(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 September 2011 (22.09.2011)

PCT

(10) International Publication Number
WO 2011/115514 A2

(51) International Patent Classification:
B32B 5/02 (2006.01)

(21) International Application Number:
PCT/PT2011/000007

(22) International Filing Date:
15 March 2011 (15.03.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
105013 16 March 2010 (16.03.2010) PT

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WO 2011/115514 A2

(54) **Title**: CERAMIC LAMINATED PANEL WITH CORK AND FIBRES

(57) **Abstract**: The present invention relates to ceramic and cork material based laminated panels, compatibilized with fibres. More particularly, the invention relates to lightened ceramic panels, with improved mechanical and insulation properties, for application, for instance, in the construction industry. In comparison with traditional flooring made only of ceramic floor tiles, the laminated panels of the present invention allow significant weight reduction of floors, improving its mechanical properties and combining the characteristics of ceramics and cork.

"CERAMIC LAMINATED PANEL WITH CORK AND FIBRES"

FIELD OF THE INVENTION

The present invention relates to ceramic and cork material based laminated panels, compatibilized with fibres. More particularly, the invention relates to lightened ceramic panels, with improved mechanical and insulation properties, for application, for instance, in the construction industry.

BACKGROUND OF THE INVENTION

The flooring market has recently shown a strong growth and development of products that take into consideration simultaneously comfort, resistance and aesthetics requirements.

For long time the flooring market was dominated by wooden and/or cork based products, manly for indoor floors, and by tile-like ceramic products for exteriors or places where resistance and cleaning/washing factors are prevailing.

With the development of new materials and with the aim of providing better and varied products, a marked dissemination of laminated elements, also often called "sandwich" elements, was observed. Currently, a number of laminated panels for flooring that meet the growing needs for insulation (acoustic and impact), comfort, appearance, among others, is commercially available, allowing the user to obtain products that meet their needs.

The use of ceramic materials in floor and wall tiles is known for long time and it is commercially widespread.

Taking into consideration its intrinsic characteristics and processing limitations, the ceramic materials are not very prone to be combined with other materials. That is one of the reasons why this industry is more conservative in relation to product variability. Thus it is less frequent the marketing of laminated products including ceramic materials than of wooden and/or cork laminated products.

The choice of a ceramic floor is usually associated to applications that require easiness of washing and high surface resistance (wear, scratching, etc.), as for instance in exterior floors, kitchens and bathrooms. Contrary to wooden and/or cork laminated floors, these ceramic floors have the disadvantage of being difficult to install and not having good insulation properties.

Wooden and/or cork based floating laminated panels are usually chosen when acoustic and impact insulation is needed, in addition to aesthetic and comfort aspects. These laminated panels are often used in indoor floors, like bedrooms, sitting rooms, etc. However, these products do not have properties of ceramic floors, like mechanic and chemical resistance as well as waterproofing and easiness of cleaning.

So far, the market has not shown satisfactory solutions that combine the best characteristics of ceramic and wooden and/or cork materials, despite the existence of documents that disclose combinations of heterogeneous materials involving ceramic materials, some of which are herein below mentioned.

British Patent Application GB 673664A by Leslie Arthur James Gardner, published in 11-06-1952 and entitled “Improvements In Laminated Tiles for Covering Floors, Walls and Similar Surfaces“, discloses a laminated panel for floors or walls provided with two overlapping layers of, for example, ceramics and cork, bound by cement.

European Patent EP 0191892B1 by Richard Pott, published in 27-08-1986 and entitled "Shaped Objects with a Supporting Core and Method of Making Them", discloses an object having a ceramic composite material and synthetic resins inside and layers of cork among others materials can be arranged as outer layers.

Spanish Patent ES 2158759B1 by Cantabria University, published in 01-09-2001 and entitled "Ceramic Component for Partitions and Enclosures, in particular an Acoustic and/or Thermal Insulation Component", discloses a ceramic component made of three layers arranged in "sandwich", wherein the two outer layers are made of ceramics and the inner layer is a material having acoustic and thermal insulation characteristics.

International Patent Application WO 2008037834A1 by Jordi Castane Callis, published in 03-04-2008 and entitled "Large-Format Thermoacoustic Stratified Tile", discloses stratified floor tiles that combine individual elements of different characteristics in one piece only. Among others, one of the described individual elements can be ceramics, said elements being bound by acrylic material or resins.

The above mentioned documents disclose laminated elements which aim to meet the advantages of the combination of favourable characteristics of its constituent materials. However, in practice such elements do not solve the problems of binding/adherence and compatibility between the constituents and introduce inconveniences as overweight and/or high costs of production that are an obstacle to its implementation and commercial added value.

Therefore there is still the need for new products with said characteristics of ceramics and wood and/or cork.

SUMMARY OF THE INVENTION

The present invention discloses laminated panels made of layers of ceramic and cork material, having intermediate fibre layers to compatibilize the former layers.

The present invention provides laminated elements for floors and walls, among others, that combine characteristics of thermal, acoustic and impact insulation, with a high resistance to wear, scratching and crack, associating the advantages of floating laminated indoor floors with those of ceramic material traditional floors. Moreover, for an identical mechanical performance, a laminated panel of the present invention is lighter than a conventional floor tile of ceramic material.

In comparison with traditional flooring made only of ceramics floor tiles, the laminated panels of the present invention have improved mechanical and insulation properties that allow significant weight reduction of floors while guaranteeing thermal and acoustic insulation.

Accordingly, the present invention discloses a ceramic and cork panel comprising a ceramic material layer (1), a cork material layer (3) and a fibre material layer (2) arranged between the ceramic (1) and cork (3) material layers.

In one aspect of the invention, said panel further comprises another fibre layer (4), arranged on the outer face of the cork layer (3) opposed to the outer face of the ceramic material layer (1).

In another aspect, this panel has the following characteristics:

the ceramic material layer (1) has a thickness between about 1.0 mm and 16.0 mm, the fibre layers (2, 4) are formed by at least a fabric or non-woven fabric selected from the group consisting of natural fibres and glass, carbon and basalt fibres, wherein said fabric or non-woven fabric has a grammage higher than 80 g/m^2, and

the cork material layer (3) has a thickness between about 0.5 mm and 25.0 mm and a density between about 100 kg/m^3 and 1300 kg/m^3.

Still in another aspect of the invention, the previous panel further comprises a polymeric material layer or radiating electric layer (5) between the fibre layer (2) and the cork material layer (3).

In another aspect, the panel further comprises a polymeric material or radiating electric layer (5) between the fibre layer (2) and the ceramic material layer (1).

In another aspect, the panel has the following characteristics: layer (1) is porcelanate, layers (2, 4) are fibre glass fabric and layer (3) is agglomerated cork.

In another aspect of the present invention, the panel has the following characteristics:

the porcelanate layer (1) has a thickness of about 4.5 mm,

the fibre glass layers (2, 4) have a grammage of about 300 g/m^2, and

the agglomerated cork layer (3) has a thickness of about 2.0 mm and a density of about 200 kg/m^3,

wherein the total thickness of the panel is about 7.0 mm.

Still in another aspect of the present invention, the fibre glass layers (2, 4) are impregnated with a resin selected from the group consisting of polyurethane, polyester, vinylester, epoxy resins, and natural and biomass resins.

In another aspect of the invention, the fibre glass layers (2, 4) are impregnated with an epoxy resin.

The present invention further discloses the use of said panel in the construction industry.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following description of the invention reference is made to the attached drawings, wherein:

Fig. 1 is a schematic cross-sectional view of a preferred embodiment of the present invention, illustrating its composing layers.

Fig. 2 and 3 are schematic cross-sectional views of other embodiments of the present invention.

Fig. 4 is a graph showing comparative values of maximum deflection measured in a mechanical test carried out in conventional porcelanate test plates and in preferred laminated panel test plates of the invention.

Fig. 5 is a graph showing comparative values of modulus of rupture of test plates of Fig. 4.

Fig. 6 is a graph showing comparative values of breaking load of test plates of Fig. 4.

Fig. 7 is a graph showing comparative values of noise insulation of impacts measured in an acoustic test carried out in two test plates groups of Fig. 4.

DETAILED DESCRIPTION OF THE INVENTION

The ceramic and cork laminated panels of the present invention eliminate a deficit of market offer, namely in the field of flooring, for ceramic materials with additional characteristics of insulation and improved mechanical properties. Surprisingly, it was found not only possible to combine the best characteristics of wooden and/or cork based laminated panels with those of ceramic materials, but also to obtain lighter, more resistant and easy assembly products than conventional floor tiles of ceramic material.

The difficulties associated to the combination of layers of ceramic material with cork material are known. Moreover, the resilient characteristics of cork provide conditions to weaken a layer of ceramic material that is on top of it. Effectively, having the ceramic material a higher rigidity than cork it is expected that a force applied on ceramic induces a deformation in cork. The ceramic material is not resilient therefore is not expected to follow said induced deformation in cork, leading to a cracking situation. To compensate this phenomenon of cracking, the thickness of the ceramic layer has to be considerable.

The inclusion of fibre layers between the ceramics and cork layers allows surprisingly not only to increase the adhesion between said layers, but also to eliminate said cracking phenomenon of the ceramic material layer for loads much higher than those observed in a current use. This makes compatible the behaviour of both materials.

It is more surprising the fact that the ceramic material layer of the laminated panel with fibre layers has an increased resistance to deflection compared with a conventional floor tile of the same ceramic material and with similar thickness.

It is important to emphasize that fibre materials are usually used as reinforcement material, therefore the favourable results of making compatible the behaviour of ceramics and cork and the increase of maximum deflection (deformation) obtained by the laminated ceramic layer of the invention, would not be expected by the inclusion of fibres.

Said technical effects result in the possibility of significantly reduce the thickness of the ceramic layer, keeping a high mechanical performance and allowing to produce lightened laminated elements in comparison with a conventional ceramic floor, adding to it the advantages of insulation (acoustic and thermal), easy assembly and comfort.

In the present description, the term "ceramic material" is intended to mean any class of non-metallic inorganic solid material that it is submitted to high temperatures (above 540 °C) during manufacturing or use.

Porcelain stoneware or porcelanic stoneware or simply porcelanate is a ceramic material that originates in the eighties as a product with high technical performance and that it is closer to the concept of rocks or natural rocks more than any other ceramic material. In respect to the main characteristics of porcelanate, this material:

- is a totally vitrified product,
- has an extremely low porosity (< 0.5%),
- has excellent mechanical and physical properties (namely, good resistance to abrasion and high modulus of rupture),
- is resistant to ice,
- has great resistance to chemical agents, namely cleaning products,

- provides easiness of cleaning.

In the limit, the porcelanate is formulated with very similar composition criteria as those of porcelain, i.e., mixture of quartz or feldspar sands, feldspars and clay with high content of kaolin.

The term "cork material" or simply "cork" is intended to mean natural cork, colmatated natural cork, agglomerated cork, micro-agglomerated cork or the like and combinations thereof.

The term "agglomerated cork" is intended to mean, according to ISO 2190 standards, a cork material that comprises at least 51% (by weight) of granulated cork with a minimum grain size of 0.5 mm and a water content equal or lower than 8%. Furthermore, the term "micro-agglomerated cork" is intended to mean agglomerated cork with a grain size in the range of 0.5 - 2 mm.

The term "material fibre" is intended to mean a material composed of fibres of several types and usually classified into two groups: fabrics and non-woven fabrics. In case of natural fibres these can be also of several types, as for example coconut, flax or hemp. The fibres used in non-woven fabrics do not show a specific orientation. In the case of fabrics, the fibres can be unidirectional, biaxial, triaxial or tetra-axial. The grammage of fabrics and the non-woven fabrics vary usually of about 80 g/m^2 to 400 g/m^2.

The term "polymeric material" is intended to mean a material that according to its mechanical characteristics can be divided into thermoplastics, thermosets and elastomers. The thermoplastics include the known plastics, wide available in the market, which can be melted several times and in same cases can be dissolved in several solvents, being therefore recycling materials. The thermosets are rigid and fragile, being very stable to temperature changes, although heating the finished thermoset polymer promotes decomposition of the material before melting, thus making it difficult to recycle. The elastomers show high elasticity, being not rigid as the thermosets and not meltable, thus reducing the recycling possibilities.

The term “radiating electric layer” is intended to mean any material that is susceptible of being integrated into a laminated panel for controlled heating using electric energy. By way of example one can mention an electric metallic frame or any system of electric resistances integrated into a laminated layer, among others.

The term “resins with biomass origin” is intended to mean raw material based resins of natural origin from either specific plantation processes, or waste from food processing that otherwise would be classified as residues. These resins are thermoset.

Generally, a ceramic and cork laminated element of the invention comprises a layer of ceramic material, a layer of cork material and an interface and compatibilizing layer of fibre material arranged between said layers of ceramic and cork. Said fibre layer provides a good adhesion between the cork and ceramic layers and allows the compatibilization of mechanical performances of both ceramic and cork materials in view of external load requirements, in such way that it improves the mechanical properties of the laminated panel thus formed. Such characteristic allows thickness reduction of the ceramic layer, to lighten the floor, while keeping the advantages of a conventional ceramic floor and increasing the advantages of a cork floor.

To bind the layers, one usually uses bonding agents (also called binders) known to the skilled artisans, so no further description is needed. However, any binding means adequate to bind the layers can be used.

Such binders can be selected from the group comprising polyurethane, polyester, vinylester and epoxy resins, natural resins, resins with biomass origin and the like, and combinations thereof.

The comparison between a laminated panel with a porcelanate and cork base of the present invention, and a porcelanate equivalent conventional floor tile, it is observed that the laminated panel of the invention has:

- higher mechanical resistance to deflection, maximal deflection reached and higher ultimate strength,
- improved resistance to object fall (better dissipation of kinetic energy),
- higher acoustic insulation in relation to impact noises,
- higher thermal insulation.

Making reference to the drawings, several embodiments of the present invention are hereinafter described.

Note that the following description of the laminated panels, in terms of layer arrangement, it is described from the top layer to the bottom layer, i.e., in the case of a floor the top layer (ceramic) has the outer surface in contact with the user, and the bottom layer (cork or fibres) has its outer surface (opposed to the outer surface of top layer) seating on the ground.

The first embodiment of the invention is shown in Fig. 1, with a ceramic and cork panel comprising:

- at least one ceramic material layer (1) with a thickness between about 1.0 mm and 16.0 mm,
- at least one fibre layer (2) made of a fabric or non-woven fabric selected from the group consisting of natural fibres and glass, carbon and basalt

fibres and the like, and combinations thereof, having a grammage higher than 80 g/m^2,

- at least one cork material layer (3) with a thickness between about 0.5 mm and 25.0 mm and a density between about 100 kg/m^3 and 1300 kg/m^3, and

- at least one fibre layer (4) identical to said layer (2).

Still with reference to Fig. 1, in a second embodiment (not shown), the ceramic material layer (1) is a porcelanate layer, the fibre layer (2) is a layer as described in the first embodiment, the cork material layer (3) is a layer of agglomerated cork, and no further fibre layer (4) exists in this second embodiment.

Making reference to Fig. 2, a third embodiment is shown representing a laminated panel similar to that of the second embodiment, but comprising additionally at least one polymeric material or radiating electric layer (5) between said fibre layer (2) and said cork material layer (3).

Fig. 3 shows the fourth embodiment that results from the combination of the characteristics of the first and third embodiments previously described.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

The preferred embodiment of the invention consists of a laminated panel having a first layer (1) of porcelanate with a thickness of about 4.5 mm. This layer acts as an impermeable and wearing layer corresponding to the top layer in contact with the user.

Said porcelanate layer (1) is overlapping a fibre glass layer (2) with a grammage of about 300 g/m^2 that, in turn, overlaps an agglomerated cork layer (3) with a density of about 200 kg/m^3 and a thickness of about 2.0 mm. This layer (3) of agglomerated cork is formed by granulated cork with a grain size between about 2 mm and 4 mm;

Finally, the bottom layer of the preferred laminated panel of the invention, overlapped by said agglomerated cork layer (3), is a fibre glass layer (4) with a grammage of about 300 g/m^2.

The fibre layers (2, 4) can be impregnated with one of the above mentioned resins or by a combination thereof, so in that way, they firmly adhere to the agglomerated cork layer (3). The preferred resin for said impregnation is an epoxy resin.

The preferred laminated panel of the present invention has a total thickness of about 7.0 mm.

EXPERIMENTAL TESTS

1- <u>Mechanical Test</u>

Several mechanical characterization tests were carried out by measuring the modulus of rupture and the breaking load, in test plates described below.

The tests are based on NP EN ISO 10545 Standard referring to ceramic floors and walls.

The test plates were divided into four distinct groups, shown in Fig. 4 to 6 (A, B, C and D), wherein groups (A, B, C) were composed of conventional ceramic plates and group (D) composed of plates of the preferred laminated panel of the present invention, previously described.

Each group was composed of 7 test plates, having each plate the length x width dimensions of 250 mm x 50 mm (± 1 mm), respectively. Other characteristics of the test plates are shown on the following table.

Groups	Material	Thickness (mm)
A	porcelanate	4.5
B	porcelanate	8
C	porcelanate	12
D	preferred laminated panel of the invention	7

Note that preferred laminated panel of the invention is described in the section "Description of the preferred embodiment of the invention" of the present Description.

The test equipment used was composed by a MTS dynomometre with a load cell of 50 kN equipped with a device for deflection tests in three points.

The test plates were placed horizontally over the supports of the test device, with the ceramic side facing upwards, with its longitudinal axis perpendicular to the axes of said supports and with the central point under the load (load head of the device). A force with a constant speed of 10 mm/min was applied, which was maintained until the determination of the modulus of rupture/yield strain.

For each test plate the following was measured/calculated:

- maximum deflection (mm), Fig. 4;
- modulus of rupture (N/mm^2), Fig. 5; and
- ultimate load (N), Fig. 6.

The values indicated in graphs of Fig. 4 to 6 are the result of the calculation of the average values obtained for each test group.

Making reference to Fig. 4, it was possible to observe a maximum deflection of 17 mm for plate (D) of the invention, whereas the conventional plates (A, B, C) have shown an almost null deflection, as expected since porcelanate is known to be a rigid and fragile material. Thus, comparatively with plates (A), the same material (porcelanate) with the same thickness integrated in plates (D) of the invention show a much higher elongation, which was totally unexpected.

In Fig. 5 the results of the modulus of rupture under the described test conditions are shown. Note that the modulus of rupture (in Newton per square millimetre) is obtained by dividing the deflection resistance calculated according to said Standard by the square of the minimum thickness measured on the rupture edge.

As shown in Fig. 5, the modulus of rupture of plates (D) of the invention is much higher than those of conventional plates (A, B, C), even considering that the porcelanate plates (C) have a thickness (12 mm) much higher than those of plates (D) of the invention.

The above results allow to use a plate (D) of the invention (with 7 mm of thickness) in more severe mechanical conditions than those supported by a conventional porcelanate plate (C) (with 12 mm of thickness), thus allowing to reduce considerably the thickness of porcelanate used in the laminated panel, guaranteeing a marked benefit associated with the weight reduction of the floor tiles.

Finally, in Fig. 6, the ultimate load results obtained in the test plates are shown. Said breaking load is the force needed to cause the rupture of the test plate, under the above described test conditions.

These results clearly show that the plates (D) of the invention integrating a porcelanate layer of 4.5 mm thickness can withstand absolute loads similar to those of conventional plates (C) with a thickness of 12 mm.

2- <u>Acoustic Insulation Test</u>

The acoustic insulation test was carried out with plates (A, D) defined in the previous mechanical test, with only a dimensional difference. In this in case the test plates have length x width dimensions of 900 mm x 300 mm (± 1 mm), respectively.

The acoustic test was carried out after assembly of the test plates in a slab test (acoustic chamber) with an acrylic based marketed glue. The test slab was reinforced concrete with a thickness of 14 cm. The test total area was approximately 10 m^2.

The equipment used for the test consisted of:

- IteCons acoustics chambers;
- PUL 02 multi-analyzer (3560-C-T46 model) with five data acquisition channels by "Bruel & Kjaer";
- GIR03 rotating microphones (3923 type) with MIC08 ½" microphones (4190 type) by "Bruel & Kjaer";
- CLS04 sound level calibrators (4321 type) by "Bruel & Kjaer";
- MPR02 impact noise generator (3207 type) by "Bruel & Kjaer";
- FSO03 omnidirectional sound source (OMNIPOWER 4292 type) by "Bruel & Kjaer";
- THR05 thermo-hygrometer, and
- TER02 thermometer.

The test was carried out in an acoustic laboratory according to NP ISO 140-8 Standard.

The procedure used for each group of test plates (A, D) consisted of:

- Measurement of the sound pressure level in the reception chamber, with the normalized step machine performing on the test slab;

- Application of the test plates;

- Evaluation of the sound pressure level in the reception chamber in 4 different positions of the normalized step machine;

- Evaluation of the reverberation times in the reception chamber considering the measurement in at least 3 microphones of a source position and 2 decay decades;

- Calculation of the difference between said two sound pressure measurements for each frequency band, the result being thereafter transposed to a normalized curve corresponding to a reinforced concrete slab with a thickness of 14 cm.

The normalized sound pressure curve of the slab was then determined according to NP ISO 140-8 Standard.

ISO 717-2 Standard is used for the calculation of the sound reduction index (DLw) using the calculation method of the normalized sound pressure level of impact noise to the slab reference curve and to the previously calculated difference of the reference slab.

Fig. 7 distinctively shows a marked difference in the results obtained by the plates of the two test groups. Thus, the conventional porcelanate plates (A) have shown a much lower acoustic insulation capacity than those shown by the invention plates (D).

The acoustic results of the preferred laminated panel plates (D) of the invention show a remarkable impact sound insulation up to 14 dB, as shown in Fig. 7.

CLAIMS

1. A ceramic and cork panel comprising a ceramic material layer (1), a cork material layer (3) and a fibre material layer (2) arranged between the ceramic (1) and cork (3) material layers.

2. The panel according to claim 1 further comprising another fibre layer (4), arranged on the outer face of the cork layer (3) opposed to outer face of the ceramic material layer (1).

3. The panel according to claim 2 wherein:

   the ceramic material layer (1) has a thickness between about 1.0 mm and 16.0 mm,

   the fibre layers (2, 4) are formed by at least a fabric or non-woven fabric selected from the group consisting of natural fibres and glass, carbon and basalt fibres, wherein said fabric or non-woven fabric has a grammage higher than 80 g/m^2, and

   the cork material layer (3) has a thickness between about 0.5 mm and 25.0 mm and a density between about 100 kg/m^3 and 1300 kg/m^3.

4. The panel according to claim 1 or 2, further comprising a polymeric material layer (5) or a radiating electric layer between the fibre layer (2) and the cork material layer (3).

5. The panel according to claim 1 or 2, further comprising a polymeric material layer (5) or a radiating electric layer between the fibre layer (2) and the ceramic material layer (1).

6. The panel according to claim 2 or 3, wherein layer (1) is porcelanate, layers (2, 4) are fibre glass fabric and layer (3) is agglomerated cork.

7. The panel according to claim 6, wherein:

the porcelanate layer (1) has a thickness of about 4.5 mm,

the fibre glass layers (2, 4) have a grammage of about 300 g/m^2, and

the agglomerated cork layer (3) has a thickness of about 2.0 mm and a density of about 200 kg/m^3,

wherein the total thickness of the panel is about 7.0 mm.

8. The panel according to any of claims 2 to 7, wherein the fibre glass layers (2, 4) are impregnated with a resin selected from the group consisting of polyurethane, polyester, vinylester, epoxy resins, and natural and biomass resins.

9. The panel according to claim 8, wherein the fibre glass layers (2, 4) are impregnated with an epoxy resin.

10. The panel as defined in any of claims 1 to 9 for use in the construction industry.

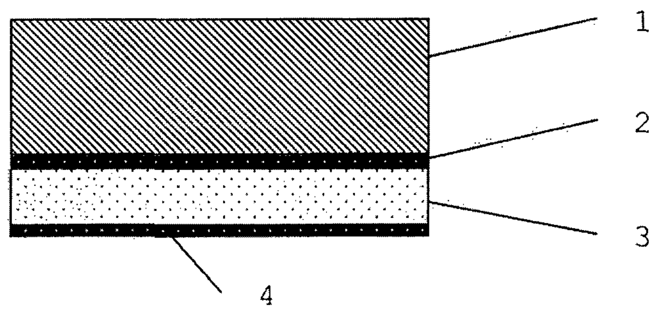


Fig. 1

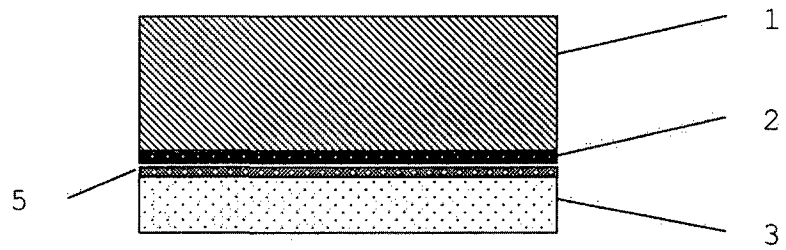


Fig. 2

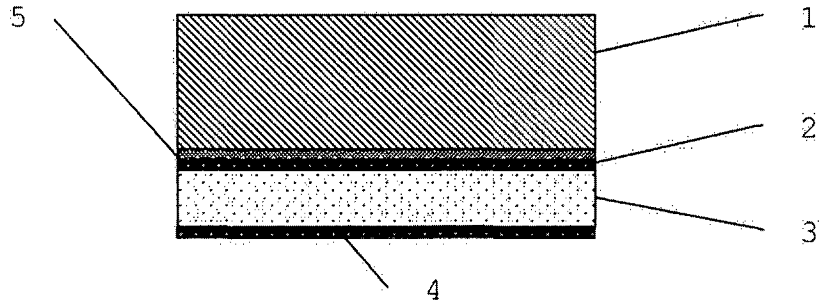


Fig. 3

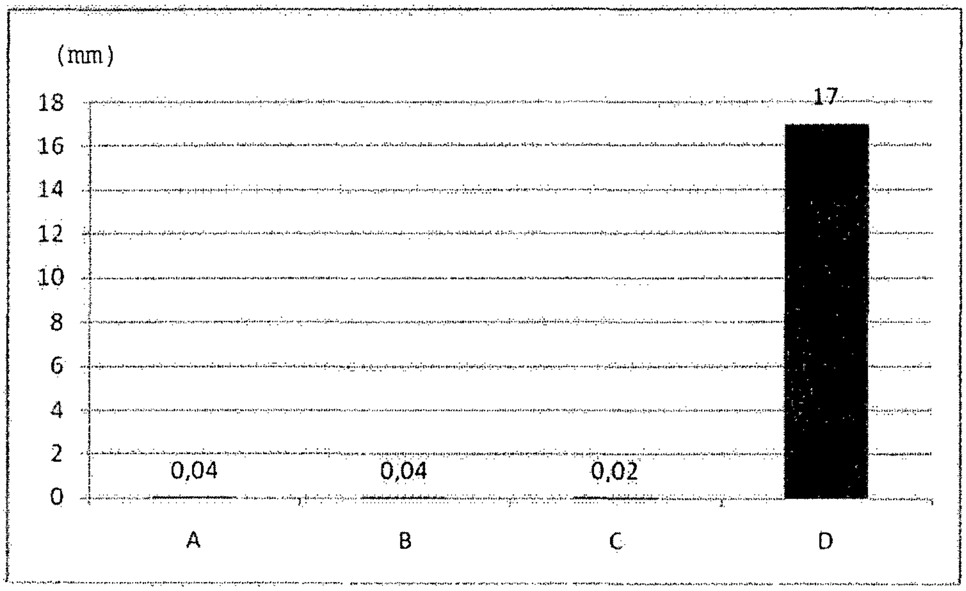
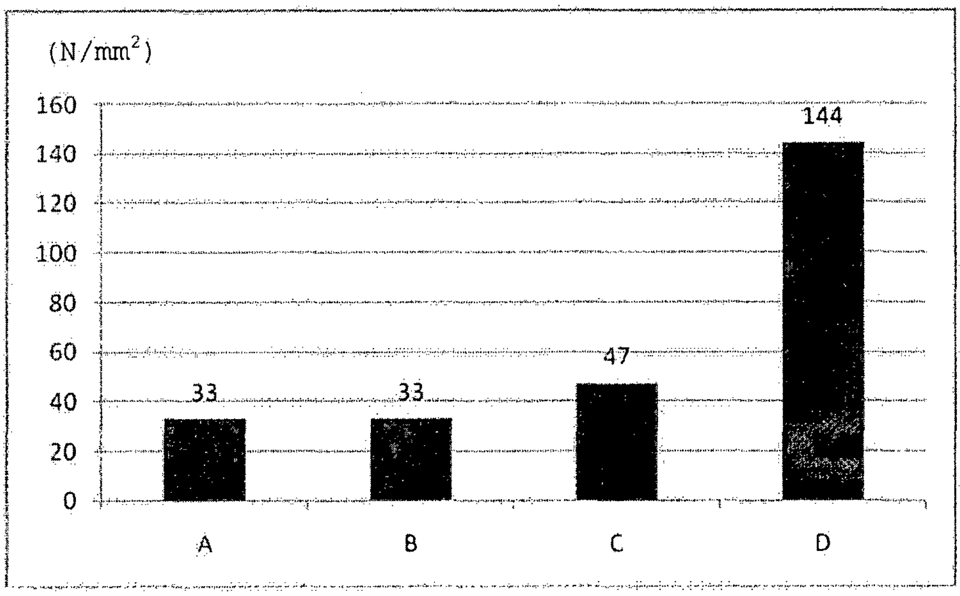


Fig. 4


(N/mm2)
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20
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33
33
47
144
A
B
C
D

Fig. 5

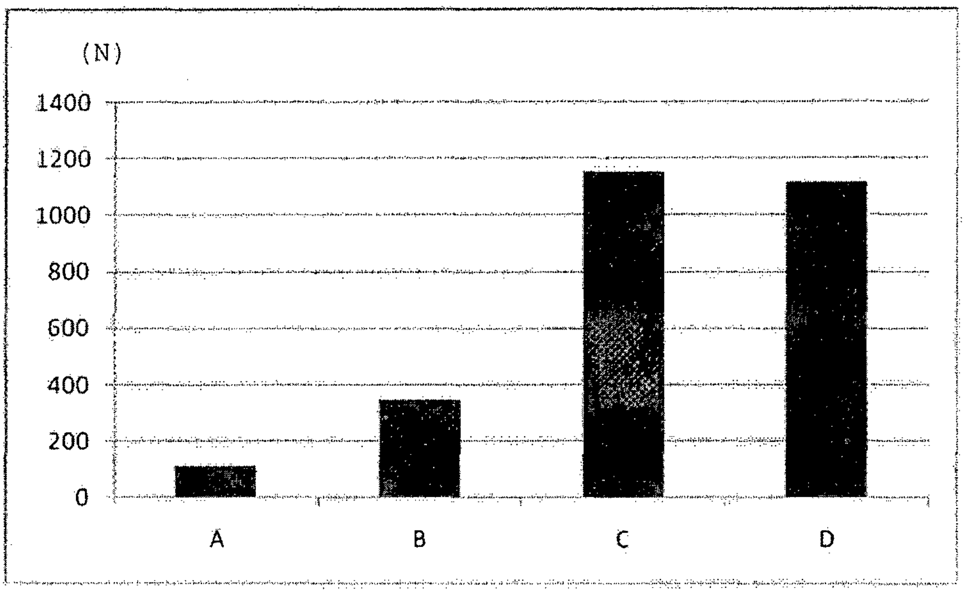
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Fig. 6

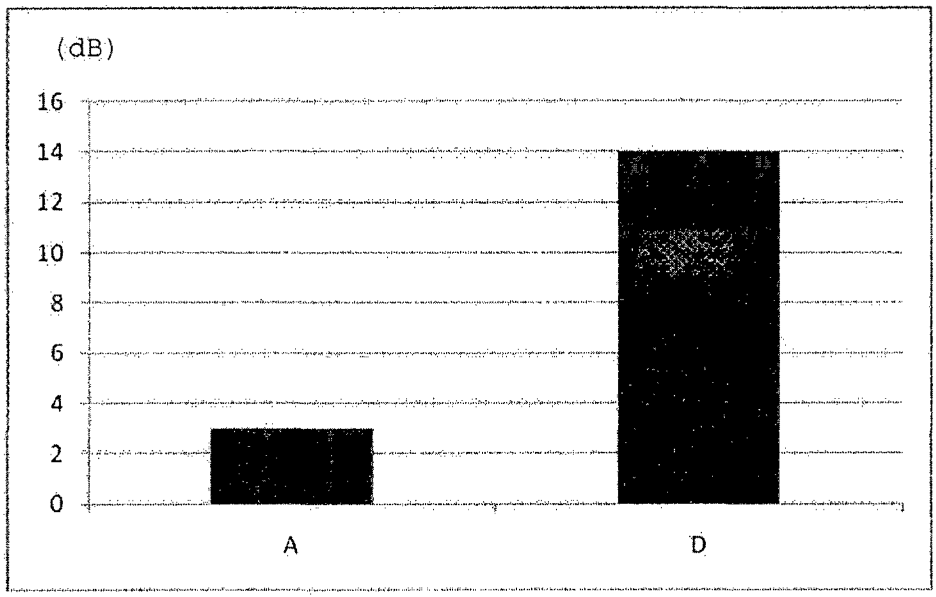

Fig. 7