected with a chain assembly capable of being secured to a room module.
8. A building under construction, as claimed in claim 5, wherein
 - the pre-fabricated room module is secured to the pair of vertical supports at about the height wherein the guides are installed.

9. A building under construction as claimed in claim 5, wherein
each of the one or more vertical supports is a reinforced cement
concrete wall.
10. A building under construction as claimed in claim 9, wherein
the walls are arranged in parallel.
11. A building under construction as claimed in claim 9, wherein
the walls are arranged angularly to each other.
12. A pre-fabricated room module for assembly into a building,
the building comprising the pre-fabricated room module secured to two
vertical supports; wherein
the room module has dimensions suitable for being inserted into a
space between two vertical supports horizontally.
13. A pre-fabricated room module for assembly into a building, as claimed
in claim 12,
having connecting portions suitable for connecting to a movement
guide between the vertical supports;
the movement guides being suitable for guiding the insertion of the
room module.

14. A pre-fabricated room module for assembly into a building, as claimed in claim 12,

having pre-fixed security mechanism for being secured to the vertical supports

.

15. A pre-fabricated room module for assembly into a building as claimed in claim

12; wherein

the pre-fabricated room module has a fan shape in the plan view.