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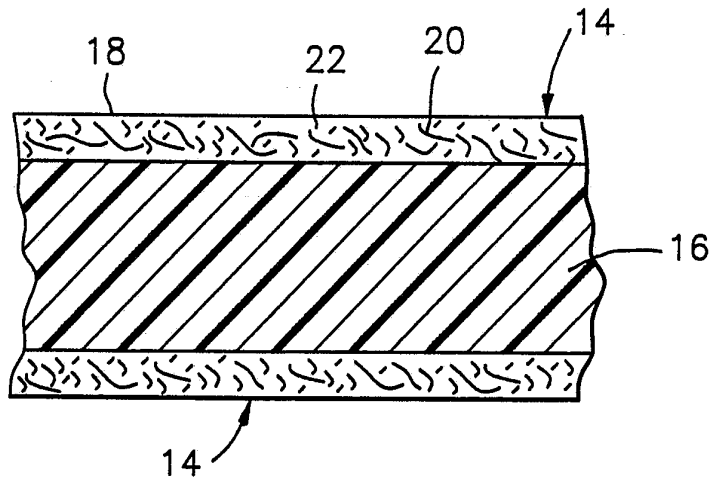
(54) Title: COMPOSITE STRUCTURE WITH FOAM PLASTIC CORE AND METHOD OF MAKING SAME




(57) Abstract

A composite structural material and the method of making a low cost, lightweight, ductile, long lasting, crack resistant, composite structural material which consists of a core (12) constructed from lightweight, expanded foam. The core is covered on one or more of its sides with a high strength outer layer (14) constructed of a layer of layers of non-woven web fibrous material impregnated with a cementitious slurry binder (22) with the fibers in the layers of non-woven web material forming a three-dimensional reinforcement matrix (18) for the cementitious slurry. The outer layer is formed and cured on one or more surfaces of the lightweight plastic core resulting in a crack resistant outer layer having greater ductility and thoughness than ordinary cement or concrete. The cement in the outer layer bonds directly to the lightweight plastic core thus requiring no additional bonding agent. Outer layers can be formed and cured around various shaped cores for various end uses.

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# COMPOSITE STRUCTURE WITH FOAM PLASTIC CORE AND METHOD OF MAKING SAME

## BACKGROUND OF THE INVENTION

### FIELD OF INVENTION

The present invention generally relates to a composite structural material and the method of making the same and more specifically the invention relates to a low cost, lightweight, fire resistant composite material and the method of making the same in which the composite consists of a core constructed from lightweight expanded foam plastic such as expanded polystyrene. The core is covered on one or more of its surfaces with a high strength outer layer constructed of a layer or layers of non-woven fabric webs impregnated or infiltrated with cementitious slurry binder with the fibers in the layers of non-woven fabric material forming a three-dimensional reinforcement matrix for the cementitious slurry. The outer layer is formed and cured on one or more surfaces of the lightweight plastic core resulting in a crack resistant outer layer having greater ductility and

toughness than ordinary cement or concrete. The cement in the outer layer bonds directly to the lightweight plastic core thus requiring no additional bonding agent. Outer layers can be formed and cured around various shaped cores for various end uses.

DESCRIPTION OF THE PRIOR ART

Composite materials comprised of high strength outer layers bonded to lightweight core materials are utilized for several applications. The outer layers serves to increase the strength, durability, ultra-violet resistance, fire resistance, chemical resistance, or combinations of these properties of the composite depending on the application.

Patent No. 4,764,238 discloses a composite material made by applying heat and pressure to fabrics preimpregnated with a thermosetting resin to bond the fabrics to an open-celled foam core. The resulting lightweight composite is claimed to be suitable for energy absorbing, impact-resistant structures.

Patent 4,050,659 relates to an electrical transformer equipment pad made with a fiberglass reinforced exterior plastic surface formed around an expanded foam core.

Patent 4,303,722 describes a panel constructed of thin facings, comprised of a fabric or web of glass fibers and a set composition of thermosetting

condensation resin and gypsum, bonded to a rigid substrate such as a foamed plastic material. In this composite, the fibers in the reinforcing material are essentially two-dimensional, advantageously placed as near to the surface of the facing as possible.

Patent 4,963,408 relates to a unitary composite laminate structure made by encapsulating a foam core with a load bearing polymer matrix reinforced with oriented fibers. This composite also utilizes a bonding material to fuse the outer layer to the core.

Patent 4,559,263 described a cement-foam composite board in which a concrete, made with lightweight aggregate and a foaming agent is bonded on one side of an expanded foam panel. This patent further claims that an unspecified reinforcing means may be included in the concrete.

Panels made in the above mentioned manners are limited in their performance due to trade-offs involved with the choice of materials utilized in the coatings or facings. The resinous and polymeric coatings are less fire resistant and more costly than the cementitious ones. However, the cementitious facings exhibit lower flexural strengths and are more prone to cracking and brittle behavior.

Non-woven webs of fibers have been utilized as reinforcement for cement matrices for thin sheet-like materials.

Patent 4,778,718 refers to a non-woven reinforced cement sheet made by screeding dry cement into the fiber matrix and then applying water to hydrate the cement and form a sheet.

Patent 4,617,219 relates to a three-dimensionally reinforced cement structure utilizing at least one non-woven web as the fibrous reinforcement. This patent further claims that layers of such non-woven reinforced cement sheets can be formed together to produce structural panels.

Thin sheets made in the above manners, with no core material, do not possess sufficient overall strengths to span typical panel lengths or support loads such as wind or foot traffic. The thin, coreless sheets do not exhibit insulative properties significantly greater than those of ordinary concrete. Panels made thick enough in the above manners to support loads, without lightweight cores, are only approximately 30% lighter than equivalent panels made with ordinary concrete.

Blocks of lightweight, foamed plastic, such as polystyrene, are utilized for buoyant support of floating structures such as boat docks. When these blocks are utilized without protective outer layers, chemicals in the water, from outboard motors, for example, can break down the block and pieces of the block are then free to pollute the body of water.

## SUMMARY OF THE INVENTION

It is the object of the present invention to provide a lightweight, low cost, ductile and crack-resistant composite material which also possesses fire resistance.

A further object of this invention is to provide a method of manufacture of this composite in suitable forms to meet such end uses as equipment pads, floating docks, building panels, noise abatement surfaces, and fire resistant self-cladded insulation.

The composite consists of a high strength outer layer formed and cured around one or more sides of a lightweight core. This outer layer is a cementitious matrix three-dimensionally reinforced with a non-woven web of fibers. The fibers are present in 3-20% volume loadings, which imparts high flexural strength, ductility, toughness, and crack resistance to the outer layer. The fibers are completely encapsulated in the cement matrix, giving the outer layer the appearance, hardness, and durability of ordinary concrete. The fibers are also protected from fire and ultra-violet radiation by the cement matrix.

This outer layer is applied to the core, preferably expanded polystyrene, while the cement matrix is in its wet, uncured form. The outer layer can be applied by hand or by mechanical pressing means to insure that the wet cement matrix is uniformly

distributed throughout the fiber web and evenly in contact with the lightweight core to allow the outer layer to bond to the core as the cement matrix cures.

The use of a lightweight, foamed plastic core gives the composite material a high strength:weight ratio. This is true in flexure due to the beam design of the sandwich panel and the high flexural strength of the outer layer. In compression, the composite exhibits high strength due to the outer layer's compressive strength, which is equivalent to ordinary concrete.

When utilized for floating structure supports, the outer layer of the composite first protects the polystyrene core from attacking chemicals and further prevents pieces of the plastic core from breaking away and polluting the marine environment.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a panel utilizing the composite structural material of the

present invention.

Figure 2 is a sectional view, on an enlarged scale, illustrating the specific arrangement of the components forming the composite structural material of this invention.

Figure 3 is a perspective view of a buoyant support for a floating structure such as a boat dock.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now specifically to the drawings, a composite structural component in the form of a panel is illustrated in Fig. 1 and generally designated by reference numeral 10 and which includes a core generally designated by reference numeral 12 and an outer layer generally designated by reference numeral 14 which may extend over one surface of the panel, both opposed surfaces or around all of the edges and all of the surfaces. The outer layers 14 form the interior and exterior surfaces of the panel and they can be textured or colored when being formed or finished with various materials such as plastic, sheathing, painting, grooving or the like for appearance purposes to enable any desired architectural finish characteristics to be obtained.

As illustrated in Fig. 2, the core 12 is constructed of lightweight foam plastic such as

expanded polystyrene in the form of a board 16, block or other structural entity.

The outer layer 14 includes a three-dimensional web of non-woven web 18 which includes non-woven fibers 20 in which the fiber volume ranges between 3 and 20%. A cementitious slurry binder 22 intimately surrounds, infiltrates and connects the fibers 20 when the cementitious slurry binder is cured. The cementitious slurry binder 22 in the outer layer is cured with the cured and hardened slurry binder 22, outer layer 14 and non-woven fibers 20 and core 12 becoming a rigid, integral body thus providing a panel with an ultra lightweight core which is reinforced and rigidified by the outer layer or layers with the core and layer or layers being rigidly formed into a single rigid unit.

In one embodiment of the invention, a panel was formed in accordance with the present invention by providing an expanded polystyrene board 16. A cement slurry was mixed in a portable mortar mixer with the following ratios by weight: 10 parts Portland cement, 1 part microsilica, 5 parts fine sand, 4 parts water and 0.1 parts water reducing superplasticizer. Sheets of a non-woven web material in the form of a needlepunched polypropelene weighing 8 ounces per sq. yd. with a loft of 1/4" were cut into pieces of appropriate size to cover the board and applied to the

core after the cement slurry has been applied in its wet uncured form by hand or mechanical press.

After curing for 24 hours, test beams were cut from the panel with the test beams being 24" in length, 6" wide and 2 1/2" thick. These test beams were tested for flexural strength after a 7 day curing period by using 3rd point loading on an 18" span with the average flexural strength being 500 psi. This flexural strength is approximately equivalent to prior art panels when constructed to be 4" thick which weigh approximately 20 pounds per sq. ft. The lightweight, low cost, insulative, fire resistant, chemical resistant, ultra-violet resistant and ductile structure enables the composite material to be used as an equipment supporting base or pad, fire resistant noise abatement panels, building panels, self-cladded insulation for pipe and ductwork and a float to support a dock with the composite structural material providing adequate buoyancy to floatingly support the dock at a desired elevation in relation to the water and having a high resistance to ultra-violet light deterioration.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and, accordingly, all

suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

WHAT IS CLAIMED AS NEW IS AS FOLLOWS:

1. A composite structural material comprising a core constructed of lightweight, low density substantially rigid material, an outer layer constructed of cementitious slurry binder reinforced with fibers, said outer layer being applied to the core and cured with the cementitious slurry binder forming a rigid matrix extending substantially continuously throughout an outer surface of the core to form a lightweight, low cost, high strength, insulative, fire resistant composite material having high toughness, crack resistance and ductility properties.

2. The composite material of claim 1 wherein the lightweight core is constructed of expanded polystyrene.

3. The composite material of claim 2 wherein the expanded polystyrene is in the form of a substantially rigid board.

4. The composite material of claim 1 wherein the reinforcing fibers of the outer layer is in the form of a non-woven web.

5. The composite material of claim 1 wherein the core has two outer layers formed on two sides of a planar core to form a sandwich panel.

6. The composite material as defined in claim 2 wherein the reinforcing fibers of the outer layer is in the form of a non-woven web.

7. The method of making a composite material consisting of the steps of placing a core of substantially rigid lightweight board of low-density material, applying a cementitious slurry binder containing Portland cement, water and admixtures onto the core, applying a layer of non-woven web fibrous material to the binder while wet and uncured, applying pressure to outer layer and curing the materials to form a composite material.

FIG. 1

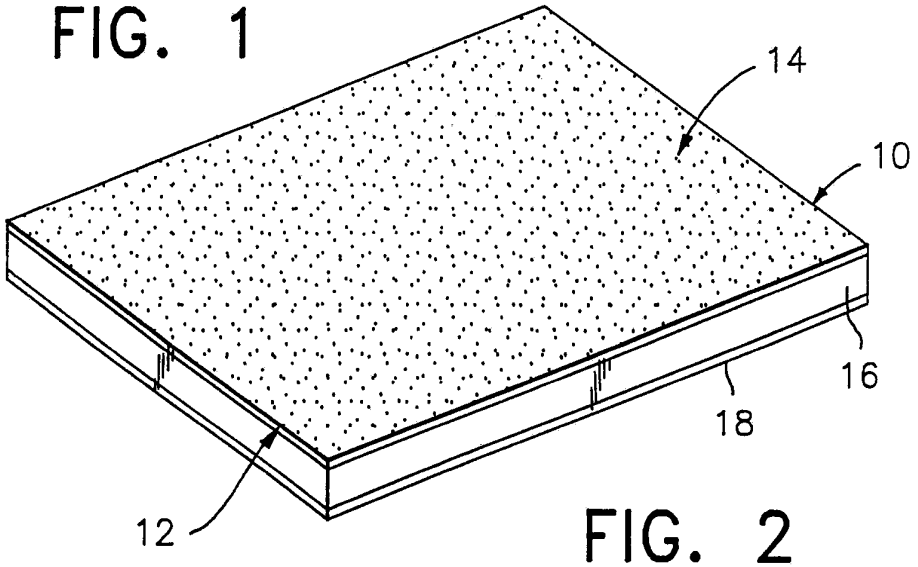



FIG. 2

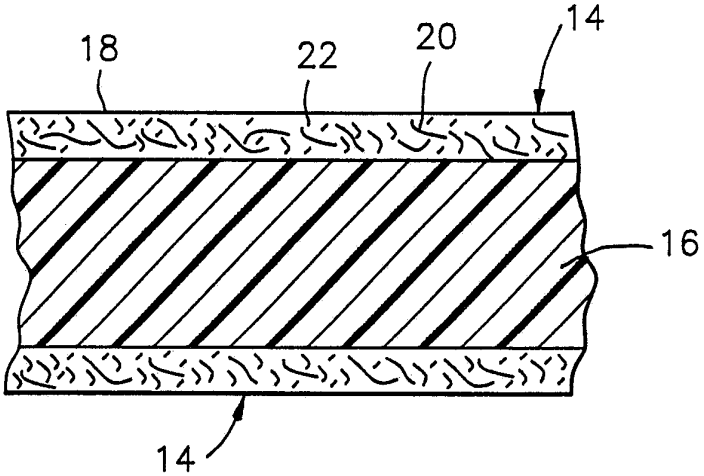
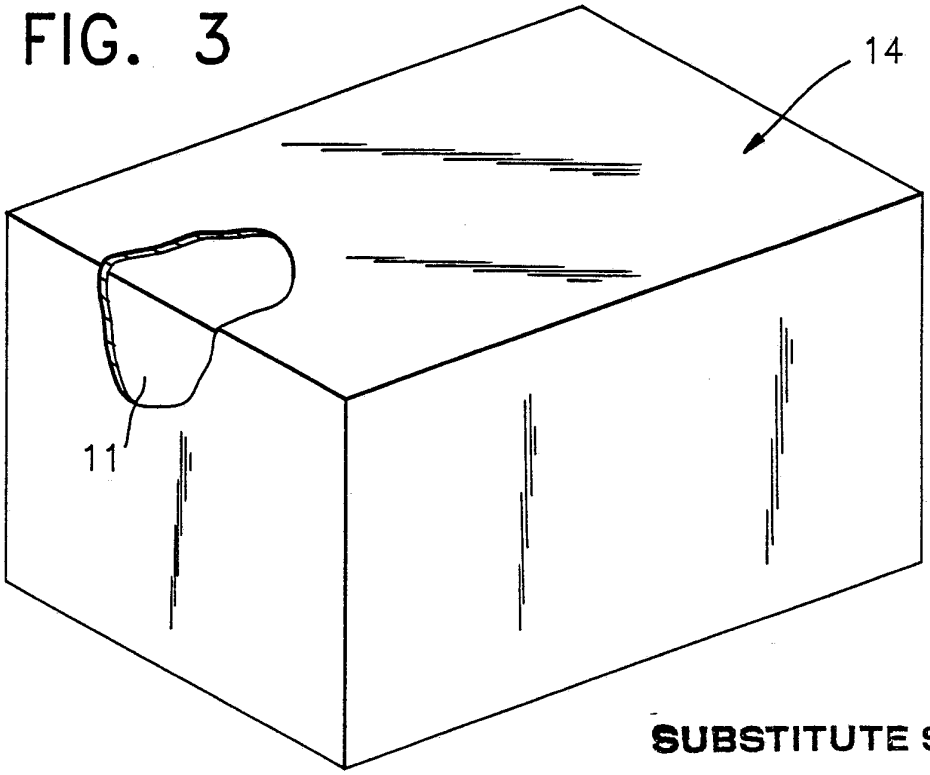



FIG. 3



# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/05978

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B32B 3/26
US CL :428/309.9,312.4,313.5,319.1,703
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/309.9,312.4,313.5,319.1,703

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | UK, A, 2136468A (DUKE), 19 SEPTEMBER 1984, See entire document. | 1-7<br>1-7 |
| X<br>Y | US,A, 3,745,058 (PAYMAL), 10 JULY 1973, See entire document. | 1-7<br>1-7 |
| X<br>Y | US,A, 4,303,722 (PILGRIM), 01 DECEMBER 1981, See entire document. | 1-7<br>1-7 |
| Y | US,A, 4,617,219 (SCHUPACK), 14 OCTOBER 1986, See entire document. | 1-7 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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