

A MODULAR BUILDING CONNECTOR ASSEMBLY AND A METHOD FOR CONNECTING MODULAR BUILDING UNITS

Technical Field

- 5 **[001]** Embodiments relate to a modular building connector assembly and a method for connecting modular building units.

Background

- 10 **[002]** Modular building construction, including modular prefabricated prefinished volumetric construction (PPVC), is a construction technique in which modules, modular units or PPVC modules are built off-site and subsequently assembled on-site. The modules, modular units or PPVC modules may include basic structures of a complete room, parts of a room, service units such as toilets or lifts, etc. The modules, modular units or PPVC modules may also be completed with internal finishes, fixtures and fittings. Such construction technique is gaining popularity as it provides for better quality control and increased productivity. Dust and noise pollution may also be minimised on-site as most of the construction activities are done off-site. Site safety may also be improved as most of the construction activities are done off-site in a factory controlled environment.
- 20 **[003]** However, one of the concerns with modular building construction is the structural integrity of the building after the module, modular units or PPVC modules are assembled. Accordingly, the type of connections being used to join up the modules, modular units or PPVC modules plays a critical role in ensuring the structural integrity of the completed building.

- [004] WO2009138770 shows a type of connector used for connecting modules, modular unit or PPVC modules. The connector includes a passageway in which an elongated member from a construction module assembled from the top of the connector may be inserted such that the construction module is correctly positioned.
- 5 The elongated member may only be fastened to the connector at the top of the connector and the connector merely sits on the bottom construction module. In other words, the construction module at the top is presumably restrained from the bottom by the bottom construction module on which the connector sits on. The above connector lacks robustness in that the top construction module is dependent on the bottom
- 10 construction module to restrain the downward movement of the top construction module. In the event that the structural integrity of the bottom construction module is compromised due to accident or other causes, the structural integrity of the entire building may be at risk of collapse.
- 15 [005] Therefore, there exists a need to address at least some of the issues identified in the existing connector and methods for connecting modular building components.

Summary

- [006] According to various embodiments, there is provided a modular building
- 20 connector assembly including a retainer; a fastener; a link plate having first and second stopper surfaces for abutting first and second modular building units respectively; a coupler element having an engagement portion for engaging with the link plate; wherein the coupler element is configured to be coupled to the first rod in a manner so as to be restrained against movement along the first rod by way of the

retainer and the fastener; and wherein the link plate is restrainable against movement along the first rod by way of engagement with the coupler element.

[007] According to various embodiments, there is provided a method for connecting modular building units. The method including providing a retainer; providing a fastener; providing a link plate having first and second stopper surfaces for abutting first and second modular building units respectively; engaging an engagement portion of a coupler element with the link plate; coupling the coupling element to a first rod in a manner so as to be restrained against movement along the first rod by way of the retainer and the fasteners, and restraining the link plate against movement along the first rod by way of engagement with the coupler element.

Brief description of the drawings

[008] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

FIG. 1A shows a typical architectural plan for a storey of a modular building;

FIG. 1B shows a closed up view of a residential apartment for the storey of FIG. 1A separated into individual modular building units;

FIG. 2 shows a perspective view of two skeletal frames of two adjacent modular building units being connected sideways;

FIGs. 3A to 3I shows a schematic diagram of a method for connecting a bottom modular building unit to a top modular building unit according to various embodiments;

FIG. 4 shows a diagram illustrating a method for connecting modular building units according to various embodiments; and

FIGs. 5A and 5B show exploded or unassembled views of a modular building connector assembly, and illustrates the sideways connection method between a first
5 modular building unit and a second modular building unit at the same height level.

Detailed description

[009] Embodiments described below in context of the apparatus are analogously valid for the respective methods, and vice versa. Furthermore, it will be understood
10 that the embodiments described below may be combined, for example, a part of one embodiment may be combined with a part of another embodiment.

[0010] It should be understood that the terms “on”, “over”, “top”, “bottom”, “down”, “side”, “back”, “left”, “right”, “front”, “lateral”, “side”, “up”, “down” etc., when used in the following description are used for convenience and to aid
15 understanding of relative positions or directions, and not intended to limit the orientation of any device, or structure or any part of any device or structure.

[0011] FIG. 1A shows a typical architectural plan for a storey 100 of a modular building. The storey 100 may be a level, a floor, or a deck of the modular building. The storey 100 of the modular building may include living spaces, office spaces,
20 storage spaces, recreation spaces, retail spaces, etc. or a combination thereof. As shown, the storey 100 of the modular building may include living spaces and may be segmented into several residential apartments 102. Each residential apartment 102 may include several modular building units 104, 106, 108, 110, 112 connected in sideways arrangement.

[0012] FIG. 1B shows a closed up view of the residential apartment 102 separated into individual modular building units. The residential apartment 102 may include five modular building units 104, 106, 108, 110, 112, which may be in the form of, but are not limited to, PPVC modules. The first modular building unit 104 may include a toilet fixtures and an entry hallway section with a main door. The second modular building unit 106 may include a bedroom section and a first part of a living room section with a partition wall separating the two sections. The third modular building unit 108 may include another toilet fixtures and a second part of the living room section with a partition wall having a door separating the two sections. The fourth modular building unit 110 may include another bedroom section and a third part of a living room section with a partition wall separating the two sections. The fifth modular building unit 112 may be a balcony section. The residential apartment 102 may be formed by connecting the five modular building units 104, 106, 108, 110 and 112 via sideway connections.

[0013] According to various embodiments, each of the modular building units 104, 106, 108, 110 and 112 may be cuboid in shape. A top surface of the cuboid may form a ceiling of the modular building units 104, 106, 108, 110 and 112. A bottom surface of the cuboid may form a floor of the modular building units 104, 106, 108, 110 and 112. One or more of the side surfaces of the cuboid may be walled. Accordingly, to maintain the cuboid shape, each of the modular building units 104, 106, 108, 110 and 112 may include a skeletal frame including vertical columns and horizontal beams. The vertical columns and the horizontal beams may be formed along the edges of the cuboid shape. In other words, the vertical columns may be formed along the vertical corners of the cuboid and the horizontal beams may be formed along the horizontal corners of the cuboid. As shown in FIG. 1B, the vertical columns of the modular

building units 104, 106, 108, 110 and 112 are indicated by the grey rectangles at the corners of each modular building units 104, 106, 108, 110 and 112. For example, the modular building unit 106 may include vertical columns 114, 116, 118, 120. The modular building unit 108 may include vertical columns 122, 124, 126, 128.

5 **[0014]** According to various embodiments, a modular building connector assembly may be provided at a top of a vertical column of a modular building unit. The modular building connector assembly may connect two adjacent vertical columns from two different modular building units such that the two modular building units are connected sideway. For example, to connect modular building unit 106 to modular
10 building unit 108, the vertical column 114 of modular building unit 106 may be connected to the vertical column 122 of modular building unit 108 via a modular building connector assembly, and the vertical column 120 of modular building unit 106 may be connected to the vertical column 128 of modular building unit 108 via another modular building connector assembly.

15 **[0015]** According to various embodiments, a modular building may include multiple stories of residential apartment stacked on top of each other. Accordingly, other than being connected sideway to form the residential apartment 102 of the modular building, each of the modular building units 104, 106, 108, 110 and 112 may be connected to one or more other modular building units forming another residential
20 apartment on top of the residential apartment 102. The modular building connector assembly at the top of the vertical columns connecting two modular building units sideway may also function to connect with other modular building units stacked on top.

[0016] FIG. 2 shows a perspective view of two skeletal frames 202, 212 of two
25 adjacent modular building units, which may be in the form of, but are not limited to,

PPVC modules, being connected sideways. Each of the two skeletal frames 202, 212 may include four vertical columns. Each pair of vertical columns may further be linked via a pair of horizontal beams, one of the pair of horizontal beams linking the pair of vertical columns at the top and the other of the pair of horizontal beams linking the pair of vertical columns at the bottom. For example, as shown in FIG. 2, horizontal beam 203 may link vertical column 204 to column 206 at the top and horizontal beam 205 may link vertical column 204 to column 206 at the bottom. Further, the first skeletal frame 202 may include two vertical columns 204, 206 arranged adjacent to two vertical columns 214, 216 of the second skeletal frame 212.

The vertical column 206 of the first skeletal frame 202 may be connected to the vertical column 216 of the second skeletal frame 212 via a modular building connector assembly 220 arranged at the top of the vertical column 206 and vertical column 216. Similar, the vertical column 204 may be connected to the vertical column 214 in the same manner. In this arrangement, the first skeletal frame 202 may be connected to the second skeletal frame 212 such that a first modular building unit embodying the first skeletal frame 202 may be connected to a second modular building unit embodying the second skeletal frame 212.

[0017] FIGs. 3A to 3I show a schematic diagram of a method for connecting modular building units, which may be in the form of, but are not limited to, PPVC modules, according to various embodiments.

[0018] FIG. 3A shows a cross-section of a top corner portion 304 of a bottom modular building unit (in other words a first modular building unit) 302 connected sideways to a top corner portion of another bottom modular building unit. The top corner portion 304 of the bottom modular building unit 302 may include a horizontal beam 303 and a vertical column 305 forming a corner. The top corner portion 304 of

the bottom modular building unit 302 may further include a plate 306 embedded into a top surface 307 of the vertical column 305 of the bottom modular building unit 302. The plate 306 may be a strengthened plate. According to various embodiments, the vertical column 305 may be made of concrete. The concrete vertical column 305 may be casted with the plate 306 embedded into the top surface 307 of the vertical column 305 during casting. A top surface 318 of the plate 306 may protrude from the top surface 307 of the vertical column 305 such that the top surface 318 of the plate 306 may form a step from the top surface 307 of the vertical column 305. This may allow the plate 306 to bear axial load acting vertically downward on the vertical column 305. The bottom modular building unit 302 may further include an elongated hollow tubular cavity 308. The elongated hollow tubular cavity 308 may run vertically through the vertical column 305 of the bottom modular building unit 302 along a height of the vertical column 305. The elongated hollow tubular cavity 308 may have a profile in which the end diameter of the elongated hollow tubular cavity 308 at the top corner portion 304 of the bottom modular building unit 302 may be wider than the diameter of the elongated hollow tubular cavity 308 running along the mid section of the vertical column 305. The plate 306 may include a through-hole 310 which may be aligned with an opening 309 of the elongated hollow tubular cavity 308 at the top corner portion 304 of the bottom modular building unit 302.

[0019] As shown, an elongated rod (in other words a first rod) 312 may be inserted into the elongated hollow tubular cavity 308 of the bottom modular unit 302 via the through-hole 310 of the plate 306 and through the opening 309 into the elongated hollow tubular cavity 308. The elongated rod 312 may be a long bolt or other similar element. According to various embodiments, the assembling of modular building units to build an assembled modular building may start with the installation of the

elongated rod 312 on or into a foundation for a building such as a concrete slab forming a foundation level. The bottom modular unit 302 may then be placed on the foundation with the elongated rod 312 inserted through the elongated hollow tubular cavity 308 of the bottom modular building unit 302. The elongated rod 312 may act as
5 a guide to position the bottom modular building unit 302 at the intended/predetermined position within the desired assembled modular building. According to various embodiments, the assembling of modular building units to build an assembled modular building may start with placing the bottom modular unit 302 on the foundation. The elongated rod 312 may then be inserted through the elongated
10 hollow tubular cavity 308 of the bottom modular building unit 302. The elongated hollow tubular cavity 308 may act as a guide for the elongated rod 312 to slide into position.

[0020] FIG. 3B shows a retainer 314 being connected directly to the elongated rod 312 within the bottom modular building unit 302. According to various embodiments,
15 the retainer 314 may be for engaging with the elongated rod 312. For example, the retainer 314 may be a nut screwed onto the elongated rod 312 such that the nut engages the elongated rod 312. The retainer 314 may also be a pin inserted through a hole extending perpendicularly across the elongated rod 312 such that the pin engages with the elongated rod 312. The retainer 314 may also be welded to the elongated rod
20 312 such that the retainer 314 engages with the elongated rod 312. According to various embodiments, the retainer 314 may be formed integrally with the elongated rod 312. The retainer 314 may be engaged or formed integrally with the elongated rod 312 at a predetermined position of the elongated rod 312 within the through-hole 310 and/or the elongated hollow tubular cavity 308. The retainer 314 may be a restraining
25 nut. The restraining nut may be screwed onto the elongated rod 312, for example

when the elongated rod 312 is a long bolt, such that the restraining nut may be fixed at a predetermined position on the elongated rod 312.

[0021] In FIG. 3C, a plurality of shim plates 316 is shown to be laid on the top surface 318 of the plate 306 of the vertical column 305 of the bottom modular building unit 302. In other words, a shim 316 may be disposed on a top surface 307 of the vertical column 305 of the bottom modular unit 302. The shim or shim plates 316 may provide levelling function. The levelling may be preferred to ensure height consistency throughout each level of the assembled building because a height of the each of the modular building units 302 forming each level of the assembled building may vary due to manufacturing or constructional imperfections.

[0022] In FIG. 3D, a link plate 320 may be placed on the top surface 307 of the vertical column 305 of the bottom modular building unit 302. The link plate 320 may be placed such that the elongated rod 312 may protrude through a hole 322 in the link plate 320 and a bottom surface (in other words a first stopper surface) 324 of the link plate 320 may be arranged to abut or sit on the top surface 307 of the vertical column 305 of the bottom modular building unit 302. The bottom surface 324 of the link plate 320 may be received on the top surface 318 of the plate 306 embedded in the top surface 307 of the vertical column 305 of the bottom modular building unit 302. A top surface (in other words a second stopper surface) 326 of the link plate 320 may be adapted to receive or abut a bottom surface of a top modular building unit (in other words a second modular building unit). Thus, the link plate 320 may have a first and second stopper surfaces for abutting the first and second modular building units respectively.

[0023] According to various embodiments, the link plate 320 may be configured to co-operate with the first and second modular building units to set the first and second

modular building units in a predetermined alignment of the overall intended assembled modular building. Accordingly, the link plate 320 may function to align and position the first and second modular building units relative to one another. The link plate 320 may also function to restrain relative movement between the first and second modular building units after the first and second modular building units have been installed in the predetermined alignment of the overall intended assembled building. In other words, the link plate 320 may restrain the relative movement of the first and second modular building units in three orthogonal directions, namely a vertical direction and two perpendicular horizontal directions.

10 **[0024]** As shown in FIG. 3D, the link plate 320 may include a first protruding portion 328 on the bottom surface 324 of the link plate 320. The top surface 318 of the plate 306 on the vertical column 305 of the bottom modular unit 302 may include a corresponding first recessed portion 330. The link plate 320 may be placed on the top surface 307 of the top corner 304 of the bottom modular unit 302 such that the first protruding portion 328 of the bottom surface 324 of the link plate 320 may be received in the corresponding first recessed portion 330 of the top surface 318 of the plate 306 in the top surface 307 of the bottom modular unit 302. In this manner, the link plate 320 may co-operate with the bottom modular unit 302 according to the predetermined alignment of the overall intended assembled modular building.

20 **[0025]** According to various embodiments, a dimension of the first protruding portion 328 of the link plate 320 may be smaller than a dimension of the corresponding first recessed portion 330 of the bottom modular unit 302. In other words, the first recessed portion 330 of the bottom modular unit 302 may be larger than the first protruding portion 328 of the link plate 320. This may allow the link plate 320 to be aligned with the predetermined alignment of the desired assembled

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modular building while accommodating any misfit due to manufacturing or constructional imperfection of each of the modular building units. During the placement of the link plate 320, the link plate 320 may be aligned by taking reference from the predetermined alignment of the overall intended assembled modular building.

[0026] In FIG. 3E, a coupler element 332 may be inserted in the hole 322 in the link plate 320 to engage the link plate 320 to the elongated rod 312. The coupler element 332 may have an engagement portion 334 for engaging with the link plate 320. The coupler element 332 may be adapted to couple to the elongated rod 312 with the elongated rod 312 inserted through a through-hole of the coupler element 332 while the link plate 320 engages with the engaging portion 334 of the coupler element 332. The engaging portion 334 of the coupler element 332 may be a peripheral surface of the coupler element 332. According to various embodiments, the hole 322 in the link plate 320 may have internal screw threads and the engaging portion 334 of the coupler element 332 may have corresponding external screw threads. Thus, the coupler element 332 may engage with the link plate 120 by screwing the coupler element 332 into the hole 122 of the link plate 120. According to various embodiments, the link plate 332 may be welded to the coupler element 332 for engaging with the engagement portion 334 of the coupler element 332.

[0027] The coupler element 332 may further abut the retainer 314. In this arrangement, the retainer 314 may restrain against downward movement of the coupler element 332. In this arrangement, the link plate 320, which is in engagement with the coupler element 332, may be restrained from moving downward by the retainer 314. Advantageously, the provision of the coupler element 332 and the link plate 320 may allow ease of assembly from the top while still allowing the retainer

314 to provide the necessary restrain to prevent downward movement of the coupler element 332 and the link plate 320. The arrangement of the coupler element 332 and the link plate 320 preferably avoids the need of providing access points in the walls of the bottom modular building unit 302 for accessing the retainer 314 to tighten the
5 retainer 314 for restraining the downward movement of the link plate 320.

[0028] FIG. 3F shows a fastener 336 connected directly to the elongated rod 312. In other words, the fastener 336 is for engaging with the elongated rod 312. As shown, the retainer 314 and the fastener 336 may be adapted to sandwich the coupler element 332 to fasten the coupler element 332 to the elongated rod 312 such that the link plate
10 320, which is in engagement with the coupler element 332, may be fixed to the elongated rod 312. In other words, the coupler element 332 may be configured to be coupled to the elongated rod 312 in a manner so as to be restrained against movement along the elongated rod 312 by way of the retainer 314 and the fastener 336. Accordingly, the link plate 320 may be restrainable against movement along the
15 elongated rod 312 by way of engagement with the coupler element 332.

[0029] The fastener 336 may be a restraining nut. The restraining nut may be screwed onto the elongated rod 312, for example when the elongated rod 312 is a long bolt, such that the restraining nut may be tightened against the coupler element 332 from a top end of the elongated rod 312. The fastener 336 may restrain upward
20 movement of the coupler element 332 such that the link plate 320, which is in engagement with the coupler element 332, may also be restrained from moving upward.

[0030] As shown in FIGs. 3D, 3E and 3F, a gap 338 may be formed between the top surface 318 of the plate 306 on the vertical column 305 of the bottom modular
25 building unit 302 and the bottom surface 324 of the link plate 320. The gap 338 may

be formed between the protruding portion 328 of the bottom surface 324 of the link plate 320 and the corresponding recessed portion 330 of the top surface 318 of the plate 306 in the top surface 307 of vertical column 305 of the bottom modular unit 302. The gap 338 may be formed due to the difference in dimension between the protruding portion 328 and the recessed portion 330. The gap 338 may also be formed due to the shim 316 disposed between the bottom surface 324 of the link plate 320 and the top surface 318 of the plate 306 on the vertical column 305 of the bottom modular building unit 302. The shim 316 may prop the link plate 320 from the top surface 307 of vertical column 305 of the bottom modular unit 302 to create the gap 338. The shim 316 may be configured to level the link plate 320 to a predetermined height according to the predetermined alignment of the overall intended assembled modular building.

[0031] In FIG. 3G, the gap 338 may be filled by a layer of grout 340. A conduit 339 may be provided in the link plate 320 such that the conduit 339 may provide a passage from the top surface 326 of the link plate 320, through the link plate 320 and to the bottom surface 324 of the link plate 320. The conduit 339 may lead to the gap 338. The grout 340 may be flowed through the conduit 339 to fill the gap 338. The filling of the grout 340 through the conduit 339 may be performed under pressurized condition. The grout 340 may be of high strength and high resilience for facilitating axial load bearing between the link plate 320 and the bottom modular unit 302. The grout 340 may prevent relative movement between the bottom modular unit 302 and the link plate 320. Accordingly, the layer of grout 340 may be configured to restrain relative movement between the link plate 320 and the bottom modular unit 302. According to various embodiments, the layer of grout 340 provided in the gap 338 between the protruding portion 328 of the link plate 320 and the recessed portion 330

of the bottom modular unit 302 may restrain relative horizontal movement of the bottom modular unit 302.

[0032] To assemble a top modular building unit 344 (in other words a second modular building unit) on the bottom modular building unit 302, a second elongated rod 342 (in other words a second rod) may be connected to the fastener 336 as shown in FIG. 3H. The fastener 336 may function to connect the second elongated rod 342 to the first elongated rod 312 such that the second elongated rod 342 may function to extend the first elongated rod 312 vertically. The second elongated rod 342 may be a long bolt. When the fastener 336 is a nut, the long bolt may be screwed into the fastener 336 to about the top of the first elongated rod 312. According to various embodiments, the second elongated rod 342 may be integrally formed with the fastener 336 such that when the fastener 336 is fastened to the first elongated rod 312, the second elongated rod would have been connected to the first elongated rod 312.

[0033] As shown in FIG. 3I, a top modular building unit 352 may then be placed on the bottom modular building unit 302 with the second elongated rod 342 inserted through an elongated hollow tubular cavity 346 of the top modular building unit 352. The second elongated rod 342 may act as a guide to position the top modular building unit 352 on the bottom modular building unit 302 at the intended position within the desired assembled modular building. As shown in FIG. 3I, the top modular building unit 352 may include a bottom plate 350 embedded in a bottom corner of the top modular building unit 352. The bottom plate 350 may be a strengthened plate. The bottom plate 350 may include a second recessed portion 348. The link plate 320 may include a corresponding second protruding portion 344 on the top surface (in other words the second stopper surface) 326 on the link plate 320. The second protruding portion 344 may be received in the second recessed portion 348 of the top modular

building unit 352. Thus, the top surface 326 of the link plate 320 may include a second protruding portion 344 receivable in a corresponding second recessed portion 348 of the top modular building unit 352. The link plate 320 may be configured to couple with two or more coupler elements 332 for sideways connection of the bottom and/or top modular building units 302, 352 (in other words the first and/or second modular building units) to one or more other modular building units (not shown) in various embodiments, as will be described below with reference to FIGs. 5A and 5B. According to various embodiments, the link plate 320 may also be strengthened to enhanced resistance against bending and/or torsional distortion. For example, additional material may be provided in selected area(s) on or in the link plate 320 such that the link plate 320 may include areas of thicker material, such as in the form of ridges or stiffeners.

[0034] According to various embodiments, the first protruding portion 328 of the bottom surface 324 of the link plate 320 and the second protruding portion 344 of the top surface 326 of the link plate 320 may be configured to set the bottom and top modular building units 302, 352 in the predetermined alignment of the overall intended assembled modular building. The first protruding portion 328 and the second protruding portion 344 of the link plate 320 may define an alignment and a position in which the bottom and top modular building units 302, 352 are to be set respective to each other.

[0035] As shown in FIG. 3I, the link plate 320 may be configured to couple with the first coupler element 332 and a second coupler element 382 for sideways connection of the first top and first bottom modular building units 352, 302 to a second top and second bottom modular building units 351, 301. The second top and second bottom

modular building units 351, 301 may be connected to each other in a similar way as the connection between the first top and first bottom modular building units 352, 302.

[0036] In the arrangement shown in FIG. 3I, advantageously, in the event that the structural integrity of the first bottom modular building unit 302, such as the vertical column 305 of the first bottom modular building unit 302, is compromised, the first top modular building unit 352 may be prevented from collapsing downward by the link plate 320. This is because the second top and second bottom modular building units 351, 301 connected to the link plate 320 may still hold the link plate 320 in place. Thus, the link plate 320 may hold the first top modular building unit 352 and prevent the first top modular building unit 352 from collapsing.

[0037] Further, in the event that the structural integrity of the first bottom and the second bottom modular building units 302, 301, such as the vertical column 305 of the first bottom modular building unit 302 and the vertical column 355 of the second bottom modular building unit 301, is compromised, both the first top and the second top modular building units 352, 351 may be prevented from collapsing downward by the link plate 320. This is because at a top (not shown) of the first top and the second top modular building units 352, 352, another modular building connector assembly similar to the one as shown in FIG. 3I may connect the first top and the second top modular building units 352, 351 in a sideways connection. Elongated rods of the modular building connector assembly at the top of the first top and the second top modular building units 352, 351 may be connected to the fasteners 336, 386 of the modular building connector assembly at the bottom of the first top and the second top modular building units 352, 351. The fasteners 336, 386, together with the retainers 314, 364 of the modular building connector assembly at the bottom of the first top and the second top modular building units 352, 351, may restrain the coupler elements

332, 382 of the modular building connector assembly at the bottom of the first top and the second top modular building units 352, 351 from downward movement. Accordingly, the link plate 320 of the modular building connector assembly at the bottom of the first top and the second top modular building units 352, 351, which engages with the coupler element 332, 382 may be restrained against downward movement. Thus, the link plate 320 abutting the bottom of the first top and the second top modular building units 352, 351 may hold the first top and the second top modular building unit 352, 351 in place and prevent the first top and the second top modular building unit 352, 351 from collapsing.

[0038] The arrangement in FIG. 3I may possibly introduce new flexibility for modular building construction, for example by allowing the owner of the modular building to have the option of post-construction removal of vertical columns, such as one or more of vertical columns 305, 355 of the first bottom and second bottom modular building units 302, 301, to reduce the number of columns within a space after the modular building is completed. Currently, it is typically not possible to remove any vertical columns of a completed modular building built using conventional methods. .

[0039] In FIG. 3F, a modular building connector assembly 300 is shown, in an assembled state. It will be appreciated that the parts of the modular building connector assembly 300 may be provided in an un-assembled state, e.g. for assembly during the construction of a modular building structure such as a building. The modular building connector assembly 300 may include a retainer 314. The modular building connector assembly 300 may further include a fastener 336. The modular building connector assembly 300 may further include a link plate 320 having first and second stopper surfaces 324, 326 for abutting first and second modular building units 302, 352

respectively. The modular building connector assembly 300 may further include a coupler element 332 having an engagement portion 334 for engaging with the link plate 320. The coupling element 332 may be configured to be coupled to the first rod 312 in a manner so as to be restrained against movement along the first rod 312 by way of the retainer 314 and fastener 336. The link plate 320 may be restrainable against movement along the first rod 312 by way of engagement with the coupler element 332.

[0040] According to various embodiments, the retainer 314 may be configured to engage with or is formed integrally with the first rod 312 for restraining against movement of the coupler element 332 along the first rod 312.

[0041] According to various embodiments, the fastener 336 may be configured to engage with the first rod 312 for restraining against movement of the coupler element 332 along the first rod 312.

[0042] According to various embodiments, the link plate 320 may be configured to co-operate with the first and second modular building units 302, 352 to set the first and second modular building units 302, 352 in a predetermined alignment.

[0043] According to various embodiments, the first stopper surface 324 of the link plate 320 may include a first protruding portion 328 receivable in a corresponding first recessed portion 330 of the first modular building unit 302.

[0044] According to various embodiments, the second stopper surface 326 of the link plate 320 may include a second protruding portion 344 receivable in a corresponding second recessed portion 348 of the second modular building unit 352.

[0045] According to various embodiments, the first protruding portion 328 of the first stopper surface 324 of the link plate 320 and the second protruding portion 344

of the second stopper surface 326 of the link plate 320 are configured to set the first and second modular building units 302, 352 in the predetermined alignment.

[0046] According to various embodiments, the first and/or second recessed portions 330, 348 are formed in respective plates on or integrated with the first and second modular building units 302, 352.

[0047] According to various embodiments, the modular building connector assembly 300 may further include a shim plate 316 for disposing in a gap 338 between the first stopper surface 324 of the link plate 320 and the first modular building unit 302.

[0048] According to various embodiments, the shim plate 316 may be configured to level the link plate 320 to a predetermined height.

[0049] According to various embodiments, the modular building connector assembly 300 may further include a layer of grout 340 for filling a gap 338 between the first stopper surface of the link plate 320 and the first modular building unit 302 for facilitating axial load bearing from the link plate to the first modular building unit 302.

[0050] According to various embodiments, the layer of grout 340 may be configured to restrain relative movement between the link plate 320 and the first modular building unit 302.

[0051] According to various embodiments, the fastener 336 may be further configured to connect a second rod 342 to the first rod 312.

[0052] According to various embodiments, a second rod 342 may be integrally formed with the fastener 336.

[0053] According to various embodiments, the second rod 342 may be received in the second modular building unit 352.

[0054] According to various embodiments, the retainer 314 may include a nut.

[0055] According to various embodiments, the fastener 336 may include a nut.

[0056] According to various embodiments, the link plate 320 may be configured to couple with two or more coupler elements 332 for sideways connection of the first
5 and/or second modular building units to one or more other modular building units.

[0057] According to various embodiments, the link plate 320 may include one or more areas of increased thickness compared to a remainder of the link plate for strengthening the link plate 320.

[0058] FIG. 4 shows a diagram illustrating a method 400 for connecting modular
10 building units. At step 402, a retainer is provided. At step 404, a fastener is provided. At step 406, a link plate having a first and second stopper surfaces for abutting first and second modular building units respectively is provided. At step 408, an engagement portion of a coupler element is engaged with the link plate. At step 410, the coupling element is coupled to the first rod in a manner so as to be restrained
15 against movement along the first rod by way of the retainer and the fastener. At step 212, the link plate is restrained against movement along the first rod by way of engagement with the coupler element.

[0059] According to various embodiments, providing the retainer may include engaging the retainer with or forming the retainer integrally with the first rod for
20 restraining against movement of the coupler element along the first rod.

[0060] According to various embodiments, providing the fastener may include engaging the fastener with the first rod for restraining against movement of the coupler element along the first rod.

[0061] According to various embodiments, the link plate may be for co-operating with the first and second modular building units to set the first and second modular building units in a predetermined alignment.

[0062] According to various embodiments, providing the link plate may include
5 inserting a first protruding portion of the first stopper surface of the link plate into a corresponding first recessed portion of the first modular building unit.

[0063] According to various embodiments, abutting the second modular building unit may include positioning a corresponding second recessed portion of the second modular building unit so that a second protruding portion of the second stopper
10 surface of the link plate may be received in the corresponding second recessed portion of the second modular building unit.

[0064] According to various embodiments, the method 400 may further include connecting a second rod to the fastener.

[0065] According to various embodiments, the method 400 may further include
15 placing the second modular building unit on the second stopper surface of the link plate with the second rod inserted in the second modular building unit.

[0066] According to various embodiments, the method 400 may further include providing a shim plate in a gap between the first stopper surface of the link plate and the first modular building unit.

[0067] According to various embodiments, the method 400 may further include
20 filling a gap between the first stopper surface of the link plate and the first modular building unit with a layer of grout for facilitating axial load bearing from the link plate to the first modular building unit.

[0068] According to various embodiments, the method 400 may further include
25 coupling the link plate with two or more coupler elements for sideways connecting of

the first and/or second modular building units to one or more other modular building units.

[0069] According to various embodiments, the link plate may be provided with one or more areas of increased thickness compared to a remainder of the link plate for strengthening the link plate

[0070] FIG. 5A and 5B show exploded or un-assembled views of a modular building connector assembly 500, and illustrates the sideways connection method between a first modular building unit 502 and a second modular building unit 552 at the same height level. In other words, the link plate 520 is configured to couple with two or more coupler elements 532, 582 for sideways connection of the first modular building unit 502 to the second modular building unit 552. As shown in FIG. 5, the modular building connector assembly 500 includes a link plate 520. The link plate 520 may be rectangular shape and may include a first hole 522 and a second hole 572. The first hole 522 and the second hole 572 may be adapted to receive a first coupler element 532 and a second coupler element 582 respectively, such that the link plate 520 may be engaged with an engagement portion 534 of the first coupler element 532 and an engagement portion 584 of the second coupler element 582. As shown, the first hole 522 and the second hole 572 of the link plate 520 may include internal screw thread. The engagement portion 534 of the first coupler element 532 and the engagement portion 584 of the second coupler element 582 may include external screw thread. The first coupler element 532 and the second coupler element 582 may be coupled to the link plate 520 by being screwed into the respective first hole 522 and the second hole 572.

[0071] The first coupler element 532 may further be adapted to be coupled to a first rod 512 receivable in the first modular building unit 502. The second coupler element

582 may further be adapted to be coupled to a third rod 562 receivable in the second modular building unit 552. In this manner, the link plate 520 may function to connect the first modular building component 502 to the second building unit 552 in a side-to-side arrangement or sideways connection. The link plate 520 may be configured to
5 restrain relative lateral movements between the first modular building unit 502 and the second modular building unit 552. According to various embodiments, the link plate 520 may include three or four holes for coupling with three or four coupler elements such that the link plate 520 may be further adapted to connect three or four modular building units in a corner-to-corner arrangement or connection. According to
10 various embodiments, the link plate 520 may also be strengthened to enhanced resistance against bending and/or torsional distortion. For example, additional material may be provided in selected area(s) on or in the link plate 520 such that the link plate 520 may include areas of thicker material, such as in the form of ridges or stiffeners.

15 **[0072]** In FIGs. 5A and 5B, the first coupler element 532 may be coupled to the first rod 512 with the first rod 512 inserted through a through-hole 533 of the first coupler element 532. A first retainer 514 and a first fastener 536 may be connected directly to the first rod 512. The first retainer 514 and the first fastener 536 may be adapted to sandwich the first coupler element 532 such that the first coupler element 532 may be
20 fastened to the first rod 512 and may be restrained against movement along the first rod 512 by way of the first retainer 514 and the first fastener 536. Accordingly, the link plate 520, which is engaged to the engagement portion 534 of the first coupler element 532, may be fixed onto the first rod 512 such that the link plate 520 may be restrainable against movement along the first rod 512 by way of engagement with the
25 first coupler element 532.

[0073] The second coupler element 582 may be coupled to the third rod 562 with the third rod 562 inserted through a through-hole 583 of the second coupler element 582. A second retainer 564 and a second fastener 586 may be connected directly to the third rod 562. The second retainer 564 and the second fastener 586 may be adapted to sandwich the second coupler element 582 such that the second coupler element 582 may be fastened to the third rod 562 and may be restrained against movement along the third rod 562 by way of the second retainer 564 and second fastener 586. Accordingly, the link plate 520 which is coupled to the engagement portion 584 of the second coupler element 582 may be fixed onto the third rod 562 such that the link plate 520 may be restrainable against movement along the third rod 562 by way of engagement with the second coupler element 582.

[0074] With the first rod 512 received in the vertical column 505 (FIG. 5B) of the first modular building unit 502 and the third rod 562 received in the vertical column 555 (FIG. 5B) of the second modular building unit 552, a portion of the bottom surface 524 of the link plate 520 may be arranged to sit or abut on a top surface 518 of the plate 506 embedded in a top surface 507 of the vertical column 505 of the first modular building unit 502 and another portion of the bottom surface 524 of the link plate 520 may be arranged to sit or abut on a top surface 518 of the plate 556 embedded in a top surface 557 of the vertical column 555 of the second modular building unit 552. The bottom surface 524 of the link plate 520 may include a first protruding portion 528 and a second protruding portion 578. The first protruding portion 528 may encircle the first hole 522 and the second protruding portion 578 may encircle the second hole 572. The plate 506 of the first modular building unit 502 may include a recessed portion 530 on the top surface 518 of the plate 506. The plate 556 of the second modular building unit 552 may include a recessed portion 580 on the

top surface 568 of the plate 556. The first protruding portion 528 of the link plate 520 may be received in the recessed portion 530 of the plate 506 of the first modular building unit 502. The second protruding portion 578 of the link plate 520 may be received in the recessed portion 580 of the plate 556 of the second modular building unit 552.

[0075] According to various embodiments, a height of the first modular building unit 502 may differ slightly from a height of the second modular building unit 552. The difference may be due to manufacturing or constructional imperfection. To ensure that the link plate 520 may be levelled and may sit or abut on both the first modular building unit 502 and the second modular building unit 552, shim plates 516 may be laid on the first modular building unit 502 and shim plates 566 may be laid on the second modular building unit 552. The shim plates 516, 566 may function to level the difference in height between the first modular building unit 502 and the second modular building unit 552 such that the link plate 520 may be levelled and may be connected to both the first modular building unit 502 and the second modular building unit 552. The number and configuration of the shim plates 516, 566 to be placed on the first modular building unit 502 and the second modular building unit 552 may be such that the link plate 520 may be at a desired predetermined height.

[0076] With the modular building connector assembly 500 assembled to connect the first modular building unit 502 to the second modular building unit 552 in a side-to-side arrangement or sideways connection, a second rod 542 may be connected to the first fastener 536 such that the second rod 542 may be an extension of the first rod 512 in a vertically upward direction. In other words, the second fastener 536 may connect a top end of the first rod 512 to a bottom end of the second rod 542. Similarly, a fourth rod 592 may be connected to the second fastener 586 such that the

fourth rod 592 may be an extension of the third rod 562 in a vertically upward direction. In other words, the fourth fastener 586 may connect a top end of the third rod 562 to a bottom end of the fourth rod 592. With the second rod 542 in place, a third modular building unit may be received on a portion of a top surface 526 of the link plate 520 such that the second rod 542 is received in the third modular building unit and the third modular building unit is on top of the first modular building unit 502. Similarly, with the fourth rod 592 in place, a fourth modular building unit may be received on another portion of the top surface 526 of the link plate 520 such that the fourth rod 592 is received in the fourth modular building unit and the fourth modular building unit is on top of the second modular building unit 552. Accordingly, the modular building connector assembly 500 may function to connect four modular building units such that a first pair of the modular building units is connected sideways and a second pair of the modular building units is connected on top of the first pair of the modular building units.

[0077] Embodiments of the modular building connector assembly and the method for connecting modular building units as described above may provide restraint of movements of the assembled modular building units in three orthogonal directions, namely the vertical direction and two perpendicular horizontal directions. Embodiments may restrain the movements of the modular building unit in both upward and downward directions along the vertical direction. Embodiments may also accommodate any dimensional imperfection of the modular building units in both the perpendicular horizontal directions. Embodiments may also provide an ease to assembly.

[0078] The materials and dimensions of various components of a modular building unit according to various embodiments are described in the following, by way of

example only. Each modular building unit may have a dimension of approximately 3 to 15 m in length, 1.5 – 4 m in width and 1.5 to 4 m in height. The vertical column and the horizontal beam of the modular building unit may be made of any one or more of a group consisting of concrete, steel, aluminum, timber, etc. The plate on a top surface of the vertical column may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc.

[0079] The materials and dimensions of various components of a modular building connector assembly according to various embodiments are described in the following, by way of example only. The elongated rod of the modular building connector assembly may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc. The elongated rod may have a diameter of approximately 18 to 40 mm. The retainer of the modular building connector assembly may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc. The link plate of the modular building connector assembly may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc. The link plate may have a thickness of approximately 5 to 50 mm, a length of approximately 150 to 900 mm, and a width of approximately 150 to 900 mm. The coupler element of the modular building connector assembly may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc. The layer of grout may be made of one or more of a group consisting of cement, epoxy resin, sand, grit, polymers, fibres, surfactant, dispersant, etc. The shim plates may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc. The fastener may be made of one or more of a group consisting of steel, aluminum, fibreglass, etc.

[0080] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art

that various changes in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A modular building connector assembly comprising:
 - a retainer;
 - a fastener;
 - 5 a link plate having first and second stopper surfaces for abutting first and second modular building units respectively;
 - a coupler element having an engagement portion for engaging with the link plate;
 - wherein the coupler element is configured to be coupled to a first rod in a
 - 10 manner so as to be restrained against movement along the first rod by way of the retainer and the fastener; and
 - wherein the link plate is restrainable against movement along the first rod by way of engagement with the coupler element.
- 15 2. The modular building connector assembly as claimed in claim 1, wherein the retainer is configured to engage with or is formed integrally with the first rod for restraining against movement of the coupler element along the first rod.
3. The modular building connector assembly as claimed in claim 1 or 2, wherein
- 20 the fastener is configured to engage with the first rod for restraining against movement of the coupler element along the first rod.
4. The modular building connector assembly as claimed in any of claims 1 to 3, wherein the link plate is configured to co-operate with the first and second modular

building units to set the first and second modular building units in a predetermined alignment.

5. The modular building connector assembly as claimed in claim 4, wherein the
5 first stopper surface of the link plate comprises a first protruding portion receivable in a corresponding first recessed portion of the first modular building unit.

6. The modular building connector assembly as claimed in claim 4 or 5, wherein
the second stopper surface of the link plate comprises a second protruding portion
10 receivable in a corresponding second recessed portion of the second modular building unit.

7. The modular building connector assembly as claimed in claim 6, wherein the
first protruding portion of the first stopper surface of the link plate and the second
15 protruding portion of the second stopper surface of the link plate are configured to set the first and second modular building units in the predetermined alignment.

8. The modular building connector assembly as claimed in claims 6 or 7, wherein
the first and/or second recessed portions are formed in respective plates on or
20 integrated with the first and second modular building units.

9. The modular building connector assembly as claimed in any of claims 1 to 8,
further comprising a shim plate for disposing in a gap between the first stopper
surface of the link plate and the first modular building unit.

10. The modular building connector assembly as claimed in claim 9, wherein the shim plate is configured to level the link plate to a predetermined height.
11. The modular building connector assembly as claimed in any one of claims 1 to 10, further comprising a layer of grout for filling a gap between the first stopper surface of the link plate and the first modular building unit for facilitating axial load bearing from the link plate to the first modular building unit.
12. The modular building connector assembly as claimed in claim 11, wherein the layer of grout is configured to restrain relative movement between the link plate and the first modular building unit.
13. The modular building connector assembly as claimed in any of claims 1 to 12, wherein the fastener is further configured to connect a second rod to the first rod.
14. The modular building connector assembly as claimed in any of claims 1 to 12, wherein a second rod is integrally formed with the fastener.
15. The modular building connector assembly as claimed in claim 13 or 14, wherein the second rod is received in the second modular building unit.
16. The modular building connector assembly as claimed in any of claims 1 to 15, wherein the retainer comprises a nut.

17. The modular building connector assembly as claimed in any of claims 1 to 16, wherein the fastener comprises a nut.

18. The modular building connector assembly as claimed in any of claims 1 to 17,
5 wherein the link plate is configured to couple with two or more coupler elements for sideways connection of the first and/or second modular building units to one or more other modular building units.

19. The modular building connector assembly as claimed in any of claims 1 to 18,
10 wherein the link plate comprises one or more areas of increased thickness compared to a remainder of the link plate for strengthening the link plate.

20. A method for connecting modular building components, the method comprising:

15 providing a retainer;
providing a fastener;
providing a link plate having first and second stopper surfaces for abutting first and second modular building units respectively;
engaging an engagement portion of a coupler element with the link plate;
20 coupling the coupling element to a first rod in a manner so as to be restrained against movement along the first rod by way of the retainer and the fastener, and
restraining the link plate against movement along the first rod by way of engagement with the coupler element.

21. The method as claimed in claim 20, wherein providing the retainer comprises engaging the retainer with or forming the retainer integrally with the first rod for restraining against movement of the coupler element along the first rod.

5 22. The method as claimed in claim 20 or 21, wherein providing the fastener comprises engaging the fastener with the first rod for restraining against movement of the coupler element along the first rod.

23. The method as claimed in any of claims 20 to 21, wherein the link plate is for
10 co-operating with the first and second modular building units to set the first and second modular building units in a predetermined alignment.

24. The method as claimed in claim 23, wherein providing the link plate comprises inserting a first protruding portion of the first stopper surface of the link
15 plate into a corresponding first recessed portion of the first modular building unit.

25. The method as claimed in claim 24, wherein abutting the second modular building unit comprises positioning a corresponding second recessed portion of the second modular building unit so that a second protruding portion of the second
20 stopper surface of the link plate is received in a corresponding second recessed portion of the second modular building unit.

26. The method as claimed in any of claims 20 to 25, further comprising connecting a second rod to the fastener.

27. The method as claimed in claim 26, further comprising placing the second modular building unit on the second stopper surface of the link plate with the second rod inserted in the second modular building unit.

5 28. The method as claimed in any of claims 20 to 27, further comprising providing a shim plate in a gap between the first stopper surface of the link plate and the first modular building unit.

29. The method as claimed in any of claims 20 to 28, further comprising filling a
10 gap between the first stopper surface of the link plate and the first modular building unit with a layer of grout for facilitating axial load bearing from the link plate to the first modular building unit.

30. The method as claimed in any of claims 20 to 29, further comprising coupling
15 the link plate with two or more coupler elements for sideways connecting of the first and/or second modular building units to one or more other modular building units.

31. The method as claimed in any of claims 20 to 30, wherein the link plate is provided with one or more areas of increased thickness compared to a remainder of
20 the link plate for strengthening the link plate.