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(54) **MULTILAYER PANEL FOR CIVIL CONSTRUCTION**

(57) The present invention refers to a multilayer panel for civil construction successively comprising: a composite structure (1,2) obtained from fibers and thermosetting polymer matrix; a polymer foam layer (3); a concrete layer (4); wherein the composite structure (1, 2) comprises a lower face from which two outer side faces

(2) and one or more inner side faces (1) extend, wherein said inner side faces (1) extend from the lower face of the composite structure (1, 2), through the polymer foam layer (3) to a predetermined thickness of the concrete layer (4).

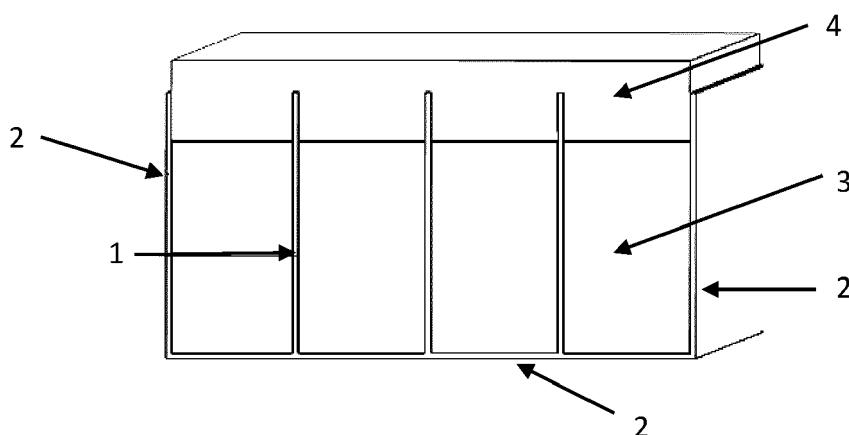


Fig. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to a multilayer panel, the construction material of which comprises a composite formed by at least two types of glass fiber impregnated with a thermosetting polymer matrix, a polymer foam core and a concrete layer. More specifically, said multilayer panel is intended for use in civil construction.

BACKGROUND

[0002] Concrete, an indispensable material in civil construction industry, is in itself a material of high durability. However, many structures having concrete in their composition, such as bridges, roads and buildings, are deteriorating and collapsing over time.

[0003] In addition to degradation resulting from the useful life of the material, from its exposure to the environment, where it is susceptible to external factors, as well as aggressive actions, degradation is also associated with the reinforcement elements in iron-based material located inside the concrete in constructions. Particularly, steel elements.

[0004] The disadvantage of concrete structures provided with such elements, consists of the reduced durability of such elements due to the unchanged oxidation property of iron, which consequently is also reflected in the durability of the structures where it is used. As these elements are found inside the structure, it is difficult to detect damages at an early stage, which results in the late detection of the problem, thus representing high repair costs.

[0005] In addition to durability, another disadvantage of iron-based elements is that they are quite heavy, making the final structure very heavy, thus hampering the transport and installation thereof.

[0006] Taking these disadvantages into consideration, glass fiber reinforced polymer composites are normally used. These composites present solutions that meet the requirements demanded by the industry, that is, sustainable and optimized constructions for high performance and efficiency, considering as parameters, for example, lightness, greater durability to corrosion factors and mechanical properties similar to those of conventional structures, that is, those made of concrete with iron-based reinforcement elements.

[0007] As an example, the following documents are cited:

[0008] CN 108 774 932 (A) refers to a type of road pavement resistant to corrosion, as well as a method of paving. The corrosion resistant road pavement, as disclosed in said document, has a multi-cavity structure made of composite material, including the upper panel, the lower panel, the reinforcement rib, the pins and the ends of the housing. The composite material is formed

by polyurethane resin reinforced with glass fiber. This type of pavement has as its main limitation the fact that the composite materials perform poorly when subjected to compression loads.

[0009] Multicellular panels are also disclosed in the document entitled "Structural behavior in flexure of multicellular pultruded GFRP panels applied to pedestrian bridge decks". This document proposes a study on multicellular glass fiber reinforced plastic panels (GFRP), produced by pultrusion. The panel under analysis consists of a polymer matrix of isophthalic polyester, reinforced with E-type glass fiber (E-glass is known as electric glass, since it is a good electricity insulator), in the form of rovings and multidirectional woven webs. These slab elements have a cellular cross section consisting of seven foams wrapped by 4 mm thick GFRP (Glass Fiber Reinforced Polymers) laminates with an increase to 5 mm in the flange connections (face of the composite) - core (foam) and in the end flaps corresponding to the fit between the various panels. The major limitation of this solution is due to the fact that there is a delamination (separation) between the composite upper face, which is subject to compression loads, and the upper face of the foam core. This delamination phenomenon always occurs at low loads due to the weak bonding strength between the adhesive binding the composite and the foam, and the low compression performance of the GFR face.

[0010] Document "Flexural Behaviors of Concrete/EPS-Foam/Glass-Fiber Composite Sandwich Panel" refers to a multilayer structural panel using a composite material on the lower face, a foam in the core, a mesh of steel rods (between the foam and the concrete) and a concrete layer on the upper face of the structure. However, one of the limitations of this solution comes from the fact that the panel was developed through the deposition of layers of different materials, without a mechanical anchoring between them. This situation implies that the different layers of the panel will not work in a solidary way, thus the panel will not withstand high loads which will lead to its structural failure. In order to address this problem, a mesh of steel rods was placed to reinforce the structure, causing an increase in the mechanical properties of the panel. However, the use of steel rods again poses the problem regarding corrosion by atmospheric factors, which will result in the degradation of the product, as well as a reduction in the efficiency of the mechanical properties of the panel and a decrease in the durability thereof.

[0011] Considering composites, those skilled in the art recognize that currently the literature is full of solutions involving this type of material for structural use in the field of civil construction. However, as already mentioned above, it is clear that none of these solutions has a concept similar to conventional structures. More specifically, structures comprising a combination of materials that work in a more solidary way to promote increased durability of the final structure.

[0012] Thus, the present invention was developed in order to provide the state of the art with a panel that works in a cooperating manner with all materials and is able to support loads as one, with no separation (delamination) of the layers forming the same, nor a degradation of the mechanical properties of the panel.

[0013] These facts are described in order to illustrate the technical problem solved by the embodiments of the present document.

GENERAL DESCRIPTION

[0014] The present invention relates to a multilayer panel, which can be used in civil construction industry, for example on walls, pavements and roofs. Said panel, which can also be used as a slab, comprises a composite basically formed by at least two types of reinforcement fibers, impregnated with a thermosetting polymer matrix, a polymer foam core and a concrete layer. This panel consists of a more economical material that provides the mechanical, tensile and compressive as well as chemical properties necessary for the use in civil industry. Additionally, the panel meets the requirements of structural design based on composites using a polymer matrix, as required by civil construction industry.

[0015] One aspect of the disclosure refers to a multilayer panel for civil construction successively comprising:

- a composite structure (1,2) obtained from fibers and thermosetting polymer matrix;
- a polymer foam layer (3);
- a concrete layer (4);
- wherein the composite structure comprises a lower face from which two outer side faces (2) and one or more inner side faces (1) extend,
- wherein said inner side faces (1) extend from the lower face of the composite structure, through the polymer foam layer to a predetermined thickness of the concrete layer.

[0016] In one embodiment, the plurality of side faces comprises, at its end, a "T" shaped structure to anchor the concrete layer to the other layers of the multilayer panel.

[0017] In one embodiment, the side faces with an end with a T-shaped structure are the inner side faces (1).

[0018] In one embodiment, the polymer foam layer (3) is divided into foam cores separated by one or more inner side faces (1).

[0019] In one embodiment, the composite structure comprises a ratio of 65% to 75% (w/w) of fibers to 25% to 35% (w/w) of thermosetting polymer matrix.

[0020] In one embodiment, the composite structure comprises a ratio of 70% (w/w) of fibers and 30% (w/w) of thermosetting polymer matrix.

[0021] In one embodiment, the fibers of the composite structure are glass fibers and are in the form of a web or fabric with unidirectional or bidirectional orientation.

[0022] In one embodiment, the glass fibers are selected from E-glass fiber, ECR-glass, D-glass, S-glass, AE-glass, C-glass, A-glass, Z-glass or mixtures thereof.

[0023] In one embodiment, the lower face and the two outer side faces (2) of the composite structure comprise at least two E-glass fiber layers in the form of a web and two E-glass fiber layers in fabric with unidirectional orientation.

[0024] In one embodiment, one or more inner side faces (1) of the composite structure comprise at least three E-glass fiber layers in fabric with unidirectional orientation and one E-glass fiber layer in the form of a web.

[0025] In one embodiment, the thermosetting polymer matrix is an epoxy- or polyester- or vinyl ester-based resin.

[0026] In one embodiment, the polymer foam layer (3) is selected from polyethylene, polystyrene, polyurethane or mixtures thereof, preferably polyurethane.

[0027] In one embodiment, the "T" structure comprises a thickness between 1 and 2 mm and a width between 17 and 24 mm.

[0028] In one embodiment, the thickness of the lower face and the two outer side faces (2) of the composite structure is 1.5 mm and the thickness of the inner side faces (1) of the composite structure is 1.3 mm.

[0029] In one embodiment, the thickness of the polymer foam layer (3) is 160 to 180 mm and the thickness of the concrete layer (4) is from 50 to 70 mm.

[0030] In one embodiment, the constructive arrangement in the form of a multilayer panel with high mechanical resistance for the construction industry, can comprise a composite (1) (2), a foam (3), a concrete layer (4) and a "T" structure (5), arranged in such a way that: the composite comprises (i) a first layer (lower and side walls, said lower and side faces of the panel - inner and outer) with an approximate thickness between 1 and 2 mm consisting of laminates of at least two types of reinforcement fiber, with different orientations, impregnated with thermosetting polymer matrix (1) and (2) and (ii) a second layer (panel core) formed by polymer foams (3) with an approximate thickness between 160 and 180 mm; a layer (upper face of the panel) formed of concrete (4) with an approximate thickness between 50 and 70 mm; and a "T" structure (5) that promotes the anchoring of the concrete layer to the composite and presents a thickness between 1 and 2 mm and a width between 17 and 24 mm.

[0031] In one embodiment, the glass fiber used may be E-glass fiber, it may be in the form of a web and a fabric with unidirectional orientation.

[0032] In one embodiment, the foam (3) used for forming the multilayer panel, may be a rigid foam of polymer material selected from polyethylene, polystyrene and polyurethane.

[0033] In one embodiment, the foam (3) may be polyurethane and the resin may be vinyl ester based.

[0034] In one embodiment, the "T" structure (5) can mechanically or physically anchor the concrete (4) to the foam (3) and to the composite material to allow these

three layers to work in solidarity with each other.

[0035] In one embodiment, the concrete layer (4) can be half the thickness below the "T" structure (5) and the other half be above that same structure.

[0036] In one embodiment, the composite can comprise two layers of type E-glass fiber in the form of unidirectional fabric and two layers of type E-glass fiber in the form of a web (1), which wrap each of the four foam cores and, three layers of type E-glass fiber in the form of unidirectional fabric and one layer of type E-glass fiber in the form of a web (2), impregnated with vinyl ester resin impregnated with vinyl ester resin, which wrap the foam core assembly (3).

[0037] In one embodiment, the different layers of the constructive arrangement can work together, supporting loads as one.

[0038] In one embodiment, the panel may comprise a width between 300 to 1000 mm and a length between 1000 and 8000 mm, preferably a width between 350 and 500 mm and a length between 3000 and 4000 mm.

[0039] In one embodiment, the thickness (i) of the panel can be about 232 mm; (ii) the "T" structure (5) can be about 1.5 mm and the width can be about 20.5 mm, (iii) the first layer can be about 1.3 mm on the inner side faces (1) and about 1.5 mm on the outer side faces and lower face (2), (iv) the second layer (3) can be approximately 170 mm and (v) the third layer (4) can be approximately 60 mm.

[0040] In one embodiment, the composition of the composite layer can comprise mixing the glass fiber with the polymer matrix in a ratio of about 65 to about 75% fiber to about 25 to about 35% polymer matrix by weight of the total composite layer.

[0041] In one embodiment, the ratio of glass fiber to polymer matrix, in the composite layer is 70% fiber and 30% polymer matrix.

[0042] In one embodiment, this panel presents a decrease in the mass amount per unit area of approximately 230%, in relation to a conventional solution - lightened slab - for pavements or roofs, with structural functions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] For an easier understanding, figures are herein attached, which represent preferred embodiments which are not intended to limit the object of the present description.

Figure 1: Schematic representation of an embodiment of the panel wherein: (1) corresponds to the internal laminate of two glass fiber layers (type E) as unidirectional fabric (oriented in one direction) and two glass fiber layers (type E) in the form of a web (dispersed fiber, without orientation); (2) three glass fiber layers (type E) surface laminate in the form of a unidirectional fabric and one glass fiber layer (type E) in the form of a web; (3) polymer polyurethane foam core and (4) concrete.

Figure 2: Schematic representation of an embodiment of a mold for the production of the final panel wherein: (5) corresponds to the "T" in composite material.

DETAILED DESCRIPTION

[0044] The present invention relates to a multilayer panel, the construction material of said panel comprises a composite (1,2) formed by at least two types of glass fiber impregnated with a thermosetting polymer matrix, a polymer foam core (3) and a concrete layer (4). More specifically, the panel is intended for use in civil construction industry.

[0045] More particularly, said multilayer panel comprises at least one composite layer (1, 2), developed with fibers, with excellent mechanical and chemical properties.

[0046] In a preferred embodiment of the present description, the fiber selected for use was glass fiber. In particular, a reinforcement glass fiber, which can be selected from fiber E-glass, ECR-glass, D-glass, S-glass, AE-glass, C-glass, A-glass, Z-glass or mixtures thereof.

[0047] The most common types of glass fiber used in glass fiber are E-borosilicate glass with less than 1% alkaline oxides, mainly used for glass reinforced plastics. Other types of glass used are A-glass (alkali-lime glass with little or no boron oxide), E-CR-glass (Electrical/Chemical Resistance), alumino-lime silicate with less than 1% c/w alkali oxides, with high acid resistance), C-glass (alkali-lime glass with high boron oxide content, used for glass staple fibers and insulation), D-glass (borosilicate glass, named for its low dielectric constant), and S-glass (alumino silicate glass without CaO but with high MgO content with high strength).

[0048] In a preferred embodiment of the present description, the glass fiber used was E-glass fiber, which is a more cost-effective glass fiber with mechanical properties that meet the necessary usage requirements.

[0049] The multilayer panel must reach the deflection corresponding to $L/500$, for spans (distance between bending supports) greater than 2 m, without damage and the strength required to reach $L/500$ must be greater than or equal to 13 kN/m^2 , which is the necessary strength according to the usability criteria of this type of structure. These are the requirements that must be met regarding the design code criteria of the EUROCOMP - *Design code and handbook*, which governs the requirements for structural design based on composites using a polymer matrix.

[0050] The orientation of the fiber is relevant in the evaluation of the performance of the composite, since it influences the mechanical properties thereof and, therefore, the properties of the multilayer panel proposed herein.

[0051] Accordingly, in a preferred embodiment of the present description, in relation to the orientation of the fibers, they can be in the form of a web (dispersed fiber,

without orientation) or of fabric with unidirectional or bi-directional orientation. Preferably, the glass fiber used in the present description is in the form of a web and in fabric with unidirectional orientation. Said orientation defines the two types of E fiber used in the present invention.

[0052] Regarding the foam (3) used for forming panel, it was used to fill the multilayer panel and to promote the stability of the faces thereof. Foams provide the multilayer panel with thermal and acoustic insulation, shock absorption, vibration isolation and resistance to chemicals and moisture. At the same time, the use of foam (3) reduces the amount of panel mass per m², since this is a low density (about 0.250 g/cm³) and low-cost material.

[0053] In a preferred embodiment, the foam (3) used was a rigid foam of polymer material selected from polyethylene, polystyrene and polyurethane. Preferably, the foam used herein was a rigid polyurethane foam.

[0054] The function of concrete (4) in the multilayer panel herein developed is to reinforce the mechanical properties of the panels, providing an excellent ability to withstand the compression loads applied onto the panel.

[0055] The thermosetting matrix serves as the basis of the composite material (1, 2). It provides the composite with structural function, since after processing the resin, said matrix provides mechanical resistance to the composite, in order to allow the composite to withstand loads up to a certain limit, distributing the stresses applied efficiently onto the reinforcement material (glass fiber), thus allowing it to be responsible for increasing the mechanical properties of the composite material.

[0056] The thermosetting matrix resin is selected from the group of epoxy-, polyester- or vinyl ester- based compounds. However, the present invention is not limited to these options. Any other resin having properties and performing a function similar to these, can be used in the present embodiment.

[0057] In a preferred embodiment, the resin making up the polymer matrix of the multilayer panel herein presented is a vinyl ester-based resin, since it has chemical resistance and physical properties superior to those of polyester resins, as well as processing properties superior to epoxy and polyester resins.

[0058] The panel herein presented by the present description has a differentiating concept, compared to similar structures existing in the market.

[0059] Said panel is provided with a physical connection, promoted by a "T" structure (5), located between the concrete (4), which is on the upper part of the panel and shall be responsible for supporting the compression loads felt by the panel, and the reoriented composite material that makes the connection between the concrete and the composite structure present in the lower zone of the panel (2) and in the outer (2) and inner side areas of the panel (1) (separation between the foam cores).

[0060] In one embodiment as shown in Figure 1, the composite structure herein presented comprises two glass fiber layers (type E) in the form of a unidirectional fabric and two glass fiber layers (type E) in the form of a

web, impregnated with vinyl ester resin that wrap each of the four foam cores (3) (lower face of the panel (2) and inner (1) and outer side areas thereof (2)) and three glass fiber layers (type E) in the form of a unidirectional fabric and one glass fiber layer (type E) in the form of a web, impregnated with vinyl ester resin, which wrap the foam core assembly (lower face (2) and outer side areas of the panel (2)), which will be responsible for withstanding great tensile loads.

[0061] In one embodiment, Figure 2 shows a preferred embodiment of the panel mold herein developed, used for the production of the panels. In particular, a "T"-shaped structure (5) has been designed on the top surface of the panel, which consists of an extension of the side faces (1) of the composite material and that extends to an intermediate portion of the concrete layer.

[0062] In one embodiment, as the "T" structure (5) is an important part of the differentiating concept of the constructive arrangement presented herein, since this structure is responsible for mechanically anchoring the concrete (4) to foam (3) and to composite material (1, 2), in order to allow these three layers to work in solidarity with each other, that is, the different layers, with different materials, that make up the panel, work in a cooperating manner to support the different types of loads that the panel will be subjected to, at a given moment, which does not happen with similar elements currently on the market.

[0063] In other words, when a load is applied to the panel, one of the faces will be subjected to a compressive load (concrete), while the other face (composite) will be subjected to a tensile load. With this concept, the panel is able to work in a cooperating manner, the different layers work together, supporting the loads as one, with no separation (delamination) of the layers, nor a degradation of the mechanical properties of the panel. Without this concept, the panel would not have the same level of mechanical resistance, and there would be delamination of the different layers, and consequent structural failure of the panel, as seen in some existing structures.

[0064] For the present embodiment, the "T" structure (5) herein developed has a thickness between 1 and 2 mm and a width between 17 and 24 mm. Preferably, in one embodiment, the thickness of the "T" (5) is about 1.5 mm and the width is about 20.5 mm.

[0065] In a preferred embodiment, the fixation provided by the "T" anchoring (5), occurs by mechanical means, which allows the panel to withstand loads higher than those it would withstand if the "T" structure (5) was not present, since the different layers of the panel work in a cooperating manner and not individually which would result in the separation of the layers and a respective structural failure in the construction, such as is the case with the state of the art panels.

[0066] A preferred embodiment relates to a constructive arrangement that comprises three layers:

- a first layer (lower face and sides of the panel - inner and outer) composed of E-glass fiber laminates, with

different orientations, which were previously impregnated with thermosetting polymer matrix (1) and (2);

- a second layer (panel core) formed by polymer foams (3); and
- a third layer (upper face of the panel) comprising concrete (4).

[0067] In particular, the first layer (1, 2) of the panel of the present invention is impregnated with the polymer matrix until said layer reaches the desired thickness. Specifically, the thickness of the first layer should be approximately between 1 and 2 mm on the lower face (2) and on the side faces of the panel (1, 2).

[0068] In a preferred embodiment, the thickness of the first layer should be about 1.3 mm on the inner side faces (1) and about 1.5 mm on the outer side faces and lower face (2). Tensile loads will be applied onto the first layer when the panel is in service.

[0069] The second layer now formed by the polymer foams (3) should have a thickness approximately between 160 and 180 mm. If the foam layer (3) has a thickness relatively less than the minimum limit (160 mm), it will affect the overall mass of the multilayer panel, the mass per unit area will increase, which will attenuate the loss of mass effect of the final structure developed. In a preferred embodiment, the second layer should have a thickness of approximately 170 mm.

[0070] The third layer composed of concrete (4), where the compression loads will be applied to when the panel is in service, should have a thickness approximately between 50 and 70 mm. In a preferred embodiment, the third layer should have a thickness of approximately 60 mm.

[0071] In one embodiment, the total thickness of the panel should preferably be approximately 232 mm. The multilayer panel should be approximately 300 to 1000 mm wide. In a preferred embodiment of the present invention, the width of the panel should preferably be between 350 and 500 mm. The length of the multilayer panel should be between 1000 and 8000 mm. In a preferred embodiment of the present invention, the length of the panel should preferably be between 3000 and 4000 mm.

[0072] In one embodiment, the production method comprises the following steps. Glass fiber laminates forming the first layer are deposited and impregnated on top of the foam that forms the core of the panel, that is, on the second layer that makes up the panel, preferably, before the resin setting process begins, in order to promote the bonding of the composite layer with the foam.

[0073] After the deposition of the glass fiber impregnated with thermosetting resin, corresponding to the first layer (1, 2), in the mold for forming the multilayer panel, which includes the "T" structure (Figure 2), and subsequent placement of the foam (3), the last layer is deposited on concrete (4) on the upper surface of the foam.

[0074] The concrete layer (4) must preferably be arranged on the surface of the panel so that approximately half of its thickness is housed below the "T" structure (5)

and the other half above that structure.

[0075] For a preferred embodiment of the present invention, the composition of the composite layer (1, 2) must comprise mixing the glass fiber with the polymer matrix in a ratio of about 65 to about 75% fiber to about 25 to about 35% polymer matrix by weight of the total composite layer. In one embodiment, the ratio of glass fiber to polymer matrix, in the composite layer (1,2) should preferably be 70% fiber and 30% polymer matrix.

[0076] This composition allows a layer of composite material to be obtained that has the necessary mechanical strength to withstand the tensile loads to which the elements will be subjected, when in service.

[0077] It should be noted that when a higher percentage of resin is used, above 35% in weight, the mechanical properties of the panel will not be improved, since glass fiber is the element that contributes the most to the mechanical properties - tensile strength-in the composite. Thus, by increasing the amount of resin and decreasing the amount of glass fiber, the mechanical properties will suffer a decrease that could lead to the structural failure of the panel, since it will not have the same capacity to withstand the tensile load it will be subjected to.

[0078] The multilayer panel developed herein is intended for civil construction industry. More specifically, without constituting a limitation of the present invention, the application of this panel is intended for the finishing of internal and external areas, in the construction of walls, pavements, room partitions and roofs.

[0079] In one embodiment, the panel may comprise on its surface a finishing of any nature, such as painting with different materials, application of resins and glues for application of wallpaper and other elements, fixation of ceramics, stones, melamine laminates, metals, glass, withstand adverse weather conditions, among others.

[0080] The panel presented herein, presents a decrease of the mass amount per unit area of approximately 230%, in relation to a conventional solution - lightened slab - for pavements or roofs, with structural functions.

[0081] In one embodiment, the processing technique of the composite of the present invention is pultrusion, which has been applied in a process comprising at least three steps:

Step 1: Impregnation of the composite reinforcement fiber

[0082] Placing the two glass fiber rollers (E-glass fiber) with different orientations in the pultrusion machine, which will be used in the manufacture of the panel. This fiber advances along the equipment due to the stretching force it will be subjected to. In the present embodiment, the drawing speed ranges between 12 and 25 rpm, preferably between 15 and 20 rpm. Particularly, in the present embodiment, the drawing speed was 20 rpm. Then, the glass fiber is impregnated with vinyl ester resin, once the fiber is stretched through the equipment, it passes through a container where the resin is present, which

must be in liquid form, and absorbs the same thus getting impregnated.

Step 2: Setting of the resin present in the reinforcement fiber and formation of the composite

[0083] In the second step of the process, the mass formed by the resin-impregnated fiber (1, 2) enters the mold so that the structure with the profile geometry is obtained, including the "T" structure (5), as shown in Figure 2, and is heated approximately between 110 and 160 °C, preferably between 120 and 140 °C. In the present embodiment, the setting temperature was approximately 140 °C. The heating of the mold causes the resin to set by the polymerization process, which provides the composite with its high chemical strength. In the present embodiment, the setting cycle occurs between 30 and 50 minutes, preferably between 35 and 45 minutes, until total setting of the material is achieved.

Step 3: Molded composite

[0084] Considering that this is a continuous process, said process is completed when obtaining the composite and by cutting the profile to the desired length.

[0085] In the present embodiment, the foam (3) that makes up the panel now developed, can be injected after forming the composite, by gluing it through an adhesive. However, preferably, the foam (3) is added during the pultrusion process, before setting the resin, at the end of step 1, to promote the bonding of the foam to the composite (1, 2).

[0086] The concrete (4) is added to the structure that will form the final panel after the foam being placed. However, it is only deposited on the structure at the construction site, where the structural composite panel will be used.

[0087] However, the processing conditions of the process herein developed are influenced by the type of polymer matrix used, since the use of another type of polymer matrices implies different processing conditions (curing time, curing temperature and curing agent).

[0088] The term "comprises" or "comprising" when used herein is intended to indicate the presence of the features, elements, integers, steps and components mentioned, but does not preclude the presence or addition of one or more other features, elements, integers, steps and components, or groups thereof.

[0089] The present invention is of course in no way restricted to the embodiments described herein and a person of ordinary skill in the art can foresee many possibilities of modifying it and replacing technical features with equivalents depending on the requirements of each situation, as defined in the appended claims.

[0090] The following claims define additional embodiments of the present description.

Claims

1. Multilayer panel for civil construction successively comprising:

a composite structure (1,2) obtained from fibers and thermosetting polymer matrix;
a polymer foam layer (3);
a concrete layer (4);
wherein the composite structure comprises a lower face from which two outer side faces (2) and one or more inner side faces (1) extend, wherein said inner side faces (1) extend from the lower face of the composite structure, through the polymer foam layer to a predetermined thickness of the concrete layer.

2. Multilayer panel according to the preceding claim, wherein the plurality of side faces comprises, at the end thereof, a "T" shaped structure to anchor the concrete layer to the other layers of the multilayer panel.

3. Multilayer panel according to any one of the preceding claims, wherein the side faces with an end with a T-shaped structure are the inner side faces (1).

4. Multilayer panel according to any one of the preceding claims, wherein the polymer foam layer (3) is divided into foam cores separated by one or more inner side faces (1).

5. Multilayer panel according to any one of the preceding claims, wherein the composite structure comprises a ratio of 65% to 75% (w/w) fibers to 25% to 35% (w/w) thermosetting polymer matrix.

6. Multilayer panel according to any one of the preceding claims, wherein the composite structure comprises a ratio of 70% (w/w) fibers and 30% (w/w) thermosetting polymer matrix.

7. Multilayer panel according to any one of the preceding claims, wherein the fibers of the composite structure are glass fibers and are in the form of a web or fabric with unidirectional or bidirectional orientation.

8. Multilayer panel according to any one of the preceding claims, wherein the glass fibers are selected from fiber E-glass, ECR-glass, D-glass, S-glass, AE-glass, C-glass, A-glass, Z-glass or mixtures thereof.

9. Multilayer panel according to any one of the preceding claims, wherein the lower face and the two outer side faces (2) of the composite structure comprise at least two E-glass fiber layers in the form of a web and two E-glass fiber layers in fabric with unidirectional orientation.

10. Multilayer panel according to any one of the preceding claims, wherein one or more inner side faces (1) of the composite structure comprise at least three E-glass fiber layers in fabric with unidirectional orientation and one E-glass fiber layer in the form of a web. 5
11. Multilayer panel according to any one of the preceding claims, wherein the thermosetting polymer matrix is an epoxy-, polyester-, or vinyl ester-based resin. 10
12. Multilayer panel according to any one of the preceding claims, wherein the polymer foam layer (3) is selected from polyethylene, polystyrene, polyurethane or mixtures thereof, preferably polyurethane. 15
13. Multilayer panel according to any one of the preceding claims, wherein the "T" structure comprises a thickness between 1 and 2 mm and a width between 17 and 24 mm. 20
14. Multilayer panel according to any one of the preceding claims, wherein the thickness of the lower face and the two outer side faces (2) of the composite structure is 1.5 mm and the thickness of the inner side faces (1) of the composite structure is 1.3 mm. 25
15. Multilayer panel according to any one of the preceding claims, wherein the thickness of the polymer foam layer (3) is 160 to 180 mm and the thickness of the concrete layer (4) is 50 to 70 mm. 30

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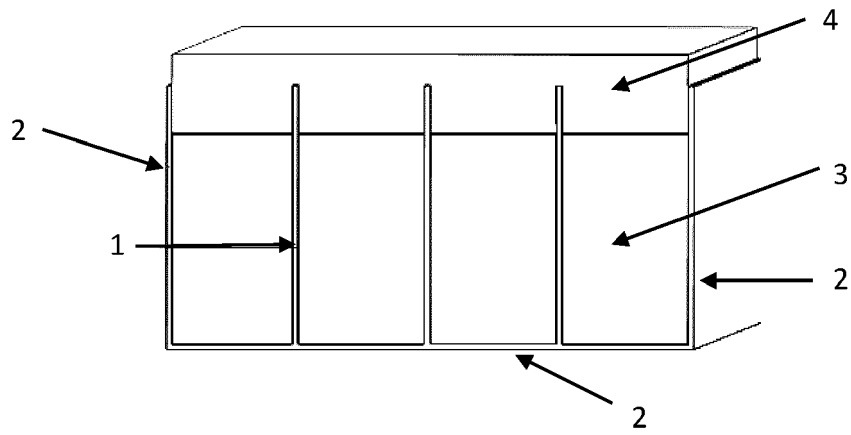


Fig. 1

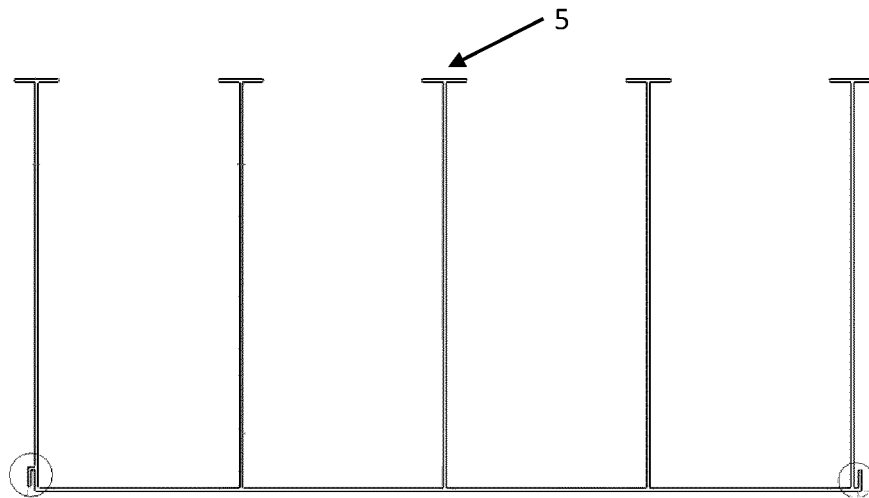


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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