

Unitised Building System

Field of the invention

This invention relates to a building system. The invention will be described in connection with construction of high rise buildings, however aspects of the invention will find application outside this field and the invention should not be considered as being limited to that exemplary field of use.

Background of the invention

There have been many proposals to utilise prefabricated building methodologies in order to enable inexpensive and fast construction of buildings. Examples of prefabricated modular systems include those disclosed in the following prior art documents: US 6,625,937; US 5,706,614; US 4,120,133; US 6,826,879; US 4,045,937; US 5,402,608; US 4,807,401; US 4,545,159 and WO 2005/038155.

Generally speaking, however, the prefabricated systems which have been proposed are suitable only for single storey or low rise buildings and are generally modular in their approach so that there is an inherent inflexibility that limits their application.

It is an object of the invention to provide a non-modular, flexible building system which is capable of being used to construct high rise buildings. By high rise buildings it is contemplated that there would be four or more levels above ground level. Although clearly similar techniques can be applied to buildings of a lower height without departing from the present invention. It is an object of another aspect of the present invention to provide improved techniques for interconnecting the units used in construction of a building.

Summary of the invention

In one aspect the present invention provides a method of building a building having a plurality of levels using a plurality of building unit assemblies wherein each building unit assembly is structurally self supporting and has at least one sidewall, a floor and a roof, the method including the steps of: lifting the building unit assemblies into position in the building so that each level of the building includes a predetermined number of units; connecting adjacent units to one another in each level; and connecting units in one level to corresponding units in at least one adjacent level that is vertically above or below the one level.

The method can further include, constructing at least one core; and connecting units which are adjacent to a core to a core, the arrangement being such that the vertical loads between adjacent levels are transmitted mainly through the building unit assemblies and lateral loads are transmitted to the core.

The method can further include: attaching structural frame segments to at least one sidewall of a building unit to form a building unit assembly; and stacking the building unit assemblies so as to form the levels of the building with the structural frame segments in one level being vertically aligned with structural frame segments in at least one adjacent level whereby substantially all vertical load of the building unit assemblies are transmitted through the structural frame segments.

In some embodiments lateral loads are borne by the building units.

In some embodiments lateral loads are borne by one or more cores.

The method can further include the step of providing top and bottom connecting plates on the top and bottom of each of the structural frame segments and using fastening means to connect together top and bottom plates of structural frame segments which are vertically adjacent to one another.

In some embodiments the structural frame segments are attached to the sidewalls of a building unit such that when the building unit is placed laterally adjacent to another structural frame segment in a predetermined relative alignment a structural frame segment of the building unit assembly is located side by side with a structural frame segment on the laterally adjacent building unit assembly; and the method can include the step of connecting together the structural frame segments which are located side by side to one another.

In some embodiments the step of connecting the units in one level to corresponding units in a vertically adjacent level includes the step of connecting the tops of structural frame segments in lower levels to the bottoms of structural frame segments in higher levels.

The method can include the step of mounting top and lower connecting plates on the top and lower ends of said column elements respectively; and connecting together the top connecting plates of the structural frame segments which are located side by side to one another.

The method can include the step of connecting the top connecting plates of the structural frame segments which are located side by side to one another to one of the lower connecting plates of structural frame segments located side by side to one another in the next upper level.

The method can include the step of clamping the other of the lower connecting plates between vertically adjacent top connecting plates by means of an elongate clamping rod.

In another aspect the present invention provides a building having a plurality of levels, the building including: a plurality of building unit assemblies, each of which is structurally self supporting and has at least one sidewall, a floor and a roof; and structural frame segments attached to the at least one sidewall

thereof, groups of the building unit assemblies being stacked to form the levels in the building, and wherein the building unit assemblies are stacked with the structural frame segments in one level being vertically aligned with structural frame segments at least one adjacent level whereby substantially all vertical loads are transmitted through the structural frame segments and lateral loads are borne by the building unit assemblies.

In some embodiments the building can further include a core, and the groups of building unit assemblies can be arranged about the core and connected thereto, such that vertical loads between adjacent levels are transmitted mainly through the building unit assemblies rather than through the core.

In some embodiments the building further includes one or more elongate connecting means extending between a top of a corresponding first structural frame segment attached to a building unit in one level to a top of a vertically aligned second structural frame segment attached to a building unit assembly in another level such that the top of the first building element can be connected by said elongate connecting means to top of the second structural frame segment.

In some embodiments the a plurality of levels include at least one building unit assembly placed in a first orientation and at least one second building unit assembly placed orthogonally to said first orientation such that said building unit assemblies in the first and second orthogonal orientations act as bracing to bear lateral loads.

In some embodiments the ends of the column elements have mounting means connected thereto whereby the mounting means and structural frame segment can be connected to adjacent plates of structural frame segments vertically above or below said one structural frame segment.

In some embodiments the mounting means include top and lower connecting plates, and the location of the structural frame segments relative to the building unit to which they are connected can be such that within a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another and wherein at least one of the lower connecting plates of a structural frame segment of a further building unit assembly stacked on one of said adjacent building unit assemblies overlies at least part of the top connecting plates of said pair whereby said at least one lower connecting plate can be connected thereto to thereby connect together said adjacent building unit assemblies and said further building unit assembly.

In some embodiments the mounting means include top and lower connecting plates, and the location of the structural frame segments relative to the building unit to which they are connected can be such that in a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another, the arrangement of the connecting plates is such that for vertically

aligned pairs of structural frame segments at least three of their connecting plates can be connected together.

In some embodiments the building can further include first connecting means for connecting adjacent building unit assemblies within a level to one another; and second connecting means for connecting
5 building unit assemblies within one level to adjacent building unit assembly levels which are adjacent to said one level.

In another aspect the present invention provides a building having a plurality of levels, at least some of said levels including a plurality of self supporting building units each including a structural frame segment connected thereto that is being adapted to support the vertical load of another level above said level,
10 wherein: the building includes at least one higher level and one lower level, wherein the structural strength of the frame segments of the building units on the lower level is greater than the structural strength of corresponding frame segments in the higher level.

In some embodiments the building includes a group of higher levels and a group of lower levels wherein the structural strength of corresponding structural frame segments within the group of lower level are
15 substantially equal and the structural strength of corresponding structural frame segments within the group of higher levels is substantially equal.

In some embodiments the structural strength of the structural frame segments in the group of lower levels can be greater than the structural strength of the corresponding frame segments in the group of higher levels.

20 The structural frame segments are preferably external to the self supporting building units.

In some embodiments the structural frame segments comprise column elements attached to the self supporting building units.

In some embodiments the building units are arranged within a level so as to define spaces between and neighbouring self supporting building units in which the structural frame segments are located.

25 In some embodiments the spaces between vertically aligned neighbouring pairs of self supporting building units are substantially the same width.

In some embodiments the spaces between all neighbouring self supporting building units are substantially the same width.

In some embodiments the structural frame elements all have substantially the same width transverse to the spaces between neighbouring self supporting building units in which they are located.

In some embodiments a relative difference in strength between two structural frame elements is provided by varying at least one of the following:

- 5 a relative wall thickness of the structural frame elements;

a relative depth of the structural frame elements measured along the spaces between neighbouring self supporting building units.

- 10 In a further aspect there is provided a structural frame segment for fitment to a self supporting building units the structural frame segment including: at least one load bearing column member; mounting means on each end thereof for fastening the structural frame segment to another similar self supporting building unit or building element.

In some embodiments the mounting means includes an engagement portion for engaging a cooperatively shaped engagement portion of a vertically aligned structural frame segment in use.

- 15 In some embodiments the mounting means are connecting plates attached to the ends of the column member.

In some embodiments the at least one column member includes any one of a steel column or a concrete column.

- 20 In use, the location of the column elements relative to the building unit to which they are connected can be such that within a level of the building at least some column elements of adjacent building units are located in pairs beside one another and wherein at least one of the lower connecting plates of a column element of a further building unit stacked on one of said adjacent building units overlies at least part of the top connecting plates of said pair whereby said at least one lower connecting plate can be connected thereto to thereby connect together said adjacent building units and said further building unit.

- 25 In some embodiments the location of the column elements relative to the building unit to which they are connected is such that in a level of the building at least some column elements of adjacent building units are located in pairs beside one another, the arrangement of the connecting plates is such that for vertically aligned pairs of column elements at least three of their connecting plates can be connected together.

In some embodiments the structural frame segment has a mounting means shaped to match a mounting means of a horizontally adjacent structural frame segment in use.

In some embodiments the structural frame segment includes a plurality of column elements coupled by a means to distribute load between at least pairs of the plurality of columns.

- 5 In some embodiments includes a guide surface for facilitating alignment with the other building element.

In some embodiments the guide surface includes at least a portion of a surface of the mounting means.

In some embodiments the guide surface includes at least a portion of a column element.

In some embodiments the mounting means includes an angled guide surface for guiding the mounting means into correct alignment of a correspondingly shaped mounting means in use.

- 10 In some embodiments the guiding surface includes a vertically extending portion in use which enables vertical alignment of the structural frame segment with respect to another building etc to be adjusted by sliding the guide surface against the building element.

In some embodiments the mounting means include at least one mounting plate including a taper to provide an angled guide surface.

- 15 In some embodiments the mounting means includes a generally trapezoidal plate that provides a tapered guiding surface to a horizontally aligned corresponding structural frame segment in use.

In some embodiments at least one column element extending from a surface of the mounting plate in a generally perpendicular direction and positioned such that at least a portion of a surface of a column element is substantially aligned with a vertex of a trapezoidal top plate that forms part of a guiding surface of a mounting means and extends away therefrom such that the portion of a surface of the column element provides a continuation of the guide surface.

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In another aspect the present invention provides a method of constructing a building unit for use in building a building having a plurality of levels, the method including: (a) constructing a self supporting unit including a floor, roof and at least one sidewall, to thereby define an interior of the unit and an exterior of the unit; (b) attaching at least one frame segment to the exterior of the unit for structurally supporting a building unit assembly arranged above the building unit assembly in use.

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The method can further include: (c) performing a stress relieving step prior to step (b).

Step (a) can further include: constructing the self supporting unit in a jig or clamp; and step (c) can include releasing a clamping force applied by the jig or clamp.

Step (c) can include allowing thermally induced stresses in the self supporting unit to dissipate.

In some embodiments step (a) can include one or more of the following construction steps:

- 5 forming a floor from a plurality of floor panels;
- forming at least one wall from a plurality of wall panels;
- forming a frame from a plurality of frame members;
- forming a roof from a plurality of roof panels;
- attaching at least one of a wall, floor or roof to a frame;
- 10 attaching at least one wall or wall component floor;
- attaching a roof or at least one roof panel to at least one wall.

In some embodiments the frame segments include a structural frame segment according to an embodiment of an aspect of the present invention.

- The method can include defining at least one datum point exterior to the self supporting unit with
- 15 reference to the one or more structural frame segments.

The method can further include fitting out at least part of the interior of the building unit with reference to the at least one datum point.

The method can further include affixing at least one façade element to the building unit assembly with reference to the at least one datum point.

- 20 In some embodiments the method can include transferring a measurement from the at least one datum point to the interior of the self supporting unit.

In another aspect the present invention includes a method of laying out a building having a plurality of levels including:

designing a layout of said floors;

defining a structural column grid that is common to a plurality of vertically continuous levels;

defining a plurality of units in each level, between the columns of the column grid such that the column grid lies in a space between horizontally adjacent units.

- 5 In some embodiments the method further includes: adjusting the layout to accommodate the column grid and spaces between the horizontally adjacent units.

The method can further include: defining a structural column grid common to all levels.

In some embodiments the method further includes: defining a plurality of column grids corresponding to a plurality of groups of levels.

- 10 The method can further include positioning a transfer structure between the groups of levels forming the plurality of groups.

In another aspect the present invention provides a method in the construction of a building; the method including: laying out a building using a method according to an embodiment of another aspect of the present invention and manufacturing a plurality of self supporting building units of the layout, wherein
15 each unit has an associated structural support segment attached thereto which aligns with the defined column grid.

In some embodiments the method further includes constructing at least one in situ component of the building.

- 20 In some embodiments the method further includes stacking the plurality of self supporting building unit assemblies in a defined arrangement with the in situ component of the building and connecting the self supporting building unit assemblies together and to the self supporting building unit assemblies.

In some embodiments the method further includes positioning a plurality of the self supporting building unit assemblies in a relationship with one another as defined by the layout prior to construction of the building.

- 25 In some embodiments the method can further includes performing any one of the following steps on the so positioned self supporting building unit assemblies:

checking tolerances between at least components of neighbouring self supporting building unit assemblies;

checking for correct vertical and/or horizontal alignment between the structural support segments of neighbouring self supporting building unit assemblies;

5 fitting out at least part of an interior of the self supporting building unit assemblies;

temporarily connecting a service between at least two self supporting building unit assemblies;

disconnecting a temporarily connected service from a self supporting building unit assembly;

fitting a façade or cladding component to a self supporting building unit assembly.

Further aspects of the present invention include, but are not limited to buildings, building unit assemblies,
10 building units, structural support segments, and components of the foregoing which are made or assembled according to a method described herein, or which are used in said methods.

According to the present invention there is provided a method of building a building having a plurality of levels using a plurality of building unit assemblies wherein each building unit assembly is structurally self supporting and has sidewalls, a floor and a roof, the method including the steps of: lifting the building unit
15 assembly into position in the building so that each level of the building includes a predetermined number of units; connecting adjacent units to one another in each level; and connecting units in one level to corresponding units which are vertically above and below the units in adjacent levels.

The invention also provides a method of building a high rise building having a plurality of levels using a plurality of building unit assemblies wherein each building unit assembly is structurally self supporting and
20 has sidewalls, a floor and a roof, the method including the steps of: constructing a core; lifting the building unit assemblies into position in the building so that each level of the building includes a predetermined number of units; and connecting units which are adjacent to the core to the core, the arrangement being such that the vertical loads between adjacent levels can be transmitted mainly through the building unit assemblies and lateral loads are transmitted through walls, floor, roof or other stiff element or via use of
25 bracing means to the core.

The invention also provides a method of building a high rise building having a plurality of levels using a plurality of building unit assemblies wherein each building unit assembly is structurally self supporting and has sidewalls, a floor and a roof, the method including the steps of: attaching structural frame segments to the sidewalls of the building unit assemblies; stacking the building unit assemblies so as to form the
30 levels of the building with the structural frame segments in one level being vertically aligned with

structural frame segments in at least one adjacent level whereby substantially all vertical loads are transmitted through the structural frame segments and lateral loads are either borne by building unit assemblies placed orthogonally to each other to act as bracing or other stiff element such as core.

5 Preferably the method further includes the step of providing top and bottom connecting plates on the top and bottom of each of the structural frame segments and using fastening means to connect together top and bottom plates of structural frame segments which are vertically adjacent to one another.

10 Preferably the method further includes the step of locating structural frame segments of building unit assemblies which are laterally adjacent to one another such that their top and bottom plates are laterally adjacent to one another and using fastening means to connect together the top and bottom plates of structural frame segments which are laterally adjacent to one another.

15 Preferably the method further includes the step of providing complementary portions on the top plates of building unit assemblies which are laterally adjacent to one another and wherein the method includes the step of providing first and second bottom plates respectively of the structural frame segments of building unit assemblies which are laterally adjacent to one another and locating the first bottom plates over said complementary portions whereby the fastening means connect the top and bottom plates vertically and laterally.

20 Preferably, the method includes the step of connecting the lower end of an elongate connecting rod to a first top plate of a structural frame segment of first building unit assembly which is stacked vertically below a second building unit assembly and connecting the top end of the connecting rod to a second top plate of the second building unit assembly whereby the first and second top plates are clamped together.

25 The invention also provides a building having a plurality of levels, the building including: a plurality of building unit assemblies, each of which is structurally self supporting and having sidewalls, a floor and a roof, groups of the building unit assemblies being stacked to form the levels in the building; first connecting means for connecting adjacent building unit assemblies within a level to one another; and second connecting means for connecting building unit assemblies within one level to adjacent building unit assembly levels which are adjacent to said one level.

Preferably the building is characterised in that it has no structural framework other than that provided by the interconnected building unit assemblies.

30 The invention also provides a building having a plurality of levels, the building including: a plurality of building unit assemblies, each of which is structurally self supporting and having sidewalls, a floor and a roof; a core, groups of building unit assemblies being stacked alongside the core to form the levels in the building; and connecting means for connecting units which are adjacent to the core to the core, the

arrangement being such that vertical loads between adjacent levels are transmitted mainly through the building unit assemblies rather than through the core.

The invention also provides a building having a plurality of levels, the building including: a plurality of building unit assemblies, each of which is structurally self supporting and having sidewalls, a floor and a roof and structural frame segments attached to the sidewalls of the building unit assemblies, groups of the building unit assemblies being stacked to form the levels in the building, and wherein the building unit assemblies are stacked with the structural frame segments in one level being vertically aligned with structural frame segments in at least one adjacent level whereby substantially all vertical loads are transmitted through the structural frame segments and lateral loads are either borne by building unit assemblies placed to act as bracing or other stiff elements such as concrete or steel cores.

Preferably the building includes connecting means for connecting the structural frame segments of building unit assemblies in one level to adjacent structural frame segments of building unit assemblies in an adjacent level.

Preferably, the ends of the structural frame segments have connecting plates connected thereto whereby the plates and structural frame segment can be connected to adjacent plates of structural frame segments vertically above or below said one plate.

Preferably the plates of said one structural frame segment can be connected to plates of structural frame segments laterally adjacent thereto.

Preferably, vertically aligned adjacent structural frame segments have plates that are provided with projections and recesses which are complementary to one another to enable accurate alignment of the columns when stacked.

Preferably the top or bottom plates of first and second laterally adjacent structural frame segments include complementary portions having respective bolt holes therein whereby the bottom or top plate of a third structural frame segment which is vertically adjacent to the first or second structural frame segment, overlies said complementary portions and has bolt holes which align with the bolt holes in said complementary portions whereby bolts can be used to clamp together the plates of said first, second and third structural frame segments.

Preferably the top plates of the structural frame segments include said complementary portions.

Preferably further, the top plates include said recesses and the bottom plates include said projections.

In some embodiments the structural frame segments are provided with top and lower connecting plates, and wherein the location of the structural frame segments relative to the building unit assembly to which they are connected is such that in a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another and wherein at least one of the
5 lower connecting plates of a structural frame segment of a further building unit assembly stacked on one of said adjacent building unit assemblies overlies at least part of the top connecting plates of said pairs whereby said at least one lower connecting plate can be connected thereto to connect together said adjacent building unit assemblies and said further building unit assembly.

10 In some embodiments the structural frame segments are provided with top and lower connecting plates, and wherein the location of the structural frame segments relative to the building unit assembly to which they are connected is such that in a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another, the arrangement of the connecting plates is such that for vertically aligned pairs of structural frame segments at least three of their connecting plates can be connected together.

15 Preferably two of the top connecting plates or the lower connecting plates are of complementary shape so that the third of said at least three connecting plates overlies or underlies said two plates.

Preferably the connecting plates include bores which are located so that the bores are aligned in said at least three connecting plates and fasteners can be passed through the bores to connect said three connecting plates together.

20 Preferably the pairs of overlying and underlying connecting plates include first and second formations which interlock with one another.

Preferably the formations include projections and recesses.

Preferably the projections are on the undersides of the overlying connecting plates and the recesses are on the upper sides of the underlying connecting plates.

25 In some embodiments lateral loads can be borne by the floor and roof of the building units and wherein at least some of structural frame segments include at least one hollow column element; the building further including elongate connecting means extending through at least some of the hollow column elements whereby tops of structural frame segments in one level can be connected by said elongate connecting means to tops of structural frame segments in an adjacent level in the building.

Brief description of the drawings

Illustrative embodiments of the present invention will now be further described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of a building unit assembly of an embodiment the invention;

- 5 Figures 2A to 2E show building unit assemblies of embodiments of the invention constructed using different building materials;

Figure 3A is a schematic plan view of two building unit assemblies spaced apart from one another;

Figure 3B is a schematic plan view showing two adjacent building unit assemblies connected together;

Figures 4A to 4D are schematic plan views illustrating different plan shapes for the building units;

- 10 Figures 5A to 5G are schematic views showing building unit assemblies stacked in various ways to construct differently shaped high rise buildings;

Figure 6 is a schematic side view of a twenty level building;

Figures 7A, 7B and 7C are schematic isometric views of buildings having cores;

Figure 8 is a schematic isometric view of a building having a distributed core;

- 15 Figure 9 is a schematic side view of a building showing how column elements can vary in size in accordance with the height within the building;

Figure 10 is a schematic isometric view of five levels of a high rise building;

Figures 11A to 11E show units in the various levels;

Figure 12 is a more detailed schematic view showing interconnection of units within a level of the building;

- 20 Figure 13A is a floor plan for an apartment building;

Figures 13B, 13C, 13D and 13E are typical apartments using units of the invention;

Figures 14A and 14B show lower and higher floor plan levels in a hotel constructed in accordance with the invention;

Figure 14C is a more detailed view of a building unit assembly suitable for use in the building of Figures 14A and 14B;

5 Figure 15A is a floor plan layout of a building which has residential and office accommodation;

Figure 15B shows a possible arrangement of the units for the residential part of the building of Figure 15A;

Figure 16 is a schematic cross-sectional end view showing more details of a building unit assembly;

Figure 17 is a schematic perspective view of one form of a lower mounting block;

10 Figure 18 is a plan view of a lower mounting block;

Figures 19 and 20 are orthogonal side views of the lower mounting block;

Figure 21 is a schematic perspective view of an upper mounting block;

Figure 22 is a plan view of the upper mounting block;

Figures 23 and 24 are orthogonal side views of the upper mounting block;

15 Figure 25 is an isometric view showing interconnection of vertically adjacent building unit assemblies;

Figure 26 is a fragmentary isometric view showing vertically and horizontally adjacent building unit assemblies;

Figure 27 is a fragmentary side view showing interconnection of mounting blocks of four building unit assemblies;

20 Figure 28 is a more detailed schematic end view showing vertical interconnection of mounting blocks of two building unit assemblies;

Figure 29 is a more detailed schematic side view showing horizontal interconnection of mounting blocks of two building unit assemblies;

Figure 30 is a more detailed schematic end view showing interconnection of mounting blocks of two building unit assemblies utilising elongate connecting elements;

Figures 31 and 32 are schematic views showing the orientation of connecting elements during lifting of the building unit assemblies;

5 Figure 33 is a schematic side view of a four level building;

Figure 34 is a top plan view of a lower connecting plate;

Figure 35 is an end view of the side plate;

Figure 36 is a top plan view of another lower connecting plate;

Figure 37 is a side view of the connecting plates shown in Figures 34 and 36;

10 Figure 38 is a plan view of an upper connecting plate;

Figure 39 is an end view of the upper connecting plate;

Figure 40 is a sectional view along the line 24-24;

Figure 41 is a side view of the top plate;

Figures 42 and 43 are more detailed fragmentary views of two forms of structural frame segments;

15 Figure 44 is a schematic plan view of two building unit assemblies having the structural frame segments shown in Figures 42 and 43 and being spaced apart from one another;

Figure 45 is a schematic plan view showing the building unit assemblies of Figure 44 connected together;

Figures 46 to 50 schematically illustrate the manner in which the structural frame segments of Figures 42 and 43 are interconnected;

20 Figure 51 is a schematic exploded view showing various components of the interconnection;

Figure 52 is a side view of the lower connecting plate;

Figure 53 is a plan view of a lower mounting block;

Figure 54 is an end view of the lower mounting block;

Figure 55 is a plan view of an alternative upper connecting plate;

Figure 56 is a side view of the upper connecting plate of Figure 55;

5 Figure 57 is an end view of the upper connecting plate of Figure 55;

Figure 58 is a plan view of an alternative upper mounting block;

Figure 59 is a side view of the upper mounting block of Figure 58;

Figure 60 is an end view of the upper mounting block of Figure 58;

Figure 61 is a plan view of an elongate bolt;

10 Figure 62 is a fragmentary end view of the bolt head;

Figure 63 is a side view of the upper end of the bolt;

Figure 64 is a fragmentary side view showing the bolt head;

Figure 65 is a fragmentary view showing the upper end of the shaft of the bolt;

15 Figures 66 and 66A are schematic perspective views showing an alternative connecting technique for the building unit assemblies;

Figure 67 is a fragmentary side view showing interconnection of connecting plates and blocks of four building unit assemblies in one embodiment; and

Figure 68 is a schematic side view showing some internal details of the building unit assembly and the manner in which the structural frame segments are connected thereto;

20 Figure 69 shows a number of roof panels for the building unit;

Figure 70 is a cross-sectional view along the line 37-37;

Figure 71 is a cross-sectional view along the line 38-38;

Figure 72 is an exploded view of a modified building unit of the invention;

Figure 73 is a schematic view showing the location of the structural frame segments on the building unit assembly;

- 5 Figure 74 is a schematic side view of a building unit assembly suitable for cantilevering;

Figure 75 is a schematic end view of six building unit assemblies;

Figure 76 is a schematic perspective view of the floor panel for the building unit of Figures 72 and 73;

Figure 77 is a schematic cross-sectional end view showing more details of the modified building unit assembly;

- 10 Figure 78 is a schematic cross-sectional end view showing more details of a further modified building unit assembly;

Figure 79 is a schematic cross-sectional end view showing more details of yet a further modified building unit;

Figure 80 is a schematic cross-sectional end view showing more details of another modified building unit;

- 15 Figure 81 shows a perspective view of an alternative mounting plate usable in an embodiment of the present invention;

Figure 82 illustrates a plan view of the mounting plate of figure 81;

Figure 83 illustrates three building unit assemblies which are to be mounted together using a mounting plate of figure 82;

- 20 Figures 84A to 84C illustrate a manner in which neighbouring building unit assemblies come together using a mounting plate of figure 82; and

Figure 85 shows the same portion of a structural frame segment as shown in figure 81 with detail added.

Detailed description of the embodiments

In broad concept the inventor has realised that the building units per se (which delineates the interior space of the unit) can be considered separately from the structural frame of the unit, when this is implemented in a preferred form this can allow both flexibility of design and improved ease of manufacture.

- 5 In terms of ease of manufacture the building units can be manufactured to relatively relaxed tolerances, say $\pm 20\text{mm}$, which is relatively easy to achieve. The structural frame segments can be manufactured to much tighter tolerances, say within $\pm 1\text{mm}$ so as to provide an accurate framework for the building. The building unit and associated structural frame segments assemblies can then be attached together in a manner that accounts for any inaccuracy in the building unit to form a building unit assembly for assembly
10 into the building which has an accurately positioned structural frame segment attached to it.

The preferred embodiments provide an independent column system that sets up an accurate dimensional grid from which to dimensionally reference all other building elements.

- In alternative systems where the structural frame for the building forms part of its framework for the building the whole unit needs to be manufactured to meet the tighter tolerances required by the frame,
15 which is expensive and complicated.

In terms of design and flexibility, de-coupling the design and manufacture of the structural frame segments from the units gives a designer flexibility to position the structural frame segments at a broad range of positions relative to the building unit. This allows flexibility of design that is not practically possible if the structural frame of the building unit is built into the walls of the unit.

- 20 The unitised building system of the invention can be used for constructing buildings to be used for any purpose including, but not limited to, residential, hotel and office use. Preferred embodiments are also suitable for high rise use, that is to say for buildings which have four levels or more above ground level.

- The building unit assemblies are fabricated in accordance with the building layout to be created. In the system of the invention, a building designer is free to layout a building in the conventional manner to suit
25 a client's needs and the requirements of the market. Next a structural column grid that is common to a plurality of vertically contiguous levels is defined and a plurality of units in each level are defined. The units lie between the columns of the column grid and conversely the column grid lies in a space between adjacent units. The design of the building may need to be adjusted to be divided into building units that can vary in width and length but are of a size suitable for transportation and lifting into position by crane
30 on site. It can be a prefabricated system that provides the structure of the building complete with the architectural finishes and services, ready for assembly on site.

As will be explained in more detail below, embodiments can have the following features: the building unit's length, width and height can vary from project to project; the building units can incorporate all components of a building including stairs, corridors and services; the building unit assemblies are constructed in a production facility; the completed building unit assemblies are transported to site for assembly; the building unit assemblies are lifted into position by construction cranes; there is minimal work on site to complete the buildings as the façade and interiors can be connected to or fitted in the building unit assemblies before delivery; special bolted connections can be used to connect the building unit assemblies together; and each building unit is structurally self-supporting and can have structural frame segments connected thereto so that when connected together the building unit assemblies including structural frame segments form the vertical and lateral support of the building.

Each building unit can be regarded as a rectilinear box frame which is structurally independent and self-supporting in terms of its own weight and the live loads it will carry.

The units can be constructed from a variety of materials including: timber framed construction with plywood bracing to walls, floor and roof plates; steel framed truss construction, using steel sections and profiled sheet steel to walls and roof and rolled steel channels and profiled sheet steel or purlins to floor; and profiled sheet steel construction constituting diaphragm wall and roof sections, the wall and roof sections being sufficiently rigid so as not to require additional cross bracing and therefore the sheet steel walls constitute a major part of the strength of the unit in the manner of monocoque or systems used in the automotive and aerospace industries. In general the building units are relatively strong in a longitudinal direction, that is along the plane of their walls, when compared to the transverse direction. They may be stiffened in the transverse direction by providing bracing across that direction. This bracing can take the form of a frame type bracing, wall, tensioning cables or other means. The strength of the building units along their length can advantageously be used to provide support for lateral loads in a manner described elsewhere herein. In the transverse direction lateral loads can be transmitted by floors, roofs and laterally extending walls that traverse the interior space of the building units.

Fire protection can be achieved through the use of fire rated plasterboard linings to the interior walls and roofs of the building units.

Interior fit-out can be finished completely, including painting, tiling, carpet and joinery or left at the "rough in" stage for completion on site. Façade elements, circulation corridors and stairs can also be incorporated into the building units prior to delivery or finished on site. As noted above these elements can also be accurately positioned by taking location measurements from a datum point associated with the structural frame segments rather than the building unit.

The building units may have four or more structural frame segments including structural steel or concrete column elements fixed to their exterior to carry the total loads and form, in combination with the building

units, the building structure. The column elements are designed to take the load that its position within the structure imposes. Additional structural support can be included, if required, to spread load or increase rigidity. This can be regarded as forming an exo-structure for the building units that will be connected together with the exo-structure of neighbouring units to form the load bearing structure of the building.

- 5 The exo-structure occupies a zone outside the building unit's occupiable interior space so that there is no conflict between the two in terms of constructability and assembly. The structural zone between the building units typically ranges from 100mm to 150mm. This zone is where all structural frame segments are located and where all connections that lock together the entire building, are made.

- 10 The advantage of this in constructability terms is that the building units, the exo-structure comprising the structural frame segments of the building unit assemblies and the façade elements can, after fabrication, be temporarily aligned and even locked together at the production facility, in the exact positions they will occupy in the multi story structure due to the accuracy of the placement of the structural frame segments. This process facilitates checking of tolerances to ensure ease of assembly on-site and quality control. It also allows finishing at ground level, which is far more cost effective and less dangerous than doing so in
15 an elevated position on side, as would be the alternative in a high-rise building. This makes building and façade tolerances much easier to check, manage and achieve during the manufacturing stage rather than in the assembly stage.

- 20 The structural frame segment or column elements thereof may increase in size with the increase in building height and/or load bearing requirements. The elements are sized to suit their position within the structure so that the building unit assemblies at the base of the building may have larger column elements connected to them compared to those at the top. The building units can, however, remain unchanged as they are designed to support only themselves.

- 25 The building units transmit lateral loads through the walls, roof and floor plates to the stability or bracing elements. These stability elements can be in the form of other units placed in the opposing direction to the main bulk of the units. They can be framed cores within selected units or a conventional concrete or steel framed core system, subject to the height of the building. Vertical loads within the building units are transferred through their sidewalls to the structural frame segments, which are connected thereto.

- 30 The building unit in its most basic form can be regarded as a box frame supported at four points with open ends. The structure is light and highly resistant to wind and earthquake loads. It is also sufficiently weather proof to allow it to be transported and erected without the possibility of water damage to the interior elements.

The building unit's interiors are unaffected by structural elements as all columns are outside the skin of the units in a column zone of 100mm to 150mm. This zone remains the same regardless of the building

height of up to 50 stories. This is achieved by maintaining the column width while increasing the column depth and strength.

For some structures, usually low to medium rise structures, the lateral load can be taken out by turning some of the building units perpendicular to the general direction of the other building units. This will be determined by the layout of the building. Alternatively, the ends of the units can be stiffened by using heavier frames and/or bracing additional walls, or introducing additional elements to suit the loading conditions of each particular building or site. The lifts and stairs can also be framed to take the lateral loads. The lifts and stairs can be incorporated within a building unit assembly or be constructed separately.

- 10 For taller structures beyond 12 to 15 levels, a more conventional bracing system utilizing an in situ concrete core can be advantageous. Where an in situ concrete core is utilised as the main bracing element, the core would be partially or fully constructed prior to installation of the fabricated building unit assemblies.

- 15 For very tall buildings it may be necessary to introduce concrete or steel transfer structures where the requirements of practicality and economy are required or to suit altered loading or bracing requirements dictated by the building design and site conditions.

- 20 This effectively breaks up a tall building into two or more stacks of units carried by concrete on a steel core structure. Where a concrete core is utilised, it can also be used as a supporting element through the use of transfer structures which transfer the vertical loads back to the core, thus reducing the sizes of the structural frame segments connected to the building units, thereby effectively reducing the building to a series of smaller structures. For example, a 20 level building could incorporate three transfer structures, thereby reducing the effective height for the structural frame segments to what would be required for a five level building.

- 25 The transfer structures could be connected to the structure of the building unit assemblies themselves so that the transfer structures would be assembled with the building unit assemblies.

Alternatively, the transfer structures could be provided as a separate steel or concrete structure, depending on the circumstances.

- 30 As indicated above, the building unit assemblies can be of a size which is varied according to requirements and transport limitations. Typically, however, each building unit assembly would have a width of say 2m to 5m, a length from 10m to 28m and a height from 2.7m to 3.3m.

It will further be appreciated that in a building, building unit assemblies of different sizes and shapes can be arranged so as to produce required floor plan areas for the useful space of the building. The sidewalls of a building unit can have openings formed therein for doors, windows etc. Corridors and balconies, etc., can also be added.

- 5 Figure 1 shows a schematic view of a building unit assembly 2 constructed in accordance with an embodiment of the invention. The building unit assembly 2 includes a building unit including two sidewalls 4 and 6, floor 8 and roof 10, with structural frame segments, in the form of column elements 14, 16, 18 and 22 attached thereto.

10 In the illustrated arrangement, the ends 12 and 14 are open but these could be closed in accordance with requirements. As will be described in more detail below, the sidewalls 4 and 6, floor 8 and roof 10 are of robust construction so that the building unit assembly 2 is capable of being self supporting during transport and lifting. It is also capable of withstanding loads which are applied to it in use such as the internal fit-out and live loads. As will be described in more detail below, the building unit assemblies 2 can be manufactured in a factory remote from where a building using the units 2 is to be erected (e.g. in a
15 factory of other production facility). Manufacturing building unit assemblies in the manner of industrial products lends itself to cost and time savings and achievement of better manufacturing tolerances in the finished units.

In the illustrated arrangement, the building unit assembly 2 has four column elements 16, 18, 20 and 22 connected to the sidewalls, the elements 16 and 18 being connected to the sidewall 4 and the elements
20 20 and 22 being connected to the sidewall 6. As will be described below, the function of the structural frame segments is to provide mounting points for the building unit assemblies 2 and also to bear vertical loading when the building unit assemblies are stacked on top of each other. The elements 16, 18, 20 and 22 include respective lower mounting means 24 and respective upper mounting means 26. The upper mounting means 26 can form the attachment point for lifting cables during transport and construction
25 stages. Also the members 24 and 26 can be used for coupling adjacent building unit assemblies 2 to each other in a completed building, as will be described in more detail below.

The building unit 2 itself can be constructed in a variety of materials. Figure 2A diagrammatically illustrates an arrangement in which the sidewalls 4 and 6 and roof 10 are timber framed with plywood cladding. The floor 8 can be of profiled steel plate. Figure 2B illustrates an alternative arrangement where
30 the building unit 2 has sidewalls and roof which are steel framed and braced, the floor 8 being of profiled steel plate. Figure 2C shows an alternative arrangement where the sidewalls and roof are in the form of a framed truss with profiled sheet steel bracing for the sidewalls and roof as well as the floor.

Figure 2D shows an alternative arrangement in which the building unit has the sidewalls, floor and roof all made from profiled steel sheet. Figure 2E shows an alternative arrangement in which the building unit is

formed from glassfibre reinforced concrete (GRC) or other composite material panels, the floor 8 being of profiled steel sheeting, GRC or composite construction.

Figure 3A is a schematic plan view showing two building unit assemblies 2A and 2B located adjacent to one another. As can be seen in Figure 3A, the structural frame segments 16 and 18 on the sidewall 4 are offset relative to the positions of the structural frame segments 20 and 22 on the sidewall 6. This arrangement permits the structural frame segments to be located adjacent to one another in the final mounted position of the building unit assemblies 2A and 2B, as shown in Figure 3B.

It will be appreciated that there is a gap 28 between the adjacent sidewalls 4 and 6 of the assembled building units, as shown in Figure 3B. The gap or column zone 28 is defined by the width of the columns and provides space to accommodate the vertical structure support. Also, the column zone 28 also assists with sound and thermal isolation between adjacent units.

The upper and lower mounting means 24 and 26 are shown schematically in Figures 1 to 3. As will be described in more detail, the upper mounting means can be of different types as can be the lower mounting means. Several embodiments will be described in more detail below.

It will be appreciated that similar units can be stacked in various arrays in accordance with requirements. The units can also be arranged so that their ends are adjacent to one another and in that case structural frame segments (not shown) in Figures 3A and 3B would be provided on the end walls 12 or 14 so that the units can be connected end to end (rather than side by side) in an analogous way to that shown in Figures 3A and 3B. Because the mounting means 24 and 26 project below and above the floor 8 and roof 10 respectively, they also create gaps between vertically stacked building units and these have a similar function in improving fire rating, sound and thermal isolation between building units in different levels in the building.

The mounting means 24 and 26 are used to interconnect adjacent building unit assemblies and the combination of the self supporting building units and interconnected structural frame segments can preferably constitute the sole framework of the building. Depending on the layout of the building units, the height of the building and the relevant site conditions, additional stability or bracing elements can be added.

The building units 2 shown in Figures 1 to 3 have a rectangular shape in plan view. Figures 4B, C and D show three, of the many, alternative plan shapes for the units. More specifically, Figure 4B shows a unit with an irregular quadrilateral plan view; Figure 4C illustrates a unit with a wedge shaped (or trapezoidal) plan shape; Figure 4D illustrates a unit with three orthogonal linear sides and one curves side. Other shapes are also possible. As will be appreciated, the units can be interconnected in an analogous way to that shown in Figures 2 and 3.

The building unit assemblies 2 can be stacked in various ways to construct buildings with different shapes. Figure 5A diagrammatically illustrates four units 201,202,203,204 stacked on top of one another to form a four level building 30. Figure 5B shows a four level building 32 having pairs of units forming each level wherein a pair of units 203 on the third level are effectively turned orthogonally to levels 1, 2 and 4 to thereby provide a cantilevered arrangement for units 2.3 and 2.4 relative to the units beneath them.

Figure 5C shows a four level building 38 which has two banks of wedge shaped units 40 and 42 which are of a different length to a central bank of units 44 and mounted in offset relation to the central bank 44 of rectangular units so as to create a more complex shaped building. Figure 5D shows a building 46 having a central bank 48 of rectangular building unit assemblies flanked by banks of lateral units 50 and 52, some of the upper units e.g. 50.4 and 50.5 have rounded ends so as to create a building with a curved appearance. Figure 5E shows a five level building 54 constructed from banks of units having an irregular quadrilateral plan shape. Figure 5F shows a building 55 in which there are six banks 57.1 to 57.6 of building unit assemblies which are stacked side by side and two banks 59.1 and 59.2 which are stacked end for end. The combination of the banks in orthogonal directions provides bracing for the building.

Figure 5G shows a further building 61 which has three banks of building unit assemblies 61.1,61.2,61.3 arranged such that each bank is orthogonal to its neighbour, again to provide inherent bracing because of the orientation of the building unit assemblies.

Figure 6 diagrammatically shows a twenty level building 56 having a central concrete core 58. The core 58 would normally include lift shafts in the usual way. The levels of the building are built up from the building unit assemblies which are manufactured offsite and lifted into position. In taller buildings of this size, the core 58 contributes to the bracing of the building. In the illustrated arrangement, the building 56 includes three transfer structures 60, 62 and 64 which are supported by the core 58. The transfer structures could be formed from reinforced concrete or steel structures connected to the core. The main function of the transfer structures 60, 62 and 64 is to transfer vertical loading from the five levels of building unit assemblies stacked upon them to the core, so that the entire vertical loading of the building does not have to be transferred through the structural frame segments of the various building unit assemblies beneath. In this way the size of the structural frame segments do not have to be so large that the entire vertical loading of the building is borne by the lowermost structural frame segments in the structure. Initial calculations have, however, surprisingly shown that for buildings up to 50 levels in height, it would not be necessary to utilise transfer structures as mentioned above. The calculations also demonstrate that the gap or column zone 28 between the building units can remain constant throughout the whole building and the depth, wall thickness, material strength or grade of the column elements of the structural frame segment can be varied in order to provide sufficient strength depending on their location within the overall building.

Table 1 below is a summary of typical values for axial compression applied to the structural frame segments as a function of height in the building. The table includes data for column sizes of different widths as indicated.

In Table 1 the "Storey" column indicates the storey number the unit will occupy, when counted from the top of the building. Thus storey 1 is the top storey, and in a 50 storey building storey 50 is the bottom. The "Axial Compression" column sets out the loading on each column of a building unit assembly in that storey. The "Column Size" columns identify the cross sectional dimensions of columns and wall thickness needed for each of a 100mm, 125mm and 150mm column width to support the identified loading. For rectangular columns width x depth dimensions are given in millimetres and wall thickness in mm. For square columns only a single wide wall length and thickness is indicated. Where four measurements are given this represents the dimensions of a column element formed from an I-beam. Thus **125x250x40x25** indicates use of an I-beam having a total width along its end flanges 125mm and width along its central axis of 250mm. The end flanges are 40mm thick and the central web 25mm thick..

The final group of columns labelled "Column Capacity" indicated the load capacity for RHS and SHS with sizes specified in the corresponding "Column Size" column, when made from 450MPa steel and fitted with mounting members made from 350 MPa steel.

Storey	Axial Compression (kN per column)	Column Size			Column Capacity (SHS/RHS = 450MPa, Plates = 350MPa)		
		100 wide	125 wide	150 wide	100 wide	125 wide	150 wide
1	90	100x9	125x6	150x6	100x9 SHS = 571kN	125x6 SHS = 750kN	150x6 SHS = 1060kN
2	181	100x9	125x6	150x6			
3	271	100x9	125x6	150x6			
4	362	100x9	125x6	150x6			
5	452	100x9	125x6	150x6			
6	543	100x9	125x6	150x6			
7	633	150x100x10	125x6	150x6	150x100x10 RHS=877kN		
8	723	150x100x10	125x6	150x6			
9	814	150x100x10	125x10	150x6		125x10SHS=1120kN	
10	904	200x100x10	125x10	150x6	200x100x10RHS=1140kN		
11	995	200x100x10	125x10	150x6			
12	1085	200x100x10	125x10	150x10			150x10SHS=1640kN
13	1176	100x200x25x12	125x200x25x12	150x10	100x200x25x12=1750kN	125x200x25x12=2350kN	
14	1266	100x200x25x12	125x200x25x12	150x10			
15	1356	100x200x25x12	125x200x25x12	150x10			
16	1447	100x200x25x12	125x200x25x12	150x10			
17	1537	100x200x25x12	125x200x25x12	150x10			
18	1628	100x200x25x12	125x200x25x12	150x10			
19	1718	100x200x25x12	125x200x25x12	150x250x10			150x250x10RHS=2360kN
20	1809	100x300x25x25	125x200x25x12	150x250x10	100x300x25x25=2660kN		
21	1899	100x300x25x25	125x200x25x12	150x250x10			
22	1990	100x300x25x25	125x200x25x12	150x250x10			
23	2080	100x300x25x25	125x200x25x12	150x250x10			
24	2170	100x300x25x25	125x200x25x12	150x250x10			
25	2261	100x300x25x25	125x200x25x12	150x250x10			
26	2351	100x300x25x25	125x200x40x16	150x250x10		125x200x40x16=3250kN	
27	2442	100x300x25x25	125x200x40x16	150x250x16	100x350x25x25=3090kN		150x250x16RHS=3440kN
28	2532	100x300x25x25	125x200x40x16	150x250x16			
29	2623	100x300x25x25	125x200x40x16	150x250x16			
30	2713	100x350x25x25	125x200x40x16	150x250x16			
31	2803	100x350x25x25	125x200x40x16	150x250x16			
32	2894	100x350x25x25	125x200x40x16	150x250x16			
33	2984	100x350x25x25	125x200x40x16	150x250x16			
34	3075	100x350x25x25	125x200x40x16	150x250x16			
35	3165	100x400x25x25	125x200x40x16	150x250x16	100x400x25x25=3510kN		
36	3256	100x400x25x25	125x250x40x25	150x250x16		125x250x40x25=4080kN	
37	3346	100x400x25x25	125x250x40x25	150x250x16			
38	3436	100x400x25x25	125x250x40x25	150x250x16			
39	3527		125x250x40x25	150x250x40x25			150x250x40x25=5040kN
40	3617		125x250x40x25	150x250x40x25			
41	3708	125x250x40x25		150x250x40x25		125x300x40x25=4370kN	
42	3798		125x250x40x25	150x250x40x25			

43	3889		125x250x40x25	150x250x40x25			
44	3979		125x250x40x25	150x250x40x25			
45	4069		125x250x40x25	150x250x40x25			
46	4160		125x300x40x25	150x250x40x25		125x300x40x25=4870kN	
47	4260		125x300x40x25	150x250x40x25			
48	4341		125x300x40x25	150x250x40x25			
49	4431		125x300x40x25	150x250x40x25			
50	4522		125x300x40x25	150x250x40x25			

As can be seen from Table 1 the load capacity of the column elements can be greater in the building unit assemblies at lower levels of the building because they need to absorb or transmit higher vertical loads. Conversely this means that the higher levels can use less strong column members to avoid unnecessary weight and cost at top of the building. For convenience, groups of levels within the building can be provided with columns having the same strength, rather than having different columns in each level. The relative increase in strength is either provided by increasing the column size or wall thickness at the lower levels e.g. as set out in Table 1.

The column elements may be in the form of reinforced concrete columns which are robustly attached to the sidewalls of the building units. Alternatively, they could comprise steel column elements which are bolted or welded to the sidewalls. Other materials may also be used.

Table 1 assumes that a single column element is used in each structural frame segment, but more than one may be used. In this case a separate member can be used for balancing the load between the multiple column elements. This load sharing function may be performed by the mounting means attached thereto or by a separate dedicated structure, e.g. bracing between the multiple column elements. In some cases the structural frame segment may include a wide column such as a blade column or even a wall to support the vertical loads needed. In either case the mechanism for operation will be similar to that of the narrow column elements described in connection with the preferred embodiments.

With this flexibility in mind the concept of vertical alignment should be considered broadly, that is vertical alignment need only be sufficiently accurate to the extent necessary to transfer the vertical load to the aligned structural support segment. For example, for narrow structural frame segments with small mounting means vertical alignment will require relatively tight tolerances so that the vertical loads from the upper structural frame segment can be adequately supported by the lower structural frame segment. However when a wall-shaped structural frame segment abuts a column-like structural frame segment (or several column like structural frame segments) the degree of vertical alignment (in the direction along the column gap) need not be so exact, so long as the vertical loads are transferred.

Figure 7A is a schematic isometric view of a group of five levels 70, 72, 74, 76 and 78 which can form part of the building 56 as shown in Figure 6. The orientation of the building units 2 which make up the levels 70,72...78, can be varied in accordance with requirements.

Figure 7B shows a building 63 having a central core 58 but with a different arrangement of banks of building units. The building units are arranged to surround the core 58. Figure 7C shows another building 65 again made up from banks of building units but this time being braced by a side core 67.

Figure 8 illustrates a building 80 which has a distributed services arrangement rather than the central core 58 of the arrangement shown in Figures 6 and 7. In this arrangement the building 80 has five levels 82, 84, 86, 88 and 90 and the components which make up the distributed services arrangement can be built into the building units which make up the various levels. In the illustrated arrangement, there is a lift core 98, two stairwells 100 and 102 and a duct core 104. These components are separated from one another and by using heavier structural components these services arrangements therein add to the overall stability of the building because the various vertical ducts are distributed over a wider area, as seen in plan view compared to the use of a single central arrangement

Figure 9 is a schematic side view of a multi-storey building in which levels 1 to 5 are fabricated from building unit assemblies designated by the reference numeral 112; levels 6 to 10 designated by the reference numeral 114; levels 11 to 15 designated by the reference numeral 116; and levels 16 to 20 designated by the reference numeral 118. The structural frame segments associated with the building units in the various groups of levels increase in load bearing capacity toward the bottom, in accordance with the height in the building. It is desirable that the column zone between neighbouring units remains constant throughout the height of the building, thus the maximum column width is fixed. Therefore to accommodate increased load nearer the bottom of the building the columns 120, 122 and 124 are deeper (longitudinally) at their bottom than at the top. In this arrangement a first group of levels 112 will have columns of a first, larger size and a second group of levels, e.g. 114 will have columns of a second, smaller size. This continues up the building. This progression of increasing column size down a building (preferably in a grouped/stages fashion) can be seen in table 1. This allows all units to maintain a constant width regardless of the height of the building.

Figure 10 is a perspective view of a building 130 which has 20 levels shown for simplicity in five groups of four levels 132, 134, 136, 138 and 140 and a central core 142. As seen in Figure 11A, the level 132 is made up from a first bank of three building units 132A, 132B and 132C and a second bank of three building units 132D, 132E and 132F. The level 132 includes two further building units 132G and 132H which are oriented at 90° relative to the other building units, as shown in Figure 11A. Figures 11B, 11C, 11D and 11E show a similar arrangement of the building units therein. There is no set order of installation of the various building unit assemblies in a building as this would depend on parameters of the site and the design of the building.

Figure 12 is a more detailed schematic view of the level 132 of the building 130. It will be seen that the structural frame segments of the building unit assemblies 132A, 132B, 132C and of the building unit assemblies 132D, 132E and 132F are interconnected with one another in a similar way to that shown in

Figure 3. The inner ends of building unit assemblies 132A, 132C, 132D and 132F include end structural frame segments 150 and 152 which cooperate with complementary structural frame segments on the building unit assemblies 132G and 132H, which are adjacent thereto. In the case of building unit assemblies 132B and 132E, the end structural frame segments 150 and 152 are directly bolted to mounting plates 154, 156, 158 and 160 which are cast into or otherwise connected to the core 142, as shown.

Figure 12 also diagrammatically illustrates the use of façade elements to provide the façade for the building 130. In particular, end façade elements 162 are connected to each of the building unit assemblies 132A-132F. Side façade elements 164 are connected to the outer sides of the building unit assemblies 132A, 132C, 132D and 132F. The side façade elements 164 are connected to the structural frame segments 16, 18, 20 and 22 of these building unit assemblies, as shown. End façade elements (not shown) are connected to the ends of the building unit assemblies 132G and 132H. Side façade elements 166 are connected to the sides of the building unit assemblies 132G and 132H via structural frame segments 168, as shown. The end façade elements 162 could be load bearing and integrated into the building unit assemblies. Steel and/or reinforced concrete could be utilised as both a feature and supporting structure dependent on the structural requirements of the building. The façade elements could be solid or hollow to allow for site jointing or mass concrete filling of the concrete elements. This can provide large rigid shear walls made up of the façade elements. The balconies, balustrades and screens could be added to the façade as required. The façade elements may include non-structural cladding such as various metal panels, timber, terracotta, glass, etc.

Figure 13A is a schematic view of a floor plan of an apartment building 69 which has ten apartments on each level. The building has a distributed core arrangement somewhat similar to that shown in Figure 8 and includes two stairwells 71 and 73 and two lift wells 75 and 77. As shown in Figures 13B and C, each of the individual apartments is formed from two adjacent building units 72.1 & 72.2, 72.1 & 72.2 fitted out to provide the necessary rooms for the apartments. In this arrangement, the stairwells 71 and 73 are built into the building units.

Figures 13D and E show alternative apartment layouts using three and two building units respectively.

Figures 14A to B show two levels of a hotel building 79 which has fourteen rooms on lower levels 81 (Figure 14A) and twelve rooms on upper levels 83 (Figure 14B). In this general arrangement, the lift well 91 constitutes a side core similar to the side core 67 of Figure 7C whereas the stairwells 87 and 89 are internal, similar to the arrangement of Figure 8. Basically in this arrangement a single building unit 93, as shown in Figure 14C, is used for each room in the hotel building. In this construction, the lift wells and stairwells are separately constructed rather than being part of building units. This contributes to the bracing and stability of the building.

Figures 15A and B show a mixed use building 85 which has both office space in the lower levels of the building and residential accommodation in the higher levels. Figure 15A shows a typical floor plan for the residential accommodation using various building units. Similar or differently shaped building units could be utilised on lower levels and serve as commercial office space.

- 5 As mentioned above, the building units 2 can be partly or substantially completely fitted out in accordance with the requirements of the finished building. The techniques for arrangement of the various building units to achieve particular floor plans need not be described in detail as similar techniques have been used in low rise structures, as described in some of the prior art documents referred to above.

- 10 Other parts of the structure and/or fit-out of the building can be carried out using known techniques or techniques which are similar to known techniques. For instance, the footings of any building assembled in this way will have footings constructed in the conventional manner to suit the site conditions and height of the building. However, the size and capacity of the footings will be reduced and therefore less costly than a conventionally constructed concrete building due to weight reduction in buildings constructed in accordance with the invention.

- 15 Where carpark are required, they can be constructed in concrete in the conventional manner, as this type of construction is best suited. A transfer level can be formed at the top level of the carpark, as required to transfer the loads from the units to the carpark structure. In this way the most economical and efficient layout of structural members can be achieved.

- 20 The roofs of the units can be fabricated as a separate framed section and is lifted into position on the topmost units and connected in the same way as the connections between the units. The roof is formed with short stub columns that align with the structural frame segments below, steel side beams and steel purlins. A parapet is formed around the perimeter of each unit such that the entire roof is made up of unit sized sections that are each drained independently. After installation a metal capping is fitted over all the parapets to waterproof the junctions between the units. The covering to the roof can either be steel roof
25 sheeting with conventional gutters and flashings or sheeted with plywood and a bituminous waterproof membrane. Additional finishes such as concrete pavers or timber decking can be added to created rooftop terraces. Plant platforms and walkways can be added as required.

- 30 Drainage can be achieved with downpipes from the gutters in a steel sheeted roof or from downpipes connected to roof outlets. The downpipes will generally be positioned on the external faces of the building.

Drainage to balconies can be achieved in the same way as a membrane roof with the downpipes connected to balcony drains. It is common for the balcony drains to align with the roof outlets so a single downpipe connecting the roof outlet and balcony drains, in each run, can be used.

Services and fittings can be included in each unit and can be fitted off from the fixtures and fittings to a central point suitable for connection after installation.

Installation of the main risers (water, gas, sewer, etc) and cabling (electrical, phone and data, etc) can be carried out on site in the conventional way.

- 5 Plant equipment is set up in much the same way as in conventional buildings. The type of plant is determined by the building size, type of services available or required and availability.

Figure 16 illustrates in more detail the structure of one embodiment of the building unit assembly 2 and novel connection assemblies for interconnecting various units. In broad terms the construction of such a building unit assembly follows a process of, constructing a self supporting unit, followed by the
10 attachment of one or more support columns to its exterior.

In the illustrated arrangement, the sidewall 6 is formed from profiled steel sheeting 179 which is similar to that used in shipping containers. Typically the sheet has a thickness of say 1.6mm and a single sheet is used for the entire wall which may have a height of say 2700mm and a length between 10m to 20m. The sidewall 6 includes an upper rail 180 which is welded to the top edge of the profiled wall sheeting 179.
15 Typically the rail 180 is 60x60mm and having a wall thickness of say 3mm. The sidewall 6 also includes a bottom rail 182 which is of generally C shaped section having a lower flange 183 and a wider upper flange 185 which is welded to the bottom edge of the sheeting 179. The depth of the central web of the bottom rail 182 is typically 160mm and the material has a thickness of say 4.5mm.

The floor 8 could be made up from a plurality of steel purlins 184 extending laterally across the building
20 between the sidewalls 6 and located at 400mm centres. The ends of the purlins are welded or bolted to the central web of the bottom rail 182 of the sidewall 6, as shown. The floor further includes plywood flooring 186 mounted by screws or the like to the purlins 184.

The roof 10 is made up from profiled steel sheeting 186 which can be the same as that used in the sidewall 6. The roof further includes a roof rail 188 which in the illustrated arrangement is an L-section
25 channel, say 55x55mm having a wall thickness of 6mm. The roof rail 188 can be welded or bolted to the upper rail 180 of the sidewall 6.

The other sidewall 4 of the building unit 2 is of similar construction and need not be described.

The components of the sidewalls 4 and 6 and the floor and roof 8 and 10 define the box like structure of the building unit which is capable of supporting its own weight and live loads applied to it in use. In the
30 illustrated arrangement, the internal sidewalls are lined with a double layer of fire rated plasterboard 190 and 192 which are connected to the inside of the sheeting 179 by means of upper and lower battens 194

and 196. Similarly, the roof is lined by two plasterboards 198 and 200 connected to the inner face of the panels 186 by ceiling battens 202. The double layers of plasterboards together with the air spaces between the plasterboards and the profiled sheeting 179 and panels 186 increases fire rating and soundproofing of and between the building units.

- 5 Figure 16 also shows the column element 22 and the lower and upper mounting blocks 24 and 26. In the arrangement illustrated arrangement, the column element 22 is formed from a square section steel beam, say 100x100mm and having a wall thickness of say 9mm. Its upper end 20 is welded directly to the upper rail 180 of the sidewall 6. The top of the column element 22 is welded to the upper mounting block 26 and bottom of the column element 22 is welded to the lower mounting block 24. In the illustrated arrangement,
10 the lower mounting block 24 is somewhat wider than the upper block 26 and its inner side extends into the channel which forms the bottom rail 182 of the sidewall 6 and is welded thereto. This completes the connection of the column element 22 and the mounting blocks 24 and 26 to the sidewall 6. The other column elements 16, 18 and 20 of the building unit assembly are connected in a similar way and need not be described.
- 15 It is advantageous to perform a stress relieving step prior to attachment structural frame segments 22. For example when the unit is constructed in a jig or by clamping the stress relieving step will typically include releasing a clamping force applied by the jig or clamp. For a unit having a welded metal construction this could include allowing any heat stresses in the metal to dissipate e.g. by cooling. In this way the box-like unit or monocoque relaxes into its natural shape, which may include deformations or
20 deviations from its designed shape. Then the column elements 22 can be attached as described herein. In this way accurate placement of the column elements (with respect to the original design) can be achieved as they are not dependent upon accuracy in the shape of the unit monocoque. Typically the mounting means for attaching the column elements 22 to the unit have sufficient tolerance to take up the deviation of the unit.
- 25 As noted above this decoupling of the construction of the building units and the structural frame segments of a building unit assembly improves ease of manufacture since only those portions of the building unit assembly that need to be accurately positioned are made to exacting tolerances. The remainder – e.g. the building unit shell can be made to other tolerance levels.

- 30 Because of the accuracy of the placement of the structural frame segment they (or a point on them) can serve as a datum for the fit-out of the interior of the unit and fitment of any façade elements. That is rather than using the walls of the building unit for guiding fit-out or attachment of a facade, because they may not be straight, or vertical, a reference from the structural frame segment 22 is taken. To do this a measurement from the datum point (e.g. a point on the inside wall of the columns is taken and transferred to the interior of the self supporting unit. Measurements for the fit-out of the interior can then be taken

from this transferred reference point. As will be appreciated several such reference points may be needed.

A first mounting means, in the form of the lower mounting block 24, is illustrated in more detail in Figures 17 to 20. The mounting block generally takes the form of a hollow cuboidal body having open ends as best seen in Figure 17. More particularly, the block has a top wall 210, bottom wall 212 and sidewalls 214 and 216. The block has inner and outer open sides 218 and 220. The top and bottom walls 210 and 212 include aligned holes 222 and 224 which are offset towards the outer open side 220, as best shown in Figure 18. The block 24 typically has a width of say 165mm, height of say 160mm and a length of say 160mm. It is preferably fabricated from structural steel and the sidewalls have a thickness of say 16mm whereas the top and bottom walls 210 and 212 have a thickness of 20mm.

Figures 21 to 24 diagrammatically illustrate the structure for the upper mounting block 26. The block 26 is again a generally cuboid hollow body. It has a top wall 230, bottom wall 232 and sidewalls 234 and 236. It also has open sidewalls 238 and 240. The sidewalls 234 and 236 include aligned holes 242 and 244 which are located generally centrally of the sidewalls. The bottom wall 232 includes an opening 246 generally centrally thereof. The top wall 230 includes a larger tapered opening 248. The opening 248 is generally rectangular but with curved corners. The taper is about 10° with the wider part of the opening 248 located at the upper surface of the top wall 230, as shown. In the illustrated arrangement, the upper mounting block 26 has a height of about 195mm, width of say 120mm and depth of 160mm. The block is fabricated from structural grade steel and the sidewalls 234 and 236 have a wall thickness of say 16mm, the bottom wall 232 a wall thickness of 20mm and the top wall 230 a wall thickness of 40mm.

Figures 25, 26 and 27 are fragmentary views showing how a pair of lower adjacent building unit assemblies 2A and 2B are connected to a pair of upper adjacent building unit assemblies 2C and 2D. It will be seen from Figure 25 that the lower mounting block 24A of the upper unit 2C is directly mounted on the upper mounting block 26A of the lower building unit assembly 2A. More particularly, the bottom wall 212C of the upper building unit assembly 2C bears directly on the top wall 230A of the lower unit. It will also be seen that the column elements 22A and 22C are aligned with one another. A similar arrangement is present at the other points where the mounting blocks of two building unit assemblies 2A and 2C engage one another. In this way, the entire vertical loading of the upper building unit assembly 2C is transmitted to the lower building unit assembly 2A via the mounting blocks and then into the column elements.

Figure 26 is a similar view to Figure 25 except that it shows the location of some of the components of the building unit assemblies 2B and 2C which are located beside the building unit assemblies 2A and 2C respectively. More particularly, Figure 26 shows the location of the structural frame segments 16B and 16D together with the location of the mounting blocks 26B and 24D.

In the illustrated arrangement, there are three types of connections which, for convenience, will be referred to as a Type 1 connection 250, Type 2 connection 252 and Type 3 connection 254. [Generally speaking, Type 1 connections 250 as shown in Figure 28 are used to connect together the upper mounting blocks of lowermost building unit assemblies to the lower mounting blocks of uppermost units.

- 5 In the illustrated arrangement, a Type 1 connection 250 is used to connect the upper mounting block 26A to the lower mounting block 24C, as shown. Similarly, a Type 1 connection 250 is used to connect the upper mounting block 26C to the next vertically adjacent mounting block.

- 10 Type 2 connections 252 as shown in Figure 29 are used to connect together adjacent upper mounting blocks 26. In the illustrated arrangement, a Type 2 connection 252 is used to connect together the upper mounting blocks 26A and 26B. Similarly, a Type 2 connection 252 is used to connect together the upper mounting blocks 26C and 26D.

- 15 Type 3 connections 254 as shown in Figure 30 are used to vertically connect adjacent units where Type 1 connections 250 cannot be used because the interior of the lower mounting block 24 cannot be accessed, as will be described below. A Type 3 connection 254 includes an elongate connecting rod which extends from the upper mounting block 26 of one building unit assembly to the upper mounting block 26 of the next vertically adjacent unit.

- Figure 28 illustrates in more detail a Type 1 connection 250. The Type 1 connection 250 includes a bolt 260 having a rectangular head 262 which has tapered sides as shown. The connection includes a tapered spacer 264 which is generally cuboid in shape but having tapered sides so as to be complementary to the shape of the opening 248 in the top wall 230 of the upper mounting blocks 26. The tapered spacer 264 includes a central bore 265 to permit the shaft of the bolt 260 to pass therethrough. The connection includes a washer 266 and nut 268. It will be seen in Figure 25 that the lower and upper mounting blocks 24 and 26 have their open sidewalls 218A and 238C exposed so that building workers have access to the interior of the mounting blocks. Prior to placing the upper building unit assembly 2C on the lower building unit assembly 2A, the tapered spacer 264 is first located in the opening 248. The building unit assembly 2C can then be lowered into position and the shaft of the bolt 260 can be introduced through the bore 265 of the spacer 264 and then through the opening 246 in the bottom wall 232 of the lower mounting block 24. The building workers can then place the washer 266 and nut 268 on the shaft of the bolt 260 and tighten the nut, access being gained through the open sidewall 218 of the lower mounting block 24. The complementary tapers of the spacer 264 and the opening 248 ensure that the shaft of the bolt is correctly centred so as to give correct alignment between the upper and lower building unit assemblies. Figure 31 diagrammatically illustrates the position of the head 262 of the bolt of a Type 1 connection 250 prior to lowering the upper building unit assembly into position. It will be seen that the tapered sides of the head 262 are generally aligned with those of the tapered spacer 264. After lowering of the uppermost unit into position, the head 262 can then be rotated through 90° so that it

assumes the position as shown in Figure 28 where it can bear against the underside of the top wall 230 of the top mounting block 26.

Figure 29 schematically illustrates a Type 2 connection 252 between adjacent upper mounting blocks 26A and 26B. The connection includes a bolt 270, nut 272 and washer 274.

- 5 As can be seen, sidewalls 236A and 234B are adjacent to one another and their respective openings 244A and 242B are also aligned. The shaft of the bolt 270 can pass through the aligned openings so that the operator can then mount the washer 274 and tighten the nut 272. Access to the interior of the mounting blocks 26A and 26B is via their open sidewalls 238A and 238B.

- Figure 30 diagrammatically illustrates the Type 3 connection 254 which is used to vertically connect
 10 together the building unit assemblies 2B and 2D. The Type 3 connection 254 includes an elongate rod 271 and head 273. The head 273 is generally cuboidal with tapered sides and is similar in shape to the head 262. The connection includes a tapered spacer 275 which is of generally complementary shape to the tapered opening 248B of the upper mounting block 26B. The tapered spacer 275 includes a central bore 276 to permit the rod 271 to pass therethrough. The upper end of the rod 271 is threaded so that it
 15 can receive a washer 278 and nut 280 thereon. In the illustrated arrangement, the head 271 engages the underside of the top wall 230B of the mounting block 26B. The shaft of the rod 271 extends through the openings 222D and 224D of the lower mounting block 24D through the structural frame segment 16D so that its free end is located within the upper mounting block 26D as shown. Figure 32 shows the position of the head 271 of the Type 3 connection 254 as it is lowered into position. After lowering of the uppermost
 20 building unit assembly 20 into position, the head 273 can be rotated through 90° so that it again engages the underside of the top wall of the mounting block 26B. The aligned tapered faces of the bolt heads and tapered spacers assist in alignment of the units during installation and fastening. The building worker can then tighten the nut 280 so as to securely interconnect the building unit assemblies 2B and 2D.

- Normally, the building unit assemblies can be lifted using a crane which has hooks or other fastening
 25 means which can be connected to the four upper mounting blocks 26 of a building unit assembly. The type of connection can be similar to that used for lifting and transport of shipping containers.

- Referring now to Figure 27 which shows a side view of a connection between a pair of lower adjacent building unit assemblies 1A,2B and a pair of upper adjacent building unit assemblies 2C and 2D. This arrangement includes all three connections (Type 1, Type 2 and Type 3) to connect the units
 30 2A,2B,2C,2D, and are assembled in a assembly as follows: The building unit assembly 2C is mounted on the building unit assembly 2A and vertical connections are made by Type 1 connections 250. This would then be followed by lowering into position of the building unit assembly 2B adjacent to the building unit assembly 2A and horizontal connections made using Type 2 connections 252. Once building unit assembly 2B has been lowered into position, it is no longer possible to access the interiors of the

mounting blocks 26A and 26B and therefore the fabricators are unable to place the components of a Type 1 connection therein. Accordingly, Type 3 connections are needed.

Figure 33 is a diagrammatic side view showing a four level building 280 including a plurality of building unit assemblies of the type described previously. The units are interconnected using Type 1, 2 and 3 connections 250, 252 and 254 as indicated. The drawing shows in large bold numerals, the preferred sequence of assembly of the various building units in the building 280. The exact order of the installation of units is determined by site and lifting conditions but is generally working up in a diagonal direction. In this drawing, the building includes a foundation 282 which includes mounting plates to which Type 1 connections 250 are coupled in order to securely anchor the building to the foundation.

Figures 34 to 51 illustrate an alternative set of mounting means. That can be used in embodiments of the present invention. In this regard, instead of mounting blocks each column is fitted with a connecting plate which is used for fixing together adjacent building unit assemblies as will be described.

Details of a further embodiment of the lower and upper connecting plates 24 and 26 will now be described with reference to Figures 34 to 51. In the preceding description, the lower connecting plates were generically identified by the reference numeral 24. In the preferred form of the invention, however, there are two types of lower connecting plate. The first lower connecting plate 206 is schematically illustrated in Figures 34, 35 and 36. It basically comprises a rectangular plate of steel 210 having a nominal thickness of say 25mm but the thickness can be varied according to requirements. In the illustrated arrangement, the length of the plate is 290mm and the width is 145mm these dimensions can be varied according to requirements. On the underside of the plate 210 is a tapered projection 211. The projection 211 can be fixed to the plate 210 by welding or the like. In the illustrated arrangement, the projection 211 is generally cuboid in shape and has a depth of 20mm, length of about 91mm and width of about 53mm. The taper amounts to about 2.5mm on each of the sides or between about 5° to 10°. The corners of the projection are preferably rounded and have a radius of curvature in the range from 5mm to 15mm. The plate 210 includes first, second and third bores 212, 213 and 214. The bore 212 is larger in diameter than the other bores and is located on the central longitudinal axis. It is preferably 32mm in diameter. The bores 213 and 214 are aligned generally symmetrically between the projection 211 and one of the ends of the plate. The bores 213 and 214 are preferably 26mm in diameter.

A second type of lower connecting plate 215 is shown in Figures 36 and 37. The second type of connecting plate 215 includes a square plate 216 which is of the same thickness as the plate 210 and its edges are half the length of the longitudinal length of the plate 210.

Thus in the illustrated arrangement the sides are 145mm in length. The underside of the plate 216 includes a symmetrically disposed projection 217 which is identical in shape to the projection 211. The

end view shown in Figure 36 of the first type of lower connecting plate 206 would be the same for the second type of lower connecting plate 215. The plate 216 does not include any bores.

In the foregoing description, the upper connecting plates were generically shown by the reference numeral 26. There are in fact two forms of upper connecting plate. As will be described below, similar components are used to make the different types of upper connecting plate but they are differently oriented in the building unit assembly.

Figures 38 to 41 diagrammatically illustrate the preferred shape of an upper connecting plate 218. The connecting plate 218 can be formed from an initially rectangular plate 219 of steel, the dimensions of the plate 219 being generally the same as the plate 210 shown in Figure 16 except for the thickness which is preferably 40mm. The upper connecting plate 218 has one corner removed therefrom so as to define a rectangular tab portion 220. The corner that is removed is preferably 75mm x 75mm. The plate 219 includes a centrally located tapered recess 221 which is complementary in size and taper angle to the projections 211 and 217 of the lower connecting plates 206 and 215. The plate 219 includes a first bore 222 located generally along the longitudinal axis of the plate 219 between one end of the plate and the recess 221 and a second bore 223 located generally centrally of the tab portion 220.

The bores 222 and 223 preferably have diameters of 34mm and 28mm respectively. As will be described in more detail below, the upper connecting plate 218 can be mounted in different orientations on a building unit assembly 2 so that the upper and lower connecting plates can be used to interconnect laterally and vertically adjacent building unit assemblies 2. All of the connecting plates are made from 350 grade steel or greater.

Figures 42 and 43 schematically illustrate how the mounting means in the form of connecting plates 206, 215 and 218 are connected to the column elements 18 and 20 to form structural frame segment 4218 and 4220. Figure 42 shows the column element 18 which in this arrangement is a hollow steel column of square cross-section having a length and width 125mm by 125mm, wall thickness of about 4mm to 10mm with an overall length of 3050mm, including connecting plates. One of the top connecting plates 206 is welded to the upper end of the column element 18 such that the centre of the recess 221 is aligned with the longitudinal axis of the column element 18. One of the lower connecting plates 215 is welded to the lower end of the column element 18 such that the centre of its projection 217 is aligned with the longitudinal axis of the column 18. This ensures that the recess 221 is accurately aligned with the projection 217.

Figure 43 schematically illustrates the structural frame segment 4220. This structural frame segment is formed by welding one of the top connecting plates 218 to the upper end of the column element 20 and one of the lower connecting plates 206 to the lower end of the column element 20. Again the centres of the recess 221 and projection 211 are aligned with the longitudinal axis of the column element 20. The

column element 20 is formed from the same section as that used to form the element 18 and has the same dimensions.

In an alternative embodiment a structural frame segment can have its mounting means and column element formed integrally. In this case the mounting means will be that part of the column element that engages a neighbouring column element in use and that part that is used for fastening them together.

Figure 44 shows the location of the structural frame segments of a pair of laterally adjacent building unit assemblies 2A and 2B. For the structural frame segment 18A of the building unit assembly 2A, the orientation of the upper connecting plate 218 is chosen so that the tab 220 is adjacent to the sidewall 4 and directed away from the structural frame segment 16A. On the same side, the structural frame segment 16A has its tab 220 oriented the same way. The structural frame segment 16A is the same as the structural frame segment 18A and therefore lower connecting plates 215 will be located at the lower ends of these structural frame segments.

On the other sidewall 6A, the structural frame segment 20A is located so that its tab portion 220 is oppositely oriented relative to those adjacent to the sidewall 4A. The structural frame segment 22A is of the same construction as the structural frame segment 20A. It will therefore be appreciated that both of the structural frame segments 20A and 22A will have first lower connecting plates 206 at the lower ends thereof.

The building unit assembly 2B is of identical construction to the building unit assembly 2A and therefore its column elements and upper and lower connecting plates will be the same as those of building unit assembly 2A.

Figure 45 shows the building unit assemblies 2A and 2B laterally stacked together such that the tab portions 220 of the lower connecting plates 206 will inter-engage, as shown.

The column elements 16, 18, 20 and 22 can be welded to the sidewalls and/or framework for the building units 2A and 2B at selected locations so that they can be laterally connected together as shown in Figure 45 as well as vertically connected, as will be described in more detail below.

Figure 46 schematically shows an isometric view of a plurality of building unit assemblies assembled together. The front most visible unit 2B has a structural frame segment 18B connected to the sidewall 4B of the building unit assembly 2B. The length of the structural frame segment 18B is chosen so that the top of the upper connecting plate 218B is located about 100mm above the plane of the roof 10B.

An elongate connecting rod 207B having threaded ends is passed through the bore 222B and its lower end engages a threaded coupling member (not shown in Figure 41) located adjacent to the bottom of the

structural frame segment 18B, as will be described in more detail below. A nut 209B is tightened on the threaded end of the connecting rod 207B. As shown in Figure 47, a laterally adjacent building unit assembly 2A can then be positioned so that its side structural frame segment 20A is adjacent to the structural frame segment 18B as shown. In this position, the tab portions 220A and 220B are side by side.

5 At the other end of the building unit assemblies 2A and 2B, the structural frame segments 22A and 16B are similarly disposed.

After alignment of the building unit assemblies 2A and 2B, a third building unit assembly 2C can be lowered on top of the building unit assembly 2B with the structural frame segment 20C vertically aligned with the structural frame segment 20A as shown in Figure 48. A coupling member 233B can be

10 connected to the projecting end of the connecting rod 207B, as shown.

The coupling member 233B is essentially an elongate nut which can receive the threaded lower end of an upwardly adjacent elongate connecting rod 207D (as shown in Figure 50). The building unit assembly 2C is lowered such that the projection 211C of column 20C enters the recess 221A of column 20A and because of their complementary tapering shapes, this will tend to automatically correctly align the building

15 unit assemblies 2C and 2A. As the building unit assembly 2C is lowered, all of its projections 211 and 217 will enter corresponding recesses 221 of the building unit assembly 2B. Bolts 224, 225 and 226 can then be introduced through the aligned bores in the plates 206C and 218A, 218B. More particularly, the bolt 224 passes through the bores 212C and 222A; the bolt 225 passes through the bores 214C and 223A and the bolt 226 passes through the bores 213C and 223B. Nuts 227, 228 and 229 can be tightened on

20 the respective bolts to securely couple the plates together, as shown in Figure 49.

After all of the nuts have been tightened, a fourth building unit assembly 2D can then be lowered into position above the building unit assembly 2A. For clarity of illustration in Figure 49, only the structural frame segment 20D of the building unit assembly 2D is shown. It is lowered into position such that its projections 217D enter the recess 221B of the building unit assembly 2B. The four tapering projections of

25 the building unit assembly 2D will assist in correct alignment of the building unit assembly 2D above the building unit assembly 2A.

Figure 50 shows the final position of the various plates. It will be seen that the plate 215D bears against the plate 218B and is held in position by means of the elongate connecting rod 207D, as shown. The elongate connecting rod 207 is preferably made from 30mm diameter steel rod and is threaded at its ends

30 or along its entire length.

It will be appreciated that the nuts 227, 228 and 229 can be tightened before the fourth building unit assembly 2D is lowered into position. Once this occurs, there is no access to the connecting plates and the use of the elongate connecting rod 207D enables the final connection to be made by assemblers working from the roofs of the upper building unit assemblies 2C and 2D. The normal procedure for fitting

the elongate connecting rod 207D would be to screw its lower end into the coupling member 233B prior to positioning of the fourth building unit assembly 2D. The building unit assembly 2D is then positioned above the building unit assembly 2A and the upper end of the rod 207D is aligned with the bore 222 of the top plate (not shown) of the structural frame segment 18D. The building unit assembly 2D can then be
5 lowered so that the upper end of the rod 207D passes through the bore. A similar sequence occurs for all of the structural frame segments of the building unit assembly 2D.

It will be further appreciated that the illustrated arrangement provides a very robust connection both vertically and laterally for the connecting plates and hence for the structural frame segments. This imparts rigidity and stability to the building.

10 It will be appreciated that the positions of the connecting plates could be interposed, i.e. the projections could be on the upper plates. Also, the complementary plates could be used for the lower plates rather than the illustrated arrangement in which the upper plates are complementary.

Figures 52 to 67 illustrate yet another embodiment of mounting means and their method of use in connecting building unit assemblies to one another. This example represents a hybrid between the
15 previous embodiments using both connecting plates and mounting blocks.

An exemplary lower connecting plate 310 is illustrated in more detail in Figures 52, 53 and 54. It will be seen that the plate 310 includes a rectangular base 312 which has sidewalls say 125mm long and a thickness of 25mm, the upper edges of the base being chamfered. The plate 310 includes a locating projection 314 which is cast or fabricated from steel and welded to the underside of the base 312. The
20 projection 314 is generally cuboid but having downwardly tapered side and end walls, as shown. The lower connecting plate 310 includes a central bore 316 which extends through the base 312 and the projection 314. Typically the diameter of the bore 316 is about 332mm.

In the building unit assembly 300 the upper ends of the structural frame segments 16, 18, 20 and 22 are provided with upper connecting plates 318 or upper mounting blocks 320 depending where the units are
25 to be deployed. Basically the building mounting blocks 320 are used where access is a problem and elongate connectors are required, similar to the Type 3 connections 254 of the earlier embodiments, as will be described in more detail below.

Figures 55 to 57 illustrate the upper connecting plate 318 in more detail. It will be seen that it is in a form of a rectangular plate which is the same size as the base 312 of the lower connecting plate. It includes a
30 rectangular opening 324 having tapered sidewalls which are complementary to the tapered sidewalls of the projection 314 so that the projection 314 can be fitted snugly therein.

Figures 58 to 60 illustrate in more detail the upper mounting block 320. The upper mounting block 320 is welded to the upper ends of the column elements as shown below and is used in places where an elongate rod is required owing to lack of access, as in the case where Type 3 connections 254 were required. The upper mounting block 320 is of generally similar construction to the upper mounting block 26 shown in Figures 21 to 24 and the same reference numerals have been used to denote parts which are the same as or correspond to those of that embodiment. In this case, the opening 248 is of complementary shape to the projection 314 so that these components can be snugly fitted together when the building unit assemblies 300 are stacked on top of each other.

Figures 61 to 65 illustrate a bolt 330 which can be used in conjunction with the lower and upper connecting plates 310 and 320 for connecting them together. The bolt 330 has a head 332 and shaft 334. The head 332 is generally cuboid in shape but having side and end walls which are tapered at about 10 degrees. The shaft 334 is made in two lengths, the shorter being about 120mm (similar to a Type 1 connector) and the longer being of a length such that it can extend the full height of the building unit 300 (similar to a Type 3 connector). Typically the longer version has a length of say 3025mm. In either case the upper end 336 of the shaft is threaded so that it can receive a nut 338. Projecting beyond the threads is a square projection 340, as best seen in Figures 63 and 65.

Figures 66 and 66A illustrate how an upper connecting plate 310C are welded to respective support columns 22A and 22C respectively to cooperate to align units 310C and 310A with each other for connection using the features as described. Figure 67 illustrates a similar example, but using an upper mounting block 320 and lower connecting plate 310C.

Figure 67 shows how the bolts 330 are used to interconnect four adjacent building unit assemblies 300A, 300B, 300C and 300D. This arrangement is similar to that shown in Figure 27 of the previous embodiments and therefore need not be described in detail. It will be seen, however, that the lower ends of the structural frame segments 22 include access openings 360 to enable access to the nuts 338 for connecting the upper and lower connecting plates. In addition, where the column elements are provided with upper connecting plates 318, access openings 362 are provided so as to enable horizontally disposed bolts 364 to extend therethrough to interconnect the structural frame segments, as shown. In the illustrated arrangement, the head of the bolt 364 is located outside of the hollow interior of the column element 22A. This enables it to be held to facilitate tightening of the nut 365 which is located within the upper mounting block 320D. In this arrangement, the bolt includes a flange 367 and a washer is located on the shaft of the bolt 364 between the upper mounting block 320B, the arrangement being such that tightening of the nut 365 effectively clamps the upper end of the structural frame segment 22A, washer 369 and upper mounting block 320B together. Figure 68 shows a view similar to that of Figure 16 but showing a different unit construction. In the illustrated arrangement, the sidewall 6 is formed from profiled steel sheeting 179 which is similar to that used in shipping containers. Typically the sheet has a thickness of say 1.6mm and a single sheet is used for the entire wall which may have a height of say 2700mm and

a length between 10m to 20m. The sidewall 6 includes an upper rail 180 which is welded to the top edge of the profiled wall sheeting 179. Typically the rail 180 is 60x60mm and having a wall thickness of say 3mm. The sidewall 6 also includes a bottom rail 182 which is of generally C shaped section having a lower flange 183 and a wider upper flange 185 which is welded to the bottom edge of the sheeting 179.

5 The depth of the central web of the bottom rail 182 is typically 160mm and the material has a thickness of say 4.5mm.

The floor 8 could be made up from purlins which run laterally across the building unit. It is preferred, however, that the floor is made from profiled steel sheeting panels 184, the material being similar to that of the sidewalls except that the depth of the profile is say 200 mm. The panels extend laterally, the arrangement providing sufficient rigidity and strength for the building unit. The ends of the floor panels 184 are welded to the bottom rail 182 at either side of the building unit. The roof 10 is preferably made from roofing panels 186, an example of which is shown in Figures 69, 70 and 71. Normally between 4 and 8 panels would be welded together to form the entire roof for the building unit. Each panel 186 is formed with longitudinal and lateral strengthening ribs, as shown diagrammatically in Figure 70. The panels are

10 preferably made from steel having a thickness of say 2mm, a width of 1045mm and length of 2356mm. The floor further includes plywood or other flooring material 186 located on the top of the profiled floor panels 184. The other sidewall 4 of the building unit 2 is of similar construction and need not be described.

The components of the sidewalls 4 and 6 and the floor and roof 8 and 10 define a box like structure which is capable of supporting its own weight and live loads applied to it in use. In the illustrated arrangement, the internal sidewalls are lined with a layer of fire rated plasterboard 190 which is adjacent to an insulation panel 192. The roof is lined by two plasterboards 198 and 200 connected to the inner face of the panels 186 by ceiling battens 202. The double layers of plasterboards together with the air spaces between the plasterboards and the profiled sheeting 179 and panels 186 increases fire rating and soundproofing of

20 and between the building units.

In the arrangement illustrated in Figure 76, the column element 20 is welded directly to the upper rail 180. At the lower end, two connecting plates 187 (one of which is shown in Figure 68) are used to connect the lower ends of the column element 20 to the bottom rail 182 preferably by welding. The other structural frame segments of the building unit assembly are connected in a similar way.

Figures 72 to 77 schematically illustrate a modified building unit assembly 300 and the same reference numerals will be used to denote parts which are the same as or correspond to those of the building unit assembly 2. The main difference between the building unit assembly 300 and the building unit assembly 2 is the construction of the floor 8 and the connecting plates 24 and 26. In the arrangement of Figures 72 to 74, the floor purlins 184 are replaced by a floor panels 304 which is of generally corrugated steel construction as shown in Figure 76. The panels 304is are similar to that used in the sidewalls and roof

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except that it is deeper, typically say 200mm (as measured in the vertical direction). The pitch of the corrugations is typically about 650mm. A number of panels 304 can be welded together into a single piece so that it constitutes the whole structure of the floor for the unit 300. Typically the wall thickness of the panel 304 is 1.6mm. The structural frame segments 16, 18, 20 and 22 are affixed to the sidewalls 4 and 6 as before. As has been explained in more detail above, the connecting plates 24 and 26 of the building unit assembly 2 are the same as described previously.

In the illustrated arrangement, the building unit assembly 300 includes two cross bracing panels 306 and 308 which are provided to give additional rigidity. The panels 306 and 308 are welded to the sidewalls 4 and 6 and to the roof 10 inwardly adjacent to the structural frame segments 16 and 22 and 18 and 20 respectively.

Figure 74 shows locations of the structural frame segments 20 and 22 where the building unit assembly 300 is to be used in a cantilever construction. As indicated in this drawing, the centre span, i.e. that between the structural frame segments 20 and 22, can be up to say 16mm16 metres and each of the ends can be cantilevered up to 6mm6 metres.

Figure 75 shows six building unit assemblies 300B, 300C, 300D, 300E, 300F and 300G stacked, as before. The gap or column zone between adjacent building units 300 is chosen to suit structural frame segments of different widths. As in the previous embodiments, the gaps can remain the same throughout the height of the building.

As best seen in Figure 77, the lower ends of the column elements 16, 18, 20 and 22 are provided with lower connecting plates 310 which are welded to the lower ends of the column elements and replace the lower mounting block 24 of the earlier embodiments.

Figure 77 is a schematic cross-sectional view showing in more detail part of the building unit assembly 300. Figure 44 is a similar view to Figure 68 but showing different details of construction for the building unit assembly 2. It will be seen in this arrangement that the bottom rail 182 is formed from rolled steel and has its upper and lower flanges projecting in opposite directions. The lower flange 183 is welded to the underside of the floor panel 304, as shown. The upper flange 185 is welded to the lower edge of the profiled wall sheeting 179, as in the previous embodiments.

Figure 78 shows a further modified building unit assembly 350 which combines elements of the building unit assemblies 2 and 300. More particularly, the floor 8 includes purlins 184 but the connections on the tops and bottoms of the structural frame segments are the same as in the building unit assembly 300. In this embodiment a reinforcing beam 352 can be welded between the rail 182 and the lower end of the structural frame segments, if required.

Figure 79 illustrates the construction of a further alternative building unit which may be used in embodiments of the present invention. This embodiment generally differs from that of the previous embodiments in that it chiefly uses flat sheet material for its wall, floor and roof construction, rather than the corrugated profiled sheets used in the previous embodiments. In the embodiment of Figure 79 the walls, floor and roof are strengthened by placing purlins at intervals along the length of the section. In figure 79, one can see a partially exploded cross-sectional view of a building unit 400. The building unit includes a wall panel 402, a roof panel 404 and a floor panel 406.

The roof panel 404 has a corner angle section 408, which may for example be an angled section 110mm x 110mm with a thickness of 4mm. This is welded to wall sheet material 410, which may be of sheet steel of 1.6mm thick.

A series of purlins 411 extend across the roof panel 404 to another angle section the same as section 408. The purlins 411 are welded to the angle 408 on its end face and along its top edge to the sheet 410. Similar purlins 411 are spaced apart along the roof panel at intervals, for example at 600mm centres. In the preferred embodiment the purlins are C10019 specification purlins.

The wall panel 402 construction is similar to that of the roof panel 404. At the top of the wall panel 402 there is an angled section 412. The angled section 412 supports the roof panel and may be of similar dimensions to the angled section 408 on the roof panel. A second angled section 414 is located at the bottom of the roof panel 402. This angled section 414 supports the floor panel 406. In this example the lower angle 414 has dimensions 210mm x 110mm and is 3mm thick. The wall panel is skinned with sheet steel, for example 2.4mm 450 MPa steel sheets. This is welded to the angle 412 at its top and angle 414 at its bottom. The sheet steel wall panel 416 is strengthened using C purlins 418 which extend between the lower angled section 414 and the upper angled section 412. The C purlins are spaced along the length of the wall and welded there to at intervals. In the illustrated embodiment the purlins 418 can be C7519 specification purlins set at 600 mm centres along the wall.

The floor panel 406 has a similar construction to the roof 404 and wall 402. The floor panel 406 has an angled section 420 at each end (only one end is shown in this diagram) to which is welded a lower floor panel comprised of sheet steel panel 422. On top of the floor panel 422 there are welded C purlins which extend between the angled sections 420 either side of the floor. In this case the floor purlins can be of C20019 specifications set at 600 mm centres along the floor panel.

As in the previous embodiments the roof panel, floor panel and wall panel will be brought into engagement and welded together.

It should be appreciated that in the embodiments described herein the building unit structures are being described as being welded together. However, a person skilled in the art will readily understand that

alternative fastening and attaching means may be employed. For example, in the place of welding, rivets, bolting or other mechanical fastening systems may be used to join components together. Depending on the construction material used gluing may also be suitable. Moreover, different welding techniques may be used such as MIG welding, TIG welding, spot welding or other alternatives, depending on accessibility
5 and also material used.

Figure 80 shows the further alternative wall construction that is very similar to that of Figure 79. The only difference being that the angled section at the lower end of the wall panel is inverted in the embodiment of Figure 80. Accordingly, additional description of this embodiment is not needed and features corresponding to features of figure 79 have been like numbered.

10 Figure 81 shows a perspective view of an alternative connecting plate usable in an embodiment of the present invention. In general terms the structural frame segment 800 illustrated in figure 81 is substantially similar to those structural frame segments already described herein and accordingly only one end thereof is illustrated in this figure. In this regard, the structural frame segment 800 includes a support column 802 and a connecting plate 804. In this example, the connecting plate 804 has a first end
15 which is generally rectangular 806 and a second end 808 which is tapered. Thus, in plan view the connecting plate 804 is generally trapezoidal in shape as best illustrated in figure 82. As with the previous embodiments, the connecting plate has a central recess 810 for receiving an engagement means from a similar connecting plate of a vertically adjacent structural frame segment and a number of bolt holes 812 and 814 for fastening to other connecting plates of adjacent structural frame segments. The structural
20 frame segment 800 in use is mounted to a building unit with the wider side of the trapezoidal connecting plate 804 nearest the building unit. Accordingly, face 816 of the connecting plate 804 tapers towards the wall of the building unit to which it is attached.

Figure 82 illustrates a plan view of the connecting plate 804 to better show its shape. In preferred forms of this structural frame segment 800 the column element 802 is mounted such that one of its surfaces is
25 substantially aligned with surface 818 of the connecting plate and more preferably that it has an edge 820 which is substantially vertically aligned with the vertex 822 of the trapezoidal connecting plate 804. The reason for this preferred alignment will be described below.

Figure 83 illustrates three building unit assemblies 828, 830 and 832 which are to be positioned side-by-side to construct a level of a building. Each of the building unit assemblies 828, 830 and 832 comprise a
30 rectangular building unit with four structural frame segments attached thereto. As can be seen in building unit assembly 828 the structural frame segments 834 and 836 are mounted such that their tapered sides 834A and 836A face inwardly, towards each other. On the other side of the building unit the structural frame segments 838 and 840 are mounted in the opposite sense so that their tapered faces 838A and 840A taper away from each other. In this manner, the tapered faces of the connecting plates operate like
35 a tapered key assembly with respect to a horizontally adjacent building unit assembly. This keying effect

between neighbouring building unit assemblies allows accurate and easy positioning of the building unit assemblies with respect to each other on site.

Figures 84A to 84C illustrate a manner in which neighbouring building unit assemblies come together using this keying effect. In figure 84A two building unit assemblies 844 and 846 are positioned side by side and spaced apart. In this position their oppositely directed connecting plates 844A and 844B are aligned. In figure 84B as the building unit assemblies 844 and 846 come together, the tapered faces of the connecting plates 844A and 846A of their respective structural frame segments come together such that they engage. The tapered faces provide guiding surface which is angled and as the units move together is used to guide the building unit assemblies 844 and 846 into the correct relative alignment. To illustrate the misalignment, in figure 84B the building unit assemblies 844 and 846 are out of alignment by distance X. In this case when correctly aligned, the Z purlins 850 and 852 will be in alignment – although alignment of the structural frame segments is the key for structural integrity reference to the purlins is made for convenience in illustrating the alignment distance.

Turning now to figure 84C which shows the final accurately positioned locations of the building units 844 and 846. As can be seen the building unit assemblies are in position such that the structural frame segment 844A and 846A are aligned along the column gap 854 between the building units and they are substantially in contact along their tapered faces. The can now be joined together as described elsewhere herein, by bolting, welding or other means.

As can be seen from figures 84A to 84C the tapered faces of the connecting plates operate as guiding surfaces to allow for easy alignment of building units in the horizontal direction. However, the outermost face of the columns of the structural frame segments and particularly the horizontally extending edge of the column element which substantially aligns with the obtuse vertex of the trapezoidal connecting plate also acts as guiding surface in the event that there is poor vertical alignment between building unit assemblies during positioning. This vertical guiding will almost always be needed as the building unit assemblies will typically be lowered into position using a crane. To further explain this, figure 85 shows the same portion of a structural frame segment as shown in figure 81 but has cross-hatching to illustrate those portions of the structural frame segment 800 which may be used as guiding surfaces during assembly of a building.

In order to facilitate smooth guiding of the building unit assemblies into position the guiding surfaces of the column element 802 are substantially aligned with the guiding surfaces of the connecting plate 804. As will be appreciated, perfect alignment need not be necessary particularly where only a small discontinuity in the guiding surface exists, such as at a welded joint between the column element 802 and the connecting plate 804. In this case, the weld itself will tend to provide an angled surface which acts as part of the guiding surface to relatively smoothly bridge the discontinuity in alignment. As will be appreciated, with this preferred alignment even if two building units are brought into contact such that

their connecting plates are not horizontally aligned the guiding surface 860 of the column element 802 will contact a guiding surface of the corresponding connecting plate of the adjacent building unit and allow smooth guiding of the building unit element into place in correct alignment as described above.

Advantages of embodiments of the system of the invention include:

- 5 lightweight construction - substitutes steel for concrete as structural components in medium and high rise construction (typically about 200kg/m² compared to normal concrete construction which is typically about 500kg/m²);

fire protection - building units and exo-structure are completely protected with fire rated plasterboard from fire sources inside the building units;

- 10 construction is undertaken inside production facility and building unit assemblies can be stacked one, two or three high;

the system allows for a wider work force to be utilised including semi-skilled workers, apprentices and women;

lower energy use – lightweight materials have significantly less embodied energy;

- 15 less building weight estimated at 200kg/m² than conventional concrete structures which are typically 500kg/m²;

constructing the building unit assembly off site within a production facility is estimated to use 50% less transport energy, produce 75% less waste and take 50% less time than a conventionally constructed on site building;

- 20 acoustic separation is higher than normal construction because exterior perimeter of one building unit is isolated from exterior perimeter of other building units. Physical contact between building units is only at junction points of exo-structure so that acoustic isolation is inherent in the system;

reduces time of construction significantly by substituting normal linear sequence of vertical construction with the ability to prepare and proceed with work on site such as excavation, footings, carpark structure,

- 25 concrete core, while in parallel constructing building unit assemblies in a production facility;

higher degree of recyclability than concrete structures. They can be dismantled in the opposite sequence to their assembly. The gypsum content is recyclable as gypsum board again where as concrete has to be

broken up and used as aggregate or gravel. The building unit assemblies are generic space containing structures that once dismantled and can be used to construct new structures with many potential uses;

whole fit-out of a building can be constructed on the ground so that an unusually high degree of dimensioned accuracy can be maintained and insures an accurate fit during assembly;

- 5 the layouts contained within the building units are variable due to the fact that the wall positions do not relate to the structural system.

Many modifications will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

- 10 It will be understood that the invention disclosed and defined in this specification extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.

CLAIMS

1. A method of building a building having a plurality of levels using a plurality of building unit assemblies wherein each building unit assembly is structurally self supporting and has at least one sidewall, a floor and a roof, the method including the steps of:
 - 5 lifting the building unit assemblies into position in the building so that each level of the building includes a predetermined number of units;
 - connecting adjacent units to one another in each level; and
 - connecting units in one level to corresponding units in at least one adjacent level that is vertically above or below the one level.
- 10 2. A method as claimed in claim 1 which further includes:
 - constructing at least one core; and
 - connecting units which are adjacent to a core to a core, the arrangement being such that the vertical loads between adjacent levels are transmitted mainly through the building unit assemblies and lateral loads can be transmitted to the core.
- 15 3. A method of building as claimed in claim 1, which further includes:
 - attaching structural frame segments to at least one sidewall of a building unit to form a building unit assembly; and
 - stacking the building unit assemblies so as to form the levels of the building with the structural frame segments in one level being vertically aligned with structural frame segments in at least one adjacent
 - 20 level whereby substantially all vertical load of the building unit assemblies are transmitted through the structural frame segments.
4. A method as claimed in claim 3 wherein lateral loads can be borne by the building units.
5. A method as claimed in claim 3 wherein lateral loads can be borne by one or more cores.
6. A method as claimed in claim 4 or 5 wherein each of the structural frame segments includes a
- 25 connecting plate at the top and bottom thereof and the method includes using fastening means to connect together top and bottom plates of structural frame segments which are vertically adjacent to one another.

7. A method of building a building as claimed in claim 3 wherein the structural frame segments are attached to the sidewalls of a building unit such that when the building unit is placed laterally adjacent to another structural frame segment in a predetermined relative alignment a structural frame segment of the building unit assembly is located side by side with a structural frame segment on the laterally adjacent building unit assembly; and the method includes the step of connecting together the structural frame segments which are located side by side to one another.
8. A method as claimed in claim 7 ; wherein said step of connecting the units in one level to corresponding units in a vertically adjacent level includes the step of connecting the tops of structural frame segments in lower levels to the bottoms of structural frame segments in higher levels.
9. A method as claimed in claim 8 wherein the method includes the step of mounting top and lower connecting plates on the top and lower ends of said column elements respectively; and connecting together the top connecting plates of the structural frame segments which are located side by side to one another.
10. A method as claimed in claim 9 wherein the method includes the step of connecting the top connecting plates of the structural frame segments which are located side by side to one another to one of the lower connecting plates of structural frame segments located side by side to one another in the next upper level.
11. A method as claimed in claim 10 including the step of clamping the other of the lower connecting plates between vertically adjacent top connecting plates by means of an elongate clamping rod.
12. A building having a plurality of levels, the building including: a plurality of building unit assemblies, each of which is structurally self supporting and has at least one sidewall, a floor and a roof; and structural frame segments attached to the at least one sidewall thereof, groups of the building unit assemblies being stacked to form the levels in the building, and wherein the building unit assemblies are stacked with the structural frame segments in one level being vertically aligned with structural frame segments at least one adjacent level whereby substantially all vertical loads are transmitted through the structural frame segments and lateral loads can be borne by the building unit assemblies.
13. A building as claimed in claim 12 wherein the building further includes a core, and wherein the groups of building unit assemblies are arranged about the core and connected thereto such that vertical loads between adjacent levels are transmitted mainly through the building unit assemblies rather than through the core.
14. A building as claimed in either of claims 12 or 13 wherein the building further includes one or more elongate connecting means extending between a top of a corresponding first structural frame

segment attached to a building unit in one level to a top of a vertically aligned second structural frame segment attached to a building unit assembly in another level such that the top of the first building element can be connected by said elongate connecting means to top of the second structural frame segment.

5 15. A building as claimed in any one of claims 12 and 14 wherein a plurality of levels include at least one building unit assembly placed in a first orientation and at least one second building unit assembly placed orthogonally to said first orientation such that said building unit assemblies in the first and second orthogonal orientations act as bracing to bear lateral loads.

10 16. A building as claimed in claim 12 wherein the ends of the column elements have mounting means connected thereto whereby the mounting means and structural frame segment can be connected to adjacent plates of structural frame segments substantially vertically above or below said one structural frame segment.

15 17. A building as claimed in claim 16 wherein the mounting means include top and lower connecting plates, and wherein the location of the structural frame segments relative to the building unit to which they are connected is such that within a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another and wherein at least one of the lower connecting plates of a structural frame segment of a further building unit assembly stacked on one of said adjacent building unit assemblies overlies at least part of the top connecting plates of said pair whereby said at least one lower connecting plate can be connected thereto to thereby connect together
20 said adjacent building unit assemblies and said further building unit assembly.

18. A building as claimed in claim 16 wherein the mounting means include top and lower connecting plates, and wherein the location of the structural frame segments relative to the building unit to which they are connected is such that in a level of the building at least some structural frame segments of adjacent building unit assemblies are located in pairs beside one another, the arrangement of the connecting
25 plates is such that for vertically aligned pairs of structural frame segments at least three of their connecting plates can be connected together.

19. A building as claimed in claim 12 which further includes first connecting means for connecting adjacent building unit assemblies within a level to one another;

and second connecting means for connecting building unit assemblies within one level to adjacent
30 building unit assembly levels which are adjacent to said one level.

20. A building having a plurality of levels, at least some of said levels including a plurality of self supporting building units each including a structural frame segment connected thereto that is being adapted to support the vertical load of another level above said level, wherein:

the building includes at least one higher level and one lower level, wherein the structural strength of the frame segments of the building units on the lower level is greater than the structural strength of corresponding frame segments in the higher level.

21. A building as claimed in claim 20 wherein the building includes a group of higher levels and a group of lower levels wherein the structural strength of corresponding structural frame segments within the group of lower level are substantially equal and the structural strength of corresponding structural frame segments within the group of higher levels is substantially equal.

22. A building as claimed in claim 21 wherein the structural strength of the structural frame segments in the group of lower levels is greater than the structural strength of the corresponding frame segments in the group of higher levels.

23. A building as claimed in any one of claims 20 to 22 wherein the structural frame segments are external to the self supporting building units.

24. A building as claimed in any one of claims 20 to 23 wherein the structural frame segments comprise column elements attached to the self supporting building units.

25. A building as claimed in any one of claims 20 to 24 wherein the building units are arranged within a level so as to define spaces between neighbouring self supporting building units in which the structural frame segments are located.

26. A building as claimed in claim 25 wherein the spaces between vertically aligned neighbouring pairs of self supporting building units are substantially the same width.

27. A building as claimed in claim 26 wherein the spaces between all neighbouring self supporting building units are substantially the same width.

28. A building as claimed in any one of claims 25 to 27 wherein the structural frame elements all have substantially the same width transverse to the spaces between neighbouring self supporting building units in which they are located.

29. A building as claimed in claim 28 wherein a relative difference in strength between two structural frame elements is provided by varying at least one of the following:

a relative wall thickness of the structural frame elements;

a relative depth of the structural frame elements measured along the spaces between neighbouring self supporting building units.

30. A structural frame segment for fitment to a self supporting building units the structural frame
5 segment including:

at least one load bearing column element;

mounting means on each end thereof for fastening the structural frame segment to another similar self supporting building unit or building element.

31. A structural frame segment as claimed in claim 30 wherein the mounting means includes an
10 engagement portion for engaging a cooperatively shaped engagement portion of a vertically aligned structural frame segment in use.

32. A structural frame segment as claimed in either of claims 31 or 32 where the mounting means are connecting plates attached to the ends of the column element.

33. A structural frame segment as claimed in any one of claims 30 to 32 wherein the at least one
15 column element includes any one of a steel column or a concrete column.

34. A structural frame segment as claimed in claim 32 wherein, in use, the location of the column elements relative to the building unit to which they are connected is such that within a level of the building at least some column elements of adjacent building units are located in pairs beside one another and wherein at least one of the lower connecting plates of a column element of a further building unit stacked
20 on one of said adjacent building units overlies at least part of the top connecting plates of said pair whereby said at least one lower connecting plate can be connected thereto to thereby connect together said adjacent building units and said further building unit.

35. A structural frame segment as claimed in claim 32 wherein the location of the column elements relative to the building unit to which they are connected is such that in a level of the building at least some
25 column elements of adjacent building units are located in pairs beside one another, the arrangement of the connecting plates is such that for vertically aligned pairs of column elements at least three of their connecting plates can be connected together.

36. A structural frame segment as claimed in any one of claims 30 to 35 wherein the structural frame segment has a mounting means shaped to match a mounting means of a horizontally adjacent structural frame segment in use.
37. A structural frame segment as claimed in any one of claims 30 to 35 wherein the structural frame
5 segment includes a plurality of column elements coupled by a means to distribute load between at least pairs of the plurality of columns.
38. A structural frame segment as claimed in any one of claims 30 to 37 which includes a guide surface for facilitating alignment with the other building element.
39. A structural frame segment as claimed in claim 38 wherein the guide surface includes at least a
10 portion of a surface of the mounting means.
40. A structural frame segment as claimed in either of claims 38 or 39 wherein the guide surface includes at least a portion of a column element.
41. A structural frame segment as claimed in any one of claims 30 to 40 wherein the mounting means includes an angled guide surface for guiding the mounting means into correct alignment of a
15 correspondingly shaped mounting means in use.
42. A structural frame segment as claimed in any one of claims 38 to 41 wherein the guiding surface includes a vertically extending portion in use which enables vertical alignment of the structural frame segment with respect to another building etc to be adjusted by sliding the guide surface against the building element.
- 20 43. A structural frame segment as claimed in any one of claims 30 to 42 wherein the mounting means including at least one mounting plate including a taper to provide an angled guide surface.
44. A structural frame segment as claimed in any one of claims 30 to 43 mounting means includes a generally trapezoidal plate that provides a tapered guiding surface to a horizontally aligned corresponding structural frame segment in use.
- 25 45. A structural frame segment as claimed in any one of claims 38 to 44 including at least one column element extending from a surface of the mounting plate in a generally perpendicular direction and positioned such that at least a portion of a surface of a column element is substantially aligned with a vertex of a trapezoidal top plate that forms part of a guiding surface of a mounting means and extends away therefrom such that the portion of a surface of the column element provides a continuation of the
30 guide surface.

46. A method of constructing a building unit for use in building a building having a plurality of levels, the method including:

(a) constructing a self supporting unit including a floor, roof and at least one sidewall, to thereby define an interior of the unit and an exterior of the unit;

5 (b) attaching at least one frame segment to the exterior of the unit for structurally supporting a building unit assembly arranged above the building unit assembly in use.

47. A method as claimed in claim 46 wherein the method includes:

(c) performing a stress relieving step prior to step (b).

48. A method as claimed in claim 47 wherein step (a) includes:

10 constructing the self supporting unit in a jig or clamp; and wherein step (c) includes releasing a clamping force applied by the jig or clamp.

49. A method as claimed in claim 47 wherein step (c) includes allowing thermally induced stresses in the self supporting unit to dissipate.

50. A method as claimed in any one of claims 46 to 49 wherein step (a) includes one or more of the
15 following construction steps:

forming a floor from a plurality of floor panels;

forming at least one wall from a plurality of wall panels;

forming a frame from a plurality of frame members;

forming a roof from a plurality of roof panels;

20 attaching at least one of a wall, floor or roof to a frame;

attaching at least one wall or wall component floor;

attaching a roof or at least one roof panel to at least one wall.

51. A method as claimed in any one of claims 46 to 50 wherein the frame segments include a structural frame segment as claimed in any one of claims 30 to 45.
52. A method as claimed in any one of claims 46 to 51 wherein the method includes defining at least one datum point exterior to the self supporting unit with reference to the one or more structural frame segments.
53. A method as claimed in claim 52 wherein the method further includes fitting out at least part of the interior of the building unit with reference to the at least one datum point.
54. A method as claimed in claim 52 wherein the method further includes affixing at least one façade element to the building unit assembly with reference to the at least one datum point.
55. A method as claimed in claim 54 wherein the method includes transferring a measurement from the at least one datum point to the interior of the self supporting unit.
56. A method of laying out a building having a plurality of levels including:
- designing a layout of said levels;
- defining a structural column grid that is common to a plurality of vertically contiguous levels;
- 15 defining a plurality of units in each level, between the columns of the column grid such that the column grid lies in a space between horizontally adjacent units.
57. A method as claimed in claim 56 which further includes:
- adjusting the layout to accommodate the column grid and spaces between the horizontally adjacent units.
58. A method as claimed in claim 56 which further includes:
- 20 defining a structural column grid common to all levels.
59. A method as claimed in claim 56 which further includes:
- defining a plurality of column grids corresponding to a plurality of groups of levels.

60. A method as claimed in claim 59 which further includes positioning a transfer structure between the groups of levels forming the plurality of groups.

61. A method in the construction of a building; the method including:

laying out a building using a method as claimed in any one of claims 56 to 60;

5 manufacturing a plurality of self supporting building units corresponding to the units of the layout, wherein each self supporting building unit has at least one associated structural support segment attached thereto which aligns with the defined column grid.

62. The method of claim 61 which further includes constructing at least one in situ component of the building.

10 63. The method of claim 62 which further includes stacking the plurality of self supporting building unit assemblies in a defined arrangement with the in situ component of the building and connecting the self supporting building unit assemblies together and to the self supporting building unit assemblies.

64. The method as claimed in any one of claims 61 to 63 which further includes positioning a plurality of the self supporting building unit assemblies in a relationship with one another as defined by the layout
15 prior to construction of the building.

65. The method of claim 64 which includes performing any one of the following steps on the so positioned self supporting building unit assemblies:

checking tolerances between at least components of neighbouring self supporting building unit assemblies;

20 checking for correct vertical and/or horizontal alignment between the structural support segments of neighbouring self supporting building unit assemblies;

fitting out at least part of an interior of the self supporting building unit assemblies;

temporarily connecting a service between at least two self supporting building unit assemblies;

disconnecting a temporarily connected service from a self supporting building unit assembly;

25 fitting a façade or cladding component to a self supporting building unit assembly.