Abstract: A pre-fabricated panel comprising: first and second upper plates; first and second lower plates; at least one central joining member; and at least one core between said upper and lower plates; wherein said at least one central joining member is positioned between at least one of said upper plates and at least one of said lower plates.
PREFABRICATED PANELS AND
METHOD OF MAKING THE SAME

The present invention relates to pre-fabricated panels, e.g. to flooring panels, particularly to flooring panels for buildings.

Many modern buildings are constructed with a framework of steel or reinforced concrete columns supporting horizontal beams at the level of each floor. Floor panels are then placed on or made composite with the beams to form each floor. The floor panels may be of the order of 10m by 2.5m so that four panels fill a square 10m by 10m bay in the frame and are connected to each other or the beams at their edges and ends.

Conventionally such floor panels have been made of reinforced or prestressed concrete, though proposals to use pultruded fibre-reinforced composites have also been made. Floors may also be cast in place with concrete or made of composite construction such as a preformed metal deck with a concrete finishing slab.

Concrete floor panels of this type are heavy, increasing the load that must be borne by the framework, and up to 30cm thick, reducing the number of floors, and hence usable area, that can be achieved in a given height of building.

Structural sandwich plate members are described in US 5,778,813 and US 6,050,208, which documents are hereby incorporated by reference, and comprise outer metal, e.g. steel, plates bonded together with an intermediate elastomer core, e.g. of unfoamed polyurethane. These sandwich plate systems may be used in many forms of construction to replace stiffened steel plates, formed steel plates, reinforced concrete or composite steel-concrete structures and greatly simplify the resultant structures, improving strength and structural performance (e.g. stiffness, damping characteristics) while saving weight.

Further developments of these structural sandwich plate members are described in WO 01/32414, also incorporated hereby by reference. As described therein, hollow or solid forms may be incorporated in the core layer to reduce weight and transverse metal shear plates may be added to improve stiffness. Hollow forms generate a greater weight reduction than solid forms and are therefore often advantageous. The forms may be made of
lightweight foam material or other materials such as wood or steel boxes, plastic extruded shapes and hollow plastic spheres.

Where floor panels, especially of concrete, are cast in place, until the floor panels have set, they do not have any structural strength. Thus, the framework that is constructed first must be designed so as to be able to support the dead load of the flooring system and additional framework or shuttering to support the concrete before it curves. Thus, in some cases, the framework of a building needs to be constructed to have a strength greater than is ultimately required in the finished building. This of course increases costs and delays construction of the building. It would therefore be desirable to provide a flooring system for a building taking up its full strength immediately upon installation.

It is desirable to make floor panels as large as possible whilst still being easily handable for assembly. Standard steel plates come in a size of 9 x 1.5m. One option is to seam weld two 1.5m wide plates but this introduces an extra cost and may introduce problematic weld distortions.

It is an aim of the present invention to provide a structural sandwich plate member that is particularly well-suited to use in floors of buildings.

According to the present invention, there is provided a pre-fabricated panel comprising: first and second upper plates; first and second lower plates; at least one central joining member; a first core between said first upper and lower plates; and a second core between said second upper and lower plates; wherein at least one central joining member is positioned between at least one of said upper plates and at least one of said lower plates and at least one central joining member connects at least one of (a) said first and second upper plates and (b) said first and second lower plates.

In this way standard plates of 1.5m can be used to produce a 9 x 3m pre-fabricated panel which may be used as a floor. Less distortion is present than by seam welding two 1.5m plates together so that the present invention results in better flatness. Furthermore, the presence of the central joining member results in increased stiffness and other mechanical performance increases of the panel. A side effect of the invention is improved fire protection because of the presence of the joining member between the plates. In the absence
of the joining member, the space between the two plates (for example in the seam welded version of the panel), would be taken up by intermediate layer which may be less fire retardant.

According to the present invention, there is provided a pre-fabricated panel comprising: an upper plate; a lower plate; and a core between the upper plate and the lower plate, wherein an outer edge of at least one of said upper and lower plates is bent towards the other of the upper and lower plates.

According to the present invention, there is provided a pre-fabricated panel comprising: an upper plate; a lower plate; a core between the upper plate and the lower plate; and an edge member between the upper plate and the lower plate adjacent outer edges of the upper and lower plates.

According to the present invention, there is provided a method of manufacturing a pre-fabricated panel according to any one of claims 28-67, said method comprising: joining said first upper plate, said first lower plate and said at least one central joining member; joining said second upper plate, said second lower plate and said at least one central joining member; joining said first upper plate to said second upper plate; joining said first lower plate to said second lower plate; sealing between outer edges and ends of said first upper and first lower plates and between outer edges and ends of said second upper and second lower plates thereby to form at least one cavity between said upper and lower plates; filling said at least one cavity with uncured plastics or polymer material; and allowing or causing said plastics or polymer material to cure to form at least one core.

The materials, dimensions and general properties of the upper and lower plates of the structural sandwich plate member of the invention may be chosen as desired for the particular use to which the structural sandwich plate member is to be put. In general they may be as described in US-5,778,813 and US-6,050,208 for the case that the core is of a polymer or plastics material. Steel or stainless steel is commonly used in thicknesses of 0.5 to 20mm (preferably 3-5mm) and aluminium may be used where light weight is desirable. Similarly, the core may be a plastics or polymer material which is preferably compact (i.e. not foamed) and may be any suitable material, for example an elastomer such as polyurethane, as described in US-5,778,813 and US-6,050,208. Lightweight forms or inserts
may also be included as described in WO 01/32414. The core is preferably a thermosetting material rather than thermoplastic.

The present invention will be described below with reference to exemplary embodiments and the accompanying schematic drawings, in which:

Figure 1 is a cross-sectional view showing the connection of first and second upper plates and first and second lower plates to a joining member according to a first embodiment;

Figure 2 illustrates, in plan, a pre-fabricated panel;

Figure 3 is a cross-sectional view showing the connection of first and second upper plates and first and second lower plates to joining members according to a second embodiment;

Figure 4 is a cross-sectional view showing the connection of first and second upper plates and first and second lower plates to joining members according to a third embodiment;

Figure 5 is a cross-sectional view showing the connection of first and second upper plates and first and second lower plates to a joining member according to a fourth embodiment;

Figures 6a and 6b are cross-sectional views showing the connection of first and second upper plates and first and second lower plates to joining members according to a fifth embodiment;

Figure 7 is a cross-sectional view showing the connection of first and second upper plates and first and second lower plates to joining members according to a sixth embodiment;

Figure 8 illustrates, in cross-section, a detail of the outer edges of a pre-fabricated panel of an embodiment;

Figure 9 illustrates, in cross-section, a detail of transverse ends of a pre-fabricated panel of an embodiment;

Figure 10 illustrates, in cross-section, a different embodiment of outer edges of a pre-fabricated panel;
Figure 11 illustrates, in cross-section, a detail of the outer edges of a pre-fabricated panel according to another embodiment;

Figure 12 illustrates, in cross-section, a detail of the outer edges of a pre-fabricated panel of an alternative embodiment to that of Figure 11;

Figure 13 illustrates, in perspective view, a portion of a pre-fabricated panel of an alternative embodiment;

Figure 14 illustrates, in cross-section, a detail of a longitudinal outer edge of the pre-fabricated panel of Figure 13;

Figure 15 illustrates, in cross-section, a detail of a transverse outer edge of the pre-fabricated panel of Figure 13; and

Figure 16 is a flow diagram of a method of manufacturing a building according to the invention.

In the various drawings, like parts are indicated by like reference numerals.

Figure 1 shows a central joint of a pre-fabricated panel 10 according to an embodiment of the invention. As described below, the panel 10 may be bolted to a beam 200 forming part of the framework of a building. The building may be any form of building constructed with a structural framework that supports a flooring system and curtain walls. The present invention is particularly applicable in buildings such as office blocks, apartment blocks, shopping centres (malls) or the like and may also be used in off-shore structures. As a floor panel, the pre-fabricated panel 10 preferably presents a generally flat upper surface but the lower surface need not be flat and either or both surfaces may be provided with recesses, trenches, grooves or openings to accommodate utility conduits and outlets. Both vertical and horizontal passages may also be provided within the floor panel for utility conduits.

The panel 10 shown in Figure 1 is a structural sandwich plate member that comprises upper and lower outer plates (faceplates) 11a, 11b, 12a, 12b which may be of steel or aluminium and have a thickness, for example, in the range of from 3 to 8mm, more preferably 3 to 5mm. Members, described further below, are provided between the face plates 11a, 11b, 12a, 12b around their outer peripheries for sealing, thereby to form a closed
cavity. In the cavity between the face plates 11, 12 is a core 13a, 13b described further below. This core may have a thickness in the range of from 15 to 200mm; in many applications 25 to 55mm is preferable. The overall dimensions of the pre-fabricated panel in plan may be from 2 to 4m width by 8 to 10m length. A preferred size is 3m by 9m. Pre-fabricated panels 10 may be made in standard sizes or tailor-made to specific shapes and/or dimensions.

As can be seen in Figure 2, the pre-fabricated panel 10 is comprised of two upper plates 11a, 11b as well as the two lower plates 12a, 12b (illustrated in Figure 1). Each of the plates 11a, 11b, 12a, 12b is, in an embodiment, of a dimension of 1.5 m wide and 9 m long. Thus, the pre-fabricated panel can be made from standard steel plates which are 1.5 m wide and 3 m long while still allowing the pre-fabricated panel to be 3 m wide overall. Other sizes of panel can also be made by this present invention. For example, third upper and lower plates could be added next to the second upper and lower plates to make a panel which is 4.5 m wide by 9 m long. Other sizes of panel are possible. As can be seen in Figure 2, through-holes 220 can be positioned around the outer edge of the panel in order to affix the panel to the frame of a building using bolts 34, for example.

The way in which the first and second upper 11a, 11b and first and second lower 12a, 12b panels are connected together is illustrated in Figure 1 and will now be described. A joining member 20 is provided for connecting the first upper and lower plates 11a, 12a to the second upper and lower plates 11b, 12b. The joining member 20 is illustrated as being hollow and of substantially square cross-section. However, other shapes of joining member are possible. For example the cross-section could be substantially rectangular and/or solid. The joining member 10 is elongate in the longitudinal direction of the panel 10. The joining member 20 extends substantially from one transverse end to another transverse end of the panel 10. The joining member 20 is continuous. Other cross-sections of joining member which may be appropriate are rectangular cross-sections (which could be used with the longer face parallel to the upper and lower outer plates 11a, 11b, 12a, 12b), or an I beam, for example. In a preferred embodiment the joining member 20 is hollow. This results both in light weight as well as in improved fire resistance from the perspective of heat transfer through the panel in a fire.
The first and second upper plates 11a, 11b are attached to a first side 21 of the joining member 20. The first and second lower plates 12a, 12b are joined to a second side 22 of the joining member 20. The first side 21 and the second side 22 are on opposite sides of the joining member 20. For example, opposite sides of the square or rectangular transverse cross-section of the joining member 20.

Preferably the plates 11a, 1ib, 12a, 12b are attached to the joining member 20 by welds. Preferably these welds are longitudinal welds. In the most preferred embodiment illustrated in Figure 1, a single longitudinal weld 24 welds both the first and second upper plates 11a, 11b to the joining member 20. Similarly, a single longitudinal weld 26 connects both the first and second lower plates 12a, 12b to the joining member 20. In order to achieve this, the first and second plates are positioned about 4 mm apart on the joining member 20 and are then welded to the joining member 20 in a single pass, for example. This reduces the number of welds necessary compared, for example, to the case where each of the four plates 11a, 11b, 12a, 12b is attached separately to the joining member 20. Furthermore, the presence of the joining member 20 reduces weld distortion and is cheaper to carry out than seam welding two 1.5 m plates together, for example. The core 13a, 13b can be provided between the upper and lower panels in any way. In one embodiment this is done by sealing around the outer (longitudinal) edges 25 and outer (transverse) ends 26. Therefore, a panel has at least two cavities formed between the upper and lower plates and separated by at least one joining member 20. These cavities can then be injected with material to form the core 13.

In an alternative embodiment, the hollow joining member 20 of Figure 1 may be replaced by a different shape. Indeed, the member may be solid. For example, the joining member 20 could have an I-beam cross-section. In this embodiment the web would extend between the upper and lower plates 11a, 1ib, 12a, 12b and the inner edges of the plates would rest on the flanges and the longitudinal weld 24 would weld the plates to the flanges. It would be possible to manufacture holes in the I-beam. In particular, these holes could be through the web. This would help in lightening the weight of the I-beam. Holes through the web would make the two cavities of the embodiment of Figure 1 (between first upper 11a and first lower 12a plates and between second upper 1ib and second lower 12b plates) into
a single cavity. Therefore one injection step could be used to inject core between both sets of upper and lower plates.

The core 13a, 13b may take various different forms. In one embodiment its major structural component is a main core layer of plastics or polymer material (preferably a thermoset, compact elastomer such as polyurethane elastomer) which is bonded to the face plates 11a, 11b, 12a, 12b with sufficient strength and has sufficient mechanical properties to transfer shear forces expected in use. The core 13a, 13b may be a concrete layer. The concrete layer may be normal concrete which typically weighs about 2400 kg/m³ (e.g. between 2100 and 2700 kg/m³), but preferably light weight concrete which typically weighs about 1900 kg/m³ (e.g. between 1200 and 2200 kg/m³), more preferably ultra light weight concrete that typically weighs about 1200 kg/m³ or less (e.g. between 500 and 1200 kg/m³). The concrete may be of any type of cementitious material (e.g. cements such as Portland cement, fly ash, ground granulated blast furnace slags, limestone fines and silica fume). The core 13a, 13b is formed of a material which transfers shear forces between the face plates 11a, 11b, 12a, 12b. The core 13a, 13b may have a thickness in the range of from 15 to 300 mm (preferably 15-30mm, e.g. 20mm) and is bonded to the face plates 11a, 11b, 12a, 12b with sufficient strength and has sufficient mechanical properties to transfer shear forces expected in use between those face plates. The bond strength between the core 13 and face plates 11a, 11b, 12a, 12b should be greater than 3MPa, preferably greater than 6MPa, and the modulus of elasticity of the core material should be greater than 200MPa, preferably greater than 250MPa. For low load applications, where the typical use and occupancy loads are of the order of 1.4kPa to 7.2kPa, the bond strength may be lower, e.g. approximately 1.0MPa, but sufficient to provide the required resistance, based on safety indices associated with construction for all anticipated loads, including use and occupancy loads, construction loads and wind, earthquake and temperature loads.

In this embodiment, the core 13 also includes a plurality of hollow forms 15 enclosing voids 16. The size and material of the forms 15 are chosen so that the overall density of the forms is lower than the density of the material of the main core, preferably less than 50% of the density of the material of the core layer, or preferably less than 25% and most preferably less than 10%. The purpose of the forms 15 is to take up space within the
core and thus reduce the amount of the main core material required whilst maintaining or even increasing the desired spacing between faceplates 11a, 11b and 12a, 12b. This reduces cost both directly as the forms are less expensive by volume than the main core material and secondly because the weight of the panels is reduced which may enable savings in the building’s framework. The forms 15 do not need to contribute to the overall structural strength of the pre-fabricated panel 10 but if the pre-fabricated panel 10 is formed by injection of the main core layer, the forms 15 must have physical properties sufficient to withstand pressures and temperatures arising during casting and curing of the main core layer. The size, shape and distribution of forms 15 within the core is chosen so that a sufficient number of ribs and/or columns of main core layer material extend between and bond to faceplates 11a, 11b and 12a, 12b at regular intervals across the length and width of the panel 10. If the forms 15 run continuously along or across plate members, they may also be used for utility conduits or air ducting. The forms 15 do not have to be hollow, e.g. if made of a suitable lightweight material such as a foam, or may be filled with lightweight material, which may be insulating and/or fire resistant. A particularly useful material for the forms is expanded polystyrene, having a density of 20-40g/l, which may be provided, e.g., either as spheres or ribs. Alternatively the forms may be of polypropylene such as in EP 1,682,341. This may allow use of thinner upper and lower outer plates 11a, 11b, 12a, 12b. In this embodiment the core 13 is partially filled with hollow forms 15, e.g. in the form of polypropylene spheres. This form of core is sometimes known as bubble core and is further described in WO 2005/051645, which document is hereby incorporated in its entirety by reference.

In an embodiment, the forms 15 comprise hollow, solid skin polypropylene balls having a diameter substantially equal to the distance D between the outer plates 11, 12. The balls 15 may be arranged in orthogonal rows and columns so that substantial gaps are left between them. This arrangement of forms is particularly appropriate where the major loads in use are directed along the lateral and longitudinal directions. These gaps fill with core material which bonds the outer metal plates 11,12 together. Because of the curvature of the balls, the core material forms column-like structures extending directly between the outer plates and bonded to the plates over a wide area. Thus the bond strength compared to a solid
core is reduced by no more than about 5% and the shear transfer capability is maintained.

The balls 15 may also be closely packed in a hexagonal array. This results in a higher floor panel as the proportion of the core cavity that is occupied by the main core layer is reduced. This arrangement is also particularly suited to applications in which the major loads will lie on oblique directions. The balls 15 may naturally fall in this configuration so reducing manufacturing costs.

Two layers or more of balls may also be used. This enables a thicker floor panel to be made without increasing the spacing of the column-like structures of the core. Preferably, the balls of one layer overly the balls of the other layer but in lower load applications the balls may be close packed in the vertical direction as well as in the horizontal direction. The different layers of forms need not all be the same, however it is preferred that there are 5 or fewer layers.

In general, the forms 15 should not tesselate in a plane parallel to said outer metal layers and have principal dimensions in the range of from 20 to 200% of the distance between said outer metal layers. The term "principal dimensions" is intended to refer to the diameter of a sphere, the major and minor diameters of an ovoid, the length, depth and breadth of a cuboid, etc.. In the case of irregular shapes, the principal dimensions may be regarded as the dimensions of the smallest rectangular box in which the shape will fit.

By using forms that are comparable in dimensions to the gap between the metal layers, and hence relatively small compared to the lateral dimension (length and/or width) of the plate member, any shape of plate can be manufactured using standard mass-produced forms, without the need for hand adaptation. The exact shape of the form is not crucial in many cases, though additional advantages can be obtained with specific shapes. It is required that the forms do not tesselate so that there are spaces between them for the core material which bonds to the outer plates. The shape and arrangement of the forms can be varied to vary the proportion of the volume between the outer plates that is occupied by core material.

The forms may be arranged in a single layer or multiple layers. In the case of multiple layers, it is preferred in some applications that the forms of one layer directly overly the forms of the layer below so that there are parts of the core material extending
perpendicularly between the outer metal layers. Where there are multiple layers of forms, an interlayer may be provided between the layers of forms. The layer may be made of a high tensile strength material such as metal, a high tensile strength fabric, such as Kevlar(TM) or Spectra(TM), fibre reinforced plastic, other suitable fabrics, mesh or ceramic sheets to improve the blast and/or ballistic resistance of the plate member. The layer may be perforated or shaped to allow flow of core material throughout the core during fabrication and to enhance the shear strength between the layers. The layer may also be used to assist the placing of the forms - e.g. to determine the spacing between layers or the relative positions of the forms in different layers - and thereby enhance the performance of the plate member.

A particularly preferred form is a spherical hollow ball having a diameter substantially equal to 1/N of the distance between said outer metal layers, N being a natural number between 1 and 5. The balls may for example have a diameter in the range of from 20 to 100mm and can be used in single or multiple layers in plate members with core thicknesses in the range of from 20 to 100mm. Balls made of polypropylene are particularly suitable and may be solid or preferably hollow with a solid skin. Solid balls provide less weight reduction but may still be advantageous as they are cheaper than the elastomers preferred as the main core material. Such balls are widely available and cheap to manufacture.

The forms may also be provided with a plurality of protrusions so as to increase the spacing between the forms, and hence the proportion of the core cavity occupied by core material. The protrusions may also be arranged to determine the relative shapes and positions adopted by adjacent forms and hence the shape of the void space that is filled by core material, e.g. to ensure a continuous mass of core material. A mesh, e.g. of wire, may be used to assist the placing of the forms and space them apart from each other and/or from the metal layers.

In a further alternative (not shown) the inner part of the core 13 is a corrugated metal, e.g. steel, plate with the corrugations at least partly filled by a foam or other lightweight filler material. Preferably the corrugations are substantially completely filled so that the inner core, comprising corrugated plate and filler material, presents substantially flat outer
surfaces. The corrugated plate may have embossments or openings to increase composite action with the foam or elastomer bonded to it. The filler material need not contribute significantly to the strength of the panel and hence many materials are suitable. It should be of lower density than the material of the main core layer, preferably less than 50% of the density of the material of the main core layer, more preferably less than 25% and most preferably less than 10%. Both open and closed cell foams may be used but if the panel is manufactured by injection (see below) closed cell foams may be preferred to limit ingress of the material of the main core layer and in such cases it is desirable that the filler material have sufficient strength to substantially maintain its shape during the casting process. A suitable filter material is polypropylene foam with a density of from 40 to 50 kg/m³. The filler material is preferably cast onto the corrugated steel plate. Also, preformed foam sections may be glued to the corrugated metal plate. The filler material preferably contains fire retardants so that it does not ignite under fire conditions mandated by relevant building codes. Other materials, such as a ceramic coating, may be inserted into the core or bonded to the corrugated metal plate to act as a thermal break, thereby increasing the fire resistance of the plate member.

The corrugated plate and filler are arranged so that on the major faces of the inner part of the core, parts of the corrugated plate are exposed and bonded to the main core layer with similar strength to the bond between the main core layer and the faceplates. The total area of the exposed parts of the corrugated plate on each of the major faces is sufficient to transfer shear forces from either faceplate through the elastomer to the corrugated metal plate and to stabilise the faceplate to prevent local buckling. The total area is preferably in the range of from 10 to 45% of the total area of the face, more preferably in the range of from 20 to 40% and most preferably in the range of 25 to 35%. If the panel is elongate, corrugations of the corrugated plate preferably extend substantially parallel to the longest dimension of the panel. The exposed parts are in that case elongate strips and may have a width in the plane parallel to the major faces of the panel in the range of from 50mm to 200mm.

The corrugated plate may have a thickness in the range of from 0.5mm to 5mm and may be perforated, especially in the webs, to facilitate casting of the filler material onto the corrugated plate. Surface treatments, such as adhesives, roughening, cleaning or embossing,
may be applied to the corrugated metal plate to enhance its bond to the main core layer 13 and/or the filler material. The main core layer, each side of the inner core, preferably has a thickness of 10mm or more and may have a thickness of between 10 and 25% of the total core thickness.

Figure 3 illustrates a second embodiment which is the same as the first embodiment except as described below. In all of Figures 3-7 the hollow forms 15 enclosing voids 16 of Figure 1 have been omitted. However, these embodiments may also have those features.

In Figure 3 two joining members 20a, 20b are used. The joining members 20a, 20b are positioned between the first upper 11a and first lower 12a plates and between the second upper 11b and second lower 12b plates respectively. The first upper plate 11a is welded along its inner edge to the first joining member 20a on the top surface of the first joining member 20a. The first lower plate 12a is welded along its inner edge to the bottom surface of the first joining member 20a. Similarly, the second upper plate 11b and second lower plate 12b are welded to top and bottom surfaces of the second joining member 20b. The first and second joining members 20a, 20b are welded together using welds, for example fillet welds 201. The first and second joining members 20a, 20b may be joined together before or after the upper and lower plates 11a, 11b, 12a, 12b have been welded to the joining members 20a, 20b. The welds may be made in any order. This embodiment may be advantageous over the first embodiment it may be easier to ensure air tightness of the cavities whereby the core 13a, 13b can be injected more easily.

Figure 4 illustrates a third embodiment which is the same as the first embodiment except as described below. In the embodiment of Figure 4, two central joining members 20a, 20b are used. The first and second upper plates 11a, 11b are welded together onto the top of the joining member 20a in the same way that those two upper plates are joined to the joining member 20 in the first embodiment. However, the first and second lower plates 12a, 12b are not joined to the first joining member 20a but are joined to the second joining member 20b. The join on the top and bottom is therefore staggered. The first and second joining members 20a, 20b run substantially parallel to one another in their elongate direction. In one embodiment the two joining members 20a, 20b are not in contact, in another embodiment those two members may be in contact and may be welded together.
This embodiment has the advantage of easier fit up prior to welding and that smaller welds may be used. The joining members 20a, 20b may be adhered to the plate 12a, 11b on the opposite side to where the upper or lower plates are joined.

Figure 5 illustrates a fourth embodiment. The fourth embodiment is the same as the first embodiment except as described below. In this embodiment a support member 400 is used in addition to the joining member 20. The support member 400 is placed adjacent the inner edges of a pair of upper and lower plates 1ib, 12b (only one support member 400 is illustrated in Figure 5, but another could be alternatively positioned between the first pair of plates or a support member 400 could be positioned between both the first and second pairs). The support member 400 is positioned to leave the upper and lower plates over hanging so that there is enough space for the joining member 20 to be positioned between the second upper lib and second lower 12b plates. The support member 400 may or may not be fixed to the plates, for example by welding or gluing.

In the fifth embodiment of Figures 6a and 6b, two separate panels 10a, 10b may be produced which may later be joined together. Each panel 10a, 10b has what is to be the joined panel’s 10 inner edge blocked by a joining member 20a, 20b. With reference to the first panel 10a, the first joining member 20a is positioned between the first upper plate 11a and the first lower plate 12a. The inner edges of the first upper plate 11a and first lower plate 12a are welded to the top and bottom faces of the first joining member 20a respectively. The second panel 10b is prepared in the same way. An I-beam 500 is then introduced between the two panels 10a, 10b. The I-beam 500 is sized such that its web is long enough so that the inner edges of the panels 10a, 10b can be inserted between the flanges of the I-beam 500. After the inner edges of the panels 10a, 10b have been inserted into either side of the I-beam, welds 510 can be made between the flanges and the adjacent plate.

A sixth embodiment is illustrated in Figure 7. The sixth embodiment is the same as the first embodiment except as described below. In the sixth embodiment, four joining members 20a, 20b, 600, 610 are used. First and second joining members 20a, 20b are similar to the joining member 20 of the first embodiment. In the sixth embodiment, the first upper plate 11a is attached to the top of the first joining member 20a. Similarly, the second
upper plate 11b is attached to the second joining member 20b. The gap between the first and second upper plates 11a, 11b is bridged using a third joining member 600. The third joining member 600 may be a plate. For example, the third joining member 600 may be a plate with the same thickness as the upper plates 11a, 11b.

A similar joint between the two upper plates could be fashioned between the two lower plates 12a, 12b. However, as is illustrated, a different method may be used. In this method a fourth joining member 610 is positioned on the opposite side of the lower plates 12a, 12b to the first and second joining members 20a, 20b. The first and second lower plates 12a, 12b are then butt welded together onto the fourth joining member 610 in a similar way to how the two upper plates 11a, 11b of the first embodiment are welded to the joining member 20 of the first embodiment. Because the panels are to be used as floors, it is acceptable to have a protrusion on the lower side of the panel 10. However, a protrusion may not be acceptable on the upper side. The cavity formed between the first and second joining members 20a, 20b, the third joining member 600 and the two lower plates 12a, 12b may optionally be filled with a core.

Figure 8 shows one embodiment of how the cavity formed between respective upper and lower plates can be sealed at an outer (longitudinal or transverse but preferably longitudinal) edge. An edge member 30 is positioned between upper and lower plates 11a, 12a adjacent an outer edge of those plates. The outer edge of at least one of the face plates, preferably both the upper and lower plates 11,12 is bent around the edge member 30. Thus an edge bent portion 110,120 of the plate extends along an outer edge of the edge member 30. Preferably outer corners 31 of the edge member 30 are rounded. This can help in minimising any gaps between the top and bottom surfaces of the edge member 30 and the upper and lower plates 11,12 as well as the outer edge of the edge member 30 and the upper and lower plates at their bent portions 110,120. Preferably the outer edges of the upper and lower plates 11a, 12a are bent such that their very ends do not quite meet. Preferably a single weld 32 can then be used to attach both of the upper and lower plates 11a, 12a to the edge member 30. This means that the cavity can be sealed at the edge using only a single weld. An alternative embodiment is to use a system similar to that illustrated in Figure 9, at the expense of having to make two welds. The Figure 4 embodiment can be used for the
transverse ends of the panel where the length of welding required is less than for the longitudinal edges.

The edge member 30 may be a solid bar of metal having a generally rectangular cross-section. Other shapes may be preferable, including hollow shapes.

In the Figure 9 embodiment which is of a transverse edge (but could be used at a longitudinal edge), an end or edge member 40 is positioned between upper and lower plates 11a, 12a. If the longitudinal edge portions 110 have been bent over, it may not be possible to form a similar seal at the transverse ends. Therefore, at the transverse ends the upper and lower plates 11a, 12a are not bent. This means that each outer edge needs to be welded to the end member 40 individually using welds 41. This arrangement may be used at the longitudinal and/or transverse edges, just like any other embodiment.

It will be appreciated that a reduction in width occurs if the edge portions 110 are bent over as is illustrated in Figure 8. For this reason it may be desirable to provide the bent over edge portion embodiment at the transverse ends and to use the embodiment of Figure 9 for sealing along the longitudinal edges. Using this system a pre-fabricated panel width of 3 m is achievable using standard 1.5 m wide steel plates. Such steel plates are easier to obtain longer than 9 m than they are to obtain wider than 1.5 m. Therefore, a small increase in the length of the plate is easy to arrange so that the bending over of the outer ends such as illustrated in Figure 8 for the outer edges can be implemented whilst maintaining the overall length of the panel of 9 m.

A further embodiment is illustrated in Figure 10. In this embodiment the outer edge portions 110 of the upper and lower plates are bent such that the edge portions 110,120 overlap. This allows a single longitudinal weld 140 to be used to join the upper and lower face plates 11,12 without the need for a continuous edge member 30 as in the Figure 8 embodiment. In order to take the load at areas of a bolt 34, a plurality of inserts 50 may be provided at the location of each bolt 34. Such inserts 50 are preferably welded to one or other or both of the upper and lower plates 11,12 to hold them in place during manufacture. The advantage of this embodiment over that illustrated in Figure 8 is that the panel 10 can be assembled prior to injection, with fewer steps because there is no need to turn the panel upside down to complete it. For example, the weld 140 between the two edge portions 110
can be made in an injection bed, from above.

As will be appreciated, in Figure 10 the upper plate 11a is bent so that its width is less than the width of the lower plate. This allows the outer edge portion 110 of the upper plate 11a to sit inside of the outer edge portion 120 of the lower plate 12a. Thereby the weld 140 can be made from above.

Pre-fabricated panels according to the present invention can be manufactured in a number of different ways. It may be convenient to weld all upper and lower plates 11,12 to each of the joining member 20, edge member 30 and end member 40 in any order. It may be desirable first to weld the upper or lower plates to the joining member 20, followed by the edge member 30 and end member 40. A different order may be preferable or it may be better first to weld the lower plates 12 to the various members 20,30,40 before welding the upper plates 11. A confirmation of those two orders may be desirable. It may be desirable to bend the outer edge portions 110,120 of the upper and lower plates 11a, 11b, 12a, 12b prior to commencing any of the welding steps. The bending may take place by rolling. Once all the welding has taken place to seal the first cavity between the first upper 11a and first lower 12a plates and the second cavity between the second upper 11b and second lower 12b plates, injection or vacuum filling of the intermediate layer 13 can take place. Welding to the edge member 30 or end member 40 or welding between the upper and lower plates as is illustrated in Figure 5 can be seen as sealing between outer edges and ends of the upper and lower plates thereby to form a cavity between the upper and lower plates.

Spaced along the length of edge member 30 and end member 40 are a plurality of recesses 210 and through-holes 220 by which the sandwich plate members 10 are fixed using bolts 34 and nuts 35 to corresponding holes in the flange of a girder or beam 200 forming part of the framework of the building. The through-holes in the edge member and flange may be slightly oversized to accommodate any fabrication errors: in a preferred embodiment the through-hole 220 in the edge member 30 and end member 40 is elongate in a first direction and the through-hole 222 in the flange of the beam 200 is elongate in a perpendicular direction. The recesses 210 are sufficiently large to accommodate the head of bolt 34 and a tool required to tighten it. Recess 210 should also be sufficiently deep to accommodate the full height of the head of bolt 34. After installation of the panels, the
recess 21 may be filled in with a suitable filler, or covered by a plate or whatever architectural floor covering is to be used in the building. The spacing and number and size of bolts required to fix the pre-fabricated panels 10 is determined by the expected loads. Standard bolts or tension control bolts may be used.

Two panels 10 may be fixed to a girder 200, one to either side. Any resulting space between edge members 20 for the two panels may be filled with an expansion joint filler (not illustrated) of conventional type. Angle irons may be attached, by any convenient manner, to vertical pillars of the building framework to provide additional support to the panels 10, if required or desired.

Figure 11 shows an end member 40 which is the same as the embodiment of Figure 9 except as described below. In the embodiment of Figure 11 the end member 40 is hollow. Therefore, the through hole 220 is through the upper plate 11a, through the top wall of the end member 40, through the bottom wall of the end member 40 and through the lower plate 12a. The embodiment of Figure 12 is very similar except that the through hole 220 is made larger through the upper plate 11a and the top wall of the end member 40 than through the bottom wall of the end member 40 and through the lower plate 12a. This allows a bolt to be entirely within the cavity formed by the hollow end member 40 and allows tools to be used to fix the bolt 34 so that the bolt head (with appropriate washer) presses against the bottom wall of the end member 40 and is contained within the chamber formed by the hollow end member 40. This arrangement does away with the need for a recess 210. The hole in the upper plate 11a and top wall of the end member 40 may be blocked after the bolt 34 has been tightened.

Figures 13-15 illustrate further embodiments of detailing of a pre-fabricated panel 10. Figure 13 is a perspective view of part of a pre-fabricated panel 10. The pre-fabricated panel 10 of Figure 13 is comprised of a single upper plate 11 and a single lower plate 12. However, the pre-fabricated panel 10 of Figure 13 may be comprised of two or more upper and two or more lower plates as for example, the embodiment of Figure 2. Figure 14 illustrates how the longitudinal outer edge of the pre-fabricated panel 10 of Figure 13 is arranged. Figure 15 illustrates how the transverse edge of the pre-fabricated panel 10 of Figure 13 is arranged. As can be seen the longitudinal edges 25 are produced by
bending the outer edge of the upper plate 11 towards the lower plate 12. At the transverse edge 26 a end member 40 is positioned between the upper and lower plates 11, 12. As with the other embodiments, the end member 40 may also be regarded as an edge member (such as edge member 30 in Figure 8). The difference is that in the terminology of the description an end member is used at the transverse edge and an edge member is used at the longitudinal edge.

The pre-fabricated panel of Figure 13 is provided with through holes 220 around its circumference. At the longitudinal edge 25 the through holes 220 pass through the upper and lower plates 11, 12. At the transverse edge 26 the through holes 220 do not pass through the upper plate 11 but pass through the end member 40 and lower plate 12.

As can be seen from Figure 14, the lower plate 12 is substantially unbent at the outer edge corresponding to the bent outer edge of the top plate 11. In cross-section the outer edge of the top plate 11 is bent at two positions. This forms it into a substantially z shaped profile. Although each of the two bends illustrated in Figure 14 is about 90°, this is not necessarily the case and the bends could form angles of anywhere between 60 and 135° with the neighbouring part of the plate. Therefore a small overhang could be formed by the z bend or an inclined surface could be formed between the top plate 11 and the bottom plate 12. An outermost portion of the bent part of the upper plate 11 is parallel to the plane of the second plate 12. A single longitudinal weld 122 between the outer most edge of the bent part of the upper plate 11 and the lower plate 12 joins the upper and lower plates 11, 12 together. A plurality of through holes 220 are drilled between the parallel portions of the upper and lower plates 11, 12.

Suitable dimensions are now given, but other dimensions may also be suitable. The radius of the upper bent part of the outer portion of the upper plate is about 8mm and the radius of the lower bent part of the outer portion of the upper plate 11 is about 4mm. The amount of overlap is desirably about 60mm.

Also illustrated in Figure 14 is a hook engaging feature for engaging with a lifting hook which in one embodiment comprises a further plate 500. Desirably at least three or four such further plates 500 are provided on each pre-fabricated panel 10, for example at the four corners (in plan). This allows easy moving of the pre-fabricated panel 10. The further
plate 500 may be provided with a through hole 510 for the insertion therein of a hook. The through hole 510 may have a diameter of 10-40mm. The further plate 500 is welded in place and will be described in more detail with reference to Figure 13.

A through hole 220 is formed through the upper plate 11 and lower plate 12 for use in attaching the pre-fabricated panel 10 to a frame 200.

Figure 15 illustrates the end member 40 in more detail. The end member 40 is bent into a similar shape to the outer edge 11 of the upper plate 11 of Figure 14. The end member 40 is comprised of a central part 40a which extends substantially between the upper and lower plates 11, 12. First and second flanges 40b, 40c are substantially parallel the planes of the upper and lower plates 11, 12. In cross-section the end member is bent at two positions to form a substantially z shaped profile. The angle of each bend is illustrated as being 90°. However, this is not necessarily the case and the angle may be between 60-135°.

The first flange 40b extends in a first direction from the first end of the central part 40a. The second flange 40c extends in a second direction which is opposite to the first direction from a second end of the central part 40a. The second end is opposite to the first end.

The upper plate 11 is welded to the first flange 40b using a longitudinal weld 140b. The weld 140b is formed at an inner edge of the first flange 40b close to where the first flange 40b is attached to the central part 40a.

The lower plate 12 is welded by weld 140c to the second flange 40c at an outer edge of the edge member 40.

A through hole 220 is formed through the end member 40 and the lower plate 12 for use in attaching the pre-fabricated panel to a frame 200.

As can be seen from Figure 15, the lower plate 12 extends beyond the outer edge of the upper plate 11 at the transverse edge. Only the first flange 40b of the end member 40 is between the upper and lower plates 11, 12. The central portion 40a and the second flange 40c are vertically not between the upper and lower plates 11, 12.

As with Figure 14, a further plate 500 with a hook engaging feature is also illustrated.

The advantage of the edge arrangements of Figures 14 and 15 over the other embodiments, particularly those of Figures 8-11, is that the through holes 220 can be drilled
smaller to accommodate only the threaded portion of the bolt whilst the head of the bolt is still lower than the top plane of the pre-fabricated panel 10, in the assembled position. Furthermore, the use of solid perimeter bars or solid end members or edge members is avoided which reduces cost and weight. This detail also reduces the amount of PU in the panel without reducing performance, so reducing cost.

The design could be reversed (turned upside down) so that the lower plate 12 illustrated in Figure 13 becomes the upper plate. This may be beneficial because then in a assembled floor in which a plurality of pre-fabricated panels 10 are next to each other, the channels between the panels need not be filled (because they are on the underside of the floor).

The bends may be formed by a break press or by roll-forming the edge with a suitable duplex roll-former. The welds can be fabricated in an automated way thereby helping production through put and reducing cost. Alignment prior to welding is more easily achieved.

Figure 13 illustrates one way in which the further plate 500 with a hook engaging feature may be incorporated into the pre-fabricated panel 13. In the Figure 13 embodiment the further plate 500 is used partly to block between the upper and lower plates 11, 12 at the transverse end 26, in combination with the end member 40. The further plate 500 is welded to the upper and lower plates 11, 12 as well as to the end member 40. The further plate 500 may be partly inserted between the upper and lower plates 11, 12. The hook engaging feature of the further plate is a through hole 510. A diameter of between 10 and 40mm is suitable for use of the through hole as a hook engaging feature. However, other hook engaging features may alternatively be used, for example a protrusion.

In order that the further plate 500 does not interfere with the floor, once laid, the further plate is positioned such that it does not protrude over the outer upper and outer lower planes of the pre-fabricated panel 10. In particular in the embodiment of Figure 13, the further plate 500 does not extend above the outer plane of the upper plate 11.

The further plate 500 is in a plane which is substantially orthogonal to the planes of the upper and lower plates 11, 12. In an alternative embodiment the hook engaging feature may take the form of a U-bolt, for example, welded to the lower plate 12 and/or the end
A preferred method of constructing a building including floor panels according to the invention is shown in Figure 16. The manufacture of pre-fabricated panels or members SI is preferably performed off-site and may involve:

joining the outer metal layers 11, 12, joining members 20, 20a, 20b, 600, 610, edge members 30, end members 40 and any forms or spacers to define at least two cavities;
injecting or vacuum filling core material such as unset concrete or liquid plastics or polymer material into the cavities through injection ports; and
causing or allowing the core material to cure to form the main core layer.

After curing, the injection ports and vent holes are filled, e.g. with threaded plugs, and ground flush with the surface of the outer metal plate. It is to be noted that multiple injection ports and vent holes per cavity may be provided to ensure complete filling.

For certain embodiments (for example embodiments of Figures 3 and 6 in particular) the liquid plastics or polymer material may be injected into the cavities before the panels are joined together. That is, once the inner edges of the plates have been sealed thereby to form a cavity between the two plates, polymer or plastics can be injected into the cavities. The two panels 10a, 10b may then be connected together, for example in the embodiment of Figure 3 by welding the joining members 20a, 20b and in the example of Figure 6 by welding third joining member 500 to the upper and lower plates.

If the floor panel is to be provided with recesses, grooves or openings, e.g. for utility conduits and outlets, or other surface features, such as fixing or lifting points, these are preferably formed in or on the outer metal plates prior to injection of the core. Grooves and other indentations can be formed by known techniques such as milling, cutting, bending, rolling and stamping as appropriate to the thickness of the plate and size of feature to be formed. Details can be attached by welding. Tubes to define passageways through the floor panel, e.g. for utility conduits, can be put in place prior to injection of the material to form main core layer. It is also possible to form such features after injection and curing of the main core layer, by coring for example, but in that case measures may need to be taken to ensure that the heat generated by activities such as welding does not deleteriously affect the
Independently of the manufacture of the panels, the construction of the building and erection of the structural frame work can proceed on site. Once the framework construction has advanced to a suitable point, the floor panels can be delivered and simply bolted in place at which point they will directly contribute to the strength of the structure. With the floor panels in place, any necessary fire proofing, utilities and architectural finishes can be installed to complete the building.

It will be appreciated that the above description is not intended to be limiting and that other modifications and variations fall within the scope of the present invention, which is defined by the appended claims.
CLAIMS

1. A pre-fabricated panel comprising:
   an upper plate;
   a lower plate;
   a core between the upper plate and the lower plate; and
   an edge member between the upper plate and the lower plate adjacent outer edges of
   the upper and lower plates.

2. The pre-fabricated panel of claim 1, wherein at least one of said outer edges is bent
   around said edge member.

3. The pre-fabricated panel of claim 2 or 3, wherein both the outer edges are bent
   around the edge member.

4. The pre-fabricated panel of claim 3, wherein said outer edges are welded together to
   the edge member buy a single longitudinal weld.

5. The pre-fabricated panel of any one of claims 1-4, wherein the upper and lower plates
   are welded to an outer portion of top and bottom surfaces of said edge member respectively.

6. The pre-fabricated panel of any one of claims 1-5, wherein said edge member is
   hollow.

7. The pre-fabricated panel of claim 1, wherein the edge member is comprised of a
   central part substantially extending between said upper and lower plates, and first and second
   flanges which are substantially parallel to the planes of the upper and lower plates.

8. The pre-fabricated panel of claim 7, wherein the edge member, in cross-section, is
   bent at two positions to form a substantially z shaped profile.
9. The pre-fabricated panel of claim 8, wherein each bend is at an angle of 60-120°.

10. The pre-fabricated panel of any one of claims 7-9, wherein the first flange extends in a first direction from a first end of the central part and the second flange extends in a second direction opposite to the first direction from a second end of the central part opposite the first end.

11. The pre-fabricated panel of any one of claim 7-10, wherein the upper plate is welded to the first flange, desirably at an inner edge of the edge member.

12. The pre-fabricated panel of any one of claims 7-11, wherein the lower plate is welded to the second flange, desirably at an outer edge of the edge member.

13. The pre-fabricated panel of any one of claims 7-12, wherein only the first flange of the edge member is between the upper and lower plates.

14. The pre-fabricated panel of any one of claims 7-13, wherein the lower plate extends further at the outer edge than the upper plate.

15. A pre-fabricated panel comprising:
   an upper plate;
   a lower plate; and
   a core between the upper plate and the lower plate,
   wherein an outer edge of at least one of said upper and lower plates is bent towards the other of the upper and lower plates.

16. The pre-fabricated panel according to claim 15, wherein the other of the upper and lower plates is substantially unbent at an outer edge corresponding to said bent outer edge.

17. The pre-fabricated panel according to claim 16, wherein, in cross-section, the bent
outer edge is bent at two positions to form a substantially z shaped profile.

18. The pre-fabricated panel according to claim 17, wherein each bend is at an angle of between 60-135°.

19. The pre-fabricated panel according to any one of claims 15-18, wherein an outer most portion of the bent outer edge is substantially parallel to a corresponding outer edge of the other of the upper and lower plates.

20. The pre-fabricated panel according to any one of claims 15-19, wherein said outer edges of said first upper and first lower plates overlap.

21. The pre-fabricated panel according to any one of claims 15-20, wherein said outer edges are welded together.

22. The pre-fabricated panel according to claim 21, wherein said weld is a single fillet weld.

23. The pre-fabricated panel of any one of claims 15-22, further comprising at least one insert adjacent said outer edges for taking loads associated with a bolt passing through said first upper and first lower plates.

24. The pre-fabricated panel of any one of claims 1-23, wherein at least one through hole passes through at least two of said upper and lower plates and said edge member.

25. The pre-fabricated panel of claim 24, wherein the at least one through hole passes through the upper and lower plates and the edge member.

26. The pre-fabricated panel of any one of claim 25, wherein at least one through hole passes through said upper and lower plates and said edge member, said through hole through said upper plate and a top wall of said edge member having a diameter which is greater than
a diameter of the through hole through said lower plate and a bottom wall of said edge member.

27. The pre-fabricated panel of claim 24, wherein the at least one through hole passes through the lower plate and the edge member, but not the upper plate.

28. A pre-fabricated panel comprising:
   first and second upper plates;
   first and second lower plates;
   at least one central joining member; and
   at least one core between said upper and lower plates;
   wherein said at least one central joining member is positioned between at least one of said upper plates and at least one of said lower plates.

29. The pre-fabricated panel of claim 28, wherein at least one of said first and second upper plates is welded along an inner edge to a first side of a first of said at least one joining member.

30. The pre-fabricated panel of claim 29, wherein at least one of said first and second lower plates is welded along an inner edge to a second side of said first joining member and the second side is opposite the first side.

31. The pre-fabricated panel of claim 28 or 29, wherein at least one of said first and second lower plates is welded along an inner edge to a second of said at least one joining member on a side opposite said first side.

32. The pre-fabricated panel of claim 28, 29 or 30, wherein at least one of said first and second upper plates is welded along an inner edge to a second of said at least one joining member on a side opposite said first side.
33. The pre-fabricated panel of claim 28 or 29, wherein said at least one central joining member is welded to inner edges of said first and second upper plates and said first and second lower plates.

34. The pre-fabricated panel of any one of claims 28-33, wherein said first and second upper plates are welded together to one of said at least one central joining member by a single longitudinal weld and/or wherein said first and second lower plates are welded together to one of said at least one central joining member by a single longitudinal weld.

35. The pre-fabricated panel of any one of claims 28-34, wherein said central joining member is an I-beam.

36. The pre-fabricated panel of any one of claims 28-32, wherein a first of said at least one central joining member is positioned between an inner edge of said first upper plate and an inner edge of said first lower plate and a second of said at least one central joining member is positioned between an inner edge of said second upper plate and an inner edge of said second lower plate.

37. The pre-fabricated panel of claim 36, wherein said first and second central joining members are joined together.

38. The pre-fabricated panel of any one of claims 28-34 or 36 or 37, wherein at least one of said at least one central joining member(s) is/are a hollow bar.

39. The pre-fabricated panel of claim 36, wherein a third of said at least one central joining member is positioned between said first and second central joining members.

40. The pre-fabricated panel of claim 39, wherein said third central joining member is attached to said first and second upper plates and said first and second lower plates.
41. The pre-fabricated panel of claim 39 or 40, wherein said third central joining member is attached to said panels with longitudinal welds.

42. The pre-fabricated panel of claim 39, 40 or 41, wherein said third central joining member is an I-beam.

43. The pre-fabricated panel of claim 28-32 or 36, wherein a third of said at least one central joining member is positioned between said first and second upper plates and/or between said first and second lower plates.

44. The pre-fabricated panel of claim 28-32, 36 or 43, wherein a fourth of said at least one central joining member overlaps, in plan, inner edges of said first and second lower plates.

45. The pre-fabricated panel of any one of claims 28-44, wherein an edge member is present between said first upper and first lower plates adjacent outer edges of said first upper and first lower plates.

46. The pre-fabricated panel of claim 45, wherein said outer edges are longitudinal outer edges.

47. The pre-fabricated panel of claim 45 or 46, wherein at least one of said outer edges is bent around said edge member.

48. The pre-fabricated panel of claim 47, wherein both said first and second outer edges are bent around said edge member and are welded together to said edge member by a single longitudinal weld.

49. The pre-fabricated panel of claim 45 or 46, wherein the edge member is comprised of a central part substantially extending between said upper and lower plates, and first and
second flanges which are substantially parallel to the planes of the first upper and first lower plates.

50. The pre-fabricated panel of claim 49, wherein the edge member, in cross-section, is bent at two positions to form a substantially z shaped profile.

51. The pre-fabricated panel of claim 50, wherein each bend is at an angle of 60-120°.

52. The pre-fabricated panel of any one of claims 49-51, wherein the first flange extends in a first direction from a first end of the central part and the second flange extends in a second direction opposite to the first direction from a second end of the central part opposite the first end.

53. The pre-fabricated panel of any one of claims 49-52, wherein the first upper plate is welded to the first flange, desirably at an inner edge of the edge member.

54. The pre-fabricated panel of any one of claim 49-53, wherein the first lower plate is welded to the second flange, desirably at an outer edge of the edge member.

55. The pre-fabricated panel of any one of claims 49-54, wherein only the first flange of the edge member is between the first upper and first lower plates.

56. The pre-fabricated panel of any one of claims 49-55, wherein the first lower plate extends further at the outer edge than the first upper plate.

57. The pre-fabricated panel of any one of claims 28-44, wherein an outer edge of at least one of said first upper and first lower plates is bent towards the other of the first upper and first lower plates.

58. The pre-fabricated panel according to claim 57, wherein the other of the first upper...
and first lower plates is substantially unbent at an outer edge corresponding to said bent outer edge.

59. The pre-fabricated panel according to claim 58, wherein, in cross-section, the bent outer edge is bent at two positions to form a substantially z shaped profile.

60. The pre-fabricated panel according to claim 59, wherein each bend is at an angle of between 60-135°.

61. The pre-fabricated panel according to any one of claims 57-60, wherein an outermost portion of the bent outer edge is substantially parallel to a corresponding outer edge of the other of the upper and lower plates.

62. The pre-fabricated panel according to any one of claims 57-60, wherein said outer edges of said first upper and first lower plates overlap.

63. The pre-fabricated panel according to any one of claims 57-62, wherein said outer edges are welded together.

64. The pre-fabricated panel according to claim 63, wherein said weld is a single fillet weld.

65. The pre-fabricated panel of any one of claims 57-64, further comprising a plurality of inserts adjacent said outer edges for taking loads associated with a bolt passing through said first upper and first lower plates.

66. The pre-fabricated panel of any one of claims 28-65, wherein an end member is present between transverse ends of said first upper and first lower plates.

67. The pre-fabricated panel of any one of claims 45-66, wherein the edge member
and/or end member has a through-hole arranged to accommodate a bolt to fix the panel to another structure and a recess arranged to accommodate a head of the bolt and a tool required to tighten the bolt.

68. The pre-fabricated panel of any one of the preceding claims, wherein said at least one core layer is arranged to transfer shear forces between their respective upper and lower plates.

69. The pre-fabricated panel of any one of the preceding claims, wherein said at least one core is a cementitious material, a plastics or a polymer material, optionally with a plurality forms therein.

70. The pre-fabricated panel of claim 69, wherein the forms have a density of less than that of the cementitious, plastics or polymer material.

71. The pre-fabricated panel of claim 70, wherein the forms are hollow.

72. The pre-fabricated panel of claim 70 or 71, wherein the forms do not tessellate and have principal dimensions in the range of from 20 to 200% of the distance between the upper and lower plates.

73. The pre-fabricated panel according to any one of the preceding claims that is adapted to bear a load in the range of from 1.4kPa to 7.2kPa.

74. The pre-fabricated panel of any one of the preceding claims, wherein the panel is for use in floors of buildings.

75. The pre-fabricated panel of any one of the preceding claims, further comprising a hook engaging feature for engaging with a lifting hook.
76. The pre-fabricated panel according to claim 75, wherein the hook engaging feature comprises a further plate with a through-hole, desirably a through-hole with a diameter of 10-40mm.

77. The pre-fabricated panel according to claim 76, wherein the further plate is in a plane substantially orthogonal to the planes of the upper and lower plates.

78. The pre-fabricated panel of any one of claims 75-77, wherein the hook engaging feature is welded to upper and lower plates or edge members at an outer edge.

79. The pre-fabricated panel of any one of claims 75-78, wherein the hook engaging feature is positioned such that it is between and does not protrude over outer upper and outer lower planes of the pre-fabricated panel.

80. A method of manufacturing a pre-fabricated panel according to any one of claims 33-74, said method comprising:

   joining said first upper plate, said first lower plate and said at least one central joining member;
   joining said second upper plate, said second lower plate and said at least one central joining member;
   joining said first upper plate to said second upper plate;
   joining said first lower plate to said second lower plate;
   sealing between outer edges and ends of said first upper and first lower plates and between outer edges and ends of said second upper and second lower plates thereby to form at least one cavity between said upper and lower plates;
   filling said at least one cavity with uncured cementitious, plastics or polymer material; and
   allowing or causing said cementitious, plastics or polymer material to cure to form at least one core.
81. The method of claim 80, wherein at least some of said joining comprises welding.

82. The method of claim 80 or 81, wherein joining said first upper plate to said second upper plate and/or joining said first lower plate to said second lower plate occurs after said filling.

83. The method of claim 80 or 81, wherein joining said first upper plate to said second upper plate and/or joining said first lower plate to said second lower plate occurs before said filling.

84. The method of any one of claims 80-83, wherein said sealing between outer edges of said first upper and first lower plates comprises positioning an edge member between said first upper and first lower plates adjacent outer edges and welding said first upper and first lower plates to said edge member.

85. The method of claim 84, wherein said outer edges are longitudinal outer edges.

86. The method of claim 84 or 85, further comprising bending at least one of said outer edges such that said outer edge extends around a corner of said edge member.

87. The method of claim 86, wherein outer edges of both said first upper plates and first lower plates are bent such that they extend around said edge member; and wherein said sealing between outer edges of said first top and first bottom plates comprises welding said first upper plate and first lower plate together to said edge member by a single longitudinal weld.

88. The method of any one of claims 80-83, wherein said sealing between outer edges of said first upper and first lower plates comprises bending outer edges of said first upper and first lower plates towards each other.
89. The method of claim 88, wherein said bending comprises bending said outer edges such that they overlap.

90. The method of claim 88 or 89, wherein said sealing between outer edges of said first upper and first lower plates further comprises welding said outer edges together.

91. The method of claim 90, wherein said weld is a single fillet weld.

92. The method of any one of claims 88-91, comprising placing said first and second lower plates in an injection bed and wherein said bending comprises bending said outer edges such that a weld between said outer edges can be made from above.

93. The method of any one of claims 88-92, further comprising inserting a plurality of inserts adjacent said outer edges, said inserts being for taking loads associated with a bolt passing through said first upper and first lower plates.

94. The method of any one of claims 88-93, wherein said sealing between ends of said first upper and first lower plates comprises placing an end member between transverse ends of said first upper and first lower plates.

95. The method of any one of claims 88-94, further comprising placing a plurality of forms in said first and second cavities prior to or at the same time as said filling.

96. A pre-fabricated panel substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

97. A method substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.
Fig. 16

1. Start
2. Manufacture SPS members off-site (S1)
3. Construct building structural framework (S2)
4. Bolt SPS members in place (S3)
5. Install fireproofing, utilities, finishes (S4)
6. End