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(54) Title: MULTILAYER LAMINATE PANEL
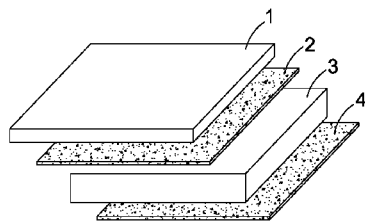
Fig. 1
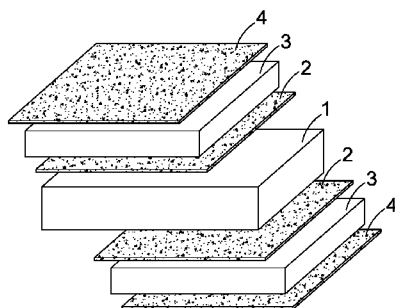
(57) **Abstract**: A multilayer laminate panel comprising a first layer of a
stone-based material and a second layer of a dissimilar material of lower
density, which are interposed by one or more layers of resin-impregnated
fibers, is provided. The dissimilar material comprises cork or a derivative of
cork, and the thickness of the layer of stone-based material is from about 2
mm to about 50 mm. A process for the production of the panel is also
provided. The panel finds use as a coating in a variety of interior and exterior
applications. A panel comprising fixing means and a process for attaching the
fixing means to the panel are also provided.

Fig. 2

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MULTILAYER LAMINATE PANEL

FIELD

The present disclosure relates to multilayer laminate panels, methods for their production

5   and their use in a number of applications, including as stone material coatings for interior and exterior use, for example in buildings for walls, floors and ceilings, and in furniture and decorative elements.

BACKGROUND

10   The industry of coatings and coverings with stone materials and derivative products has been increasing its interest and its demand for lighter and more functional systems allowing, among other things, less intrusive support structures and also seeking to provide these materials with improved thermal and acoustic insulation properties. On the other hand, the current costs associated with the transport of these materials (particularly given

15   the weight limits imposed for most used means of transport), prevent a greater capacity of stone materials utilization worldwide. Thus, whilst the use of thin stone pieces has become technically feasible, it is difficult to implement given the fragility exhibited by stone materials and derivatives. Currently the industrial processing required for this thickness reduction, as well as the difficulties inherent in their application, require time-consuming

20   processes and costs too high to be competitive with alternative materials.

Background Art

Presently available multilayer composite solutions typically employ honeycomb sandwich structures (metal or plastic) or other cores of plastic materials, and a metallic interface or

25   impregnated fibers to promote adhesion between the different layers.

The Canadian patent CA 02840850 of Forzastone LLC US, published on 01/28/2014 and entitled "Composite Stone Panels" discloses a sandwich panel with stone surface using two aluminium sheets combined with a polyethylene core.

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The PCT patent application WO 2012000893 of Fabiano Fulvi, published on 23/06/2011 and entitled "Method for reinforcing stone slabs by means of a honeycomb panel including the simultaneous construction of said honeycomb panel" discloses a method of producing a plate of stone material reinforced with a honeycomb, without skins, where the skins are

35   placed and cured during the reinforcement process.

The PCT patent application WO 9109733 of Stone Panels International Limited published on 11/07/1991 and entitled "Methods for manufacturing composite surface elements" discloses a stone plate reinforced on both sides with fiber fabric, a layer of a multicellular lightweight material and an outer skin, which is divided into two by a plane of symmetry.

5

These solutions have some characteristics that impair their implementation in the market. The incompatibility between the stone material and the metal impairs the adhesion between the different layers, forcing the use of thicker adherent substances (which hinder homogenization along the surface) and requiring also the application of higher pressures during the production process.

10

In more detail, the uneven topographies of stone or reinforcement layer surfaces require higher compressive loading to bring the surfaces together and/or thicker adhesive layers to accommodate the topographic mismatches. In contrast, in the case of the panels described herein, the cork-based layer yields under much lower compressive loads, thus advantageously accommodating any such surface protuberances on either of its sides.

15

Moreover, high rigidity and poor elastic resilience of the multilayer composites disclosed in the background art prevent recovery of the original geometry after deformation. Additionally, industrial processing of stone and derivative materials, involves operations (finishing, cutting, storage conditions and transports) that induce considerably high stresses and strains in the stone layer, typically resulting in warpage or premature cracking of these types of known panel products.

20

Also, from the point of view of the ability to absorb impact energy, the honeycomb structures have disadvantages. Specifically, its structure greatly increases the stiffness, but has no ability to absorb impact energy. Similarly, the traction vibrations from an impact at low speed can create cracks in the stone material surface.

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SUMMARY

The present disclosure allows for the use of a thin layer of stone material or stone derivative material, configured on a laminated composite panel, whose design and manufacturing process gives a panel whose mechanical, thermal and acoustic characteristics are superior to a layer of equivalent thickness of the same stone material (see Figure 1).

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35

Typically, the thickness of stone panelling currently used varies between 10-50 mm according to the application or use, for instance 30-50 mm for ventilated facade panels (exterior use) and 10-30 mm for flooring and wall covering (interior use). Moreover, the reinforcement technology for stone based materials disclosed herein offers

5 a reduction in the waste of stone material associated with typical thickness reduction operations, and provides for freestanding panels with reduced weight/dimension ratios for construction applications (see Figure 2).

Advantageously, the panels of the present disclosure are dimensioned, and manufactured,
10 such that:

- The fragile material (ie. stone or derivative material) suffers compressive stresses when mechanically loaded in use, thus exploiting its better mechanical properties.

In more detail, when a material is subjected to flexural loading, the concave region of the material is under compressive stress whereas the opposing convex region of the material

15 is under tensile stress. These two regions are divided by a zero stress line referred as the neutral axis. The multilayer laminate panels disclosed herein are constructed and dimensioned such that the neutral axis under flexural load applied from the exposed stone side is located outside the stone-based layer (and is preferably in a cork-based layer to which the stone layer is attached), leaving the stone layer under compression and,

20 therefore, much stronger.

- Homogeneous adhesion is ensured between the various layers, in order to provide a uniform behaviour of the multilayer panel product and prevent sudden detachment of the stone material or stone derivative material layer, whilst ensuring the transfer of strains to a more resilient layer of the panel (ie. the cork- or cork derivative–based layer);

25 - The panel product displays adequate rigidity to be employed in various structural applications;

- A significant improvement in the thermal and acoustic insulation characteristics of the stone or stone derivative material is provided by the incorporation of a cork-based material layer;

30 - A reduction of shear stresses is observed in the fragile stone or derivative material under structural loading, thus minimising failure due to its fragile nature and increasing its resistance to cyclic stresses. As a consequence, the panel product disclosed herein meets higher safety requirements for its implementation in a variety of structural applications.

35 A first aspect of the present disclosure provides a multilayer laminate panel, which is characterized by incorporating a first layer of a stone-based material, a second layer of a dissimilar material of lower density, interposed by one or more layers of resin-impregnated

fibers and configured such that the first layer is under compression when the panel is mechanically loaded, in particular from the exposed surface of the first layer, and supported on two or more anchoring points. The dissimilar material comprises cork or a derivative of cork, and the thickness of the layer of stone-based material is from about 2 mm to about 50 mm.

Also provided is a multilayer laminate panel comprising a first layer of a stone-based material having a thickness of from 2 mm to 50 mm, a second layer of a dissimilar material of lower density, which comprises cork or a derivative of cork, interposed by one or more layers of resin impregnated fibers.

A further aspect of the present disclosure provides a process for the production of a multilayer laminate panel as described above, which comprises the steps of:

(1) providing a layer of a stone-based material having a thickness of about 2 mm to about 50 mm;

(2) providing a layer of a dissimilar material of lower density, which comprises cork or a cork derivative; and

(3) attaching the stone-based material layer to the dissimilar material layer by means of a layer of resin-impregnated fibers interposed between the stone-based material layer and the dissimilar material layer.

Another aspect of the present disclosure provides a multilayer laminate panel comprising fixing means, wherein the panel is as described above and wherein the fixing means is located in an orifice which extends through the at least one layer of dissimilar material and the at least one layer of resin-impregnated fibers to the surface of the stone-based material layer, to which the at least one layer of resin-impregnated fibers is attached, and wherein the fixing means is held in position in the orifice with resin.

Yet further aspects include the use of the panels described above as an interior or exterior coating; and an article selected from a wall, floor, ceiling, door frame, window frame, ventilation panel, item of furniture or decorative construction element comprising the above described panels.

The present disclosure also provides a process for attaching fixing means to a multilayer laminate panel as defined above, which comprises:

(1) forming an orifice in the panel, which orifice extends through the at least one layer of dissimilar material and the at least one layer of resin-impregnated fibers to the surface of the stone-based material layer, to which the layer of resin-impregnated fibers is attached;

(2) placing fixing means in the orifice; and

5   (3) either before step (2), or after step (2) , or both before and after step (2), introducing resin into the orifice.

BRIEF DESCRIPTION OF THE FIGURES

Figures 1 and 2 illustrate multilayer laminate panels of the present disclosure.

10   Figures 3, 4 and 5 illustrate the results of various comparative tests performed on multilayer laminate panels of the present disclosure and limestone panels, in terms of mass per unit area (Figure 3), maximum load and specific load (Figure 4), and maximum flexural resistance and specific flexural resistance (Figure 5). In these Figures, the limestone panels are identified as "calc 10 mm" and "calc 30 mm". The multilayer panels

15   are identified as "Lam 5 mm calc" and "Lam 10 mm calc", each respectively containing a 5mm and a 10 mm layer of limestone.

Figure 6 illustrates the mid span deflection *versus* the applied load of a panel of the present disclosure.

Figure 7 illustrates the mid span deflection *versus* the flexural resistance of a panel of the

20   present disclosure.

DETAILED DESCRIPTION

Overview

25   The lightweight laminated panel with stone based surface finishing disclosed herein allows for the transformation of the brittle behaviour of materials used as surface finishes into a non-linear elastic behaviour. This behaviour results from the configuration and arrangement between the panel layers in order to ensure uniform transmission of stresses between the different layers, and a compression regime in the brittle material.

30

The disclosed multilayer panel comprises a layer of stone material or derivative material for surface finishing, a further layer of a material with dissimilar properties and originated from cork or its derivatives, and one or more layers of fibers impregnated with resin, which resin is typically provided in liquid form and which then solidifies providing for the coupling

35   (ie. attachment) between the various layers into one single panel.

When compared with the use of a single layer of stone or derivative material of adequate thickness for structural applications (for instance, approximately 30 mm for exterior

applications or approximately 10 mm for interior applications), improved properties afforded by the multilayer composite panel disclosed herein translate into the following:

- Increase of the mechanical strength characteristics:

For the same stone thickness, e.g. 10 mm, an increase of at least about 2-fold in flexural strength has been observed. In addition, a corresponding increase in the maximum load at rupture of at least about or superior to about 7 times, preferably at least about or superior to about 10 times, and most beneficially of about 20 times, or even more, has been observed, typically with variation depending upon the type of stone used. These parameters were measured according to ASTM C293.

The improvement in the mechanical strength characteristics of the panels disclosed herein is also evident from, for instance, a comparison of stone slabs of approximately 30 mm thickness with a multilayer panel configuration comprising approximately 10 mm stone thickness and an approximately 10 mm cork agglomerate core layer, for which a reduction in mass of approximately three times is observed, but for which an increase of more than about two-fold in flexural strength is also observed.

- Increase of the maximum specific load:

The ratio of the maximum load to the mass per square meter for a multilayer panel increases by more than about 2 fold, preferably more than about 3 fold and most beneficially by about 5 fold, with variation typically depending upon the type of stone used, in comparison with that determined for a comparable stone slab. For instance, this increase is observed when comparing stone slabs of approximately 30 mm thickness to panels according to the present disclosure of approximately 10 mm stone thickness backed with an approximately 10 mm cork agglomerate core. The maximum specific load was calculated from measurements performed according to ASTM C293.

- Increase of the thermal insulation capacity:

The use of cork or cork derivative material has been found to improve the thermal insulation capacity of the panels disclosed herein as compared to standard stone panels, by a reduction of the thermal conductivity coefficient of at least about 50 times, as calculated according to ASTM C1363. This effect upon the thermal insulation capacity of the laminate panels has been observed to increase typically with increasing cork or derivative material layer thickness and, thus, the associated thermal resistance, since stone materials typically have thermal conductivity coefficients ranging from about 2 to about 7 W/mK, whereas cork and cork derivatives, eg. cork agglomerate, typically have coefficients ranging from about 0.030 to about 0.040 W/mK, for instance from about 0.032

to about 0.036 W/mK. Additionally the thin fiber reinforced resin layers beneficially add extra thermal insulation capacity. Typically, the multilayer panels have a coefficient of heat transmission of less than about 5 W/m^{2}K, as measured according to ASTM C976.

5   - Increase of the impact sound insulation capacity:
The use of cork or cork derivative material has been found to improve the sound insulation index (measured according to ISO/CD 16251-1) of the panels disclosed herein as compared to standard stone panels by a factor of about 3 or, most beneficially, about 5. This effect has been found to be mostly dependent upon the core cork insulation
10   properties and its thickness. The panels typically have a sound insulation index of at least about 10 dB, and more preferably greater than about 10 dB, for instance about 15 dB or more. For example, panels of 10 mm stone thickness backed with a 10 mm cork agglomerate core have sound insulation indexes of about 15 dB, as compared to 30 mm thickness stone slabs, which have sound insulation indexes of ranging from about 3 to
15   about 5 dB.

- Increase of impact resistance and energy absorption:
Impact resistance and energy absorption determination as carried out according to EN 14158 has revealed an increase in these properties of more than about 3 fold. For
20   example, for a stone slab of approximately 30 mm thickness, the measured impact resistance of a free fall mass of 1 kg ranges from about 40 to about 65 cm above which the slab breaks catastrophically. In contrast, panels using the same stone in approximately 5 and 10 mm thicknesses, each panel having an approximately 10 mm cork agglomerate back reinforcement, have been determined as having significantly greater impact
25   resistances of about 150–180 cm and about 190–220 cm respectively.

- Increase of the stone or stone derivative material flexibility:
Panels disclosed herein have been found to exhibit a non-linear elastic deformation without breaking. This behaviour has been observed, and quantified, using a video
30   extensometry technique as described below. This elastic deformation of the panels extends well beyond the maximum deformations observed for stone and stone derivative materials in standard slab format.

In more detail, panels disclosed herein typically possess an ultimate deflection of about
35   two times, or more than two times, the thickness of the panel. The ultimate deflection is the distance of the deflection, or bending, at which rupture, ie. breakage, of the panel occurs. As described in more detail below, the deflection was measured by video image

correlation (VIC) using an area defined by the specimen thickness and +/- 5 mm for each side of the mid span point (in total 10 mm of the specimen width) with a total number of points within this area between 1000 and 1200. The ultimate deflection observed is a function of the span length used in the flexural test, i.e. the distance between the

5   supporting elements, also known as "support span". In the testing reported herein, a support span of approximately 250 mm was used, in accordance with the support spans typically reported in ASTM standards for flexural tests. Spacing of the supports further away from one another will allow for larger ultimate deflections.

10   More specifically, panels disclosed herein possess an ultimate deflection of from about 0.2 times to about 2.0 times their thickness for a span length of approximately 250 mm, more preferably about 0.3 times to about 2.0 times, even more preferably about 0.35 times to about 2.0 times, for instance about 0.5 times to about 2.0 times, or about 0.8 times to about 2.0 times, or about 1.2 times to about 2.0 times, or about 1.5 times to about 2.0

15   times, or about 1.8 times to about 2.0 times; with an ultimate deflection of about 2.0 times, or greater, the panel thickness being most preferred.

For example, panels with approximately 5 or 10 mm stone layer thickness and comprising an approximately 10 mm cork agglomerate core have been found to exhibit an ultimate

20   deflection of about 0.35 to about 2 times the total thickness of the panel on a span length of approximately 250 mm. When compared to a stone slab with the same thickness as that of the surface finishing layer of the above-mentioned panel, e.g. 10 mm, the deflection to rupture of the panel described herein has been found to increase by a factor greater that about 10 to 20 times, or more, depending upon the stone type. Most

25   beneficially, for deflections of up to at least about 90% of this ultimate deflection, substantial shape recovery (ie. recovery of at least about 88 % of the panel's original shape, more preferably at least about 90%, and even more preferably at least about 95%, and up to about 100%) of the panels has been observed. This is a particularly beneficial characteristic of the panels described herein.

30

This advantageous elastic deformation behaviour of the panels disclosed herein is further illustrated by Figures 6 and 7 which plot, respectively the mid span deflection (in mm) *versus* the load (in N), and the mid span deflection *versus* the flexural resistance (in MPa; as measured in accordance with ASTM C293). The mid span deflection is the variable

35   measured on the flexural test that varies according to the load applied between zero and the ultimate deflection which is observed at rupture load. Figures 6 and 7 report the properties of a panel comprising an approximately 5 mm Sea White limestone layer and

an approximately 10 mm cork agglomerate layer (NL20 from Amorim Cork Composites, Mozelos VFR, Portugal) with two layers of epoxy-impregnated glass fiber layers (the epoxy resin being Resotech 1050 from Resoltech S.A.R.L., Eguilles, France). The first fiber layer comprised a biaxial glass fabric consisting of two fabric layers of unidirectionally

5   oriented glass fibers positioned at 0 degrees and 90 degrees, and having a specific mass of approximately 600 g/m^2 ; and the second comprised a serge fabric with specific mass of approximately 300 g/m^2.

The video extensometry technique used to observe this elastic deformation of the panels

10   disclosed herein uses video image correlation (VIC). VIC is a system for measuring and visualizing both strain and movement by means of image comparison. It provides full-field, 2- or 3-Dimensional measurements of shape, displacement and strain, based upon the principle of Digital Image Correlation. Using this method, actual object movement is measured and the Lagrangian strain tensor is available at every point on the specimen

15   surface.

The system consists of one or two cameras (for 2D or 3D analysis respectively) that capture images during a mechanical test, ie. the deformation of the panel by deflection, or bending, and software that makes the correlation, based upon the mapping and

20   monitoring of the image pixels. Using this apparatus, it is possible to record the displacement very accurately on every point of the specimen by tracking the pixels in the image provided by the camera. The data so-obtained are then analysed using the associated software, and thus provide very precise information of what is happening in the structure during the bending test.

25

Panels according to the present disclosure are readily manufactured as their production is advantageously compatible with the technology currently available in the stone processing industry. Namely :
- Compatibility with a very wide range of stone materials and derivatives, which are

30   typically obtained with an average surface roughness (Ra) of from about 0.1 to about 30 μm (measured in accordance with standard surface topography techniques), and typically present an open porosity greater than about 0.01% (measured according to EN1936). These characteristics are typical of most stone materials and surface roughness values presented by slabs processed according to currently available technology.

35   -Compatibility with slab dimensions currently produced (e.g. approximately 3500 mm length and width and about 10-50 mm thickness) along with the possibility of using

conventional surface finishing processes (e.g. grinding and polishing) to thin the stone or derivative material layer down to as low as about 2mm thickness.

- Compatibility with resin application and curing processes known to the stone processing
5   industry for back reinforcement and surface finishing.

In the multilayer laminate panels described herein, the one or more stone or stone derivative layers have a thickness of from about 2mm to about 50 mm, preferably from about 2 mm to about 40 mm, more preferably from about 2mm to about 30 mm, yet more
10   preferably from about 2 mm to about 20 mm, and even more preferably from about 2 mm to about 15 mm. Further preferred thickness ranges for the stone-based layer include from about 2 mm to about 10 mm, about 5 mm to about 15 mm, and about 10 mm to about 20 mm. Most preferably, the at least one stone-based layer is about 2 mm, about 5 mm, about 10 mm or about 15 mm in thickness.
15

The overall thickness of the panel products described herein typically ranges from about 5 mm to about 60 mm, preferably from about 5 mm to about 50 mm, and more preferably from about 5 mm to about 45 mm. Other overall thicknesses are possible depending upon the individual layers included in the overall structures, as well as the intended
20   application of the panels.

The panels comprise one or more layers of fibers impregnated with resin, each of which is typically of a thickness of from about 0.5 to about 5 mm, for instance, about 0.5 to about 2.0 mm.
25

Furthermore, the one or more layers of material with characteristics based on cork or derived from cork which are included in the multilayer panels are typically of a thickness of from about 1 mm to about 50 mm, more preferably from about 3 mm to about 40 mm, yet more preferably from about 5 mm to about 30 mm, or from about 5 mm to about 25 mm,
30   or from about 5 mm to about 20 mm, with cork-based layers of about 5 mm to about 15 mm thickness, for instance approximately 10 mm, being particularly preferred.

In addition to the dimensions detailed herein, the technology may be adapted to other dimensions as necessary, for instance as required by the particular end application for
35   which the panel is intended.

The characteristics described above for the inventive panels are largely achieved by the specific choice of the various constituents, and their arrangement and dimensioning in the multilayer laminate, as well as the coupling of the different layers effected by the manufacturing process. The described technology provides new multilayer laminate

5 materials, which meet or surpass the technical requirements of applications that presently use natural stone or its derivatives. Furthermore, the multilayer materials can be fitted to different structural products (e.g. ventilated facade panels), or ornamentals, including all types of interior and exterior coatings/coverings, floors, flooring, tables and counter-tops, as well as framing structures for windows, doors and masonry, for example.

10

Therefore, in addition to the advantages associated with the use of lighter weight stone panels, for instance reduced weight and larger dimensions, panels according to the present disclosure have the following unique benefits: i) significantly higher mechanical flexibility and the ability to accommodate bending and recover to their original shape; ii)

15 enhanced impact resistance and energy absorption; and iii) superior thermal and acoustic insulation properties arising from the use of cork or derivative material.

Mechanical Behaviour of the Laminated Panel

Bending of a material induces a stress gradient, which varies between maximum tensile

20 stress to maximum compressive stress on each surface of the material. The so-called "neutral axis" defines the location separating tensile stresses from compressive stresses which corresponds to zero stress.

According to the classical theory of bending beams, for a homogeneous material with a

25 constant Young's Modulus for tensile and compressive stresses, the neutral axis is coincident with the midline. However, on a composite material with different layers, the neutral axis can be shifted by adjusting the thickness of each material and taking into account their Young's Moduli.

30 For the multilayer panel disclosed herein, and as has already been discussed, the neutral line is always located outside the material layer that provides the stone-based surface finish, and is preferably located in the cork-based layer. It is in accordance with the following relationship:

$$h2 = h\sqrt{\gamma} / (1 + \sqrt{\gamma})$$

35 where h2 is the maximum thickness (in mm) of the layer of material which provides the surface finish; h is the total thickness (in mm) of the laminated board; and γ is the ratio of

the tensile Young's modulus (ET) and the compressive Young's modulus (Ec), each as determined in accordance with ASTM C293.

In the case of the laminated multilayer composites of the present disclosure, the stone-based material used as the surface finish material, when tested alone, displays a poor response to tensile stress as compared with its response to compressive stress. The threshold stresses are typically about 7 up to 10 times lower. Thus, the thicknesses of the layers included in the presently described panels are optimized in order for the surface finish material to be mostly subjected to compressive stresses. However, for this desired effect to occur, it is also necessary to take into account how the characteristics of the various layers are related with each other. Thus, the multilayer laminate panels of the present disclosure provide optimised stone-based materials with advantageous mechanical properties.

Materials

The surface finish material with the greatest potential to be used in the disclosed panels is natural stone. In general, rock-like source materials behave differently depending upon their physical, chemical and microstructural characteristics. Using the design and manufacturing methodology according to the present disclosure, it is possible to extend the use of most of these materials, as the limitations arising from poor mechanical properties (ie. tensile strength, shear strength or impact resistance) are substantially overcome.

Natural stone types particularly suitable for use in the multilayer panels include those typically used in stone panelling applications, for example limestones, marbles, granites including gneisses and pegmatites, schist rocks including slate and quartzite, and agglomerated stone.

For the at least one layer of cork or cork derivative material, natural or industrially processed materials can be used, which typically have densities (as measured in accordance with ASTM C271) of from about 30 to about 1500 kg/m^3 and preferably from about 100 to about 400 kg/m^3. Particularly preferred materials have densities of from about 110 to about 350 kg/m^3, even more preferably from about 115 to about 300 kg/m^3, or from about 120 to about 250 kg/m^3, for instance approximately 120 kg/m^3, 200 kg/m^3, or 250 kg/m^3.

Preferred cork-based materials have a compressive strength (as measured in accordance with ASTM C365) of about 0.1 to about 1.0 MPa, preferably about 0.2 to about 0.8 MPa, and yet more preferably about 0.3 to about 0.6 MPa, for instance approximately 0.3 MPa, 0.5 MPa or 0.6 MPa.

5

Preferred cork-based materials have a compressive modulus (as measure in accordance with ASTM C365) of about 3.0 to about 10.0 MPa, more preferably about 4.0 to about 8.0 MPa, and even more preferably about 5.0 to about 7.0 MPa, for instance approximately 5.1 MPa, 6.0 MPa or 6.9 MPa.

10

Preferred cork-based materials have a tensile strength (as measured in accordance with ASTM C297) of about 0.4 to about 0.9 MPa, more preferably about 0.5 to about 0.8 MPa, and yet more preferably about 0.6 to about 0.7 MPa, for instance approximately 0.6 MPa or 0.7 MPa.

15

Preferred cork-based materials have a shear strength (as measured in accordance with ASTM C273) of about 0.7 to about 1.2 MPa, more preferably, 0.8 to about 1.1 MPa, and even more preferably about 0.9 to about 1.0 MPa, for instance approximately 0.9 MPa or 1.0 MPa.

20

Preferred cork-based materials have a shear modulus (as measured in accordance with ASTM C273) of about 5.7 to about 6.2 MPa, more preferably about 5.8 to about 6.1 MPa, and even more preferably about 5.9 to about 6.0 MPa, for instance approximately 5.9 MPa or 6.0 MPa.

25

Preferred cork-based materials have a thermal conductivity (as measured in accordance with ASTM C377) of about 0.030 to about 0.040 W/mK, more preferably about 0.031 to about 0.038 W/mK, and even more preferably about 0.032 to about 0.036 W/mK, for instance approximately 0.032 W/mK, 0.034 W/mK or 0.036 W/mK.

30

Preferred cork-based materials have a loss factor (at 1 KHz and as measured in accordance with ASTM E756) of about 0.020 to 0.070, and more preferably 0.022 to 0.062, for instance approximately 0.022, 0.043 or 0.062.

35   Particularly preferred cork-based materials for use in the disclosed multilayer panels have one of the following combinations of properties:

A material with one or more of: a density of about 120 kg/m³, a compressive strength of about 0.3 MPa, a compressive modulus of about 5.1 MPa, a tensile strength of about 0.6 MPa, a shear strength of about 0.9 MPa, a shear modulus of about 5.9 MPa, a thermal conductivity of about 0.032 W/mK and a loss factor of about 0.022. A particularly

5   preferred material has all of these properties.

A material with one or more of: a density of about 200 kg/m³, a compressive strength of about 0.5 MPa, a compressive modulus of about 6.0 MPa, a tensile strength of about 0.7 MPa, a shear strength of about 0.9 MPa, a shear modulus of about 5.9 MPa, a thermal

10   conductivity of about 0.032 W/mK and a loss factor of about 0.043. A particularly preferred material has all of these properties.

A material with one or more of: a density of about 250 kg/m³, a compressive strength of about 0.6 MPa, a compressive modulus of about 6.9 MPa, a tensile strength of about 0.7

15   MPa, a shear strength of about 1.0 MPa, a shear modulus of about 6.0 MPa, a thermal conductivity of about 0.036 W/mK and a loss factor of about 0.062. A particularly preferred material has all of these properties.

Suitable, commercially available materials include, for example, Corecork NL10, NL20

20   and NL25 available from Amorim Cork Composites, Portugal. These materials are preferably selected to provide for a minimum resin uptake, to ensure impregnation (ie. entry of the resin into at least some of the open spaces, or pores, in the cork-based material) during processing, as well as facilitating low water absorption, rot and fire resistance and a high level of attenuation of impact noise and vibrations.

25

In relation to the behaviour of the resin during production of the panels, it is noted that the resin is typically impregnated, or imbibed, into the open porosity and surface "openings" of both the stone-based and cork-based layers, the resin being provided by the fiber-containing reinforcement layer(s) which serve to couple, or attach, the other layers

30   together to form a unitary panel structure. As a consequence, the failure of multilayer laminates by delamination between layers, which was previously observed, is substantially reduced in the multilayer panels described herein, and the transfer of load/stress is more effective. This is a marked, and advantageous, difference from ordinary laminates, which typically comprise a sharp and well-defined, discrete interface

35   between layers. Whilst not wishing to be bound by theory, it is thought that this key combination of layers of specific materials, and in particular the impregnation of the resin into not only the fibrous layer(s) but also the stone- and cork-based layers, may explain

the unexpected mechanical properties of the multilayer composites described herein, such as the flexibility observed and the capacity to bend and recover shape. The resin impregnation, or imbibition, is facilitated by the fact that both stone and cork materials have open pore structures.

5

Suitable resins for use in the multilayer panels are typically provided in liquid form and include, for example, epoxy resins, for instance Resoltech 1050, which is available from Resoltech S.A.R.L., Eguilles, France, and Sicomin SR1500, which is available from Sicomin, Châteauneuf-les-Martigues, France; polyester resins including, for example,

10   Recapoli 955 DCPD, which is available from Resinas Castro S.L., Pontevedra, Spain; vinylester esters, such as Resicastro X590AC, also available from Resinas Castro S.L., Pontevedra, Spain; and acrylic resins, such as Crestapol 1250LV, available from Scott Bader, Wellingborough, UK.

15   The chemical structure and viscosity of the resins used are typically optimized taking into account the microstructure (ie. mineralogy and porosity structure) of the stone materials. Typically, the viscosity of suitable resins (as reported by the resin manufacturers) ranges from about 100 to about 2000 mPa.s, depending mostly on the stone or derivative material open porosity. More preferred resins have a viscosity of from about 100 to about

20   1000 mPa.s, more preferably from about 100 to about 500 mPa.s, and even more preferably the resin viscosity is from about 300 to about 450 mPa.s, for instance approximately 400 mPa.s. Typically, open porosity of the stone-based materials may vary between about 0.1% and about 19%, or higher (according to EN1936). The higher this figure, the higher the resin viscosity which can be used. So, for instance, for a stone-

25   based material with an open porosity of at least about 0.1 %, a resin with a viscosity of at least about 100 mPa.s may be used; whereas, for a stone-based material with an open porosity of about 19 %, or even higher, a resin with a viscosity of up to an including about 2000 mPa.s may be used. Furthermore, as viscosity has a dependence upon temperature, this may also be tuned to ensure adequate process viscosities for optimized

30   penetration of the resin into the stone or derivative material layer(s) and into the cork-based core layer(s).

With regard to the at least one resin-impregnated fiber layer comprised in the multilayer panel, as discussed above the panel preferably comprises at least two layers of fibers,

35   with one positioned at the interface between the stone or derivative material and the cork or cork derivative core layer, and the second positioned on the exterior face of the cork or cork derivative core (see Figure 1).

Fibrous materials which can be used to form the multilayer panels may be selected from those commonly used as reinforcement in construction materials, for instance. Suitable fibrous materials include woven materials, including for instance those in which the warp

5   and weft directions of the fibers are at approximately 90° to one another. Preferred woven materials include serge, tafetan, and the like. Non-woven materials may also be used, including for instance those in which the constituent fibers are unidirectionally or biaxially oriented, in particular those made from glass fibers. For instance, where the multilayer panel comprises two fibrous layers as described above, the first fiber layer is preferentially

10   a multiaxial reinforcement fabric, more preferably made from glass fibers, and which preferably has a specific mass between 150-300 g/m^2 per orientation axis, for instance a biaxial glass fabric with fibers oriented at 0/90 degrees and which has a specific mass of about 600g/m^2. The second fiber layer preferentially comprises a woven fabric with a specific mass between 150- 300 g/m^2, for instance serge or tafetan fabric. However, the

15   type and ordering of the fibrous layers may be modified. Furthermore, other fiber materials (e.g. carbon fibers, polymeric fibers such as Kevlar® and the like, and fibers of natural origin) and fiber arrangements (e.g. four-axial reinforcement, knitted fabrics and non-woven fabrics), as well as other resin types (e.g. oil based or natural source resins) may also be employed in the manufacture of the multilayer panels.

20

Exemplary configurations of the multilayer panels described herein are presented in Table I. All of the laminate panels in Table 1 comprise the same reinforcement, specifically a 10 mm core of cork agglomerate (NL20, Amorim Cork Composites), with two layers (or "skins") of glass fiber impregnated in epoxy resin. The first is located at the interface

25   between the stone layer and the cork core and the second is located on the exterior face of the core. For these two layers different types of glass fiber were used with different weights, the first being a biaxial glass fabric consisting of two fabric layers of unidirectionally oriented glass fibers positioned at 0 degrees and 90 degrees, and having a specific mass of approximately 600 g/m^2 ; and the second being a serge fabric with

30   specific mass of approximately 300 g/m^2. The resin used is the multilayer panels reported in Table 1 was a commercially available two component epoxy resin, specifically Resoltech 1050, as mentioned above.

35

Table I. Mechanical properties of multilayer panels with three different stone materials of 5 and 10 mm thickness compared to 10 and 30 mm thickness stone slabs of the same origin.

	Portuguese Stone											
	Blue Limestone - "Moleanos"				Sea White Limestone – "Branco do Mar"				SPI Granite - "Azul Alpalhão"			
	Multilayer Panel		Stone		Multilayer Panel		Stone		Multilayer Panel		Stone	
Stone Layer Thickness	5 mm	10 mm	10 mm	30 mm	5 mm	10 mm	10 mm	30 mm	5 mm	10 mm	10 mm	30 mm
Specimen Thickness (mm)	15.8	20.7	10.0	30.0	16.0	21.0	10.0	30.0	16.0	21.0	10.0	30.0
Specific Mass (kg/m^2) [a]	17.1	30.0	27.0	78.0	17.2	31.0	25.0	69.0	18.0	30.7	28.0	80.0
Maximum Load (N) [b]	1988.0	2615.0	290.0	2520.0	1486.0	2550.0	105.0	1196.0	2577.0	3884.0	330.0	2860.0
Flexural Strength (Mpa) [c]	40.2	31.3	14.3	13.9	28.0	24.7	6.5	6.6	46.0	44.0	17.2	15.7
The figures presented for maximum load and flexural strength are averages from 10 specimens.												

as determined by [a] ASTM C271; [b] ASTM C293; and [c] ASTM C293

As is shown by the results in Table 1, the multilayer panels disclosed herein possess superior mechanical properties in comparison with those of comparable, standard stone slabs made from a range of different stone types.

Figures 3, 4 and 5 further illustrate the major gains in mechanical properties of the multilayer laminate panels compared to natural stone slabs of equivalent thickness. The stone selected for the comparison illustrated in Figures 3 to 5 is a Sea White Limestone of medium porosity, ie. approximately 8-11% as per EN1936, which can be considered the most demanding material with regard to its basic properties, since it is not only one of the most fragile stone materials, but it is also very difficult to obtain and handle at reduced

thickness (e.g. 5 or 10 mm) by means of the technologies currently available to the stone processing industry.

Handling and Application Behaviour

5   As mentioned above, the used production method allows for the multilayer panel to be self-supporting such that very large panels (eg. 3500 x 2500 mm) can be handled without concern of damage by action of their own weight, thus facilitating amongst other things ease of transportation. Without the enhancement described herein, it is not possible to transport a plate of a low thickness surface finish material (typically 5 mm) near the

10   maximum dimensions currently available on the market (eg. 3500x2500 mm). The smallest thickness which is currently able to be produced from blocks by the industry is about 8 mm in granite and 12 mm in limestone, and even these are only possible to obtain using state of the art, cutting edge technologies, which are still new and not usual in the stone processing industry. With the current development, it is possible to start the

15   production of panels from blocks using standard technology, such as slabbing gang saws, and therefore obtain an element (as illustrated, for example, in Figure 2) capable of being sectioned to provide two panels of approximately the desired final thickness for surface finishing of the stone-based material.

20   On the other hand, two situations currently exist that cause a difficulty in the market associated with the application of stone or derivative materials. The first is related to comfort (thermal and acoustic) where usually the products made from these materials do not compete with others, in particular for flooring applications. The second relates to the methods of direct and indirect fixing (ie. anchorage), which currently have scaling

25   problems associated with the stone characteristics and their ability to withstand stresses encountered during the lifetime of the products.

The production method of the multilayer panels described herein allows the use of fixing/clamping systems, either by mechanical or chemical means, to be made more

30   reliably, for the following reasons (with reference to Figure 1):
- The multilayer panel has a greater total thickness as compared to individual slabs of the stone or derivative material layer (1);
- The fixing/clamping system may be in contact with or, is more preferably embedded within, the fibrous resin reinforcing layer (2), which layer is in contact with the stone-based

35   layer (1), with minimal stress being induced in stone-based layer (1);
- The pull-out resistance of the fixing/clamping system is increased by about two times in multilayer panels described herein, as compared to a standard stone slab;

- The additional reinforcing layer (4) can be explored for additional fixing or stabilisation means, as this layer is spaced from the stone or derivative material by the cork agglomerate core thickness and also possesses a different surface chemistry.

5 Fixing or clamping means suitable for use with the panels disclosed herein, in order to attach the panels to structures (eg. a wall) as required, include, for example, fixing or clamping means typically used with composite materials, in particular in the construction industry. Such means include those made from metal, for example stainless steel. With standard stone slabs, fixing or clamping means are required to be attached directly to the

10 stone, thus subjecting the stone to a large amount of stress, which can result in weakening, cracking and even eventual breakage of the slab. With the panels described herein, however, it has been found that the specific attachment of the fixing (or clamping) means such that it is located at least in part within the cork-based layer (3) and the fibrous layer (2) located between the cork-based layer (3) and the stone-based layer (1), achieves

15 a very effective system for attachment of the panels to other structures, such as walls, which does not place the stone-based layer under detrimental stress.

In more detail, a multilayer laminate panel as described herein comprises fixing means, which is located in an orifice extending through the at least one layer of dissimilar material

20 (3) and the at least one layer of resin-impregnated fibers (2) to the surface of the stone-based material layer (1), to which the at least one layer of resin-impregnated fibers (2) is attached. The fixing means is held in position in the orifice with resin. The fixing means may be attached with resin to the surface of the stone-based material layer (1) located at the end of the orifice so-formed. In addition, or in the alternative, the space in the orifice,

25 which is not occupied by the fixing means may be filled with resin.

Particularly suitable fixing means for use with the panels are those which comprise a substantially flat plate with a shaft extending from the middle of the plate, which shaft may be hollow and is typically cylindrical. In use, the shaft attaches to fastening means

30 typically located on the structure to which the panel is to be attached, thus, holding the panel in the desired position. The plate portion of the fixing means may be of a variety of shapes, for instance square, rectangular, circular or hexagonal, and it may have holes cut through it. Suitable fixing means include those commercially available under the name "Master-Plate" from Specialinsert s.r.l, of Turin, Italy (see, for example,

35 http://www.directindustry.com/prod/specialinsert-srl/product-58531-1428839.html).

Such fixing means are attached to multilayer laminate panels described herein by forming an orifice in the panel, which extends through the at least one layer of dissimilar material (3) and the at least one layer of resin-impregnated fibers (2) to the surface of the stone-based material layer (1), to which the layer of resin-impregnated fibers (2) is attached; placing fixing means in the orifice; and either before or after, or both before and after the fixing means are placed in the orifice, introducing resin into the orifice. Preferably, resin is introduced into the orifice both before and after placement of the fixing means in the orifice, such that the remaining space in the orifice, which is not occupied by the fixing means, is filled with resin.

In more detail, the process of attaching fixing means to the panel typically comprises:
1. Providing an orifice, or hole, through the reinforcement layer(s) and cork-based layer(s) which extends to the surface of the stone-base layer to which the reinforcement layer is attached, but does not extend into the stone-based layer. This orifice is sized such that the fixing means can fit into it. For instance, if a "plate and shaft" style of fixing means such as that described above is used, the orifice needs to be able to accommodate the plate of the fixing means such that it sits upon the inner surface of the stone-based layer. The shaft of the fixing means thus extends up through the orifice away from the plate, such that the fixing means is accessible to be attached to the means used to fasten the panel to the desired structure, when the panel is in use. The orifice may be formed by any suitable technique, for instance milling or drilling through the panel from its side away from the stone layer down to the inner stone surface.
2. Once the orifice has been formed, fixing means such as those described above is placed within the orifice and it is typically fixed into position using a resin. For instance, if the fixing means is made of metal, as is typically the case, a resin which is specially formulated for metal/stone compatibility is preferably used for this purpose. An example of such a resin is AKEMI 2030, which is an epoxy resin available from AKEMI GmbH, Nürnberg, Germany.
3. The remaining space in the cleared hole is then filled with a resin, such as those already mentioned for use in the preparation of the fiber/resin layers of the panel. Low viscosity epoxy resins, such as Resoltech 1050 available from Resoltech S.A.R.L, are particularly preferred for this purpose. The resin impregnates the cork-based core layer, and preferably also the other layers, surrounding the orifice.
4. Once the resin components have solidified, or hardened, the fixing means is extremely securely and effectively retained within the panel.

The key advantage of this special fixing system as compared to traditional systems is that adhesion to the stone layer ensures resistance to static loads, whilst the cork-based core impregnation provides for additional protection to cyclic loads. In particular, the cork-base layer absorbs vibration without subsequent transmission to the stone-based layer.

5

Manufacturing Method

Panels according to the present disclosure comprise the following materials (with reference to Figure 1):

• One or more layers of stone or derivative material conferring the surface finish (1);

10   • A shear-resistant core originated from cork or its derivatives (3);

• One or more fiber layers (2, 4) impregnated with resin, which confer the mechanical strength at the interfaces between (1) and (3) and/or to the exposed surface of layer (3) and ensure adequate coupling between the constituent layers.

15   Panels according to the present invention may also be manufactured having a symmetrical configuration (as shown in Figure 2), which is particularly useful for subsequent sectioning along layer (1) yielding two panels, for instance as shown in Figure 1.

20   Multilayer composite panels according to the present disclosure are generally manufactured in the following way:

1. Providing a (preferably dry) surface finish material layer (1), typically chosen from stone or a stone derivative material.

2. Providing a coupling layer of resin-impregnated fibers (2), typically by the following

25   steps:

2A. – Applying a (preferably liquid) resin to the stone or derivative material layer (1); and then

2B. – Applying a fiber arrangement, for instance a multi-axial glass fiber material, on top of the resin;

30   2C. – Subsequently applying a further amount of the (preferably liquid) resin to the fibrous component to ensure adequate impregnation of the fiber arrangement laid down in step 2B and to provide an additional amount for imbibition of the core (ie. cork or cork derivative) material layer (3). The ratio of resin to fiber is adjusted to ensure adequate coupling between the stone or derivative material and the core layer. This ratio is

35   preferentially higher than a proportion of about 50%-65% (on a weight by weight basis of resin to fibers) commonly used in existing sandwich composite manufacture.

3. Applying the core material (3), chosen from cork or cork derivative material, such as a cork agglomerate;

4. Applying a pressure of typically from about 10 to about 1000 Pa, preferably from about 20 to about 200 Pa, to ensure adhesion between the above-referenced layers;5. If

5   required for the particular panel construction, applying a second resin-impregnated fiber layer (4), which may or may not be identical to layer (2) depending upon the intended application, in a similar way as described for step 2, ie. the liquid resin is applied to the core material layer (3) and then the fiber arrangement is laid down and additional resin is applied to ensure fiber arrangement impregnation;

10   6. Allowing a period of time for the resin to reach its gel point at a given process temperature, which is a function of the selected resin (e.g. approximately 90 minutes at room temperature for Resoltech 1050);

7. Applying a pressure of typically from about 1 to about 50 kPa, preferably from about 1.5 to about 30 kPa, for a period of time and typically at a given temperature to ensure

15   adequate coupling and curing of the chosen resin (e.g. approximately 12 hours at room temperature for Resoltech 1050); and

8. Optionally conducting a post-cure process at elevated temperature (eg. approximately 60 °C) for a period of time (e.g. approximately 6 hours).

20   Additional release liners may be employed on resin coated surfaces to prevent adhesion to contact surfaces during processing, handling and transportation.

Alternative curing or post-curing processes may include one or more of the following methods: heating by conduction; heating by microwave; heating by infrared; and ultra-
25   violet photo-curing.

A further, significant advantage of the present disclosure is the possibility to leverage on already existing stone processing industrial plants. For example, stone slabs reinforced according to the present disclosure can be manufactured with large dimensions (ie. width
30   and length up to approximately 3500 mm). Moreover, the reinforcement provided by the present disclosure allows for currently available grinding and polishing processes to be carried out in a cost-effective way and without damaging the stone or derivative material layer. Additionally, using current stone industry technology (eg. sawing and wire cutting), it is possible to obtain from a surface element with an initial thickness of about 20 mm or
35   less–(see Figure 2), two thinner elements, whose final thickness depends upon the amount of material lost by abrasion due to the cutting tool used.

CLAIMS

1. Multilayer laminate panel characterized by incorporating a first layer of a stone-based material (1), a second layer of a dissimilar material (3) of lower density, interposed by one (2) or more (4) layers of resin-impregnated fibers and configured such that the first layer (1) is under compression when the panel is mechanically loaded and supported on two or more anchoring points; wherein said dissimilar material comprises cork or a derivative of cork, and wherein the thickness of the layer of stone-based material is from about 2 mm to about 50 mm.

2. Multilayer laminate panel comprising a first layer of a stone-based material (1) having a thickness of from about 2 mm to about 50 mm, a second layer of a dissimilar material (3) of lower density which comprises cork or a derivative of cork, interposed by one (2) or more (4) layers of resin impregnated fibers.

3. Panel according to claim 1 or claim 2 comprising, in order, a layer of a stone-based material (1), a layer of the dissimilar material (3), a layer of resin-impregnated fibers (2) interposed between and attached to each of the layer of stone-based material (1) and the layer of the dissimilar material (3), and a further layer of resin-impregnated fibers (4) attached to the layer of dissimilar material (3).

4. Panel according to claim 1 or claim 2 having a symmetrical configuration comprising, in order, a first layer of resin-impregnated fibers (4), a first layer of dissimilar material (3), a second layer of resin-impregnated fibers (2), a layer of stone-based material (1), a third layer of resin-impregnated material (2), a second layer of dissimilar material (3) and a fourth layer of resin-impregnated fibers (4), wherein each layer is attached to the next in said order.

5. Panel according to any preceding claim wherein the at least one layer of dissimilar material (3) consists of cork or derivatives thereof.

6. Panel according to any preceding claim wherein the dissimilar material has a density of about 30 to about 1500 kg/m^3, and preferably about 100 to about 400 kg/m^3.

7. Panel according to any preceding claim wherein the dissimilar material has a compressive strength of about 0.1 to about 1.0 MPa, and preferably about 0.3 to about 0.8 MPa.

8. Panel according to any preceding claim wherein the dissimilar material has a tensile strength of about 0.4 to about 0.9 MPa, and preferably about 0.6 to about 0.7 MPa.

9. Panel according to any preceding claim wherein the dissimilar material has a thermal conductivity of about 0.030 to about 0.040 W/mK, and preferably about 0.032 to about 0.036 W/mK.

10. Panel according to any preceding claim wherein the thickness of the stone-based layer (1) is about 2 mm to about 20 mm, and preferably about 2 mm to about 15 mm.

11. Panel according to any preceding claim wherein the thickness of the at least one layer of dissimilar material is about 1 mm to about 20 mm, and preferably about 5 mm to about 15 mm.

12. Panel according to any preceding claim wherein the fibers comprised in the at least one layer of resin-impregnated fibers (2, 4) are in the form of a woven fabric with warp and weft directions at approximately 90 degrees to one another, and wherein the specific mass of the fabric ranges from about 50 to about 800 g/m^2.

13. Panel according to any preceding claim wherein the fibers comprised in the at least one layer of resin-impregnated fibers (2, 4) are in the form of a unidirectionally oriented or biaxially oriented fabric of glass fibers, and wherein the fabric has a minimum specific mass of about 150 g/m^2.

14. Panel according to any preceding claim wherein the stone-based material has a surface roughness (Ra) of from about 0.1 to about 30 μm.

15. Panel according to any preceding claim, which has a sound insulation index of greater than about 10 dB and a coefficient of heat transmission of less than about 5W / m^2K.

16. Panel according to any preceding claim having a flexural strength which is about two times greater than the flexural strength of a stone slab of the same thickness as the stone-based material layer (1)

17. Panel according to any preceding claim having an ultimate deflection of at least about twice that of a stone slab of the same thickness as the stone-based material layer (1), for a span length of about 250 mm.

18. Panel according to any preceding claim which, following subjection to a deflection of approximately 90% of its ultimate deflection, regains at least about 88% of its original shape.

19. A process for the production of a multilayer laminate panel as defined in any of claims 1 to 18, the process comprising the steps of:

(1) providing a layer of a stone-based material (1) having a thickness of about 2 mm to about 50 mm;

(2) providing a layer of a dissimilar material (3) of lower density, which comprises cork or a cork derivative; and

(3) attaching the stone-based material layer (1) to the dissimilar material layer (3) by means of a layer (2) of resin-impregnated fibers interposed between the stone-based material layer (1) and the dissimilar material layer (3).

20. Process according to claim 19, additionally comprising:

(4) attaching a further layer of resin-impregnated fibers (4) to the opposing side of the layer of dissimilar material (3), to which the first layer of resin-impregnated fibers is not attached.

21. Process according to claim 19 or claim 20 wherein provision of the resin-impregnated fiber layer(s) (2, 4) comprises applying a resin to the stone-based material layer (1); then applying a fiber arrangement on top of the resin; and then applying a further amount of resin to the fiber arrangement.

22. Process according to any of claims 20 to 21 wherein the resin is in liquid form and has a viscosity of from about 100 mPa.s to about 2000 mPa.s.

23. Process according to any of claims 19 to 22 wherein the open porosity of the stone-based material is at least about 0.1 %.

24. Process according to claim 23 wherein the open porosity of the stone-based material is at least about 19 %.

25. Process according to any of claims 19 to 24 wherein, after step (3), but prior to step (4) if employed:

(3a) a pressure of from about 10 Pa to about 1000 Pa is applied to the layered product of step (3).

26. Process according to claim 25 wherein, following step (3a) and, if employed, step (4):

(5) the resin is allowed to cool to its gel point.

27. Process according to claim 26 wherein, following step (5):

(6) a pressure of about 1 kPa to about 50 kPa is applied to the layered product of step (5).

28. Process according to claim 27 wherein, following step (6):

(7) a post-cure process is carried out on the layered product of step (6).

29. Process according to any of claims 19 to 28 wherein the panel has a symmetrical configuration as defined in claim 4, and the symmetrical panel is cut in half through the stone-based material layer (1) to yield two panel products.

30. Multilayer laminate panel comprising fixing means, wherein the panel is as defined in any of claims 1 to 18 and wherein the fixing means is located in an orifice which extends through the at least one layer of dissimilar material (3) and the at least one layer of resin-impregnated fibers (2) to the surface of the stone-based material layer(1) to which the at least one layer of resin-impregnated fibers (2) is attached, and wherein the fixing means is held in position in the orifice with resin.

31. Panel comprising fixing means according to claim 30 wherein the fixing means is attached to the surface of the stone-based material layer (1) located at the end of the orifice with resin, and wherein the remaining space in the orifice is filled with resin.

32. Use of a multilayer laminate panel as defined in any of claims 1 to 18, or of a multilayer laminate panel comprising fixing means as defined in claim 30 or claim 31, as an interior or exterior coating.

33. Use according to claim 32, on a wall, floor, ceiling, door frame, window frame, ventilation panel or furniture, or in a decorative construction element.

34. A wall, floor, ceiling, door frame, window frame, ventilation panel, item of furniture or decorative construction element comprising a multilayer laminate panel as defined in any of claims 1 to 18 or a multilayer laminate panel comprising fixing means as defined in claim 30 or claim 31.

5

35. Process for attaching fixing means to a multilayer laminate panel as defined in any of claims 1 to 18, the process comprising:

(1) forming an orifice in the panel, which orifice extends through the at least one layer of dissimilar material (3) and the at least one layer of resin-impregnated fibers (2) to the

10   surface of the stone-based material layer (1) to which the layer of resin-impregnated fibers (2) is attached;

(2) placing fixing means in the orifice; and

(3) either before step (2), or after step (2) , or both before and after step (2), introducing resin into the orifice.

15

36. Process according to claim 35 wherein resin is introduced into the orifice both before and after step (2) such that the remaining space in the orifice, which is not occupied by the fixing means, is filled with resin.
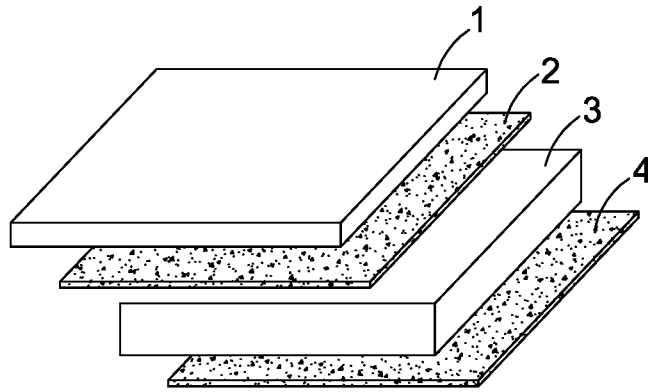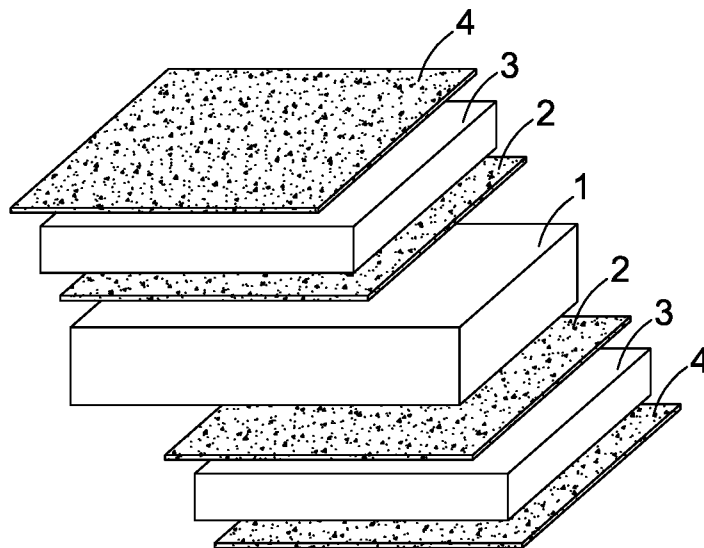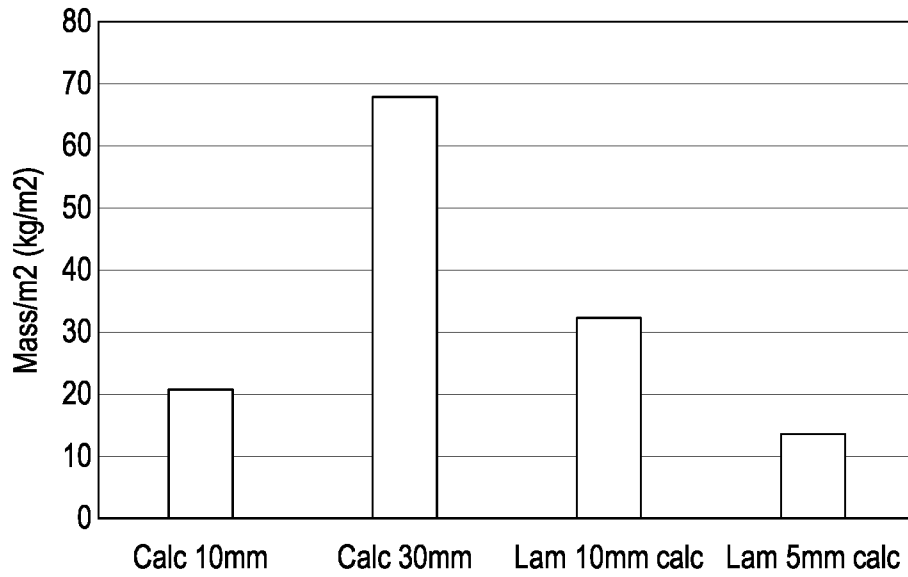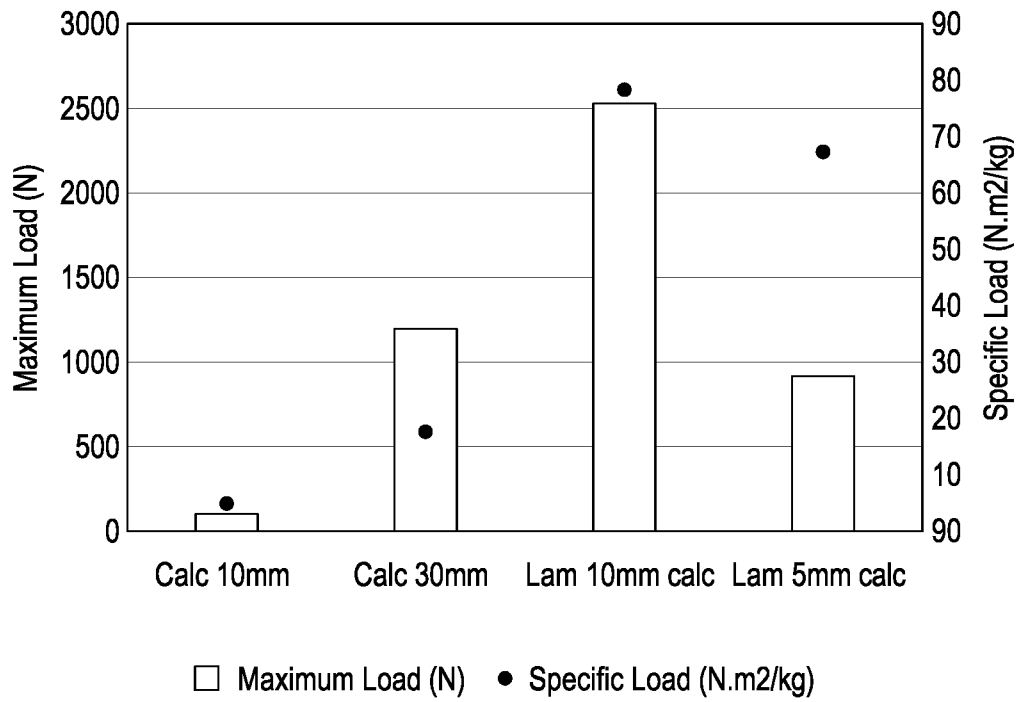
20

Fig. 1
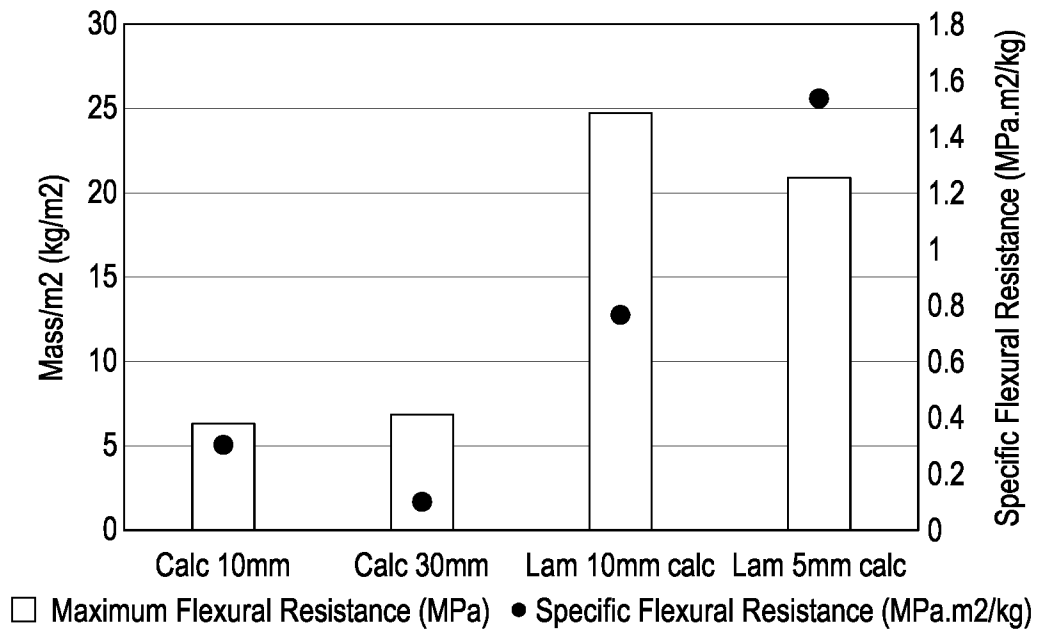

Fig. 2

Fig. 3

☐ Maximum Load (N)   ● Specific Load (N.m2/kg)

Fig. 4

Fig. 5

Load x Deflection curve for a multilayer laminate panel
comprising 5mm Sea White Limestone layer
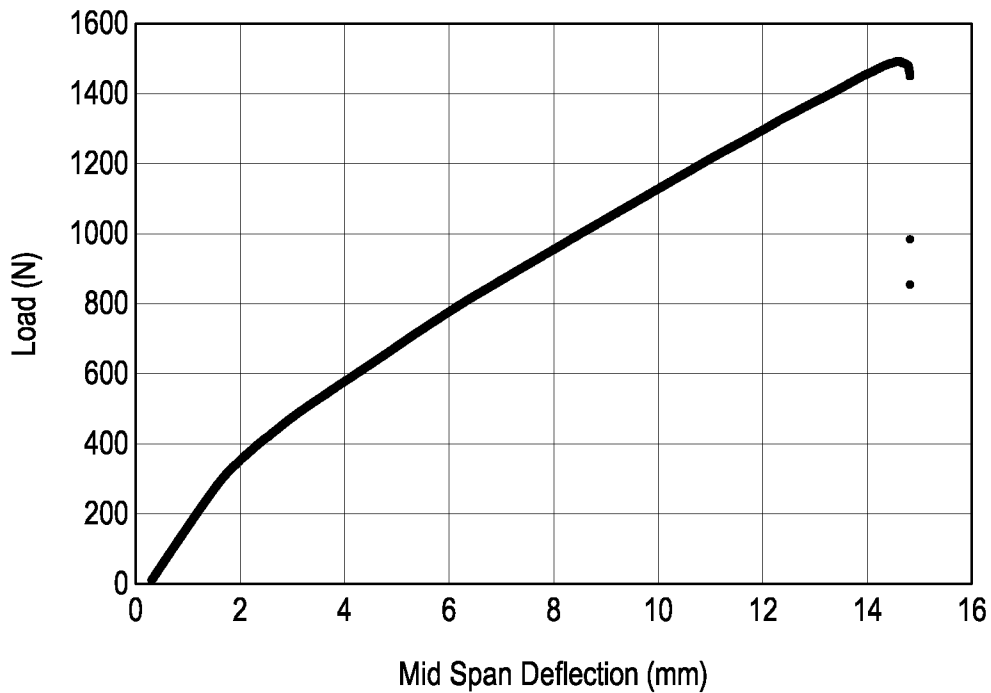

Mid Span Deflection (mm)

Fig. 6

Flexural Resistance x Deflection curve for a multilayer laminate panel
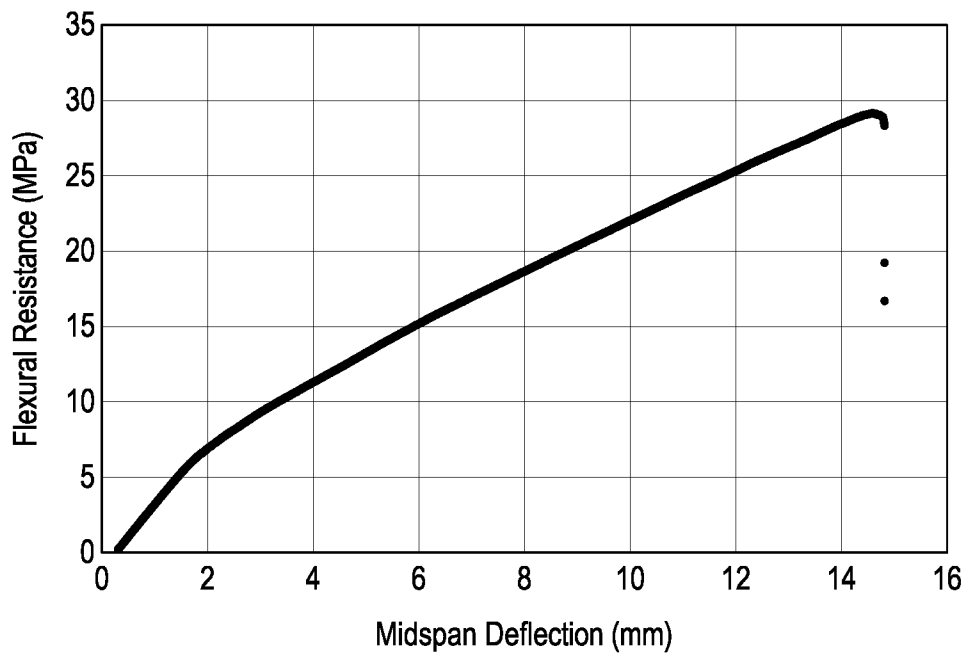comprising 5mm Sea White Limestone layer

Fig. 7

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. E04C2/288   B32B5/02   B32B5/28   B32B9/00   B32B9/02
ADD. E04C2/00

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)

E04C B32B

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/115514 A2 (AMORIM CORK COMPOSITES S A [PT]; ALELUIA CERAMICAS S A [PT]; COELHO JO) 22 September 2011 (2011-09-22) figures 1, 4, 6, 7; title; page 1, lines 5-10; page 4; page 5, lines 1-7, 16-30; page 6, lines 1-6; page 7, lines 28-30; page 8, lines 1-5, 15-20, 23; page 9, lines 7-24; page 10, lines 13-30; page 11, lines 23-30; page 12, lines 1-8, 19, 20, 25-31; page 13, lines 1-14; page 14, lines 20-22; page 15, lines 1-6, 18-30; page 18, lines 1-6; claims 1-3, 6, 7, 9 -----	1-3,5-23
X	WO 2014/118410 A1 (TORRECID SA [ES]) 7 August 2014 (2014-08-07) See US family member -/--	1-3,5-24

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2016	18/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barenbrug, Theo

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& US 2015/375473 A1 (MIRALLES TORLA FRANCISCO JAVIER [ES] ET AL) 31 December 2015 (2015-12-31) figures; paragraphs 1-6, 12, 24, 25, 28, 30-34, 37, 40, 45; claims 35, 36, 41, 42, 43, 45, 48, 53 -----	
T	Anonymous: "Cork :: MakeItFrom.com", , 6 August 2016 (2016-08-06), XP055318498, Retrieved from the Internet: URL:http://www.makeitfrom.com/material-pro perties/Cork [retrieved on 2016-11-10] the whole document -----	6-9
T	Amorim By Amorim: "Flexural Strength at yield Mechanical Properties of the Core Material Density", , 19 September 2009 (2009-09-19), XP055320655, Retrieved from the Internet: URL:http://www.matrix-composites.co.uk/pro d-data-sheet/cork/mds-gama-corecork.pdf [retrieved on 2016-11-17] the whole document -----	1,6-9, 15,16
A	FR 1 440 792 A (EXXON STANDARD SA) 3 June 1966 (1966-06-03) the whole document -----	1-3,5

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Box No. II   Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such
an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III   Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

    see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable
claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of
additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers
only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is
restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

    1, 3, 5-18, 20-24(completely); 2, 19(partially)

Remark on Protest   ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the
payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest
fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM   PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 3, 5-18, 20-24(completely); 2, 19(partially)

   A laminate panel comprising a first layer of a stone-based material, having a thickness of 2-50 mm, a second layer of resin-impregnated fibers, a third layer comprising cork or a derivative of cork, preferably a fourth layer of resin-impregnated fibers, and a straightforward process for the production of such a laminate by laying up the respective layers.

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2. claims: 4, 29(completely); 2, 19(partially)

   A symmetrical laminate panel, comprising a first layer of resin-impregnated fibers, a second layer of a dissimilar material, a third layer of resin-impregnated fibers, a fourth layer of a stone-based material [having a thickness about twice that of the desired thickness of the stone-based layer in the end product], a fifth layer of resin-impregnated fibers, a sixth layer of a dissimilar material, and a seventh layer of resin-impregnated fibers; and a straightforward process for the production of such a laminate by laying up the respective layers, finally comprising the step of cutting the stone-based layer in half, to obtain two single laminate panels comprising a stone-based top layer and a layer of a dissimilar material, interposed (and supported) by layers of resin-impregnated fibers.

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3. claims: 25-28(completely); 19(partially)

   A process for curing resin-impregnated fiber layers in laminate panels, by applying particular (under)pressures and optionally a cooling step and a post-cure step.

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4. claims: 30-36

   Fixing means for a laminate panel comprising a stone-based layer, a layer of resin-impregnated fibers, a layer of a dissimilar material and optionally another layer of resin-impregnated fibers; a process for applying fixing means to such a panel; and (use of) the panel fixed to a wall, floor, ceiling, etc. of a building by means of such fixing means.

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 2011115514	A2	22-09-2011	PT 105013 A		16-09-2011
			WO 2011115514 A2		22-09-2011
WO 2014118410	A1	07-08-2014	EP 2952650 A1		09-12-2015
			ES 2490396 A1		03-09-2014
			US 2015375473 A1		31-12-2015
			WO 2014118410 A1		07-08-2014
FR 1440792	A	03-06-1966	NONE		