

AN IMPROVED PREFABRICATED BUILDING MODULE

This application relates to a building module.

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A prefabricated prefinished construction system often take into consideration aspects of quality, productivity, sustainability, design for manufacturing and assembly (DFMA) as well as design for safety.

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The prefabricated prefinished construction system can be developed by improving its productivity. This can be accomplished by increasing knowledge and experience through overseas study trips, seminars, and workshops.

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The prefabricated prefinished construction system can be used to construct different types of buildings, including residences. Due to higher expectations with regard to the quality of residential buildings, better finishing, as well as more

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mechanical and electrical services are required. This translates to more stringent requirements for prefabricated prefinished construction systems, which are used to construct such buildings.

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These stringent requirements can be satisfied by applying the knowledge and experience gained through the above-mentioned overseas study trips, seminars, and workshops.

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Adoption of the prefabricated prefinished construction system decreases the number of work hours, which are required on-site.

The prefabricated prefinished construction system includes multiple prefabricated building modules, wherein each building

module includes key structural elements with a facade. The structural elements include steel section columns and steel channel beams for supporting a reinforced concrete slab. The facade can be constructed from a material, which is specified
5 by an end user, such as concrete base panels, ductile concrete, aluminium panels, or curtain walls.

A few methods of connecting the prefabricated building modules to each other exist. One easy to use and low cost method,
10 which met building requirements, uses shear and tension connectors, wherein the tension connectors are attached to external surfaces of the building modules.

It is an objective of the application to provide an improved
15 prefabricated building module.

The application provides an improved building module for a building. The building refers to a structure with walls and a roof.

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Each building module has a shape of a mainly rectangular block with four upper corners and four lower corners. The shape of the rectangular block allows easy stacking of the building modules to form a building. The building module can have
25 walls, a floor and a ceiling. One or more than one different building modules can be used to form a building unit, such as an office or a residential unit. The building modules are often constructed away from a work site of the building and are later transported to the work site.

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The building module includes at least one metal frame and a floor concrete slab.

The metal frame refers to a structure for providing mechanical strength to the building module. The metal frame often includes metal columns and metal beams, which are joined together to provide the metal frame.

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In detail, the metal frame includes a metal member, a floor tension plate, and a ceiling tension plate.

The metal member includes an upper part and a lower part,
10 wherein the lower part is positioned at a lower corner or in the vicinity of the lower corner of the building module. The upper part is positioned at an upper corner or in the vicinity of the upper corner of the building module.

15 The floor tension plate includes at least one first building module fastener opening and a first building module connector protrusion alignment hole, wherein the floor tension plate is positioned horizontally and an upper surface of the floor tension plate is fixed to the lower part of the metal member.

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Similarly, the ceiling tension plate includes at least one second building module fastener opening and a second building module connector protrusion alignment hole, wherein the ceiling tension plate is positioned horizontally and a lower surface of the ceiling tension plate is fixed to the upper part
25 of the metal member.

During assembly of a building, one building module is placed on top of another building module. Lower corners of the upper
30 building module are placed next to upper corners of the lower building module. First building module fastener openings of the upper building module are then fastened to corresponding second building module fastener openings of the lower building module.

These building module fastener openings allow a locking mechanism to fix a floor tension plate, which is positioned at a lower corner of the upper building module, to a ceiling tension plate, which is positioned an upper corner of the lower building module. In short, building module fastener openings enable fixing of the upper building module to the lower building module.

10 The locking mechanism can include a threaded bolt or a stud for passing through the building module fastener openings to engage with a complementary threaded element, such as a threaded nut.

15 In detail, the threaded bolt or stud can be inserted via the first building module fastener opening and via the corresponding second building module fastener opening, for fastening to the complementary threaded nut positioned in the lower building module.

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Alternatively, the threaded bolt or stud can be inserted via the second building module fastener opening and via the corresponding first building module fastener opening, for fastening to the complementary threaded nut positioned in the upper

25 building module.

The floor concrete slab includes one or more concrete slab openings. Each opening is positioned at a lower part of the building module. The concrete slab opening provides a gap for accessing the corresponding first building module fastener opening of the corresponding floor tension plate from inside of the building module. The first building module fastener opening is used for attaching to a corner of another building module.

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The building module allows a worker to access the first building module fastener opening of the floor tension plate from inside of the building module for attaching the building module to another building module.

This is different from other building modules, which includes a tension plate with a fastener opening that is adapted for accessing from an outside of the building modules. This is risky, especially when the building module is located at a high level.

The building module also facilitates ease of inspection and maintenance of the floor tension plate.

The building module enables easy concealment of the floor tension plate, thereby providing a pleasing architectural detailing.

The application also provides a further building module, which is similar to the above building module.

The building module includes at least one metal frame and a ceiling panel. The ceiling panel is also called a ceiling board.

In detail, the metal frame includes a metal member, a floor tension plate, and a ceiling tension plate.

The metal member includes an upper part and a lower part. The lower part is positioned at a lower corner of the building module while the upper part is positioned at an upper corner of the building module.

The floor tension plate includes at least one first building module fastener opening and a first building module connector protrusion alignment hole, wherein the floor tension plate is positioned horizontally and an upper surface of the floor tension plate is fixed to the lower part of the metal member.

The ceiling tension plate includes at least one second building module fastener opening and a second building module connector protrusion alignment hole, wherein the ceiling tension plate is positioned horizontally and a lower surface of the ceiling tension plate is fixed to the upper part of the metal member.

The ceiling panel is attached to an upper part of the building module, wherein a mechanical and electrical space is provided between the ceiling panel and a ceiling of the building module. The mechanical and electrical space allows for installation of mechanical and electrical components, such as electrical wiring and piping. The ceiling panel acts to conceal the mechanical and electrical space.

The ceiling panel includes at least one ceiling panel opening being positioned at an upper part of the building module. The ceiling panel opening provides a gap for accessing the corresponding second building module fastener opening of the corresponding ceiling tension plate from inside of the building module.

The building module allows a worker to safely access the second building module fastener opening of the ceiling tension plate from inside of the building module for attaching the building module to another building module.

In other words, the ceiling panel opening provides another means to access the building module fastener opening.

The application also provides several additional aspects.

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The floor tension plate can be fixed to the lower part of the metal member by welding.

10 The welding refers to melting of two surfaces of two corresponding metal part for joining the two metal parts. In general, the welding can be replaced by soldering or brazing. The soldering and brazing refer to melting of metal filler for joining two metal parts together.

15 Similarly, the ceiling tension plate can also be fixed to the upper part of the metal member by welding.

In one implementation, the metal member includes a metal section column.

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In one implementation, the floor tension plate, the metal member, and the ceiling tension plate include a steel material, although they can also include a cast iron, stainless steel, aluminium, and/or metal alloy material.

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The above building module can further include a shaft pipe and a shaft wall.

30 In detail, the shaft pipe is attached to a lower part of the building module. The lower part often refers to a floor of the building module. The shaft pipe extends vertically from the lower part to an upper part of the building module.

In use, the shaft pipe allows an external utility, such as water, electricity, and sewage to be channelled to the building module.

- 5 The shaft wall is attached to the lower part of the building module, wherein the shaft wall extends vertically from the lower part to the upper part of the building module. The shaft wall also encloses the shaft pipe.
- 10 The shaft wall includes an upper shaft wall opening, wherein the upper shaft wall opening provides a gap for accessing the second building module fastener opening. The upper shaft wall opening is often concealed by a ceiling board for providing a pleasant finish.
- 15 This arrangement of the building module provides a pipe shaft while also allowing a connection of the building module to another building module.
- 20 The building module with a shaft wall and often prefabricated at a different site from the building site, where the shaft wall can be easily incorporated in the building module.

- The shaft wall is often constructed such that it blocks a
- 25 worker, who is located inside of the building module, from accessing the fastener openings that is positioned at a lower corner of the building module. In detail, a lower part of the shaft wall encloses the fastener openings, wherein the lower part blocks the worker from accessing the fastener openings.
 - 30 A user of the building module does not need to access these fastener openings. The access to the fastener openings is needed only during assembly of the building, in order to fasten the building module to another building module.

During the assembly, a worker, who is positioned inside the building module, can access these fastener openings, which are positioned at said lower corner of the building module, by creating an opening in the shaft wall and later performing masonry work to cover and seal the opening.

The provision of the upper shaft wall opening allows the worker to avoid this masonry work, which is often tedious and time consuming.

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When one building module is placed upon another building module, the worker just needs to be positioned in the lower building module. The worker can then access the upper shaft wall opening of the lower building module and later fasten the fastener openings to each other for fixing the upper building module to the lower building module. After this, the worker just needs to place a ceiling board to conceal the upper shaft wall opening of the lower building module.

20 The application also provides a building module arrangement for a building. The building module arrangement includes at least one set of building modules, a building module connector and a building module locking mechanism.

25 The locking mechanism refers to a device for joining a part of one building module to another part of another building module. The locking mechanism can include a bolt and nut mechanism. In practise, the locking mechanism is often used to fix four upper corners of a lower building module to four lower corners of an upper building module.

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In detail, the set of building modules includes an upper building module according to the one of the above building

modules, and a lower building module according to one of the above building modules.

5 The upper building module is placed above and next to the lower building module, such that lower corners of the upper building module are placed above corresponding upper corners of the lower building module.

10 The upper building module includes a floor tension plate. The floor tension plate includes at least one first building module fastener opening and a first building module connector protrusion alignment hole.

15 Similarly, the lower building module includes a ceiling tension plate. The ceiling tension plate includes at least one second building module fastener opening and a second building module connector protrusion alignment hole.

20 The building module connector is provided for aligning the upper building module to the lower building module, wherein the building module connector includes a building module connector metal plate is positioned horizontally, a first protrusion with a first guiding chamfer being provided on an upper surface of the building module connector metal plate, and a second protrusion being provided on a lower surface of the building module connector metal plate.

30 The first protrusion is inserted into the first building module connector protrusion alignment hole of the floor tension plate for aligning the upper building module to the building module connector.

Similarly, the second protrusion is inserted into the second building module connector protrusion alignment hole of the

ceiling tension plate for aligning the lower building module to the building module connector.

5 The locking mechanism acts to fasten the floor tension plate to the ceiling tension plate, via the first building module fastener opening and via the second building module fastener opening.

10 The building can be formed easily by joining of the building modules from the inside of the building modules.

15 In one implementation, the locking mechanism includes a threaded element, such as a nut or a plate with a threaded hole, being welded to a rim of the first building module fastener opening.

20 The welding of the threaded element to the rim of the first building module fastener opening conveniently allows a corresponding element, such as a bolt or a stud, to be inserted via the second building module fastener opening, via the first building module fastener opening, in order to fasten the ceiling tension plate to the floor tension plate.

25 Alternatively, the threaded element can be welded to a rim of the second building module fastener opening, instead of the first building module fastener opening.

30 This welding also allows a corresponding element, such as a bolt or a stud, to be inserted via the first building module fastener opening, via the second building module fastener opening, in order to fasten the floor tension plate to the ceiling tension plate.

A first vibration damping rubber layer can be positioned between the floor tension plate and the building module connector metal plate for reducing transmission of vibrations between the building modules.

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Similarly, a second vibration damping rubber layer can be positioned between the ceiling tension plate and the building module connector metal plate for reducing transmission of vibrations between the building modules.

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In one implementation, a metal spacer plate is positioned between the floor tension plate and the ceiling tension plate for allowing the lower building module to bear the weight of the upper building module.

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The metal spacer plate can include a steel material, although it can also include other materials, such as cast iron, stainless steel, aluminium, and/or metal alloy material.

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The building module connector also can include a steel material, although it can also include other materials, such as cast iron, stainless steel, aluminium, and/or metal alloy material.

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Different configurations of the upper building module and the lower building module are possible.

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In one configuration, the upper building module and/or the lower building module include a floor concrete slab with four concrete slab openings. Each concrete slab opening provides a gap for accessing a corresponding first building module fastener opening of a corresponding floor tension plate from an inside of the building module.

This configuration provides a means for enabling a worker, who is located inside of the upper building module, to access the concrete slab openings for fastening the four lower corners of the upper building module to the corresponding four upper corners of the lower building module.

In another configuration, the upper building module and/or the lower building module includes a ceiling panel with four ceiling panel openings. Each ceiling panel opening provides a gap for accessing a corresponding second building module fastener opening of a corresponding ceiling tension plate from an inside of the building module.

This configuration provides another means to allow a worker, who is located inside of the lower building module, to access the ceiling panel openings for fastening the four lower corners of the upper building module to the corresponding four upper corners of the lower building module.

In a further configuration, the upper building module and/or the lower building module includes a floor concrete slab with three concrete slab openings and a ceiling panel with one ceiling panel opening.

Similar to the above configurations, each concrete slab opening provides a gap for accessing a corresponding first building module fastener opening, while the ceiling panel opening provides a gap for accessing a corresponding second building module fastener opening.

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A worker, who is located inside of the upper building module, can insert a fastener, via the concrete slab opening, via the corresponding first building module fastener opening, via a

corresponding second building module fastener opening, for fastening with a corresponding fastening element.

5 A worker, who is located inside of the lower building module, can insert a fastener, via the corresponding second building module fastener opening, via a corresponding first building module fastener opening, for fastening with a corresponding fastening element.

10 A shaft pipe with a corresponding shaft wall can also be provided near to the ceiling panel opening, for channelling utility to the building module.

15 In another configuration, the upper building module and/or the lower building module includes four metal frames.

The application provides a method of assembling a building. The method includes a step of providing an upper building module. The upper building module includes a floor tension plate,
20 which is attached to a lower corner of the upper building module. The floor tension plate includes a first building module fastener opening and a first building module connector protrusion alignment hole.

25 After this, a lower building module is provided. The lower building module includes a ceiling tension plate that is attached to an upper corner of the lower building module. The ceiling tension plate includes a second building module fastener opening and a second building module connector protrusion
30 alignment hole.

The upper building module is then positioned on top of the lower building module, wherein protrusions of a building module connector align the first building module connector pro-

trusion alignment hole to the second building module connector protrusion alignment hole.

The first building module fastener opening is later fastened to the second building module fastener opening via a building module locking mechanism from the inside of one of the upper building module and the lower building module.

The subject of the present specification is now explained in more detail with respect to the following figures in which

Fig. 1 illustrates a front view of an assembly of prefabricated building modules, the prefabricated building modules are connected with each other via a module connector unit, which includes one or more first outer connector device, one or more second outer connector device, and one or more inner connector device,

Fig. 2 illustrates a detail view of an area of the prefabricated building module assembly of Fig. 1,

Fig. 3 illustrates a sectioned view of the area of Fig. 2,

Fig. 4 illustrates a front view of a floor tension plate of the first outer connector device of Fig. 1,

Fig. 5 illustrates a bottom view of the floor tension plate of Fig. 4,

Fig. 6 illustrates a top view of a ceiling tension plate of the first outer connector device of Fig. 1,

Fig. 7 illustrates a front view of the ceiling tension plate of Fig. 6,

Fig. 8 illustrates a side view of a first outer shear connector of the first outer connector device of Fig. 1,

Fig. 9 illustrates a top view of the first outer shear connector of Fig. 8,

- Fig. 10 illustrates a top view of a first floor tension plate gasket of the first outer connector device of Fig. 1,
- Fig. 11 illustrates a top view of a sandwich plate of the first outer connector device of Fig. 1,
- Fig. 12 illustrates a front view of the sandwich plate of Fig. 11,
- Fig. 13 illustrates a front view of an inner shear connector of the inner connector device of Fig. 1,
- Fig. 14 illustrates a top view of the inner shear connector of Fig. 13,
- Fig. 15 illustrates a top view of a floor tension plate gasket of the inner connector device of Fig. 1,
- Fig. 16 illustrates an exploded view of a prefabricated building module of the assembly of Fig. 1,
- Fig. 17 illustrates a first step of a method of assembly of the prefabricated building module assembly of Fig. 1,
- Fig. 18 illustrates a second step of the method of the assembly of Fig. 1,
- Fig. 19 illustrates a third step of the method of the assembly of Fig. 1,
- Fig. 20 illustrates a fourth step of the method of the assembly of Fig. 1,
- Fig. 21 illustrates a fifth step of the method of the assembly of Fig. 1,
- Fig. 22 illustrates another view of the first step of the method of assembly of Fig. 17,
- Fig. 23 illustrates another view of the third step of the method of assembly of Fig. 19,
- Fig. 24 illustrates another view of the fourth step of the method of assembly of Fig. 20,
- Fig. 25 illustrates a front view of a further assembly of further prefabricated building modules,

Fig. 26 illustrates a sectioned view of the prefabricated building module assembly in Fig. 25, and
Fig. 27 illustrates a detail view of an area of the prefabricated building module assembly of Fig. 25.

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In the following description, details are provided to describe the embodiments of the present specification. It shall be apparent to one skilled in the art, however, that the embodiments may be practised without such details.

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The embodiments below have similar parts. The similar parts may have the same names or similar part numbers. The description of one part applies by reference to another similar part, where appropriate, thereby reducing repetition of text without
15 limiting the disclosure.

Figs. 1, 2 and 3 show different views of a prefabricated building module assembly 10. The building module assembly 10 includes a prefabricated first building module 11a, a prefabricated second building module 11b, a prefabricated third
20 building module 11c, a prefabricated fourth building module 11d, and a module connector unit 15.

The first building module 11a, the second building module 11b,
25 the third building module 11c, and the fourth building module 11d have the same rectangular shape. Each building module 11a, 11b, 11c, and 11d is placed horizontally such its four upper corners are placed above its four lower corners.

30 The first building module 11a is placed next to the second building module 11b such that they are placed on the same level. The third building module 11c is also placed above and next to the first building module 11a. Similarly, the fourth building module 11d is placed above and next to the second

building module 11b. The fourth building module 11d is also placed next to the third building module 11c, wherein the fourth building module 11d and the third building module 11c are placed on the same level.

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The module connector unit 15 includes six connector devices. For easy illustration purposes, only three connector devices are shown in Fig. 1. These connector devices include a first outer connector device 15a, a second outer connector device
10 15b, and an inner connector device 15c. The description of these connector devices apply to the other connector devices, as appropriate.

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In detail, the inner connector device 15c connects a lower inner corner 11c-li of the third building module 11c to an upper inner corner 11a-ui of the first building module 11a and connects a lower inner corner 11d-li of the fourth building module 11d to an upper inner corner 11b-ui of the second building module 11b.

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The first outer connector device 15a connects a lower outer corner 11c-lo of the third building module 11c to an upper outer corner 11a-uo of the first building module 11a.

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Similarly, the second outer connector device 15b connects a lower outer corner 11d-lo of the fourth building module 11d to an upper outer corner 11b-uo of the second building module 11b.

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In detail, the first outer connector device 15a includes a first outer shear connector 155, a first floor tension plate 152, a first ceiling tension plate 151, a first floor tension plate gasket 832, and a first ceiling tension plate gasket 846.

The first floor tension plate 152 is attached to the lower outer corner 11c-lo of the third building module 11c. The first ceiling tension plate 151 is attached to the upper outer corner 11a-uo of the first building module 11a.

As better seen in Figs. 4 and 5, the first floor tension plate 152 includes a floor shear connector alignment hole 812 and two floor bolt openings 815. In use, the first floor tension plate 152 is oriented horizontally. The first floor tension plate 152 has an upper major surface and a lower major surface, which is essentially parallel to the upper major surface. The upper major surface of the first floor tension plate 152 is welded to a bottom part of a steel column of the third building module 11c.

As better seen in Figs. 6 and 7, the first ceiling tension plate 151 includes a ceiling shear connector alignment hole 842 and two ceiling bolt openings 845 with two corresponding threaded nuts 847. In use, the first ceiling tension plate 151 is oriented horizontally. The first ceiling tension plate 151 has an upper major surface and a lower major surface, which is essentially parallel to the upper major surface. Each threaded nut 847 is welded on the lower major surface of the first ceiling tension plate 151, and is positioned next to the corresponding ceiling bolt openings 845 such that a hollow part of the threaded nut 847 and the ceiling bolt openings 845 are positioned co-axially. In other words, the threaded nut 847 and the ceiling bolt opening 845 have the same axis. The lower major surface of the first ceiling tension plate 151 is welded to a top part of a steel column of the first building module 11a.

The first outer shear connector 155, as best seen in Figs. 8 and 9, includes a rectangular steel plate 310, a steel lower protrusion 322a, and a steel upper protrusion 322b. The lower protrusion 322a has an elliptical cross-section with a lower module guiding chamfer 324a. Similarly, the upper protrusion 322b has an elliptical cross-section with an upper module guiding chamfer 324b.

In use, the steel plate 310 is oriented horizontally. The steel plate 310 has an upper major surface and a lower major surface, which is essentially parallel to the upper major surface.

The upper protrusion 322b is integrally connected to the upper major surface while the lower protrusion 322a is integrally connected to the lower major surface of the steel plate 310.

The upper protrusion 322b is inserted into the floor shear connector alignment hole 812. The lower protrusion 322a is inserted into the ceiling shear connector alignment hole 842.

Bolts 800 are inserted into the corresponding floor bolt openings 815 and the corresponding ceiling bolt openings 845 such that the bolts 800 are fastened with the corresponding threaded nuts 847.

A first outer sandwich plate 350, as better shown in Figs. 11 and 12, includes two sandwich plate bolt openings 350a, wherein each sandwich plate bolt opening 350a corresponds to the associated ceiling bolt openings 845. The first outer sandwich plate 350 is placed between the first ceiling tension plate 151 and the first floor tension plate 152 such that the bolts 800 passed through the corresponding sandwich plate bolt

openings 350a. The first outer sandwich plate 350 is also called a spacer plate.

5 The first floor tension plate gasket 832, as better shown in Fig. 10, includes a first floor tension plate gasket opening 832a. The first floor tension plate gasket 832 is placed between the first floor tension plate 152 and the steel plate 310 of the first outer shear connector 155 such that the upper protrusion 322b passed through the first floor tension plate
10 gasket opening 832a. In other words, the first floor tension plate gasket 832 contacts the lower major surface of the first ceiling tension plate 151 and contacts the upper major surface of the steel plate 310.

15 Similarly, the first ceiling tension plate gasket 846 includes a first ceiling tension plate gasket opening 846a. The first ceiling tension plate gasket 846 is placed between the first ceiling tension plate 151 and the steel plate 310 of the first outer shear connector 155 such that the lower protrusion 322a
20 and passed through the first ceiling tension plate gasket opening 846a.

Referring to the second outer connector device 15b, it is similar to the first outer connector device 15a.

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The second outer connector device 15b includes a second outer shear connector 156, a second floor tension plate 158, a second ceiling tension plate 159, a second floor tension plate gasket 852 and a second ceiling tension plate gasket 856.

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The second floor tension plate 158 is attached to the lower outer corner 11d-lo of the fourth building module 11d. The second ceiling tension plate 159 is attached to the upper outer corner 11b-uo of the second building module 11b.

An upper protrusion of the second outer shear connector 156 is inserted into a floor shear connector alignment hole of the second floor tension plate 158. A lower protrusion of the second outer shear connector 156 is inserted into a ceiling shear connector alignment hole of the second ceiling tension plate 159.

10 Bolts are inserted into the floor bolt openings of the second floor tension plate 158 and the corresponding ceiling bolt openings of the second ceiling tension plate 159 such that the bolts are fastened with the corresponding threaded nuts of the second ceiling tension plate 159.

15 A second outer sandwich plate 352 is placed between the second floor tension plate 158 and the second ceiling tension plate 159.

20 The second floor tension plate gasket 852 is placed between the second floor tension plate 158 and the steel plate of the second outer shear connector 156.

25 The second ceiling tension plate gasket 856 is placed between the second ceiling tension plate 159 and the steel plate of the second outer shear connector 156.

Referring to the inner connector device 15c, it is similar to the first outer connector device 15a.

30 The inner connector device 15c includes an inner shear connector 160, two inner floor tension plates 162 and 163, two inner ceiling tension plates 164 and 165, an inner floor tension plate gasket 372, and an inner ceiling tension plate gasket 374.

A first inner floor tension plate 162 is attached to a lower inner corner 11c-li of the third building module 11c. A second inner floor tension plate 163 is attached to a lower inner corner 11d-li of the fourth building module 11d. A first inner ceiling tension plate 164 is attached to an upper inner corner 11a-ui of the first building module 11a. A second inner ceiling tension plate 165 is attached to an upper inner corner 11b-ui of the first building module 11b.

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A first upper protrusion 362 of the inner shear connector 160, as better seen in Figs. 13 and 14, is inserted into a floor shear connector alignment hole of the first inner floor tension plate 162. The first upper protrusion 362 includes a first upper protrusion guiding chamfer 362a. Similarly, a second upper protrusion 364 of the inner shear connector 160 is inserted into a floor shear connector alignment hole of the second inner floor tension plate 163. The second upper protrusion 364 includes a second upper protrusion guiding chamfer

20 364a.

A first lower protrusion 366 of the inner shear connector 160, is inserted into a ceiling shear connector alignment hole of the first inner ceiling tension plate 164. The first lower protrusion 366 includes a first lower protrusion chamfer 366a. Similarly, a second lower protrusion 368 of the inner shear connector 160 is inserted into a ceiling shear connector alignment hole of the second inner ceiling tension plate 165. The second lower protrusion 368 includes a second lower protrusion chamfer 368a.

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Bolts are inserted into the floor bolt openings of the inner floor tension plates 162 and 163, and into the corresponding ceiling bolt openings of the ceiling tension plates 164 and

165 such that the bolts are fastened with the corresponding threaded nuts of the ceiling tension plates 164 and 165.

A first inner sandwich plate 354 is placed between the first inner floor tension plate 162 and the first inner ceiling tension plate 164. Similarly, a second inner sandwich plate 356 is placed between the second inner floor tension plate 163 and the second inner ceiling tension plate 165.

The inner floor tension plate gasket 372, as better seen in Fig. 15, includes two inner floor tension plate gasket openings 372a and 372b. The inner floor tension plate gasket 372 is placed on an upper major surface of the inner shear connector 160 such that the first upper protrusion 362 and the second upper protrusion 364 passed through a first inner floor tension plate gasket opening 372a and the second inner floor tension plate gasket opening 372b respectively.

The inner ceiling tension plate gasket 374 includes two inner ceiling tension plate gasket openings 374a and 374b. The inner ceiling tension plate gasket 374 is placed on a lower major surface of the inner shear connector 160, such that the first lower protrusion 366 and the second lower protrusion 368 passed through the first inner ceiling tension plate gasket opening 374a and the second inner ceiling tension plate gasket opening 374b respectively.

Referring to the building module 11a, it includes a steel structure 23 and concrete components 25, which is better seen in Fig. 16. The concrete components 25 are integrated with the steel structure 23 such that many parts of the steel structure 23 are often enclosed by the concrete components 25.

In detail, the steel structure 23 includes a plurality of steel section columns 231, a plurality of steel channel beams 234, and a steel plate roof 238. The steel section columns 231 are joined to the steel channel beams 234 to form a cuboid structure with one vertical steel section column 231 being placed at each corner of the cuboid structure. The steel plate roof 238 is placed on top of the cuboid structure, and is attached to the cuboid structure.

10 The steel section columns 231 form side faces of the cuboid structure while the steel channel beams 234 form a top face and a bottom face of the cuboid structure.

The concrete components 25 include a plurality of wall modules 251, a ceiling module 255, and a floor module 257.

The wall modules 251 are joined to side faces of the cuboid structure. Similarly, the ceiling module 255 is joined to the top face of the cuboid structure, and the floor module 257 is joined to the bottom face of the cuboid structure.

With reference to the wall modules 251, each wall module includes an internal wall 251a, and an external wall 251b. The internal wall 251a is attached to an inner side face of the cuboid structure. The external wall 251b is attached to an outer side face of the cuboid structure such that only the external wall 251b is exposed to the exterior of the cuboid structure.

30 The internal wall 251a can be provided by an internal drywall, or a flame resistant wall with steel studs.

The external wall 251b can be provided by a concrete panel, a ductile concrete panel, a fireboard and/or other type of cladding.

- 5 In one implementation, the wall module 251 is provided by a wall with a sliding door and associated doorframe. A balcony can be attached to the wall.

With reference to the ceiling module 255, it includes a purlin
10 frame 255a, and a ceiling board 255b. The purlin frame 255a is attached to the top face of the cuboid structure. The ceiling board 255b is attached to a bottom of the purlin frame 255a such that the purlin frame 255a is not visible when viewed from the interior of the cuboid structure. In other words, the
15 ceiling board 255b conceals the purlin frame 255a.

A mechanical and electrical space 930 is provided between the purlin frame 255a and the ceiling board 255b.

- 20 The ceiling board 255b includes four ceiling connector access openings 910, which are placed in the corresponding upper corners of the first building module 11a. One ceiling connector access opening 910 is shown in Fig. 17.

25 With reference to the floor module 257, it includes a reinforced concrete slab 257a, and a plurality of floor tiles 257b. The reinforced concrete slab 257a is attached to the bottom face of the cuboid structure. The floor tiles 257b are attached to the reinforced concrete slab 257a such that the
30 reinforced concrete slab 257a is concealed when viewed from the interior of the cuboid structure.

In a general sense, the reinforced concrete slab 257a can be formed by pouring wet liquid concrete mixture over the bottom

face of the cuboid structure. Alternatively, the reinforced concrete slab 257a is formed off-site and is later attached to the bottom face of the cuboid structure.

- 5 The floor module 257 includes floor connector access openings 920, which are placed in the corresponding lower corners of the first building module 11a. One floor connector access opening 920 is shown in Fig. 19.
- 10 The building modules 11b, 11c, and 11d have parts that are similar to parts of the first building module 11a. The above description of the parts of the first building module 11a similarly applies to these similar parts.
- 15 In one implementation, the steel plate 310 of the first outer shear connector 155 has a thickness of about 10 mm (millimetre), and a length of about 310 mm.

The first floor tension plate 152 has a thickness of about 25
20 mm, a length of about 253 mm, and a width of about 265 mm.

Similarly, the first ceiling tension plate 151 has a thickness of about 25 mm, a length of about 253 mm, and a width of about 265 mm.

25

The mechanical and electrical space 930, which is provided between the purlin frame 255a and the ceiling board 255b, has dimensions of about 200mm to 300mm.

- 30 In use, the building module assembly 10 serves as a building. The building can refer to a residential building.

In detail, the building module 11a, 11b, 11c, and 11d provides one or more rooms for the building. The building module 11a,

11b, 11c, and 11d is fabricated off-site or is constructed away from the work site of the building. The building module 11a, 11b, 11c, and 11d is then transported to the work site for joining to each other.

5

The steel structure 23 of the building module 11a, 11b, 11c, and 11d is intended for receiving and attaching to the concrete components 25. The steel structure 23 of the building module 11a, 11b, 11c, and 11d also provides additional mechanical strength to the respective building module 11a, 11b, 11c, and 11d.

10

The concrete components 25 of the respective building module 11a, 11b, 11c and 11d are used to provide the respective building module 11a, 11b, 11c, and 11d with insulation from external noise and vibration, with thermal comfort, with protection from fire hazard, and with shelter from rain.

15

With reference to the first outer connector device 15a, it is used to align or position the third building module 11c with respect to the first building module 11a. A worker, who is located inside the third building module 11c, then uses the first outer connector device 15a to connect the third building module 11c to the first building module 11a.

20

25

In detail, the first ceiling tension plate 151 is used for attaching to a top part of a steel column of the building module 11a.

30

Similarly, the first floor tension plate 152 is used for attaching to a bottom part of a steel column of the third building module 11c.

The lower protrusion 322a is inserted into the ceiling shear connector alignment hole 842 of the first ceiling tension plate 151. The lower module guiding chamfer 324a allows for easy insertion of the lower protrusion 322a into the ceiling shear connector alignment hole 842.

The upper protrusion 322b is intended for guiding and precisely and/or accurately positioning the third building module 11c with respect to the first building module 11a. The upper protrusion 322b is inserted into the floor shear connector alignment hole 812 of the first floor tension plate 152, wherein the inclination of the upper module guiding chamfer 324b contacts the edge of the floor shear connector alignment hole 812 and guides the floor shear connector alignment hole 812. In effect, this guiding acts to align and position the lower outer corner 11c-lo of the third building module 11c with respect to the upper outer corner 11a-uo of the first building module 11a. The upper protrusion 322b is also dimensioned or is sized for shifting the position and the weight of the building module 11c for the above-described alignment.

The protrusions 322b and 322a also serve to restrain the third building module 11c from moving in a horizontal direction with respect to the first building module 11a.

The steel plate 310 serves to bear or withstand the weight of the third building module 11c.

The first outer sandwich plate 350 acts to fill a space between the first floor tension plate 152 and the first ceiling tension plate 151, wherein the first outer sandwich plate 350 also acts to transfer the weight of the third building module 11c to the first building module 11a. The first outer sandwich

plate 350 then bears or withstands the weight of the third building module 11c.

5 The first floor tension plate gasket 832 and the first ceiling tension plate gasket serve 846 as a cushioning for reducing a direct surface contact area between the first building module 11a and the third building module 11c. The first floor tension plate gasket 832 and the first ceiling tension plate gasket serve 846 also a transmission of vibrations or noise between
10 the first building module 11a and the third building module 11c via the first outer shear connector 155.

The floor connector access opening 920 allows a worker, who is located inside the building module 11c, to access or reach the
15 floor bolt opening 815 for inserting a bolt into the floor bolt opening 815.

The bolt 800 is then inserted into the floor bolt opening 815, through the corresponding sandwich plate bolt opening 350a,
20 and into the corresponding ceiling bolt opening 845.

The threads of the bolt 800 are then engaged with the corresponding threads of the threaded nut 847 for fastening the bolt 800 onto the threaded nut 847.

25

This fastening also acts a bolt and nut mechanism to connect the first floor tension plate 152 to the first ceiling tension plate 151, which also acts to connect the lower corner 11c-lo of the third building module 11c to the upper corner 11a-uo of
30 the first building module 11a. The bolt and nut mechanism restrains the third building module 11c from moving vertically with respect to the first building module 11a.

It should be noted that the worker is performing his job safety from an internal part of the building module 11c.

The ceiling connector access opening 910 enables the worker, who is located in the interior of the first building module 11a, to gain access to the lower major surface of the first ceiling tension plate 151 for inspecting the connection between the first floor tension plate 152 and the first ceiling tension plate 151.

10

After this, a worker can fill the floor connector access opening 920 with a liquid concrete mixture or grout, which then hardens to join the reinforced concrete slab 257a.

15 The hardened concrete mixture can be later removed for inspection and maintenance.

Referring to the second outer connector device 15b, it has functions similar to the functions of the first outer connector device 15a.

20

The second outer connector device 15b is used to align or position the fourth building module 11d to the second building module 11b. A worker, who is located inside the fourth building module 11d, then uses the second outer connector device 15b to connect the fourth building module 11d to the second building module 11b.

25

Referring to the inner connector device 15c, it has functions similar to the functions of the first outer connector device 15a. The inner connector device 15c is used to align or position the building modules 11a, 11b, 11c and 11d to each other.

30

A worker, who is located inside the third building module 11c, then uses the inner connector device 15c to connect the third building module 11c to the first building module 11a. Similarly, a worker, who is located inside the fourth building module 11d, then uses the second outer connector device 15b to connect the fourth building module 11d to the second building module 11b.

A method of assembling the building module assembly 10 is described below.

The method includes a step of prefabricating off-site the first building module 11a, the second building module 11b, the third building module 11c, and the fourth building module 11d.

After this, the first building module 11a and the second building module 11b are placed at a construction site, wherein the first building module 11a is placed next to the second building module 11b on the same level, as shown in Fig. 22.

The gaskets and shear connectors are placed on the upper corners of the first building module 11a and the second building module 11b, in a further step.

For simplicity, steps of the method of assembling the building module assembly 10 are described below with reference to one corner of a building module. The description of these steps applies to the other corners of the building module, where appropriate.

With regards to the upper outer corner outer 11a-uo of the first building module 11a, the first ceiling tension plate gasket 846 is placed on the upper major surface of the first ceiling tension plate 151. The lower protrusion 322a of the

first outer shear connector 155 is then inserted into the first ceiling tension plate gasket opening 846a, and into the ceiling shear connector alignment hole 842, as seen in Figs. 17 and 18. The first floor tension plate gasket 832 is later placed on the upper major surface of the steel plate 310 of the first outer shear connector 155, wherein the upper protrusion 322b is inserted into the first floor tension plate gasket opening 832a. The first outer sandwich plate 350 is later placed horizontally on the upper major surface of the first ceiling tension plate 151.

The step described above applies to the other corners of the first building module 11a and other corners of the second building module 11b.

15

Next, the third building module 11c is placed above the first building module 11a and is then lowered onto the first building module 11a, in another step.

The upper protrusion 322b of the first outer shear connector 155 is inserted into the floor shear connector alignment hole 812 of the first floor tension plate 152. The inclination of the upper module guiding chamfer 324b later contacts the edge of the floor shear connector alignment hole 812 and guides the floor shear connector alignment hole 812. This guiding serves to align and position the lower outer corner 11c-lo of the third building module 11c with respect to the upper outer corner 11a-uo of the first building module 11a.

The step described above applies to the other shear connectors of the first building module 11a.

The fourth building module 11d is then lowered onto the second building module 11b, as better seen in Figs. 23 and 24, in a further step.

- 5 The description of the above step relating to the lowering of the third building module 11c applies to the lowering of the fourth building module 11d.

10 A worker later enters the third building module 11c. With respect to one corner of the third building module 11c, the worker inserts a shaft of the bolt 800 into a washer. The shaft is then inserted into the floor connector access opening 920, into the respective floor bolt opening 815, through the corresponding sandwich plate bolt opening 350a of the first
15 outer sandwich plate 350, and through the corresponding ceiling bolt opening 845, as seen in Figs. 19 and 20, the worker then fastens the bolt 800 to the corresponding threaded nut 847, in a further step.

- 20 The worker then inspects the fastening of the bolt 800 to the corresponding threaded nut 847 from the inside of the upper third building module 11c.

25 The worker also inspects the fastening of the bolt 800 to the corresponding threaded nut 847, via the ceiling connector access opening 910, from the inside of the lower first building module 11a.

30 The worker later fills the floor connector access opening 920 with liquid concrete mixture or grout from the inside of the third building module 11c. As better seen in Fig. 21, the liquid concrete mixture fills the floor connector access opening 920 and covers the first floor tension plate 152 such that an upper surface of the concrete mixture is essentially at a same

level as an upper surface of the reinforced concrete slate 257a. Tiles can be placed onto the upper surface of the concrete mixture to provide a pleasant floor finishing.

- 5 The worker then covers and conceals the ceiling connector access opening 910.

In effect, the connection of the first floor tension plate 152 with the first ceiling tension plate 151 via the fastening of
10 the bolt 800 to the corresponding threaded nut 847 is concealed easily, thereby improving architectural detailing of the building module.

The worker then performs similar work to the other corners of
15 the third building module 11c and the first building module 11a, and to the corners of the fourth building module 11d and the second building module 11b, in a further step.

Figs. 25, 26, and 27 show different views of a further building module assembly 10', which is a variant of the building
20 module assembly 10 of Figs. 1 to 24.

The building module assembly 10' include a lower building module 11a' and an upper building module 11c', which is positioned
25 above the lower building module 11a'.

Referring to the lower building module 11a', it includes a ceiling tension plate 423', a pipe shaft, and a ceiling board 255b'.
30

The pipe shaft and the ceiling board 255b' are fixed to an interior of the lower building module 11a' while the ceiling tension plate 423' is fixed to an exterior of the lower building module 11a'.

In detail, the lower building module 11a' includes a vertical steel column, which extends from a lower corner to an upper corner of the lower building module 11a'.

5

The ceiling tension plate 423' includes two ceiling bolt openings 845'. The ceiling tension plate 423' is fixed to an upper part of the steel column. The lower building module 11a' is adapted such that the ceiling bolt openings 845' can be accessed from an inside of the lower building module 11a'.

10

The pipe shaft includes a first vertical shaft pipe 410', a first shaft wall 412', and a connector pipe 411'.

15

As better seen in Fig. 25, a lower end of the first vertical shaft pipe 410' is attached to a floor area of the lower building module 11a'. This floor area is positioned near to said lower corner of the lower building module 11a'. An upper end of the first vertical shaft pipe 410' is separated from a ceiling of the lower building module 11a' by a distance of about 200 mm to about 300 mm.

20

The connector pipe 411' is positioned vertically while a lower end of the connector pipe 411' is fluidically joined to the upper end of the first vertical shaft pipe 410'. An upper end of the connector pipe 411' passed through a ceiling area of the lower building module 11a'. This ceiling area is positioned near to said upper corner of the lower building module 11a'.

25

30

The first shaft wall 412' extends vertically and it encloses and conceals the first vertical shaft pipe 410'. A lower part of the first shaft wall 412' is placed at a floor area of the lower building module 11a', wherein the floor area is posi-

tioned near to said lower corner of the lower building module 11a'. An upper part of the first shaft wall 412' is separated from the ceiling of the lower building module 11a' by a gap of about 200 mm to about 300 mm.

5

The ceiling board 255b' includes a ceiling connector access opening 910'.

10

The ceiling board 255b' is attached to an upper part of the lower building module 11a', such that a mechanical and electrical space 930' is provided between the ceiling of the lower building module 11a' and the ceiling board 255b'.

15

The ceiling connector access opening 910' is positioned near to said upper corner of the lower building module 11a'.

20

The ceiling connector access opening 910' is configured such that it allows a worker, who is located inside the lower building module 11a', to access the mechanical and electrical space 930' and to access the ceiling bolt openings 845' via the gap between the upper part of the first shaft wall 412' and the ceiling of the lower building module 11a'.

25

Referring to the upper building module 11c', it includes parts that are similar to parts of the lower building module 11a'. The similar parts are arranged in similar manner.

30

The upper building module 11c' includes a floor tension plate 425' and a pipe shaft.

The pipe shaft is fixed to an interior of the upper building module 11c' while the floor tension plate 425' is fixed to an exterior of the upper building module 11c'.

In detail, the upper building module 11c' includes a vertical steel column, which extends from a lower corner to an upper corner of the upper building module 11c'.

- 5 The floor tension plate 425' includes two floor bolt openings 815' with threaded nuts 847'. The floor tension plate 425' is fixed to a lower part of the steel column. Each threaded nut 847' is welded to a rim of the corresponding floor bolt opening 815'. In other words, each threaded nut 847' is essen-
- 10 tially positioned co-axially to the corresponding floor bolt opening 815'. The floor bolt openings 815' correspond to the ceiling bolt openings 845'.

The pipe shaft includes a second vertical shaft pipe 416' and

15 a second shaft wall 418'.

As better seen in Fig. 25, a lower end of the second vertical shaft pipe 416' is attached to a floor area and also passes through the floor area of the upper building module 11c'. The

20 floor area is positioned near to the lower corner of the upper building module 11c'. The lower end of the second vertical shaft pipe 416' is also fluidically connected to an upper end of the connector pipe 411'.

25 In short, the first vertical shaft pipe 410', the connector pipe 411', and the second vertical shaft pipe 416' to are fluidically connected to form one continuous pipe for channelling utility services from one building module to another building module.

30

Referring to the second shaft wall 418', it extends vertically as well as enclosing and concealing the second vertical shaft pipe 416'. A lower part of the second shaft wall 418' is placed at a floor area of the upper building module 11c',

wherein the floor area is positioned near to said lower corner of the upper building module 11c'.

5 In use, the mechanical and electrical space 930' allows for installing or servicing of mechanical and electrical components, such as electrical wiring, piping, which are used to provide utility to the lower building module 11a'.

10 The ceiling connector access opening 910' provides a worker, who is located inside of the lower building module 11a', with access to the mechanical and electrical space 930' and to the ceiling bolt openings 845'.

15 The ceiling bolt opening 845' and the corresponding floor bolt opening 815' are provided for receiving a bolt 800' for fastening with the corresponding threaded nut 847'. The bolt 800' then connects and fixes the lower corner of the upper building module 11c' to the upper corner of the lower building module 11a'.

20

The pipe shaft allows an external utility, such as water, electricity, and sewage, to be channelled to the different building modules of the building.

25 The ceiling board 255b' acts to conceal the mechanical and electrical space 930'.

A method of assembling the building is described below.

30 The method include a step of placing the upper building module 11c' on top of the lower building module 11a'.

A worker later enters the lower building module 11a' and accesses the ceiling connector access opening 910', and also the

gap between the upper part of the first shaft wall 412' and the ceiling of the lower building module 11a'.

After this, the worker inserts a bolt 800' into the ceiling
5 bolt opening 845' and into the corresponding floor bolt opening 815'.

The worker then fastens the bolt 800' with the threaded nut 847' to fix the ceiling tension plate 423' of the lower building module 11a' to the floor tension plate 425' of the upper
10 building module 11c'.

After this, the worker fluidically joins the connector pipe 411' to the first vertical shaft pipe 410' and to the second
15 vertical shaft pipe 416'.

The worker then easily conceals the ceiling connector access opening 910' by placing a ceiling panel over the ceiling connector access opening 910'.

20

This arrangement of the pipe shaft provides some benefits.

The gap between the upper part of the first shaft wall 412' and the ceiling of the lower building module 11a' conveniently
25 provides access to the ceiling bolt opening 845' and the corresponding floor bolt opening 815'.

The ceiling board 255b' easily conceals the gap to provide a pleasant finish.

30

The building modules 11a' and 11c' are often prefabricated at a different site where the corresponding shaft walls 412' and 416' can be easily incorporated in the building modules 11a' and 11c'.

The shaft wall 416' is often constructed such that it blocks access to the bolt openings 815' and 845' from the inside of the upper building module 11c'. This is because users of the building modules 11a' and 11c' does not need to access the bolt openings 815' and 845'. The access to the bolt openings 815' and 845' is needed only during assembly of the building for fastening the building modules 11a' and 11c' to each other.

10

In effect, a worker, who is located inside the upper building module 11c', cannot access the bolt openings 815' and 845' without first creating an opening in the shaft wall 416' and later performing masonry work to cover and seal the opening.

15

The provision of the gap between the upper part of the first shaft wall 412' and the ceiling of the lower building module 11a' conveniently allows a worker to access the bolt openings 815' and 845' while avoiding said masonry work to create and to later seal the opening. After the fastening, the worker just needs to seal the ceiling connector access opening 910'.

20

In a special embodiment, a shaft wall opening and a floor concrete slab opening of the upper building module provide an access to the floor bolt opening from an inside of the upper building module. This then allows a worker to insert a bolt into the floor bolt opening and the ceiling bolt opening in order to fasten the bolt with a threaded nut. The shaft wall opening can be later covered to provide a pleasant finish.

25

30

The building module assembly 10 provides several benefits.

The module connector unit 15 allows a worker to productively and safely connect the building modules 11a, 11b, 11c, and 11d

to each other from the inside of the building module 11a, 11b, 11c, and 11d. This is different from the other arrangements, where the worker performs connection of the building modules from the outside of the building modules, where the worker has a risk of falling. This is especially important when the building modules are located at a high level.

The module connector unit 15 also facilitates ease of inspection and maintenance of the connections between the building modules 11a, 11b, 11c, and 11d, when compared to other arrangements where the connection of the building modules is done from the outside of the building modules.

The module connector unit 15 enables easy concealment of the connection between the building modules 11a, 11b, 11c, and 11d, since the concealment can be done conveniently inside the respective building modules 11a, 11b, 11c, and 11d, without use of scaffolding for working on external surfaces of these building modules 11a, 11b, 11c, and 11d.

Furthermore, the concealment is done by filling a floor opening with a concrete mixture and later placing floor tiles on the top of the concrete mixture for matching with the other floor tiles, thereby providing an aesthetically pleasing architectural detailing. This is different from other building module connection devices, which protrude out of an external surface of the building modules, thereby affecting the architectural detailing of the building modules.

A further benefit of the module connector unit 15 is that the tension plates are welded to the steel section columns of the building modules 11a, 11b, 11c, and 11d during the fabrication off-site of the building modules 11a, 11b, 11c, and 11d. This ensures that the positioning of the building modules 11a, 11b,

11c, and 11d with respect to each other during assembly of the building modules 11a, 11b, 11c, and 11d is highly precise and accurate.

- 5 The module connector unit 15 is suitable for use in all kinds of buildings, even high-rise developments of up to 18 storeys or more.

10 The building module steel structure 23 and the module connector unit 15 are suitable for production using automated robotic welding with attached jigs for ensuring precision welding, dimension accuracy, and higher productivity.

15 The building module 11a, 11b, 11c, and 11d can be lifted via a lifting frame with safety features, which comprises a safety barricade and lifting lugs with locking mechanism.

20 The building module steel structure 23 can include steel section columns with smallest cross-sections, which are allowed by design specifications, for providing a maximum or larger usable space of the interior of the prefabricated building modules.

25 Although the above description contains much specificity, these should not be construed as limiting the scope of the embodiments but merely providing illustration of the foreseeable embodiments. Especially the above stated benefits of the embodiments should not be construed as limiting the scope of the embodiments but merely to explain possible achievements if
30 the described embodiments are put into practice. Thus, the scope of the embodiments should be determined by the claims and their equivalents, rather than by the examples given.

REFERENCE NUMBER

	10	building module assembly
	11a	first building module
	11a-ui	upper inner corner
5	11a-uo	upper outer corner
	11a-li	lower inner corner
	11a-lo	lower outer corner
	11b	second building module
	11b-ui	upper inner corner
10	11b-uo	upper outer corner
	11b-li	lower inner corner
	11b-lo	lower outer corner
	11c	third building module
	11c-ui	upper inner corner
15	11c-uo	upper outer corner
	11c-li	lower inner corner
	11c-lo	lower outer corner
	11d	fourth building module
	11d-ui	upper inner corner
20	11d-uo	upper outer corner
	11d-li	lower inner corner
	11d-lo	lower outer corner
	15	module connector unit
	15a	first outer connector device
25	15b	second outer connector device
	15c	inner connector device
	23	steel structure
	25	concrete components
	151	first ceiling tension plate
30	152	first floor tension plate
	155	first outer shear connector
	156	second outer shear connector
	158	second floor tension plate
	159	second ceiling tension plate

	160	inner shear connector
	162	first inner floor tension plate
	163	second inner floor tension plate
	164	first inner ceiling tension plate
5	165	second inner ceiling tension plate
	231	steel section columns
	234	steel beams
	238	steel plate roof
	251	wall modules
10	251a	internal wall
	251b	external wall
	255	ceiling module
	255a	purlin frame
	255b	ceiling board
15	257	floor module
	257a	reinforced concrete slab
	257b	floor tile
	310	steel plate
	322a	lower protrusion
20	322b	upper protrusion
	324a	lower module guiding chamfer
	324b	upper module guiding chamfer
	350	first outer sandwich plate
	350a	sandwich plate bolt opening
25	352	second outer sandwich plate
	354	first inner sandwich plate
	356	second inner sandwich plate
	362	first upper protrusion
	362a	first upper protrusion chamfer
30	364	second upper protrusion
	364a	second upper protrusion chamfer
	366	first lower protrusion
	366a	first lower protrusion chamfer
	368	second lower protrusion

	368a	second lower protrusion chamfer
	372	inner floor tension plate gasket
	372a	first inner floor tension plate gasket opening
	372b	second inner floor tension plate gasket opening
5	374	inner ceiling tension plate gasket
	374a	first inner ceiling tension plate gasket opening
	374b	second inner ceiling tension plate gasket opening
10	800	bolt
	812	floor shear connector alignment hole
	815	floor bolt opening
	832	first floor tension plate gasket
	832a	first floor tension plate gasket opening
15	842	ceiling shear connector alignment hole
	845	ceiling bolt opening
	846	first ceiling tension plate gasket
	846a	first ceiling tension plate gasket opening
	847	threaded nut
20	852	second floor tension plate gasket
	856	second ceiling tension plate gasket
	910	ceiling connector access opening
	920	floor connector access opening
	930	mechanical and electrical space
25	10'	building module assembly
	11c'	upper building module
	11a'	lower building module
	410'	first vertical shaft pipe
30	411'	connector shaft pipe
	412'	first shaft wall
	416'	second vertical shaft pipe
	418'	second shaft wall
	423'	ceiling tension plate

425' floor tension plate

CLAIMS

1. An upper building module for a building, the building module comprising
- 5 at least one metal frame, the metal frame comprising
- a metal member with an upper part and a lower part, wherein the lower part is positioned at a lower corner of the building module, and the upper part is positioned at an upper corner of the building module,
 - 10 - a floor tension plate that comprises at least one first building module fastener opening and a first building module connector protrusion alignment hole, wherein the floor tension plate is positioned horizontally and is fixed to the lower part of the metal member,
 - 15 - a ceiling tension plate that comprises at least one second building module fastener opening and a second building module connector protrusion alignment hole, wherein the ceiling tension plate is positioned horizontally and is fixed to the upper part of the metal member, and
- 20 a floor concrete slab with at least one concrete slab opening being positioned at a lower part of the building module, the concrete slab opening providing a gap for accessing the corresponding first building module fastener opening of the corresponding floor tension plate from inside of the building module.
- 25
- 30 2. A lower building module for a building, the building module comprising
- at least one metal frame, the metal frame comprising
- a metal member with an upper part and a lower part, wherein the lower part is positioned at a lower corner

ner of the building module, and the upper part is positioned at an upper corner of the building module,

5 - a floor tension plate that comprises at least one first building module fastener opening and a first building module connector protrusion alignment hole, wherein the floor tension plate is positioned horizontally and is fixed to the lower part of the metal member,

10 - a ceiling tension plate that comprises at least one second building module fastener opening and a second building module connector protrusion alignment hole, wherein the ceiling tension plate is positioned horizontally and is fixed to the upper part of the metal member, and

15 a ceiling panel with at least one ceiling panel opening being positioned at an upper part of the building module, the ceiling panel opening providing a gap for accessing the corresponding second building module fastener opening of the corresponding ceiling tension plate from inside of the building module.

20 3. The building module according to claim 1 or 2 further comprising

25 a shaft pipe being attached to a lower part of the building module, wherein the shaft extends from the lower part to an upper part of the building module, and

30 a shaft wall being provided such that the shaft wall encloses the shaft pipe, the shaft wall comprises an upper shaft wall opening for accessing the at least one second building module fastener opening.

4. The building module according to one of the above-mentioned claims, wherein the floor tension plate is fixed to the lower part of the metal member by welding.
- 5
5. The building module according to according to one of the above-mentioned claims, wherein the ceiling tension plate is fixed to the upper part of the metal member by welding.
- 10
6. The building module according to one of the above-mentioned claims, wherein the metal member comprises a metal section column.
- 15
7. The building module according to one of the above-mentioned claims, wherein the floor tension plate, the metal member, and the ceiling tension plate comprise a steel material.
- 20
8. A building module arrangement for a building, the building module arrangement comprising
- at least one set of building modules, the set of building modules comprising an upper building module according one of the claims 1 and 3 to 7 and a lower building module according one of the claims 2 to 7, wherein
- 25
- the upper building module comprising the floor tension plate that comprises at least one first building module fastener opening and a first building module connector protrusion alignment hole, and
- 30
- the lower building module comprising the ceiling tension plate that comprises at least one second building module fastener opening and a second building module connector protrusion alignment hole, and

a building module connector for aligning the upper building module to the lower building module, the building module connector comprising

- a building module connector metal plate for being positioned horizontally,
- a first protrusion with a first guiding chamfer being provided on an upper surface of the building module connector metal plate, and
- a second protrusion being provided on a lower surface of the building module connector metal plate, wherein

- the first protrusion is inserted into the first building module connector protrusion alignment hole of the floor tension plate for aligning the upper building module to the building module connector, and
- the second protrusion is inserted into the second building module connector protrusion alignment hole of the ceiling tension plate for aligning the lower building module to the building module connector,

the building module arrangement further comprising

- a locking mechanism for fastening the floor tension plate to the ceiling tension plate, via the first building module fastener opening and via the second building module fastener opening.

9. The building module arrangement according to claim 8, wherein the locking mechanism comprises a threaded element being welded to a rim of the first building module fastener opening.

10. The building module arrangement according to claim 8, wherein

the locking mechanism comprises a threaded element being welded to a rim of the second building module fastener opening.

- 5 11. The building module arrangement according to one of claims 8 to 10 further comprising
a first vibration damping rubber layer being positioned between the floor tension plate and the building module connector metal plate.
- 10
12. The building module arrangement according to one of claims 8 to 11 further comprising
a second vibration damping rubber layer being positioned between the ceiling tension plate and the building module
15 connector metal plate.
13. The building module arrangement according to one of claims 8 to 12 further comprising
a metal spacer plate being positioned between the floor
20 tension plate and the ceiling tension plate.
14. The building module arrangement according to claim 13, wherein
the metal spacer plate comprises a steel material.
- 25
15. The building module arrangement according to one of claims 8 to 14, wherein
the building module connector comprises a steel material.
- 30 16. The building module arrangement according to one of claims 8 to 15, wherein
at least one member of a group, which consists of the upper building module and the lower building module, the

member comprises a floor concrete slab with four concrete slab openings.

17. The building module arrangement according to one of
5 claims 8 to 15, wherein
at least one member of a group, which consists of the upper building module and the lower building module, the member comprises a ceiling panel with four ceiling panel openings.
- 10
18. The building module arrangement according to one of
claims 8 to 15, wherein
at least one member of a group, which consists the upper building module and the lower building module, the member
15 comprises a floor concrete slab with three concrete slab openings and a ceiling panel with one ceiling panel opening.
19. The building module arrangement according to one of
20 claims 8 to 15, wherein
at least one member of a group, which consists the upper building module and the lower building module, the member comprises four metal frames.
- 25 20. A method of assembling a building, the method comprising
providing an upper building module, which comprises
a floor tension plate being attached to a lower corner of
the upper building module, the floor tension plate comprising a first building module fastener opening and a
first building module connector protrusion alignment
30 hole,
providing a lower building module, which comprises a ceiling tension plate being attached to an upper corner of the lower building module, the ceiling tension plate

comprising a second building module fastener opening and a second building module connector protrusion alignment hole,

5 positioning the upper building module on top of the lower building module, wherein protrusions of a building module connector align the first building module connector protrusion alignment hole to the second building module connector protrusion alignment hole, and

10 accessing the floor tension plate of the upper building module via a gap that is provided by a concrete slab opening of the upper building module and accessing the ceiling tension plate of the lower building module via a gap that is provided by a ceiling panel opening of the lower building module for fastening the first building module fastener opening to the second building module fastener opening via a locking mechanism from the inside
15 of one of the upper building module and the lower building module.

ABSTRACT

AN IMPROVED PREFABRICATED BUILDING MODULE

5 The present application provides a building module for a
building. The building module includes at least one metal
frame and a floor concrete slab with at least one concrete
slab opening being positioned at a lower part of the building
module. The metal frame includes a metal member with an upper
10 part and a lower part, a floor tension plate that comprises at
least one first building module fastener opening and a first
building module connector protrusion alignment hole, a ceiling
tension plate that comprises at least one second building mod-
ule fastener opening and a second building module connector
15 protrusion alignment hole.

(Fig. 2)