

WALL PANEL AND METHOD OF FABRICATING THE SAME

FIELD OF INVENTION

The present invention relates broadly to a wall panel and method of fabricating the same, particularly to modular precast wall panel system.

5

BACKGROUND

Bricks and blocks have been extensively used to construct walls in the past. Such construction involves wet trade and is labour intensive. Furthermore manufacture of red bricks is prohibited in many locations due to its high energy inefficiency and pollution of the environment. Subsequent to bricks and blocks, dry wall and precast concrete hollow core wall panels have been used to erect walls. These do not involve wet trade and are less labour intensive compared to bricks and blocks.

10

15

20

The existing dry wall system uses plasterboard installed on a grid of steel or aluminium tracks and studs. The relatively high cost is the limitation in using the dry wall system. A precast hollow core wall offers a cheaper alternative to the dry wall system but weight is the limitation. The heavy weight of the wall reduces productivity and safety, increases damage and wastage, and impedes adjustability and hence accuracy of installation. Also, both the dry wall and hollow core wall can only be erected to limited heights without lintels and their surface strength for anchorage is also low. The limitation in height makes the use of these two wall systems very unproductive and expensive for high walls. The low surface anchorage strength also limits the installation of heavy fixtures on the wall. This is particularly the case in the construction of industrial buildings where headroom is high and heavy fixtures are installed onto the walls.

25

US 2008/0115442 A1 discloses a composite sandwich wall panel that constitutes of two fine sand gypsum or concrete panels with polystyrene panel disposed at the centre. Although this wall system is light, it has limitation in height. Furthermore, the use of the polystyrene panel, which is a fire hazard material, precludes the use of the wall panel as fire rated walls.

Therefore, the existing light modular wall panels cannot be erected to greater heights productively without the need of lintels, and have weak surface strength for installation of heavier fixtures.

30

Embodiments of the present invention provide a wall panel and method of fabricating the same that seek to address at least one of the above problems.

35

SUMMARY

In accordance with a first aspect of the present invention there is provided a wall panel comprising a concrete core having opposing front and back faces and opposing side face; and a fibre membrane bonded to each of the front and back faces.

- 5 In accordance with a second aspect of the present invention there is provided a method for fabricating a wall panel, comprising the steps of providing a concrete core having opposing front and back faces and opposing side face; and bonding a fibre membrane bonded to each of the front and back faces.

10 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

- 15 Figure 1 shows a schematic sectional diagram illustrating modular fibre-concrete-fibre (FCF) sandwich wall panel according to an example embodiment.

Figure 2 shows a schematic 3-dimensional diagram of the modular FCF sandwich wall panel of Figure 1.

Figure 3 shows a flow-chart illustrating a method for fabricating a wall panel, according to an example embodiment.

20

DETAILED DESCRIPTION

- Embodiments of the present invention seek to meet the need of a lightweight precast wall panel, a high precast wall panel and a wall panel with high anchorage strength in building construction. Providing a lightweight wall panel increases safety, productivity, ease of adjustment for
25 accuracy and reduces damage and wastage. A high wall panel eliminates the need for lintels and greatly increases the productivity reducing construction time significantly.

- 30 In one embodiment, the present invention relates to a sandwich wall panel comprising two layers of fibre membrane, each bonded on opposite faces of a precast wall core. The fibre membrane can be made of any fibre that has sufficient modulus and tensile strength and can be meshed into a membrane. The precast wall panel can be any panel that is made of concrete or other suitable materials with sufficient strength and durability. The sandwich wall panel of example embodiments of the present invention has the advantage of high bending strength and surface strength catering to the need of higher and thinner panels with good anchorage on the wall face to address the shortcomings of the current wall systems. The agent to bond the

membrane to the precast wall core can be combined with fine sand if bonding with plaster or skim coat is required.

Figures 1 and 2 show a schematic sectional diagram and a schematic 3-dimensional diagram respectively, illustrating a wall panel 100 according to an example embodiment. The wall panel 100 comprises a precast wall core 102, with hollow sections or cores 104 in this embodiment. However it is noted that no hollow cores may be provided in different embodiments. A layer of fibre membrane 106 is bonded on the back face 108 of the wall core 102, and one layer of fibre membrane 110 is bonded on the front face 112 of the wall core 102. The wall panel 100, which may also be described as a modular wall panel, can have a height that may vary from very small to around 6000mm, with one preferred height being about 3000mm. A width of about 600mm and thicknesses of about 70mm, about 90mm or about 100mm are preferred examples, but notwithstanding, the overall size of the wall panel in different embodiments can vary according to specific functional requirements of particular buildings, as will be appreciated by a person skilled in the art.

Side faces 114, 116 of the wall panel 100 are free from fibre membrane, i.e. at the side faces 114, 116, the surfaces of the precast wall core 102 are exposed. This facilitates the joining of adjacent wall panels 100 during construction of a wall, for example a partition wall. The side faces 114, 116 may comprise structures for facilitating the joining of the wall panels 100, such as mating ridges 115 for corresponding grooves (compare 117) in the side face of an adjacent wall panel, or vice versa.

The precast wall core 102 can be made of a material with compressive strength ranging from about 2 MPa to about 50 MPa in some example embodiments, and with elastic modulus ranging from about 5 GPa to about 100 GPa. The compressive strength and elastic modulus of the material in composite action with the fibre membranes 106, 110 provide the improved strength to the sandwich wall panel to resist the bending forces the wall is subjected to during handling, installation and in service, in particular when provided in larger heights. In addition, the compressive strength of the material also advantageously provides the necessary strength to the wall panel 100 to resist axial load during handling, installation and in service. The material also provides the strength for anchorage of fixtures, which may be further enhanced by the bonded fibre membranes 106, 110.

The material of the precast wall core 102 can be concrete made using Ordinary Portland cement (OPC) or other binders, and fillers that constitute fine and/or coarse natural, synthetic or recycled normal or lightweight aggregates. Autoclaved aerated or foamed concrete can also be used to form the precast wall core in different embodiments. The precast wall core 102 can be either cast using formworks or can be extruded using slip forms with the concrete. Any other materials suitable for use in e.g. partition walls with the material properties stated above can also be used to form the precast wall core in different embodiments.

The precast concrete core may be fabricated using techniques understood in the art, and may for example be fabricating using the method and apparatus as described in published PCT application WO2007114795 A1.

The fibre membranes 106, 110 for the sandwich wall panel 100 can be made from fibres of glass, carbon, polyvinyl alcohol (PVA), polypropylene, Kevlar kenaf (natural fibre) or other materials, weaved in a regular or random orientation. The fibre can be continuous in length or chopped into small strands, in which case the membrane is sometimes referred to as chopped strand mat. The tensile strength of the fibre membranes 106, 110 is dependent on the height of the wall panel 102, which may also be referred to as the length of the wall panel depending on its orientation, for example during transportation of the wall panel).

For example, fibre membranes 106, 110 with mass ranging from about 5 g/m² to about 50 g/m² can be used for an about 3 metres long wall panel 100, and fibre membranes 106, 110 with mass ranging from about 20 g/m² to about 200 g/m² can be used for an about 6 metres long wall panel 100. The tensile strength and elastic modulus of the fibre ranges from about 20 to about 3000 MPa and about 50 GPa to about 1000 GPa respectively. The tensile strength and elastic modulus, in combination with the bonding agent, and in composite action with the precast wall core 102, advantageously provide the necessary strength to the sandwich wall panel 100 to resist bending during handling, installation and in service.

The agent to bond the fibre membranes 106, 110 onto the front and back faces 112, 108 of the precast wall core 102 can be made from epoxy resin, or any polymer, mineral or cement based material. The agent can be premixed with fine sand of size between about 0.5mm and about 1.5mm, for example to facilitate plaster or skim coating. The bonding process of the fibre membranes 106, 110 onto the precast wall core 102 in one example embodiment segregates the fine sand to the top surface leaving the interface between the precast wall core and the fibre membranes 106, 110 substantially free of any fine sand. The fine sand at the top surface of the membranes 106, 110 preferably prepares the surface of the sandwich wall panel 100 for plaster or skim coat to adhere thereto. It is noted that the premixing of the bonding agent with fine sand or the like is optional and will e.g. not typically be used if the wall surface does not require finishing with plaster or skim coat, or if the plaster and skim coat can adhere onto the fully set bonding agent used in various embodiments.

The bonding agent preferably strongly bonds the fibre membranes 106, 110 onto the precast wall core 102 to effect composite action of the fibre-concrete-fibre. The bonding agent advantageously serves to sufficiently bond the fibre membranes 106 110 onto the faces 108, 112 of the precast wall core 102 to facilitate the composite action of the fibre membranes 106, 110 and the concrete of the precast wall core 102 in resisting bending actions or forces.

The fibre membranes 106, 110, in addition to providing flexural strength to the sandwich wall panel 102, can advantageously ads other benefiting features to the wall system. Thinner and taller walls are possible with the fibre membrane. Also, the fibre membrane can enhance the wall surface performance, increasing anchorage strength and reducing permeation of fluids into the wall. Impact and cracking resistances can also be greatly enhanced with the fibre membrane. Safety during handling and installation can be greatly enhanced while damages are significantly reduced with the use of fibre membrane in example embodiments of the present

invention. The sandwich wall panel is suitable for indoor and outdoor applications in example embodiments.

In one embodiment, a wall panel comprises a concrete core having opposing front and back faces and opposing side face; and a fibre membrane bonded to each of the front and back faces.

5 The concrete core may be precast.

The side surfaces of the concrete core may be exposed.

The side surfaces may comprise structures for joining of the wall panel to another wall panel.

The concrete core may comprise one or more hollow sections or cores.

10 An external surface of or at each of the fibre membranes may be roughened for facilitating plaster or skim coating. The external surface may comprise particles such as sand particles.

The wall panel may further comprise a plaster or skim coating on each of the fibre membranes.

A height of the wall panel may be in a range up to about 6000mm, and preferably about 3000mm.

A width of the wall panel may be about 600mm.

15 A thickness of the wall panel may be in a range from about 70mm to about 100mm.

The fibre membranes may comprise one or more of a group consisting of fibres of glass, carbon, polyvinyl alcohol (PVA), polypropylene, kenaf (natural fibre) and other materials, weaved in a regular or random orientation.

20 A bonding agent bonding the fibre membranes to the front and back faces of the concrete core may comprise one or more of a group consisting of epoxy resin, a polymer based material, a mineral based material and a cement based material.

25 The concrete core may comprise one or more of a group consisting of concrete made using Ordinary Portland cement (OPC) or other binders, and fillers that constitute fine and/or coarse natural, synthetic or recycled normal or lightweight aggregates, and autoclaved aerated or foamed concrete.

The wall panel may be prefabricated.

30 Figure 3 shows a flow-chart 300 illustrating a method for fabricating a wall panel, according to an example embodiment. At step 302, a concrete core having opposing front and back faces and opposing side face is provided. At step 304, a fibre membrane is bonded to each of the front and back faces.

Providing the concrete core may comprise precasting the concrete core.

The method may comprise leaving the side surfaces of the concrete core exposed.

The method may comprise forming structures on the side surfaces for joining of the wall panel to another wall panel.

The method may comprise providing one or more hollow sections or cores in the concrete core.

5 The method may comprise roughening an external surface of or at each of the fibre membranes for facilitating plaster or skim coating.

The method may comprise providing particles such as sand particles at the external surface.

The method may further comprise providing a plaster or skim coating on each of the fibre membranes.

10 A height of the wall panel may be in a range up to about 6000mm, and preferably about 3000mm.

A width of the wall panel may be about 600mm.

A thickness of the wall panel may be in a range from about 70mm to about 100mm.

15 The fibre membranes may comprise one or more of a group consisting of fibres of glass, carbon, polyvinyl alcohol (PVA), polypropylene, kenaf (natural fibre) and other materials, weaved in a regular or random orientation.

A bonding agent bonding the fibre membranes to the front and back faces of the concrete core may comprise one or more of a group consisting of epoxy resin, a polymer based material, a mineral based material and a cement based material.

20 The concrete core may comprise one or more of a group consisting of concrete made using Ordinary Portland cement (OPC) or other binders, and fillers that constitute fine and/or coarse natural, synthetic or recycled normal or lightweight aggregates, and autoclaved aerated or foamed concrete.

The wall panel may be prefabricated.

25 Wall panels according to example embodiments can have the following advantages over the present commercially available wall panels:

1. Allowing for thinner sections without compromise on the strength and stiffness. Thinner sections yield lighter walls with the advantage of increased safety, productivity, ease of adjustment for accuracy and reduce damage and wastage during handling and installation.
2. Increased stiffness of wall panels allowing for higher walls to be fabricated and erected.
- 30 Ability to erect high precast walls without lintels significantly increases the productivity.
3. Increased ductility of wall panels. This prevents brittle failure during handling and installation which can be catastrophic and a great concern for safety. The concern of brittle failure limits the height of commercially available plain concrete precast wall which can be

safely handled to typically about 3000mm. Embodiments of the present invention address this concern allowing for higher walls.

4. Increased surface strength of the wall panels. This not only increases the anchorage strength of fixtures, but also allows commonly available wall hangers and fixtures to be used unlike in some wall system where special fixtures are required. With higher anchorage strength, heavier objects can be supported by the wall.
5. The fibre membrane reduces warping of the precast wall core due to drying shrinkage during the curing period in the production. This results in flat wall and greatly minimises the incident of out-of-alignment or non-flushed finish between walls after installation.
- 10 6. The fibre membrane reduces warping of the precast wall core due to drying shrinkage and thermal movements after installation and during service. This minimises cracking at the face and joints of the walls as well as cracking of the plaster or skim coat.
- 15 7. Prevention of absorption or ingress of fluids into the wall panels. This greatly increases the durability and lifespan of the wall as well as prevents microbial growth on the wall. This also allows the wall to be used for external wall or in wet areas when the joints are also bonded with fibre membrane after installation.
8. With the fibre membrane contributing to the resistance against bending, the concrete strength need not be high. There is a saving in cost when lower strength concrete is used.
9. Enhanced sound insulation, thermal insulation and fire resistance of the wall panels.
- 20 10. Cost savings in reducing thickness of wall panels and increasing productivity in the installation of wall panels can offset a potential additional cost in fabrication process of the wall panels of example embodiments of the invention.

Industrial Application

Wall panels according to example embodiments can be used as internal and external partitions in buildings. They can serve to replace the brick wall that may be outmoded soon due to its labour intensive and low productivity installation. Production of bricks is also highly energy inefficient and causes pollution of the environment. Wall panels according to example embodiments can also be technically and economically superior to the current available wall systems that are used in lieu of brick walls.

With the choice of fibre membrane such as Kevlar, FCF sandwich wall panel can also be designed for good impact and blast resistance that can help to minimize damage to neighboring structures and humans during accidents or hazards such as a bomb blast. The wall panels according to example embodiments can also be used in defence applications.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present

embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive. Also, the invention includes any combination of features, in particular any combination of features in the patent claims, even if the feature or combination of features is not explicitly specified in the patent claims or the present embodiments.

CLAIMS

1. A wall panel comprising:

a pre-cast concrete core having opposing front and back faces and opposing side faces;
and

a woven fibre membrane mesh bonded to each of the front and back faces;

wherein the pre-cast concrete core comprises a pre-cast solid concrete core or a pre-cast hollow-core concrete core.
2. The wall panel as claimed in claim 1, wherein the side surfaces of the concrete core are exposed.
3. The wall panel as claimed in any one of the preceding claims, wherein the side faces comprises structures for joining of the wall panel to another wall panel.
4. The wall panel as claimed in any one of the preceding claims, wherein the pre-cast concrete core comprises one or more hollow cores.
5. The wall panel as claimed in any one of the preceding claims, wherein an external surface of or at each of the woven fibre membrane meshes is roughened for facilitating plaster or skim coating.
6. The wall panel as claimed in claim 5, wherein the external surface comprises particles such as sand particles.
7. The wall panel as claimed in any one of the preceding claims, further comprising a plaster or skim coating on each of the woven fibre membrane meshes.
8. The wall panel as claimed in any one of the preceding claims, wherein a height of the wall panel is in a range up to about 6000mm, and preferably about 3000mm.
9. The wall panel as claimed in any one of the preceding claims, wherein a width of the wall panel is about 600mm.
10. The wall panel as claimed in any one of the preceding claims, wherein a thickness of the wall panel is in a range from about 70mm to 100mm.
11. The wall panel as claimed in any one of the preceding claims, wherein the woven fibre membrane meshes comprise one or more of a group consisting of fibres of glass, carbon, polyvinyl alcohol (PVA), polypropylene, kenaf (natural fibre) and other materials, weaved in a regular or random orientation.

12. The wall panel as claimed in any one of the preceding claims, wherein a bonding agent bonding the woven fibre membrane meshes to the front and back faces of the concrete core comprises one or more of a group consisting of epoxy resin, a polymer based material, a mineral based material and a cement based material.

13. The wall panel as claimed in any one of the preceding claims, wherein the concrete core comprises one or more of a group consisting of concrete made using Ordinary Portland cement (OPC) or other binders, and fillers that constitute fine and/or coarse natural, synthetic or recycled normal or lightweight aggregates, and autoclaved aerated or foamed concrete.

14. The wall panel as claimed in any one of the preceding claims, wherein the wall panel is prefabricated.

15. A method for fabricating a wall panel, comprising the steps of:

providing a pre-cast concrete core having opposing front and back faces and opposing side faces; and

bonding a woven fibre membrane mesh to each of the front and back faces;

wherein the pre-cast concrete core comprises a pre-cast solid concrete core or a pre-cast hollow-core concrete core.

16. A method as claimed in claim 15, wherein providing the pre-cast concrete core comprises pre-casting the concrete core.

17. The method as claimed in claims 15 or 16, comprising leaving the side faces of the concrete core exposed.

18. The method as claimed in any one of claims 15 to 17, comprising forming structures on the side faces for joining of the wall panel to another wall panel.

19. The method as claimed in any one of the claims 15 to 18, wherein providing the pre-cast concrete core comprises providing one or more hollow cores in the pre-cast concrete core.

20. The method as claimed in any one of claims 15 to 19, comprising roughening an external surface of or at each of the woven fibre membrane meshes for facilitating plaster or skim coating.

21. The method as claimed in claim 20, comprising providing particles such as sand particles at the external surface.

22. The method as claimed in any one of claims 15 to 21, further comprising providing a plaster or skim coating on each of the woven fibre membrane meshes.

23. The method as claimed in any one of claims 15 to 22, wherein a height of the wall panel is in a range up to about 6000mm, and preferably about 3000mm.
24. The method as claimed in any one of claims 15 to 23, wherein a width of the wall panel is about 600mm.
25. The method as claimed in any one of claims 15 to 24, wherein a thickness of the wall panel is in a range from about 70mm to about 100mm.
26. The method as claimed in any one of claims 15 to 25, wherein the woven fibre membrane meshes comprise one or more of a group consisting of fibres of glass, carbon, polyvinyl alcohol (PVA), polypropylene, kenaf (natural fibre) and other materials, weaved in a regular or random orientation.
27. The method as claimed in any one of claims 15 to 26, wherein a bonding agent bonding the woven fibre membrane meshes to the front and back faces of the concrete core comprises one or more of a group consisting of epoxy resin, a polymer based material, a mineral based material and a cement based material.
28. The method as claimed in any one of the claims 15 to 27, wherein the concrete core comprises one or more of a group consisting of concrete made using Ordinary Portland cement (OPC) or other binders, and fillers that constitute fine and/or coarse natural, synthetic or recycled normal or lightweight aggregates, and autoclaved aerated or foamed concrete.
29. The method as claimed in any one of the claims 15 to 28, wherein the wall panel is prefabricated.