

COMPOSITE CEMENT-FOAM PANEL AND ROOF DECK SYSTEM

Technical Field

The present invention relates to cladding panel for a cladding construction for a roof, deck or similar structure, and fabricating method of the cladding panel. The present invention also relates to a cladding construction and method for a roof, deck or similar structure, constructed using the cladding panel.

Background Art

Figure 1 illustrates a typical construction 100 of a cladding construction system of a concrete roof deck 102. A cement sand base 104 is formed over the roof deck 102, the base 104 being screed to form a slope or slope-to-fall gradient to create a drainage fall into a drain 106 and downpipe 108. A waterproof membrane 110 is laid over the cement sand base 104, interrupted only by downpipe 108, and extending a height 112 of 300mm up the inside surface of walls 114. Where the deck 102 meets some walls 114, the transition of the waterproof membrane from the horizontal surface to the vertical surface may be effected by use of waterproof filler such as poly foam 116. A thermal insulating layer 118 is constructed on top of the membrane 110, the layer 118 comprising extruded polystyrene insulation board of 50mm thickness. A separation fleece layer 120 overlies the thermal insulating layer 118. Finally an overlying protective screed concrete layer 122 of 75mm thickness is provided, comprising 4.5m by 4.5m panels separated by joints filled with bituminous compound. Plastering 124 is applied to walls 114.

The thermal insulating material 118 reduces heat transfer through the concrete roof deck 102 into the building below. The protective cement screed 122 protects the thermal insulating material 118 and the waterproofing membrane 110, and bears the human traffic on the roof deck. Such a construction 100 is constructed in-situ on site, with an expansion joint provided at regular intervals.

Construction 100 suffers from a range of problems. The expansion joints in concrete screed layer 122 are a weak point in the construction and a source of leaks. Residual water becomes lodged between the thermal insulating material 118 and the waterproofing membrane 110 after rain. When exposed to heat from the sun, the water expands and evaporates, exerting pressure on the thermal insulating material 118 which in

turn exerts pressure onto the protective screed concrete 122. Both the protective screed concrete 122 and thermal insulating material 118 will generally crack due to such stress, leading to leakage and/or "sickness" in the construction 100.

5 A further problem is that on site cladding construction makes quality control difficult, can cause damage to the waterproofing system, and is subject to the vagaries of inclement weather during construction leading to time delay. In addition, mixing, handling and/or applying concrete slurry on site can be messy and laborious.

10 Still further, in the event that maintenance is required to the underlying roof deck 102, waterproofing membrane 110 and/or components of the built-up waterproofing system 104, 118, 120, 122, the protective screed 122 and some or all underlying layers need to be destructively removed such as by being cut away, effectively destroying the construction 100. The entire process of building up the waterproofing system must then be repeated to re-establish a waterproof cladding.

15 Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

20 Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

25 **Summary of the Invention**

According to a first aspect, the present invention provides a cladding panel comprising:

30 a light weight core material, a bottom surface of the core material having at least one groove extending from a first bottom edge of the core material to a second bottom edge of the core material;

a rigid casing formed over a top and sides of the core material and extending to the bottom edges of the core material;

and wherein the at least one groove in the bottom of the core material extends through bottom portions of the rigid casing, forming at least one continuous channel
5 across the bottom of the cladding panel.

In the context, the term "groove" refers to the structure formed on the core material, and the term "continuous channel" refers to the structure formed on the cladding panel.

According to a second aspect, the present invention provides a method of
10 fabricating a cladding panel, comprising:

providing at least one groove in a bottom surface of a core material;

forming a rigid casing over a top and sides of the core material and extending to the bottom edges of the core material; and

extending the at least one groove in the bottom of the core material through bottom
15 portions of the rigid casing to form at least one continuous channel across the bottom of the cladding panel.

According to a third aspect, the present invention provides a cladding construction comprising:

a waterproof membrane over a rigid surface;

20 at least one cladding panel located over the membrane, the at least one cladding panel having a lightweight core material and a rigid casing over a top and sides of the core material, the at least one cladding panel being provided with at least one continuous channel across the bottom of the cladding panel forming a drainage channel over the membrane.

25 According to a fourth aspect, the present invention provides a method of forming a cladding construction, the method comprising:

providing a waterproof membrane over a rigid surface; and

locating over the membrane at least one cladding panel having a lightweight core material and a rigid casing over a top and sides of the core material, the at least one cladding panel being provided with at least one continuous channel across the bottom of the cladding panel forming a drainage channel over the membrane.

5 By providing a cladding panel having at least one continuous channel across the bottom of the cladding panel, the present invention provides for drainage and vent of water and/or moisture which builds up beneath the cladding panel. The normal drainage slope of the membrane layer, combined with the open channel for passage of water, provides for the water to freely flow away beneath the cladding panel and above the membrane to a
10 drainage point. In the event that any remaining water lodged under the cladding panel and when temperature goes up, the remaining water may evaporate into moisture. The channels now serve as vents for the moisture to dissipate, hence helps release the moisture pressure exerted on the cladding panel. Consequently, pressure variations of the moisture caused by temperature variations can be released along the or each channel.

15 In preferred embodiments of the invention, the or each continuous channel is of sufficient cross sectional area to carry all water requiring draining during normal conditions, and to dissipate moisture. In such embodiments, no effort is required to exclude water and/or moisture from building up beneath the or each cladding panel, or to provide for drainage / vent paths above the cladding panel, due to the provision of a
20 drainage / vent path beneath the cladding panel for such water and/or moisture. Thus, in preferred embodiments of the invention, cladding panels are separated by a gap sufficient to allow thermal expansion. Embodiments of the invention eliminating panel jointing such as bituminous panel jointing thus eliminate concerns over cracking of such panel jointing.

25 Embodiments of the present invention omitting panel jointing to fixedly secure cladding panels together, provide for simple maintenance of the cladding panel and underlying layers. Such maintenance can be performed simply by lifting a cladding panel to access and perform maintenance upon the cladding panel or underlying layers, and then returning the cladding panel or a substitute cladding panel into position once maintenance
30 is complete. Such ease of maintenance can eliminate the need for disturbance of the remaining waterproofing construction.

Further, in preferred embodiments the or each cladding panel is pre-fabricated off-site, thus eliminating corresponding on-site construction difficulties.

In preferred embodiments of the invention, the cladding panel comprises a plurality of continuous channels across the bottom surface of the cladding panel. The or each channel is preferably configured such that tiling of multiple cladding panels in a cladding construction leads to alignment of a continuous channel of a first cladding panel with a continuous channel of an adjacent cladding panel. Even more preferably, the plurality of channels are preferably configured such that a continuous channel of a first cladding panel is aligned with a continuous channel of an adjacent cladding panel when tiled, regardless of the orientation of the cladding panels. For example, the continuous channels of each cladding panel may be substantially straight, and substantially evenly spaced across the bottom surface of the core material.

The or each cladding panel is preferably of geometric shape to provide for continuous tiling of the cladding panels to substantially occupy and clad an arbitrarily shaped area. While such shapes may include triangular or hexagonal, square or rectangular cladding panels are preferred both for manufacturing and storage efficiency, and for efficient tiled cladding of building structures which are most often rectangular. Colour schemes or patterns may be implemented by appropriate tiling techniques, and may be easily changed by replacing or altering the location of one or more cladding panels.

Where the cladding panel in accordance with the present invention is square or rectangular, a first set of continuous channels in the bottom surface of the cladding panel may be aligned substantially at right angles to a second set of continuous channels of the cladding panel. The first set may be substantially parallel to a side of the cladding panel. Alternatively the first set may be at substantially 45 degrees to a side of the cladding panel. The location of the first set and the second set preferably ensures alignment with such channels of a substantially identical cladding panel regardless of orientation of the cladding panels during tiling.

In further preferred embodiments of the invention, at least one groove is provided in a top surface of the lightweight core material, and each such groove is occupied by a portion of the rigid casing. In such embodiments, the portion of the rigid casing occupying the groove in the top surface functions as a strengthening beam, to provide added rigidity and strength to the top portion of the rigid casing and thus to the cladding panel as a whole.

Further preferred embodiments of the invention provide for bonding of the rigid casing to the lightweight core material. Such bonding may comprise the use of chemical bonding additives in the rigid concrete casing around the top and sides of the lightweight

core material. Such bonding may additionally or alternatively comprise the provision of at least one groove in at least one side surface of the lightweight core material, the at least one groove being occupied by a portion of the rigid casing to effect mechanical bonding of the rigid casing to the lightweight core material. The at least one groove in the or each side of the lightweight core material may extend substantially parallel to a bottom edge of the lightweight core material, such that the mechanical bonding counteracts lifting of the rigid casing from the lightweight core material.

The lightweight core material preferably provides thermal insulation. The lightweight core material preferably comprises polystyrene foam, such as extruded polystyrene foam board.

In preferred embodiments of the invention, the rigid casing is a concrete casing. The concrete casing is preferably formed by placing the core material in a mould which allows space around the four sides of the core and within which the casing can be formed. In such embodiments, the method of the second aspect of the present invention preferably comprises extending the groove through the bottom portions of the rigid concrete casing by placing inserts in the mould to provide extensions of the grooves in the bottom of the core material and then pouring concrete into the mould to form the concrete casing over the top and around the sides of the core, and over the inserts. Moulding concrete over the lightweight core material further provides for the poured concrete to occupy grooves in the top and/or side surfaces of the lightweight core material prior to setting.

The lightweight core material and rigid casing are preferably adapted to provide a cladding panel of a weight which is light enough to enable manual manipulation and installation of the cladding panel. For example, the weight of the cladding panel is preferably no more than substantially 50 kg, and more preferably no more than substantially 20kg. The area of the cladding panel is preferably no more than substantially 5 m². However, the or each cladding panel is preferably of sufficient weight to avoid wind uplift of the cladding panel when installed. For example a cladding panel of substantially 0.3844 m² area preferably weighs not less than substantially 14kg. Such embodiments provide for an easily installed cladding panel which does not require additional securement of the cladding panel to combat wind uplift. To meet such weight constraints, preferred embodiments of the invention comprise a rigid concrete casing of about 0.62m x 0.62m in size formed with a high strength concrete additive, having side portions of substantially 10mm thickness, and a top portion having a thickness of substantially 13mm.

A cladding panel in accordance with such embodiments of the invention can preferably be stacked for storage prior to or after installation, providing for efficient stacking use of storage space. Such stacking is facilitated by bottom portions of the rigid casing extending to the bottom of the cladding panel, such that during stacking such bottom portions of the rigid casing assist in bearing the weight of the cladding panel and of other cladding panels stacked above, and reduces the load bearing requirement upon the core material when stacked.

The rigid casing is preferably of sufficient strength for the cladding panels to be trafficable by foot, while still protecting the underlying membrane.

The rigid surface to be clad may comprise a concrete slab of a roof or decking, or other rigid surface requiring cladding. The rigid surface may be substantially flat, with a drainage fall provided beneath the membrane, and may be intended for foot traffic. Additionally or alternatively, the rigid surface may be at an angle.

Brief Description of the Drawings

Figure 1 illustrates a typical roof cladding construction;

Figures 2a, 2b, 2c and 2d are plan, elevation, section and isometric views, respectively, of an extruded polystyrene foam board suitable for fabrication of a cladding panel in accordance with the present invention;

Figure 3 is a flowchart of a process for fabricating a cladding panel from the extruded polystyrene foam board of Figure 2;

Figures 4a, 4b, 4c and 4d are plan, elevation, section and isometric views, respectively, of the extruded polystyrene foam board of Figure 2 after a groove formation stage of fabrication;

Figures 5a, 5b, 5c and 5d are plan, elevation, section and isometric views, respectively, of a cladding panel fabricated in accordance with the process of Figure 3 from the extruded polystyrene foam board of Figures 2 and 4;

Figure 6 is a cross sectional view of a roof cladding construction in accordance with the present invention;

Figure 7a is an exaggerated cross sectional view of a conventional warped polystyrene foam board,

Figure 7b is an exaggerated cross sectional view of a warped polystyrene foam board in accordance with the present invention;

5 Figures 8a and 8b are exploded perspective bottom views of the foam board and cement casing of the cladding panel of Figure 5.

Figures 9a and 9b are exploded perspective cross sectional top views of the foam board and cement casing of the cladding panel of Figure 5.

10 Fig. 10a is a perspective top view of a cladding panel according to another embodiment of the present invention;

Fig. 10b is an exploded cross sectional perspective view of the cladding panel of Figure 10a along B-B;

Fig. 11a is a perspective bottom view of Fig. 10a;

15 Fig. 11b is a perspective bottom view of the casing of the cladding panel of Fig. 10a;

Fig. 12 is a perspective top view of a foam board for fabrication of a cladding panel of Fig. 10a;

Fig. 13 is a perspective bottom view of Fig. 12;

Fig. 14 is a top view of Fig. 12;

20 Fig. 15 is a bottom view of Fig. 12;

Fig. 16 is a side view of Fig. 12;

Fig. 17 is a flow chart showing a method for fabricating a cladding panel according to one embodiment of the present invention.

25 **Detailed Description of the Invention**

Figure 2 illustrates an extruded polystyrene foam board 200 suitable for fabrication of a cladding panel in accordance with the present invention. Fig. 2a is a plan view showing the square shape of the foam board 200, the square having sides 202 being 600mm in length. Fig. 2b is an elevation view from elevation A in Fig. 2a, illustrating the 50mm thickness of the foam board 200. Fig. 2c is a sectional view of the foam board 200 along section X-X in Fig. 2a. Fig. 2d is an isometric view of the foam board 200, indicating a top surface 204, side surfaces 206, 208, 210 and 212, and a bottom surface 214.

Figure 3 is a flowchart of a process 300 for fabricating a cladding panel from the extruded polystyrene foam board 200 of Figure 2. At 302, the foam board 200 is placed onto a router table to lie on surface 214, and a first set of three grooves are cut into the bottom surface 214 parallel to surface 206, while simultaneously cutting a single groove along surface 206. At 304, the foam board 200 is rotated 90 degrees, and a second set of three grooves are cut into the bottom surface 214 parallel to surface 208 and perpendicular to the first set of grooves, while simultaneously cutting a single groove along surface 208. At 306, the foam board 200 is turned over to lie on the top surface 204, and then a third set of three grooves are cut into the top surface 204 parallel to surface 210, while simultaneously cutting a single groove along surface 210. At 308, the foam board 200 is rotated by 90 degrees, and a fourth set of three grooves are cut into the top surface 204 parallel to surface 212 and thus perpendicular to the third set of grooves, while simultaneously cutting a single groove along surface 212.

Figure 4 illustrates the extruded polystyrene foam board 200 after stage 308 of the fabrication process 300. A first set of grooves 216 in the bottom surface of the foam board 200 are perpendicular to a second set of grooves 218 in the bottom surface of the foam board 200. A third set of grooves 220 in the top surface of the foam board 200 are perpendicular to a fourth set of grooves 222 in the top surface of the foam board 200. Groove 224 is cut along surface 206 and groove 226 is cut along surface 208. Similar grooves (not referenced) are cut along surfaces 212 and 210.

The design of the grooves 216, 218, 220, 222, 224, 226, in terms of size, shape and numbers and positioning on the extruded polystyrene foam board 200 has been optimized, as overly large or too many grooves would excessively weaken the extruded polystyrene foam board 200, whilst under-sized grooves or an insufficient number of grooves will not hold the foam board securely within the cement casing and/or provide adequate water drainages / moisture vents. In addition to the configuration of the grooves shown in

Figure 4, this optimization has resulted in all grooves being cut to a depth of 12mm and with a 12 mm width. It is to be appreciated that, when a cladding panel, fabricated from foam board 200, is tiled with other identical cladding panels, the continuous channels formed by the grooves of foam board 200 will be aligned with the channels of each adjacent cladding panel, regardless of orientation of the tiled cladding panels. Thus, continuous drainage channels will be provided between adjacent cladding panels, forming a drainage network under the tiled cladding panels.

Turning again to Figure 3, at step 310 the grooved foam board 200 is placed centrally in a metal formwork, with gaps of 10mm between the surfaces 206, 208, 210, 212 and the respective walls of the formwork, and with inserts positioned to extend the first set of grooves 216 and the second set of grooves 218 through the rigid concrete casing once formed. At step 312 a pre-mixed self-levelling high strength cement grout with concrete hardener additive is prepared. At step 314 the grout is poured onto the foam board and into the metal formwork, until the surface 204 of the foam board is covered to a depth of 13mm. At step 316 the top surface of the grout is trowelled and finished. At step 318 the grout is left to dry and harden. At step 320 the formed cladding panel is removed from the formwork.

Fig. 5 illustrates the cladding panel 500 produced after step 320 of process 300. The lightweight core material comprising foam board 200 has a rigid concrete casing 502 formed over the top surface 204 and side surfaces 206, 208, 210, 212. With particular reference to Fig. 5c, it can be seen that the third set of grooves 220 and the fourth set of grooves 222 cut into top surface 204 are occupied by portions of concrete casing 502, which function as beams to increase the strength and rigidity of the top of the rigid casing 502 and thus increase the strength and rigidity of the cladding panel 500. Such beams serve to distribute applied weight such as foot traffic to reduce the likelihood of foam board 200 being crushed. Further, grooves in surfaces 206, 208, 210, 212, such as grooves 226 and 224, are occupied by portions of the concrete casing, thus providing a tongue and groove -type mechanical joint between the foam board 200 and the concrete casing 502. Additionally, the extruded polystyrene foam board 200 is chemically bonded to the cement casing 502 by additives in the cement. Further, as shown in Figures 5c and 5d, grooves 216 and 218 in the bottom surface 214 of foam board 200 are extended through the bottom portions of the concrete casing 502, in order to provide continuous channels across the bottom of the cladding panel 500.

Figure 6 is a cross sectional view of a roof cladding construction 600 in accordance with the present invention. A roof slab 602 is finished with a fall, indicated at 604, to cause water to flow to drain 606 and into downpipe 608. The slab 602 is finished smooth to avoid ponding. A waterproof membrane 610 is laid down onto the slab 602 and extends
5 a height 612 of 300mm up the inside of walls 614, which in turn have a waterproof coating 616. A plurality of cladding panels 618 of the type illustrated in Figure 5 are laid directly over the membrane 610, with the concrete surface facing upwards and the bottom surface 214 of foam board 200 against membrane 610. Cladding panels 618 are laid out in a tile pattern to substantially cover the roof area, withstand foot traffic and protect membrane
10 610. Gaps, indicated at 620, of 5mm are left between the cladding panels 618 to allow for thermal expansion.

Thus, in the construction 600, water is freely allowed to pass down between the cladding panels 618. The provision of continuous drainage channels in the underside of the cladding panels and above the membrane 610 provides for free flow of such water into
15 drain 606. Should the drainage channels back up during particularly heavy rainfall, water is nevertheless free to flow over the top of the cladding panels to the drain 606, as the top surface of the cladding panels 618 has the same drainage fall as the membrane layer 610.

Figure 7a is an exaggerated cross sectional view of a conventional polystyrene foam board 700, warped due to the effect of surrounding temperature / humidity. Tension
20 stress 702 and compression stress 704 are generated which cause the foam board 700 to warp. By virtue of the tension / compression stress, tear or damage 706 are possibly taken place at top and/or bottom surfaces of the foam board 700.

Figure 7b is an exaggerated cross sectional view of a polystyrene foam board 200 according to one embodiment of the present invention, illustrating the manner in which
25 grooves 216 and 222 assist in releasing stress caused by warpage of the polystyrene foam board 200. Such warping may be caused for example by temperature variations and/or pressure caused by moistures to which the foam board 200 is subjected.

Figures 8a and 8b are exploded perspective bottom views of the foam board 200
30 and the cement casing 502 of the cladding panel 500 of Figure 5. Figures 9a and 9b are exploded perspective cross sectional top views of the foam board and cement casing of the cladding panel of Figure 5. Notably, grooves 220 and 222 in the top surface of foam

board 200 lead to portions of concrete casing 502 residing in grooves 220 and 222 to function as beams 504.

Thus a prefabricated lightweight composite cladding panel made of cement and extruded polystyrene foam board is provided, for use on concrete roof decks and floors as a thermal insulating and protection medium for any underlying waterproofing membrane on the concrete roof deck and floors, incorporating a water drainage and moisture vent system and providing a surface for light human traffic. Pre-fabrication in accordance with the process of Figure 3 avoids the problems associated with on-site wet works construction for concrete roof decks and floors. Quality can be maintained as the cladding panels 500, 618 are manufactured in a controlled environment. The pre-fabricated cladding panels 500, 618 are high strength, with thermal insulating properties, are easy to handle, simple to install and allow for easy maintenance of the roof deck 602 and/or the waterproofing membrane 610.

Different sizes and thicknesses of foam boards may be utilized to achieve different thicknesses of the finished cladding panel and different thermal insulating properties. In the present embodiment, the dimensions of foam board 200 are 50mm thick by 600mm width by 600mm length. Typical specifications of the polystyrene foam board 200 are listed below.

Property	Test Method	Unit(s)	Typical Value(s)
Density		kg/m ³	40 ~ 50
Thermal Conductivity	ASTM C518: 1991	W/m °K kcal/mm °K	0.02207 0.01897
10% Compressive Strength (Average)	ASTM D 1621: 2000	N/mm ²	0.30
Flammability Classification (Average burning rate)	ASTM C635: 91	cm/min	10.0

Water Absorption (Average)	ASTM C272: 2001	%	0.01
Temperature of Hot Surface		°C	40.77
Temperature of Cold Surface		°C	19.95
Mean Temperature		°C	30.36

The dimensions of the finished cladding panel 500 is 63mm thick by 620mm width by 620mm length. The size and thermal insulating properties of the cladding panel 500 can be customized using different sizes of extruded polystyrene foam board.

- 5 The composition of the pre-mixed, self leveling, high strength cement grout is listed below.

Name	CAS	Proportion
Portland Cement	65997-15-1	10 - 60%
Sand (Crystalline Quartz)	14808-60-7	10 - 60%
Flow Aid, Plasticiser		0 - 1%
Concrete Strengthener Additive		250 ml

The specification of the concrete strengthener is listed below.

Property	Unit	Typical Value
Solid Content	%	> 40
Density	kg/m ³	1.16 ± 0.04

Crack Filing	mm	0.1 – 2
Depth of Absorption (for Grade 20 Concrete)	mm	1 – 8
Flash Point Waterborne		Not flammable
Drying Time	hours	1 – 3
Weather Condition	°C	10 – 50
UV Resistance		Stable

The continuous drainage / vent channels of cladding panels 618 form a drainage / vent grid over membrane 610. The drainage / vent grid provides a system of outlets for residual water to discharge to the gutters and to drain 606, minimizing the risk of water stagnating below the cladding panels 618. The drainage / vent grid also provides a system of outlets for residual moisture to dissipate. This reduces the risk of pressure from expanding moisture acting on the extruded polystyrene foam board 200 and the cement casing 502 causing cracks, thus minimizing possible water leakage.

In the event that maintenance is required on the roof deck 602 and/or waterproofing membrane 610, the cladding panels 618 may be simply lifted up and placed aside, without necessitating damage to the roof construction 600. On completion of maintenance work, the cladding panels can be laid back on the waterproofing membrane to re-instate roof cladding. Such cladding panels further provide a modular cladding construction 600, enabling each single cladding panel to be separately replaced if required. Further, the cladding panels 618 may be used to implement a graphic design on the roof deck, by having colored cladding panels 618 and/or shaping and arranging the cladding panels 618 to form a desired pattern.

The extruded polystyrene foam board 200 will expand when subjected to heat. As it is encased in cement casing 502, such expansion will be restricted. However, the grooves on the surfaces of the board 200 are designed to accommodate the warping and bending, preventing the extruded polystyrene foam board from cracking.

As shown in Figs. 10a to 16, a cladding panel 800 according to a further embodiment of the present invention includes a core 810 and a casing 820. Core 810 is a polystyrene foam, firstly molded to a foam board 802. Foam board 802 has a main body 830 of about 970mm x 970mm x 50mm in size. On top of main body 830, first set of grooves 832 and 834 are formed, dividing top surface 830a of the main body 830 into a 4x4 array of sub-areas 836 (only four are marked in Fig. 12 for illustration) of substantially the same size.

At bottom surface 830b, there are formed a second set of grooves 842 and 844, as shown in Fig. 13. Similarly, second set of grooves 842 and 844 divides bottom surface 830b into a 4x4 array of sub-areas 846 each of which is positioned corresponding to one sub-area 836 at top surface 830a.

An opening 838 (only four are marked in Fig. 12 for illustration) is formed at the center of each sub-area 836 and 846. Each opening 838 extends from top surface 830a to bottom surface 830b of main body 830.

Once molded, second set of grooves 844 and 846 each has a dead end, as shown in Figs. 13 and 15. Accordingly, each of the second sets of grooves 844 and 846 is a closed groove having a lug 850 formed at each end. Each lug 850 is projected outwardly from a respective side surface 830c of main body 830.

To fabricate a cladding panel under the present embodiment, cement or concrete material is cast onto the foam board 802 to form a casing 820 enclosing top surface 830a and side surfaces 830c of foam board 802. Due to the presence of openings 838, the cement or concrete material flows into each of the openings 838 and upon curing, the portion filled in each of the openings 838 forms an array of columns 828 (only four are marked in Fig. 11A for illustration) and more clearly, in Fig. 11B.

During the casting process, lugs 850 block the cement or concrete material from covering the full area of side surface 830c. Upon curing, notches 860 (Fig. 11B) are formed on the casing 820, at positions corresponding to each lug 850.

Thereafter, lugs 850 are removed to open each of the second sets of grooves 842 and 844, forming channels 870 extending through opposite side surfaces of cladding panel 800, as shown in Fig. 11A. In one example, the cladding panel has a dimension of about 1000mm x 1000mm x 65mm in size, and with a casing thickness of about 15mm on the top and the sides of the cladding panel.

In use, cladding panels are laid on the roof of a building, in a way similar to that described in the previous embodiments, with channels 870 in alignment with the channels of an adjacent cladding panel. A channel network is therefore formed on the roof which serves the purpose of draining away rain waters or other types of moistures.

5 As the columns 828 are extended from top and bottom surfaces of the cladding panel, these columns firmly bind core 810 and casing 820 together. To this extend, chemical binders may be added to increase the bonding strength. In addition, columns 828 provide a strong support to the reinforce the strength and rigidity of cladding panel. Accordingly, cladding panels fabricated according to the present embodiment may be of a
10 size larger than that provided under the previous embodiments. In turn, the total number of cladding panels to be laid on a given roof surface area is less, hence a saving of labour costs required to carry out the installation and/or maintenance work. Further, columns 828 may also serve to withstand a relatively heavy human traffic on the cladding panel when needed to, for example, carry out any roof investigation and/or maintenance work.

15 The present embodiment makes it possible to fabricate the intermediate foam board by molding, which further enjoys the high productivity and hence cost benefit.

A method 900 of fabricating a cladding panel according to the present embodiment is illustrated in Fig. 17. At least one groove is formed in a bottom surface of a core material, as shown in block 902. At each end portion of the groove there is formed a lug
20 blocking the groove, and projected outwardly from the side surface of the core material, as shown in block 904. In the meantime, at least one opening is formed on the core material, as shown in block 906. A rigid casing is then formed by casting a cement or concrete material onto the core material, shown in block 908 by which, part of cement or concrete material is filled into the at least one opening. Upon curing of the cement or concrete
25 material, as shown in block 910, the rigid casing is formed with at least one column with the portion filled into the opening, and one or more notches at the positions where the lugs are located. The lugs are then removed to form the cladding panel, as shown in block 912,

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without
30 departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

CLAIMS

1. A cladding panel comprising:

5 a light weight core material, a bottom surface of the core material having at least one groove extending from a first bottom edge of the core material to a second bottom edge of the core material;

a rigid casing formed over a top and sides of the core material and extending to the bottom edges of the core material;

10 and wherein the at least one groove in the bottom of the core material extends through bottom portions of the rigid casing, forming at least one continuous channel across the bottom of the cladding panel.

2. The cladding panel of claim 1 wherein the or each continuous channel is of sufficient cross sectional area to carry water requiring draining during normal conditions.

3. The cladding panel of claim 1 wherein the cladding panel comprises a plurality of continuous channels across the bottom surface of the cladding panel.

15 4. The cladding panel of claim 1, wherein the or each continuous channel is configured to align with a continuous channel of an adjacent cladding panel when the cladding panel is tiled.

20 5. The cladding panel of claim 4, wherein the or each continuous channel is configured to align with a continuous channel of an adjacent cladding panel when the cladding panel is tiled, regardless of panel orientation.

6. The cladding panel of claim 1, wherein the cladding panel is of a shape to provide for continuous tiling.

7. The cladding panel of claim 6, wherein the cladding panel shape is one of: rectangular and square.

25 8. The cladding panel of claim 7 wherein a first set of substantially straight continuous channels in the bottom surface of the cladding panel is aligned substantially at right angles to a second set of substantially straight continuous channels in the bottom surface of the cladding panel.

9. The cladding panel of claim 8 wherein the first set is substantially parallel to a side of the cladding panel.
10. The cladding panel of claim 8 wherein the first set is at substantially 45 degrees to a side of the cladding panel.
- 5 11. The cladding panel of claim 6, wherein the cladding panel shape is one of: triangular and hexagonal.
12. The cladding panel of claim 1, shaped and coloured to implement a colour scheme and graphic pattern.
- 10 13. The cladding panel of claim 1, further comprising at least one groove in a top surface of the lightweight core material, occupied by a portion of the rigid casing which functions as a strengthening beam.
14. The cladding panel of claim 1, further comprising bonding between the lightweight core material and the rigid casing.
- 15 15. The cladding panel of claim 14, wherein the bonding comprises chemical bonding additives in the rigid concrete casing around the top and sides of the lightweight core material.
- 20 16. The cladding panel of claim 14, wherein the bonding comprises at least one groove in at least one side surface of the lightweight core material, the at least one groove being occupied by a portion of the rigid casing to effect mechanical bonding of the rigid casing to the lightweight core material.
17. The cladding panel of claim 16 wherein the at least one groove in the or each side surface of the lightweight core material extends substantially parallel to a respective bottom edge of the lightweight core material, such that the mechanical bonding counteracts lifting of the rigid casing from the lightweight core material.
- 25 18. The cladding panel of claim 1 wherein the lightweight core material provides thermal insulation.
19. The cladding panel of claim 1 wherein the lightweight core material comprises polystyrene foam.

20. The cladding panel of claim 19 wherein the lightweight core material comprises extruded polystyrene foam board.
21. The cladding panel of claim 1 wherein the rigid casing is a concrete casing.
22. The cladding panel of claim 1 weighing not more than substantially 50 kilograms.
- 5 23. The cladding panel of claim 1, being of sufficient weight to avoid wind uplift.
24. The cladding panel of claim 23, having a surface area of substantially 0.3844 square metres, and weighing not less than substantially 14kg.
25. The cladding panel of claim 1, wherein the rigid casing is of sufficient strength for the panel to be trafficable by foot.
- 10 26. The cladding panel of claim 1, wherein the or each groove is substantially 12mm deep and substantially 12mm wide.
27. The cladding panel of claim 1, wherein the light weight core material further comprising at least one opening extending from the bottom surface to the top side.
28. The cladding panel of claim 27, wherein the at least one opening is occupied by a
15 portion of the rigid casing forming a column in the opening.
29. The cladding panel of claim 28, wherein the column extends to the bottom surface of the light weight core material through the opening.
30. The cladding panel of claim 29, wherein the column is to withstand a load applied to the cladding panel.
- 20 31. The cladding panel of claim 28, wherein the column is bond to the light weight core material.
32. The cladding panel of claim 31, wherein the column is bond to the light weight core material by chemical bonding additives.
33. A method of fabricating a cladding panel, comprising:
25 providing at least one groove in a bottom surface of a core material;

forming a rigid casing over a top and sides of the core material and extending to the bottom edges of the core material; and

extending the at least one groove in the bottom of the core material through bottom portions of the rigid casing to form at least one continuous channel across the bottom of the cladding panel.

34. The method of claim 33 wherein the or each continuous channel is of sufficient cross sectional area to carry water requiring draining during normal conditions.

35. The method of claim 33 wherein the cladding panel comprises a plurality of continuous channels across the bottom surface of the cladding panel.

36. The method of claim 33, wherein the or each continuous channel is configured to align with a continuous channel of an adjacent cladding panel when the cladding panel is tiled.

37. The method of claim 36, wherein the or each continuous channel is configured to align with a continuous channel of an adjacent cladding panel when the cladding panel is tiled, regardless of panel orientation.

38. The method of claim 33, wherein the cladding panel is of a shape to provide for continuous tiling.

39. The method of claim 38, wherein the cladding panel shape is one of: rectangular and square.

40. The method of claim 39 wherein a first set of substantially straight continuous channels in the bottom surface of the cladding panel is aligned substantially at right angles to a second set of substantially straight continuous channels in the bottom surface of the cladding panel.

41. The method of claim 40 wherein the first set is substantially parallel to a side of the cladding panel.

42. The method of claim 41 wherein the first set is at substantially 45 degrees to a side of the cladding panel.

43. The method of claim 38, wherein the cladding panel shape is one of: triangular and hexagonal.

44. The method of claim 33, wherein the cladding panel is shaped and coloured to implement a colour scheme and graphic pattern.

45. The method of claim 33, further comprising providing at least one groove in a top surface of the lightweight core material, occupied by a portion of the rigid casing which functions as a strengthening beam.

46. The method of claim 33, further comprising bonding the lightweight core material and the rigid casing.

47. The method of claim 46, wherein the bonding comprises chemical bonding additives in the rigid concrete casing around the top and sides of the lightweight core material.

48. The method of claim 46, wherein the bonding comprises providing at least one groove in at least one side surface of the lightweight core material, the at least one groove being occupied by a portion of the rigid casing to effect mechanical bonding of the rigid casing to the lightweight core material.

49. The method of claim 48 wherein the at least one groove in the or each side surface of the lightweight core material extends substantially parallel to a respective bottom edge of the lightweight core material, such that the mechanical bonding counteracts lifting of the rigid casing from the lightweight core material.

50. The method of claim 33 wherein the lightweight core material provides thermal insulation.

51. The method of claim 33 wherein the lightweight core material comprises polystyrene foam.

52. The method of claim 51 wherein the lightweight core material comprises extruded polystyrene foam board.

53. The method of claim 33 wherein the rigid casing is a concrete casing.

54. The method of claim 33 wherein the cladding panel fabricated weighs not more than substantially 50 kilograms.

55. The method of claim 33, wherein the cladding panel fabricated is of sufficient weight to avoid wind uplift.

56. The method of claim 55, wherein the cladding panel fabricated has a surface area of substantially 0.3844 square metres, and weighs not less than substantially 14kg.
57. The method of claim 33, wherein the rigid casing formed is of sufficient strength for the cladding panels to be trafficable by foot.
- 5 58. The method of claim 33, wherein the or each groove is formed to be substantially 12mm deep and substantially 12mm wide.
59. The method of any one of claims 33, wherein forming the rigid casing comprises:
- placing the core material in a mould which allows space around the sides of the core and within which the casing can be formed;
- 10 placing inserts in the mould to provide for extensions of the grooves in the bottom of the core material; and
- pouring concrete into the mould to form the concrete casing over the top and around the sides of the core, and over the inserts.
- 15 60. The method of claim 33, further comprising forming at least one opening on the core material, wherein at least one opening extends from the bottom surface to the top side of the core material.
61. The method of claim 60, wherein forming the rigid casing comprises filling into the at least one opening a portion of the rigid casing to form a column in the at least one opening.
- 20 62. The method of claim 33, further comprising forming a lug at each end portion of the groove projecting outwardly from the sides of the core material and upon forming the rigid casing, removing the lugs to form at least one continuous channel across the bottom of the cladding panel.
63. The method of claim 62, wherein the lugs are to prevent the groove from being
25 filled during forming the rigid casing.
64. The method of claim 33 wherein the lightweight core material is a molded polystyrene foam board.
65. A cladding construction comprising:

a waterproof membrane over a rigid surface;

at least one cladding panel located over the membrane, the at least one cladding panel having a lightweight core material and a rigid casing over a top and sides of the core material, the at least one cladding panel being provided with at least one continuous channel across the bottom of the cladding panel forming a drainage channel over the membrane.

66. The cladding construction of claim 65, wherein the at least one cladding panel is in accordance with claim 1.

67. The cladding construction according to claim 65, comprising a plurality of cladding panels separated by a gap sufficient to allow thermal expansion of the cladding panels.

68. The cladding construction according to claim 65, in which panel jointing is not provided.

69. The cladding construction according to claim 65 wherein the rigid surface comprises a concrete slab.

70. The cladding construction according to claim 65 wherein the rigid surface is a roof or serves as a roof.

71. The cladding construction according to claim 65 wherein the rigid surface is a deck.

72. The cladding construction according to claim 65 wherein the rigid surface is substantially flat, having only a drainage slope.

73. The cladding construction according to claim 65 wherein the rigid surface is angled.

74. The cladding construction according to claim 65, being trafficable by foot.

75. A cladding construction comprising a plurality of cladding panels as recited in claim 27.

76. A method of forming a cladding construction, the method comprising:

providing a waterproof membrane over a rigid surface; and

locating over the membrane at least one cladding panel having a lightweight core material and a rigid casing over a top and sides of the core material, the at least one cladding panel being provided with at least one continuous channel across the bottom of the cladding panel forming a drainage channel over the membrane.

- 5 77. The method of claim 76, wherein the cladding panel is in accordance claim 1 .
78. The method of claim 76, wherein the cladding construction formed is in accordance with claims 65.
79. The cladding panel of claim 1, having an area of not more than substantially 5 m².
80. The method of claim 33 wherein the cladding panel fabricated having an area of
10 not more than substantially 5 m².