

RAPIDLY DETACHABLE AND RECONSTRUCTED MODULAR INTEGRATED BUILDING AND CONSTRUCTION METHOD THEREOF

5 Field of the Invention

The present invention relates to a concrete building and its construction method, and more particularly, to a modular integrated building that can be detached for late reconstruction, and a construction method thereof. The present invention can
10 particularly be used for construction of multiple-storey buildings.

Background of the Invention

Traditional residential or office buildings are generally built through in-situ
15 casting concrete at the construction site. However, the construction of such traditional cast-in-situ buildings not only suffers disadvantages such as complicated construction steps, long construction period, intensive labor consumption and hardly controlled quality, but also brings about a large amount of construction rubbish and generates heavy noise and dust pollution, causing great disturbance on daily life of surrounding
20 residents.

To this end, the construction of current buildings gradually adopts prefabricated building units of reinforced concrete structure, such as prefabricated kitchens, prefabricated bathrooms, prefabricated bedrooms and so on. These prefabricated
25 building units have been completed at respective factories in advance, and then assembled together at the construction site. This kind of construction can essentially reduce on-site workload, shorten the construction duration, and cut down labor cost. In addition, the disturbance on surrounding residents can be greatly reduced also.

However, for this kind of modular integrated building, when prefabricated building units are integrated together at the construction site, adjacent prefabricated building units have to be connected with each other through casting concrete, and the prefabricated portion and the cast-in-situ portion of the building should be bonded together through grouting. Thus the construction duration is still relatively long. In particular, as soon as the integration of prefabricated building units is completed, these prefabricated building units can be destructively demolished only, rather than detached for reconstruction. Moreover, if maintenance, inspection or the like is necessary to be performed at the connecting area between the prefabricated building units, related operations should be taken in the living space of residents. Obviously, this will influence the life of residents.

Summary of the Invention

In order to solve the above technical problem, the present invention provides a modular integrated building, which can be rapidly assembled at the construction site, and also rapidly detached for later construction. The present invention further provides a construction method thereof.

The present invention provides a modular integrated building that can be rapidly detached for late reconstruction, comprising a plurality of prefabricated room modules of reinforced concrete structure. Each prefabricated room module is provided with an exposed, top steel column assembly at each top corner of the prefabricated room module, and an exposed, bottom steel column assembly at each bottom corner of the prefabricated room module. The bottom steel column assembly of a prefabricated room module on a floor corresponds to the top steel column assembly of a prefabricated room module on a lower floor in terms of their vertical positions. A horizontal connector is interposed between two adjacent top steel column assemblies of two adjacent prefabricated room modules on a same floor, said two adjacent top

steel column assemblies being connected to the horizontal connector through first bolts. The top steel column assembly and the bottom steel column assembly of a prefabricated room module on a floor are connected to the bottom steel column assembly of a corresponding prefabricated room module on an upper floor and the top
5 steel column assembly of a corresponding prefabricated room module on a lower floor, respectively, through second bolts.

In an embodiment, each prefabricated room module is provided with a first recess at each top corner thereof and a second recess at each bottom corner thereof,
10 the top and bottom steel column assemblies being located in the first and second recesses, respectively.

In an embodiment, each top steel column assembly of each prefabricated room module includes a top column, and a horizontal top plate that is welded and thus fixed
15 to a top surface of the top column, and each bottom steel column assembly of each prefabricated room module includes a bottom column, and a horizontal bottom plate that is welded and thus fixed to a bottom surface of the bottom column.

In an embodiment, the top column is formed by an I-beam having an H-shaped
20 horizontal cross section, and the bottom column is formed by a channel steel having a U-shaped horizontal cross section.

In an embodiment, the horizontal connector is configured as a generally square, hollow steel structural member.

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In an embodiment, each prefabricated room module is provided at a top periphery thereof with an annular boss protruding upwardly, and at a bottom periphery thereof with a bottom base protruding downwardly, so that a fireproof cavity is formed between two vertically adjacent prefabricated room modules.

In an embodiment, the modular integrated building further includes at least one prefabricated walkway panel and at least one prefabricated facade panel. The prefabricated walkway panel is supported on a prefabricated room module of a lower floor and connected thereto with connecting members and bolts, and the prefabricated facade panel is connected to an adjacent prefabricated room module with connecting members and bolts.

In an embodiment, a first backing plate is arranged between the top and bottom steel column assemblies vertically adjacent to each other, and a second backing plate is arranged between the top steel column assembly and the horizontal connector.

The present invention further provides a construction method of the modular integrated building as mentioned above, including:

step A, installing the prefabricated walkway panel of an $(N+1)^{\text{th}}$ floor after completing an N^{th} floor of the building;

step B, hoisting the prefabricated room module to a predetermined position on the $(N+1)^{\text{th}}$ floor;

step C, connecting the bottom steel column assembly of the prefabricated room module of the $(N+1)^{\text{th}}$ floor with the top steel column assembly of the prefabricated room module of the N^{th} floor that vertically corresponds to said bottom steel column assembly through bolts; and

step D, connecting the top steel column assemblies of horizontally adjacent prefabricated room modules of the $(N+1)^{\text{th}}$ floor with each other through the horizontal connector and bolts.

In an embodiment, the method further includes a step A1 before step A: filling fireproof sealant in joints between the prefabricated walkway panel of the N^{th} floor and adjacent prefabricated room modules, and in joints at the top of adjacent

prefabricated room modules of the N^{th} floor.

In an embodiment, the method further includes a step A2 before step A: providing a cement mortar cushion layer on a top periphery of the prefabricated room module of the N^{th} floor, and placing a first backing plate on a top surface of the top steel column assembly of the prefabricated room module of the N^{th} floor, for adjusting and correcting height and angle of installation of the prefabricated room module of the $(N+1)^{\text{th}}$ floor.

In an embodiment, the method further includes a step E after step D: installing the prefabricated facade panel of the $(N+1)^{\text{th}}$ floor.

Compared with the prior arts, the modular integrated building that can be rapidly detached for late reconstruction according to the present invention has the following advantages.

1. The modular integrated building is mainly formed by assembling prefabricated room modules together. The prefabricated room modules are prefabricated in respective factories. The interior decoration can be completed in advance, and various devices can be also pre-installed. In this manner, advantages such as uniform quality, high efficiency, low cost, and excellent thermal/sound insulation performances can be obtained. Accordingly, construction steps that are necessary to be performed at the construction site can be greatly reduced, and in the meantime, influences of weather conditions, labor resources and construction site restrictions on the construction procedure can be also mitigated.

2. Each prefabricated room module is provided with an exposed steel column assembly at each of the top corners and the bottom corners thereof. Therefore, prefabricated house modules that are adjacent to each other vertically and horizontally

can be rapidly connected together with bolts at the construction site, thus shortening the construction duration significantly.

3. According to actual needs, the prefabricated room modules can be rapidly and completely detached from the modular integrated building as formed, without any damages to connecting members for the prefabricated room modules and the steel column assemblies. The detached prefabricated room modules can be reused many times in other places, thus greatly reducing the cost of reconstruction. In the meantime, environmental protection can be also achieved.

4. A fireproof cavity is formed between two prefabricated room modules vertically adjacent to each other. Therefore, a large amount of fireproof materials, such as fireproof board, fireproof glue, etc., can be saved, which is beneficial to fire prevention and cost reduction.

5. The steel column assemblies of the prefabricated room modules are connected to each other through bolts at outdoor locations. Therefore, it is more convenient for repair, maintenance and inspection during use. In fact, repair, maintenance and inspection can be performed at external public places, so that it is unnecessary to enter the living space of residents for this purpose. Thus influence on the life of residents can be greatly reduced, with inconvenience being minimized.

6. The shape of the building can be designed in a more flexible manner, and different building areas can be independently constructed.

Brief Description of the Drawings

Fig. 1 schematically shows a modular integrated building that can be rapidly detached for late reconstruction according to the present invention;

Fig. 2 schematically shows the structure of a prefabricated room module according to the present invention;

5 Fig. 3 schematically shows a top corner of the prefabricated room module;

Fig. 4 schematically shows a bottom corner of the prefabricated room module;

Fig. 5 schematically shows a connection area between prefabricated room
10 modules horizontally and vertically adjacent to each other;

Fig. 6 schematically shows a connection structure between steel column assemblies horizontally and vertically adjacent to each other;

15 Fig. 7 schematically shows a vertical cross-sectional view for step 1 of a construction method for the modular integrated building according to the present invention;

Fig. 8 schematically shows a perspective view for step 1 of the construction
20 method for the modular integrated building according to the present invention;

Fig. 9 schematically shows a top view for step 2 of the construction method for the modular integrated building according to the present invention;

25 Fig. 10 schematically shows a vertical cross-sectional view for step 2 of the construction method for the modular integrated building according to the present invention;

Fig. 11 schematically shows a perspective view for step 2 of the construction

method for the modular integrated building according to the present invention;

Fig. 12 schematically shows a vertical cross-sectional view for step 3 of the construction method for the modular integrated building according to the present invention;

Fig. 13 schematically shows a perspective view for step 3 of the construction method for the modular integrated building according to the present invention;

Fig. 14 schematically shows a vertical cross-sectional view for step 4 of the construction method for the modular integrated building according to the present invention;

Fig. 15 schematically shows a perspective view for step 4 of the construction method for the modular integrated building according to the present invention;

Fig. 16 schematically shows a vertical cross-sectional view for step 5 of the construction method for the modular integrated building according to the present invention;

Fig. 17 schematically shows a perspective view for step 5 of the construction method for the modular integrated building according to the present invention;

Fig. 18 schematically shows a vertical cross-sectional view for step 6 of the construction method for the modular integrated building according to the present invention; and

Fig. 19 schematically shows a perspective view for step 6 of the construction method for the modular integrated building according to the present invention.

Detailed Description of the Embodiments

In the following, the embodiments of the present invention will be further
5 illustrated with reference to the appending drawings.

As shown in Fig. 1, a modular integrated building that can be rapidly detached
for late reconstruction according to the present invention is mainly formed by
assembling a plurality of prefabricated room modules 10 of reinforced concrete
10 structure together. As shown in Fig. 2, each prefabricated room module 10 is a
self-contained component that is prefabricated at a respective factory in advance, and
usually designed as having a square shape. The prefabricated room module 10 is
provided with a vertical corner post at each of four corners thereof, and a beam at
each of four sides of the top and bottom portions thereof, in order to increase the
15 overall strength of the prefabricated room module 10. The prefabricated room module
10 is generally provided with a floor 101, a ceiling 102 and wall bodies 103. Of
course, the prefabricated room module 10 can also be designed into other shapes
according to design needs. Alternatively, doors and/or windows can be formed on one
or more wall bodies 103 of one or more of the prefabricated room modules 10, or one
20 or more prefabricated room modules 10 may not be provided with the floor 101, the
ceiling 102, or one of the wall bodies 103. Moreover, the interior decoration of the
prefabricated room module 10 may be completed in advance and various devices may
be pre-installed, in order to minimize the on-site construction duration.

25 As shown in Figs. 2, 3 and 4, the prefabricated room module 10 is provided in
advance with a first recess 106 at each top corner thereof, and a second recess 107 at
each bottom corner thereof. A top steel column assembly 1 is provided in the first
recess 106 at the top corner. The top steel column assembly 1 is partially pre-buried in
a corresponding corner post of the prefabricated room module 10, and partially

exposed in the first recess 106. A bottom steel column assembly 2 is provided in the second recess 107 at the bottom corner. The bottom steel column assembly 2 is partially pre-buried in a corresponding corner post of the prefabricated room module 10, and partially exposed in the second recess 107.

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As shown in Fig. 3, the top steel column assembly 1 of the prefabricated room module 10 includes a top column 11, and a horizontal top plate 12 that is welded and thus fixed to a top surface of the top column 11. As shown in Fig. 4, the bottom steel column assembly 2 includes a bottom column 21, and a horizontal bottom plate 22 that is welded and thus fixed to a bottom surface of the bottom column 21. In this embodiment, the top column 11 is formed by an I-beam having an H-shaped horizontal cross section, and the bottom column 21 is formed by a channel steel having a U-shaped horizontal cross section. In order to facilitate connection, an outer wall of the top column 11, a middle portion of the top plate 12, and a middle portion of the bottom plate 22 are each provided in advance with at least one bolt hole.

As shown in Figs. 5 and 6, when several prefabricated room modules 10 are assembled, a horizontal connector 3 is interposed between two horizontally adjacent top steel column assemblies 1 of two adjacent prefabricated room modules 10 on the same floor. Said two horizontally adjacent top steel column assemblies 1 are connected to the horizontal connector 3 by respective bolts, thereby achieving horizontal connection between two adjacent prefabricated room modules 10 on the same floor. In the meantime, in terms of vertical position, the bottom steel column assembly of a prefabricated room module 10 on a floor corresponds to the top steel column assembly of a corresponding prefabricated room module 10 on a lower floor. The bottom steel column assembly 2 and the top steel column assembly 1 vertically corresponding thereto are connected together by bolts. In this manner, vertical connection between two prefabricated room modules 10 that are vertically adjacent to each other can be realized.

As shown in Fig. 6, in order to facilitate connection with the top steel column assembly 1, the horizontal connector 3 is configured as a generally square, hollow steel structural member, which is formed by welding angle steels, channel steels and/or steel plates. The horizontal connector 3 includes two side plates, each having at least one bolt hole formed therein.

In addition, in view of the installation error between two vertically adjacent steel column assemblies and that between two horizontally adjacent steel column assemblies, a first backing plate 4 is arranged between two vertically adjacent steel column assemblies 1 and 2 that are connected to each other, for adjusting and correcting the height and angle of installation of the prefabricated room module 10 on an upper floor. In addition, a second backing plate 5 may further be arranged between the top steel column assembly 1 and the horizontal connector 3, so as to fill a gap formed therebetween. The first and second backing plates 4, 5 can each be provided with at least one bolt hole for connection.

As shown in Fig. 7, the prefabricated room module 10 is provided at a top periphery thereof with an annular boss 104 protruding upwardly, and at a bottom periphery thereof with a bottom base 105 protruding downwardly. In this manner, a fireproof cavity 20 (as shown in Fig. 14) is formed between two vertically adjacent prefabricated room modules 10. Thus the fireproof performance of the building can be improved, and in the meantime a large amount of fireproof materials, such as fireproof boards, fireproof glue, etc., can be reduced, thus saving costs significantly.

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According to design requirements on the building, the modular integrated building that can be rapidly detached for late reconstruction according to the present invention may further include a prefabricated walkway panel 30 and a prefabricated facade panel 40. In the embodiment shown in Fig. 1, between two rows of

prefabricated room modules 10 there is provided with a corridor 60, at the end of which the prefabricated walkway plate 30 is arranged. As shown in Fig. 12, the prefabricated room modules 10 arranged at both sides of the corridor 60 are provided at their top portions with supporting beams 108 that extend horizontally opposite to each other. The prefabricated walkway plate 30 has an inverted U-shaped structure, two end beams 301 of which protrude downwardly and are supported on the supporting beams 108 of the prefabricated room module 10 arranged at both sides of the corridor 60 of a lower floor, and connected to said prefabricated room module 10 of the lower floor through a connecting member 81 and a bolt 82. In this embodiment, the connecting member 81 may be a U-shaped channel steel, and the prefabricated walkway plate 30 and the supporting beam 108 can be embedded therein with bolt components for easy connection. As shown in Fig. 18, the prefabricated facade panel 40 is connected to a column (such as a corner post) of an adjacent prefabricated room module 10 through a connecting member 85 and screws. The connecting member 85 may be an angle steel, and partially embedded in the prefabricated facade panel 40.

The construction method of the modular integrated building that can be rapidly detached for late reconstruction according to the present invention includes the following steps.

Sep 1. As shown in Figs. 7 and 8, after an N^{th} floor of the building is completed, fireproof sealant is filled in the joints between the prefabricated walkway panel 30 of the N^{th} floor and adjacent prefabricated room modules 10, and in the joints at the top of adjacent prefabricated room modules 10 of the N^{th} floor.

Step 2. As shown in Figs. 9, 10 and 11, a cement mortar cushion layer 7 is provided on the top periphery of the prefabricated room module 10 of the N^{th} floor, and the first backing plate 4 is placed on the top surface of the top steel column assembly 1 of the prefabricated room module 10 of the N^{th} floor, for adjusting and

correcting the height and angle of installation of the prefabricated room module 10 of a (N+1)th floor.

Step 3. As shown in Figs. 12 and 13, the end beams 301, which protrude
5 downwardly, of the prefabricated walkway plate 30 of the (N+1)th floor are placed on the supporting beams 108 that protrude outwardly along the horizontal direction on both sides of the top of the prefabricated room module 10 of the (N+1)th floor. The prefabricated walkway plate 30 of the (N+1)th floor and the prefabricated room module 10 of the Nth floor are connected together with connecting members, such as
10 the channel steel 81 and the bolt 82.

Step 4. As shown in Figs. 14 and 15, the prefabricated room module 10 is hoisted to a predetermined position on the (N+1)th floor, so that the bottom steel column assembly 2 of the prefabricated room module 10 of the (N+1)th floor corresponds to
15 the top steel column assembly 1 of the prefabricated room module 10 of the Nth floor in terms of their vertical positions.

Step 5. As shown in Figs. 16 and 17, the bottom steel column assembly 2 of the prefabricated room module 10 of the (N+1)th floor and the top steel column assembly
20 1 of the prefabricated room module 10 of the Nth floor that correspond to each other along the vertical direction are connected together with longitudinal bolts.

Step 6. The top steel column assemblies 1 of adjacent prefabricated room modules 10 of the (N+1)th floor are connected with each other through the horizontal
25 connector 3 and bolts, and if necessary, the second backing plate 5 is arranged between the top steel column assemblies 1 and the horizontal connector 3.

Step 7. Washers 84 of the longitudinal bolts at the vertical connection of the bottom steel column assembly 2 of the prefabricated house module 10 of the (N+1)th

floor are welded to the bottom plate 22, for enhancing strength and preventing vibration and displacement.

Step 8. As shown in Figs. 18 and 19, the prefabricated facade panel 40 of the
5 (N+1)th floor is installed, and the connector 85 partially embedded in the prefabricated facade panel 40, such as angle iron, is fixed with screws to the column of the adjacent prefabricated room module 10 (as shown in the position of the corner post in Fig. 18).

Step 9. The above steps 1 to 8 are repeated, so as to complete the construction of
10 an upper floor of the building.

The foregoing description is merely illustrative of preferred embodiments of the present invention, and is not intended to limit the present invention. Various changes and modifications may be made by those skilled in the art. Any modifications,
15 equivalent substitutions, improvements, and the like within the spirit and principles of the present invention are intended to be included within the scope of the present invention.

CLAIMS

1. A modular integrated building, comprising a plurality of prefabricated room modules (10) of reinforced concrete structure,

5 wherein each prefabricated room module (10) is provided with an exposed, top steel column assembly at each top corner of the prefabricated room module, and an exposed, bottom steel column assembly at each bottom corner of the prefabricated room module, the bottom steel column assembly of a prefabricated room module on a floor corresponding to the top steel column assembly of a prefabricated room module
10 on a lower floor in terms of their vertical positions;

 a horizontal connector (3) is interposed between two adjacent top steel column assemblies of two adjacent prefabricated room modules on a same floor, said two adjacent top steel column assemblies being connected to the horizontal connector (3) through first bolts;

15 the top steel column assembly and the bottom steel column assembly of a prefabricated room module on a floor are connected to the bottom steel column assembly of a corresponding prefabricated room module on an upper floor and the top steel column assembly of a corresponding prefabricated room module on a lower floor, respectively, through second bolts;

20 each prefabricated room module (10) is provided with a first recess at each top corner thereof and a second recess at each bottom corner thereof, the top and bottom steel column assemblies being located in the first and second recesses, respectively;

 each top steel column assembly (1) of each prefabricated room module (10) includes a top column (11), and a horizontal top plate (12) that is welded and thus
25 fixed to a top surface of the top column (11); and

 each bottom steel column assembly (2) of each prefabricated room module (10) includes a bottom column (21), and a horizontal bottom plate (22) that is welded and thus fixed to a bottom surface of the bottom column (21).

2. The modular integrated building according to claim 1, wherein the top column (11) is formed by an I-beam having an H-shaped horizontal cross section, and the bottom column (21) is formed by a channel steel having a U-shaped horizontal cross
5 section.

3. The modular integrated building according to claim 1 or 2, wherein the horizontal connector (3) is configured as a generally square, hollow steel structural member.

4. The modular integrated building according to claim 1 or 2, wherein each prefabricated room module (10) is provided at a top periphery thereof with an annular boss (104) protruding upwardly, and at a bottom periphery thereof with a bottom base (105) protruding downwardly, so that a fireproof cavity (20) is formed between two
15 vertically adjacent prefabricated room modules (10).

5. The modular integrated building according to claim 1 or 2, further including a prefabricated walkway panel (30) and a prefabricated facade panel (40),

wherein the prefabricated walkway panel (30) is supported on a prefabricated
20 room module (10) on a lower floor and connected thereto, and the prefabricated facade panel (40) is connected to an adjacent prefabricated room module (10).

6. The modular integrated building according to claim 1 or 2, wherein a first backing plate is arranged between two vertically adjacent steel column assemblies, and a second backing plate is arranged between the top steel column assembly (1) and
25 the horizontal connector (3).

7. A construction method of the modular integrated building according to claim 5, including:

step A, installing the prefabricated walkway panel (30) of an (N+1)th floor after completing an Nth floor of the building;

step B, hoisting the prefabricated room module (10) to a predetermined position on the (N+1)th floor;

5 step C, connecting the bottom steel column assembly of the prefabricated room module of the (N+1)th floor with the top steel column assembly of the prefabricated room module of the Nth floor that vertically correspond to said bottom steel column assembly of the prefabricated room module of the (N+1)th floor through the second bolts; and

10 step D, connecting the top steel column assemblies of horizontally adjacent prefabricated room modules (10) of the (N+1)th floor with each other through the horizontal connector and the first bolts.

8. The construction method according to claim 7, further including a step A1
15 before step A:

filling fireproof sealant in joints between the prefabricated walkway panel (30) of the Nth floor and adjacent prefabricated room modules (10), and in joints at the top of adjacent prefabricated room modules (10) of the Nth floor.

20 9. The construction method according to claim 8, further including a step A2 before step A:

providing a cement mortar cushion layer (7) on a top periphery of the prefabricated room module (10) of the Nth floor, and placing a first backing plate (4) on a top surface of the top steel column assembly of the prefabricated room module
25 (10) of the Nth floor, for adjusting and correcting height and angle of installation of the prefabricated room module (10) of the (N+1)th floor.

10. The construction method according to claim 7, 8 or 9, further including a step E after step D:

installing the prefabricated facade panel (40) of the (N+1)th floor.