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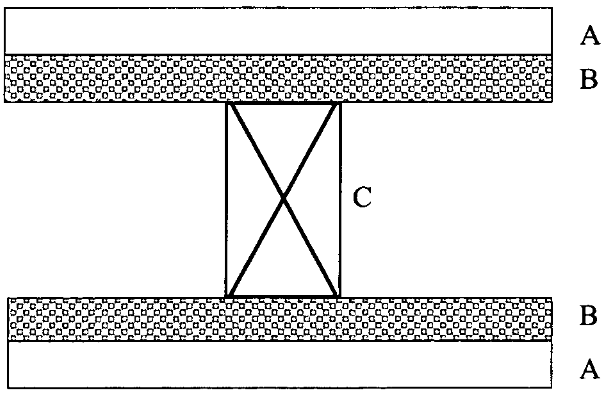
(54) **Acoustic fire-resisting insulating partition, ceiling or lining**

(57) The invention concerns an insulating system having a multi layer panel on each side of a frame or on one side of a frame (C), wherein the said panel comprises
- at least one airtight material (A);
- and at least one cementitious porous material (B) being the most inner layer to cavity, having a porosity from 80 to 95 %, percentage in volume of air voids and water voids, and having a density from 150 to 450 kg / m^3.

Figure 2



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Description

[0001] The subject of the present invention is an insulating system, in particular an acoustic, fire-resisting, insulating system as for example partition, ceiling or lining.

[0002] According to the prior art, it is known that partitions, ceilings or linings comprise a frame, at least one board cladding (most preferably plasterboard), fixing components, and an absorbent material for insulation purpose. The said absorbent material is placed inside the cavity created by the frame and the boards (see figure 1). The acoustic behaviour of partitions is well known and usually described by mass spring mass law, where the mass is created by the board cladding and the spring by the air in the cavity. It is also known that the spring effect is dependant to the cavity thickness and the absorbent material inside the cavity. The said absorbent materials are usually used to dissipate acoustic energy inside the cavity and soften the so-called "spring effect".

[0003] The fire-resisting behaviour of partitions is well known and usually described by the board cladding and the absorbent material in the cavity. The said board cladding and absorbent materials are usually used to insulate and prevent heat transfer from one side to another side of the partition.

[0004] However these systems using absorbent material have several inconveniences:

- it make the construction slighty heavier;
- the installation on jobsite is more fastidious;
- the time and the cost of installation are increased, specific personal protective equipment may be required according manufacturer;
- the technical devices are more difficult to be placed and may compress the absorbent material hence reducing its contribution to acoustic insulation but also this absorbent may cause conduction of vibration from technical device to the cladding;
- a risk of poor installation exists; the absorbent material may fall inside the cavity if a poor hanging is made, time wise.

[0005] Consequently, the problem is to improve insulating systems like partition, ceiling or lining without the necessary use of any absorbent material inside the cavity.

[0006] The solution proposed by the invention is an insulating system having a multi layer panel on each side of a frame or on one side of a frame, wherein the said panel comprises

- at least one airtight material;
- and at least one cementitious porous material being the most inner layer to cavity, having a porosity from 80 to 95 %, percentage in volume of air voids and water voids, and having a density from 150 to 450 kg / m^3.

[0007] Advantageously, the system according to the invention provides a system with total thickness comparable to prior art. That means that the difference of thickness between the system of the invention and the system of the prior art is atmost 15 mm.

[0008] More advantageously, the system according to the invention provides a system with total weight comparable to prior art, that means that the difference of weight between the system of the invention and the system of the prior art is atmost 2 kg/m^2.

[0009] More advantageously, the system according to the invention provides a lightweight system comparable to prior art.

[0010] More advantageously, the system according to the invention is mineral wool free and eliminates any risk that could be attached to the manipulation fibrous components during installation.

[0011] Ultimately, the system according to the invention could performs in term of insulation equally to system of prior art.

DEFINITIONS:

[0012] By the term "system", it is understood according to the invention an assembly of at least one board, at least one frame, like for example partition, ceiling, floor or lining.

[0013] According to the invention, the term « porosity » the total of the volume induced by the presence of air voids and the volume resulting from the evaporation of water (water voids). Consequently the porosity values take into account the airs voids and the water voids. For example a porosity of 0% means that there is non air voids or water voids inside the material. A porority of 80% means that 80% of the volume is provided by the air voids or water voids of the material.

[0014] By the expression "air voids", it is understood air voids that may be created when air is injected into a slurry.

[0015] By the expression "water voids", it is understood water voids created when water of convenience is dried out.

[0016] By the expression "airtight", it is understood according to the invention having a specific air flow resistance higher than 200 001 N.s.m^{-3}. The specific air flow resistance is measured according to the standard test method ISO 9053.

[0017] By the expression "cavity", it is understood according to the invention the space let free between two inner sides of boards in case of a partition, or the space let free between one inner sides of a board and the substrat in case of a ceiling or lining. The cavity may comprise air, this air is preferably in direct contact with the porous material.
[0018] By the expression "substrat", it is understood according to the invention floors, concrete floors, timber joist floors or others usual floors.
[0019] By the expression "R_{w+c}", it is understood according to the invention the Weighted Sound Reduction Index, showing the ability of a wall or other building structure to provide sound insulation. The R_{w+c} has been measured in an acoustic testing laboratory according to the following method *EN ISO 140 part3 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements* and calculated in an acoustic testing laboratory according *EN ISO 717 Part1 - Rating of sound insulation in buildings and in building elements.*
[0020] By the expression "fire-resisting", it is understood according to the invention a system having fire-resisting properties, especially an Integrity Insulation (EI) value of at least 30 minutes.

DETAILED INVENTION:

[0021] The invention is an insulating system having a multi layer panel on each side of a frame or on one side of a frame, wherein the said panel comprises

- at least one airtight material; and
- at least one cementitious porous material being the most inner layer to cavity, having a porosity from 80 to 95 %, percentage in volume of air voids and water voids, and having a density from 150 to 450 kg / m^3.

[0022] In particular, the insulating system according to the invention has a cementitious porous material having a porosity from 85 to 90 %, percentage in volume of air voids and water voids.
[0023] In particular, the insulating system according to the invention has a cementitious porous material having a Young Modulus in flexion from 0,1 GPa to 10 GPa, preferably from 0,1 GPa to 5 GPa, more preferably 0,1 GPa to 3 GPa.
[0024] In particular, the insulating system according to the invention has a cementitious porous material having a compressive strength of at least 0,3 MPa, preferably of at least 0,5 MPa, more preferably of at least 0,7 MPa.
[0025] In particular, the insulating system according to the invention has a cementitious porous material having a minimum thickness of 10 mm, preferably of a least 12 mm, more preferably of at least 15 mm and even more preferably of at least 18 mm and even even more preferably of at least 25 mm.
[0026] In particular, the insulating system according to the invention has a working thickness of the cavity (Tw) determined as follow :

$Tw \geq 1.4\ Ta$
with Ta being the apparent thickness of the cavity (see **figure 1**).

[0027] Advantageously, the system according to the invention provides fire-resistance. In particular the insulating system of the invention provides especially an Integrity Insulation (EI) value of at least 30 minutes, preferably of at least 45 minutes and more preferably at least 60 minutes and even more preferably of at least 90 minutes.
[0028] The frame suitable for the insulating system of the invention are all frames available for partitions, ceilings or linings, like for example studs.
[0029] The airtight material suitable for the insulating system of the invention could be a airtight facer. For example, a airtight facer suitable according to the invention may be a paper made facer being airtight or a non woven facer.
[0030] The airtight material suitable for the insulating system of the invention could be a airtight coating. For example, a airtight material suitable according to the invention may be a skimming coat or finishing coat. The said skimming coat can be made for instance with a standard readymix compound applied at 300gr/m^2, like for instance the P852 from Lafarge.
[0031] The airtight material suitable for the insulating system of the invention could be a board like any known cementitious boards, any known cementitious board available for partitions, any known gypsum boards, any known gypsum board available for partitions, ceilings or linings, as well as perforated acoustic board (sold under the commercial name Pregybel) or laminated boards. The preferred board is a heavy thin dense board, having a density of 1.2, and a thickness of 10 mm.
[0032] According to one embodiment of the invention, the insulating system of the invention comprises a multi layer panel wherein the said panel comprises

- at least one airtight material;
- and at least one cementitious porous material being the most inner layer to cavity the said airtight material and the said gypsum porous material may be one multi dense board.

[0033] An example of a multi dense board is shown on **figure 3,** with for example a first layer having a density of 0.7 to 0,9 and a second layer having a density of 0.3 to 0,5.

[0034] According to one embodiment of the invention, the insulating system of the invention comprises a multi layer panel wherein the said panel comprises

- at least one airtight material being the most outer layer to cavity;
- and at least one cementitious porous material being the most inner layer to cavity.

[0035] In particular, the insulating system according to the invention has a cementitious porous material being a gypsum porous material.

[0036] The gypsum porous material suitable for the insulating system of the invention may be, among others possibilities, a composition as described in detail below.

[0037] The said composition suitable as gypsum porous material according to the invention may be a composition comprising at least

- a set hydraulic binder; and
- a foaming agent and having
- a porosity ≥ 80% percentage in volume of air voids and water voids;
- a flow resistivity between 10 000 and 3 000 000 $N.s.m^{-4}$;
- a tortuosity between 1.2 and 3.4;
- a viscous characteristic length between 10 μm and 60 μm;
- a thermal characteristic length between 60 μm and 1500 μm.

[0038] The composition suitable as cementitious porous material according to the invention comprises a set hydraulic binder. The set hydraulic binder is a material that will set with water like for example Original Cement Portland or hydratable calcined gypsum. Preferably, it is a hydratable calcined gypsum, referred to as plaster, stucco, calcium sulfate hemi hydrate, or calcium sulfate semi-hydrate (or alternatively anhydrite). The source of the gypsum before it is calcined by any method known to one skilled in the art may be natural or synthetic production of gypsum, synthetic production of gypsum is preferred.

[0039] Hydratable calcined gypsum material is generally a fine-grained powder with a median particle size in the range of 5 to 100 μm. Specific embodiments of the composition suitable as gypsum porous material according to the invention are particularly designed for quick-setting hydraulic binder, having a setting time of less than 30 min, preferably less than 20 min, more preferably less than 10 min. One of the most preferred set hydraulic binder for use in the present composition of the invention is hydratable flue gas desulfurization (FGD) plaster.

[0040] The advantages of FGD gypsum plaster are among others higher purity, more uniform and finer particles size, lighter color and no abrasive particles. Higher purity results in more set hydraulic binder per unit weight for generally improved strength over natural gypsum plaster of lower purity. Uniform fine particles are more uniformly and completely calcined for a more uniform setting time. Lighter color is more aesthetically pleasing. The lack of abrasive particles in the gypsum plaster causes less wear on conveying equipment and mixer parts.

[0041] The composition suitable as gypsum porous material according to the invention comprises water. The final water-to-plaster (W/P) ratio in the composition suitable as gypsum porous material according to the invention prior to setting is preferably comprised between 0.3 and 0.9, more preferably between 0.45 and 0.75 and most preferably between 0.55 and 0.65.

[0042] The composition suitable as gypsum porous material according to the invention comprises a foaming agent.

[0043] By foaming agent according to the invention, it must be understood any suitable compound or any surfactant able to foam a composition comprising a hydraulic binder.

[0044] Suitable foaming agents according to the invention are preferably non-ionic foaming agents having a hydrophilic / lipophilic balance, namely HLB, from 5 to 18, preferably from 7 to 15, more preferably from 9 to 13.

[0045] Suitable foaming agents according to the invention are preferably alkylpolysaccharides.

[0046] Alkylpolysaccharides as foaming agents suitable for the invention, are those having a hydrophobic group containing from 8 to 22 carbon atoms, preferably from about 10 to about 16 carbon atoms, most preferably from 12 to 14 carbon atoms, and a polysaccharide hydrophilic group containing from 1 to 10, saccharide units (e.g., galactoside, glucoside, fructoside, glucosyl, fructosyl and/or galactosyl units).

[0047] Preferably, alkyl polysaccharides as foaming agents suitable for the invention, are alkylpolyglucosides having from 4 to 22, preferably from 4 to 16, more preferably from 8 to 12 carbon atoms.

[0048] The composition suitable as gypsum porous material according to the invention comprises, as preferred foaming agent, glycoside compound (which is also meant to cover mixtures of several glycoside compounds).

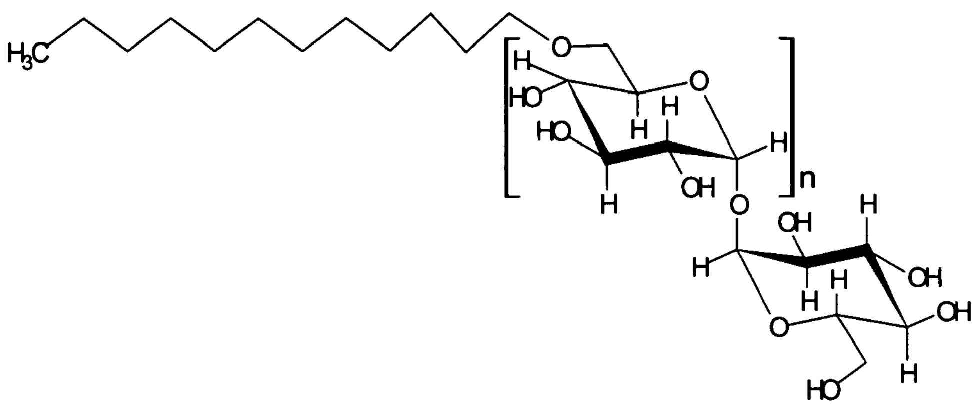
[0049] The term glycoside compound according to the invention means any chemical compound comprising a sugar part (glycone) bound to a non-sugar part (aglycone). The glycone may comprise one or more sugar units. If more than one unit is present on average, the glycoside compound may be termed polyglycoside. The glycoside compound may be a (poly)fructoside compound (if the glycone is based on fructose), a (poly)galactoside compound (if the glycone is based on galactose), a (poly)glucoronide compound (if the glycone is based on glucoronic acid) etc. Preferably, the glycoside compound is a glucoside or polyglucoside, i.e. a glycoside based on glucose.

[0050] The glycoside compound may also be an alkylpolysaccharide having the general formula $RO(R^1O)_tZ_x$ as defined in US 4,565,647 on col.1, 1.36-55, and more particularly an alkylpolysaccharide as described in US 4,565,647 on col. 2, 1.25-col.3, I.57, notably a compound having the general formula $R^2O(C_nH_{2n}O)_t(Z)_x$.

[0051] According to a preferred embodiment of the invention, the general formula of the foaming agent is : R-O-$(C_6H_{10}O_5)_n$-OH wherein R is an alkyl group with 4 to 22 carbon atoms; and n is an integer from 1 to 3, preferably 1 to 2.

[0052] Preferably, R is an alkyl group with 8 to 12 carbon atoms.

[0053] According to another preferred embodiment of the invention, the foaming agent has the following formula:



with n is an integer from 1 to 3, preferably from 1 to 2.

[0054] Molecules made by Cognis in the GLUCOPON family are particularly well-suited, notably GLUCOPON 600 CSUP or GLUCOPON 215 CS UP.

[0055] Examples of foaming agents useful for the invention are alkylpolyglucosides, betaines, amine oxydes, alkylpolysaccharides, alkylethersulfates, ethoxylated alcohols, alkylsulfonates, alkylsulfosuccinates.

[0056] Foaming agent sold by Huntsman, like alkylethersulfates, in particular the MILLIFOAM family, are also particularly well-suited, notably Millifoam C. The composition suitable as gypsum porous material according to the invention comprises preferably from 0.1 to 2.0 wt% (% by weight of the weight of the hydraulic binder) of alkylethersulfates (which is also meant to cover mixtures of several alkylethersulfates compounds), particularly from 0.25 to 0.8 wt% alkylethersulfates, more particularly from 0.30 to 0.60 wt% alkylethersulfates, and preferably from 0.35 to 0.50 wt% alkylethersulfates (% by weight of the weight of the set hydraulic binder).

[0057] Advantageously, the glycoside compound mentioned above is the sole foaming agent or surfactant used in the composition suitable as gypsum porous material according to the invention. In other terms, the composition suitable as gypsum porous material according to the invention preferably does not substantially comprise any other foaming agent or surfactant. In one embodiment, the glycoside compound represents more than 90% of any surfactant composition, advantageously more than 95%, by weight. In one embodiment, there is no other surfactant or foaming agent. It is to be understood that the absence of any other foaming agent or surfactant also covers the case where there are less than 0.01 wt% (preferably less than 0.001 wt%) of other foaming agent(s) or surfactant(s) in the composition.

[0058] The composition suitable as gypsum porous material according to the invention comprises preferably from 0.1 to 2.0 wt% (% by weight of the weight of the hydraulic binder) of the glycoside compound (which is also meant to cover mixtures of several glycoside compounds), particularly from 0.25 to 0.8 wt% glycoside compound, more particularly from 0.30 to 0.60 wt% glycoside compound, and preferably from 0.35 to 0.50 wt% glycoside compound (% by weight of the weight of the set hydraulic binder).

[0059] The composition suitable as cementitious porous material according to the invention may also comprise aggregates and/or fillers and / or others inorganic materials. Examples of fillers are FGD gypsum, fumed silica, fly ash, blast furnace slag, micro-silica and fine limestone. Examples of likely aggregates are lightweight vermiculite, silica, limestone sand, perlite, micro-spheres, and expanded shale.

[0060] Additives influencing the behavior of the composition suitable as gypsum porous material according to the invention like retarders/accelerators pairs are advantageously used in the present invention. An example of a retarder/

accelerator pair is conventional protein plaster retarder/ball milled accelerator (BMA).

[0061] It should be understood that any additive classically used in the art could also be used in the instant composition suitable as cementitious porous material according to the invention, in particular additives like thickeners or viscosity modifiers or fluidizers but not limited to them. The range of additives is very wide as will be appreciated by the skilled person.

[0062] Resins for the improvement of the mechanical and/or aesthetic properties, known in the art can be added to the composition suitable as gypsum porous material according to the invention. Examples of resins beneficial alone or in combination are: polyacrylamide polyacrylic, polyvinylalcohol, fluoropolymer and mixtures thereof. These types of resins can by combined in copolymers or other combinations, e.g. as styrenebutadiene copolymers, styrene-acrylate copolymers, vinyl-acetate-ethylene copolymers and acrylate copolymers.

[0063] The composition suitable as cementitious porous material according to the invention may also comprise a thickener (also named stabilizing agent). The thickener may be effective by increasing the viscosity of the water in the matrix, or by stabilizing the bubble formation by the foaming agent. One skilled in the art will appreciate that polyvinyl alcohol is a suitable bubble stabilizing agent.

[0064] The composition suitable as cementitious porous material according to the invention may also comprise a viscosity modifier like for example a water-soluble viscosity modifier. Examples are polymers (cellulosic, polyalcohol, polyurethane, polyester, polyether, polyacrylic, co- and terpolymers thereof), clay (modified/natural), fumed silica, hydrophobically-modified or surface-modified additives.

[0065] The composition suitable as cementitious porous material according to the invention may comprise a fluidizer which is usefully incorporated into the gypsum slurry in order to minimize the water to calcined gypsum ratio. A fluidizer (also referred to as a water-reducing agent or a plasticizer) may be added to the aqueous gypsum slurry (e.g., via a pump) to increase the flow of the slurry. Some examples of such fluidizer are carboxylate compounds such as polycarboxylate ethers. Preferred additives are polycarboxylate ethers or the like.

[0066] The composition suitable as cementitious porous material according to the invention may comprise a blocking agent which is preferably incorporated into the slurry in order to stop the setting hydraulic binder with water. A blocking agent is also referred to as a calcium sequestering agent and may also serve as a water-reducing agent in the aqueous gypsum slurry to increase the flow of the slurry. Any suitable product with a calcium sequestering functionality can be used. Blocking agents are typically used with unblocking agent in a pair. Examples of typical blocking unblocking pairs are sodium polyacrylate/aluminum sulfate and sodium phosphonate/zinc sulfate.

[0067] The present composition suitable as gypsum porous material according to the invention may be practiced in the absence of fibers. In the absence of fibers means that the amount could be less than 0.01% by weight (% by weight of the weight of the set hydraulic binder), preferably less than 0.001% (only unintended impurities) and preferably no fiber will be present at all. A fiber is any fiber typically used in the art. "In the absence of fibers" does not exclude the presence of cellulosic material, especially originating from reclaim material, as is typically used in the instant field.

[0068] Advantageously, in a particular embodiment, the composition suitable as gypsum porous material according to the invention does not comprise fibers.

[0069] The composition suitable as cementitious porous material according to the invention may have a volume of air voids incorporated into the composition in order to absorb sound. The quantity of air voids may come from two sources, water voids created when water of convenience is dried out of the composition and air voids that may be created when air is injected into the slurry.

[0070] The water voids may be smaller than the air voids and may have a slight contribution to sound absorption at higher frequencies and at higher water-to-plaster ratio.

[0071] The air voids may be larger than the water voids, and may tend to be interconnected which may allow the composition suitable as cementitious porous material according to the invention to absorb sound.

[0072] According to the invention, the term « porosity » means the total of the porosity induced by the presence of air voids and the porority resulting from the evaporation of water (water voids). Consequently the porosity values take into account the airs voids and the water voids.

[0073] According to another aspect of the invention, the composition suitable as gypsum porous material according to the invention may have

- a porosity ≥ 0.55;
- a flow resistivity between 10 000 and 3 000 000 $N.s.m^{-4}$;
- a tortuosity between 1.2 and 3.4;
- a viscous characteristic length between 10 μm and 60 μm;
- a thermal characteristic length between 60 μm and 1500 μm.

[0074] Preferably, according to the composition of the present invention

- the porosity is ≥ 0.70;

- the flow resistivity is between 50 000 and 2 500 000 $N.s.m^{-4}$;
- the tortuosity is between 1.3 and 2.5;
- the viscous characteristic length is between 15 μm and 50 μm;
- the thermal characteristic length is between 70 μm and 500 μm.

[0075] More preferably, according to the composition suitable as gypsum porous material according to the invention

- the porosity is $\geq$ 0.76;
- the flow resistivity is between 100 000 and 2 000 000 N.s.m-4;
- the tortuosity is between 1.4 and 2.3;
- the viscous characteristic length is between 15 μm and 40 μm;
- the thermal characteristic length is between 80 μm and 300 μm.

[0076] These 5 parameters correspond to those which have been well described by the model of Biot-Johnson-Allard in the following book: J.F.Allard, Propagation of Sound in Porous Media, Elsevier Applied Science, 1993):

- **porosity** is as defined above; the porosity can be easily measured by picnometry or is measured according to L. L. Beranek. Acoustic impedance of porous mateials. J. Acoust. Soc. Am., 13:248-260, 1942;
- **flow resistivity** means the velocity of air volume displacement which is the material quantity that flows through an area in a time period. The resistance to air flow is equal to the pressure loss measured between the two sides of the porous sample when it is crossed by a constant laminar air flow. Flow resistivity is thus equal to the ratio of the air pressure over the flow rate times the sample surface divided by the sample thickness: flow resistivity is measured according to the standard test method ISO 9053.
- **tortuosity** means the complexity of the internal structure of the material;
- **thermal characteristic length** characterizes the heat exchange between the air and the rigid frame. This is a measure of the effective size of the pores involved in the heat exchange. For gypsum cores, this is directly related to the bubble size.
- **viscous characteristic length** characterizes the viscous interaction of the air with the stiff frame. This is a measure of the effective size of the pores involved in the viscous interaction. For gypsum cores, this is directly related to the size of the interconnections between the *air voids.*

[0077] Several methods exist for the measurement of characteristic lengths and tortuosity. The most accurate way to achieve measurements consists in an analytic inversion of acoustic models. References of scientific articles describing these methods are:

- X. Olny, R. Panneton, and J. Tran-van, An indirect acoustical method for determining intrinsic parameters of porous materials. In Poromechanics II, Actes de la 2nde conference de BIOT, 2002.

[0078] According to another aspect of the invention, the composition of the present invention may have a density comprised between 150 and 450 kg/m^3, particularly between 320 and 420 kg/m^3, more particularly between 340 and 380 kg/m^3, preferably 350 and 360 kg/m^3, more equal to 360 kg/m^3.
[0079] The composition suitable as cementitious porous material according to the invention has sound-absorbing properties.
[0080] The composition suitable as cementitious porous material according to the invention may have a sound absorption average (SAA) of at least 0.3, preferably at least 0.5, most preferably at least 0.6 as measured by modified ASTM E1050 - 98.

EMBODIMENTS:

[0081] According to a first embodiment of the invention, the invention may be an insulating system having a multi layer panel on each side of a frame, the said system being a partition.
[0082] According to the first embodiment of the invention, the insulating system may be an acoustic insulating partition.
[0083] The system according to this first embodiment may be an insulating partition, having a multi layer panel on each side of a frame, wherein the said panel comprises at least one board and at least one cementitious porous material being the most inner layer to cavity.
[0084] The system according to the first embodiment provides an improvement of at least 5dB expressed in R w + c , preferably at least 10 dB, and more preferably of at least 15 dB.
[0085] The system according to the first embodiment of the invention may comprise as porous material, the composition

suitable as gypsum porous material described above.

[0086] The system according to the first embodiment of the invention may be an fire-resistant insulating partition.

[0087] According to a second embodiment of the invention, the invention may be a insulating system having a multi layer panel on one side of a frame, the said system being a ceiling or a lining

[0088] According to this second embodiment, the invention provides a ceiling or lining having a multi layer panel on one side of a frame, wherein the said panel comprises at least one board and at least one cementitious porous material being the most inner layer to cavity.

[0089] The system according to the second embodiment provides an improvement of at least 5dB expressed in R_{w+c}, preferably at least 10 dB, and more preferably of at least 15 dB.

[0090] The system according to the second embodiment of the invention may comprise as porous material, the composition suitable as gypsum porous material described above.

[0091] According to a third embodiment, the invention provides an insulating system having a multi layer panel on each side of a frame or on one side of a frame, wherein the said panel comprises

- at least one gypsum porous material being the most inner layer to cavity; and
- at least a skimming coat, the said skimming coat being located on the side opposite to the inner layer to cavity, more preferably the outer side.

[0092] An example of such an insulating system according to this third embodiment is shown on **figure 4.**

[0093] All previous statements on the gypsum porous material in the description, applies to this third embodiment.

FIGURES:

[0094]

The **figure 1** provides one embodiment of the acoustic insulating system according to the prior art.

The **figure 2** provides one embodiment of the acoustic insulating system according to the invention, where C represents a stud, A represents any known gypsum board and B represents a panel comprising the composition according to the invention.

The **figure 3** provides an insulating system according to the the invention with a multi dense board.

The **figure 4** provides an insulating system according to the third embodiment of the invention.

EXAMPLES:

Example 1 - production a composition suitable as gypsum porous material according to the invention:

[0095] In a stirred tank (primary mixer), a slurry was prepared using the following ingredients:

- 15 kg of gypsum hemi-hydrate from the Ottmarsheim factory (France)
- 9.45 kg of water;
- 24 g of Coatex TP169 (polyacrylate blocking agent, obtained from Coatex);
- 15 g of Ball milled accelerator (BMA, from the Ottmarsheim factory, France) which comprises gypsum, starch and lignosulfonate;
- 35.7 g of Optima 100 (phosphonate fluidizer obtained from Chryso);
- 363 g of Vinnapas CEF52W (vinyl acetate resin obtained from Wacker).

[0096] The primary slurry thus obtained was pumped in a tube at a flow rate of 1 L/min. A solution of Glucopon 215 CS UP (containing 64% by weight of alkylpolyglycoside surfactant) obtained from Cognis, prepared with 61.1 g of Glucopon diluted in water (400g Glucopon and 600g of water) was continuously injected into the circulation tube of the primary slurry by an injection pump (flow rate: 10 g/min). The mean concentration of the active material contained in the slurry is thus 0.11 %.

[0097] The primary slurry then entered a Mondomix® air mixer, [type of machine: minimondo H1776, capacity 5-50kg/hr distributed by Haas Mondomix (secondary mixer)] rotating at 450 rpm, where air was introduced at a flow rate of 1.5 L/min to 2.5 L/min so that foaming took place.

[0098] The foamed slurry was then transported to a tertiary mixer where a solution of aluminum sulfate (unblocking agent) was added and continuously mixed to the foamed slurry. The solution of aluminum sulfate was prepared with 85 g of aluminum sulfate powder, at an active content of 150 g/kg. The injection rate was 27 g/min. The tertiary mixer was a 30-cm long vertical static mixer having a 20-mm diameter, based on a Kenics® geometry. At the outlet of the mixer, the slurry was directly deposited on a liner and a second liner was applied on top of the slurry and it was allowed to set. The distance between the tertiary mixer and the liner was 10 cm.

[0099] The liner used was FF 0.55/6 supplied by Johns Manville. This liner is a nonwoven glass mat of 8 μm fibers adhered together by 20 g/m^2 of a blend of acrylic and polyvinyl alcohol polymers. A coating of 15 to 30 g/m^2 of an acrylic resin binder was applied to the boards after the dryer.

Example 2 - production a composition suitable as gypsum porous material according to the invention:

[0100] In a primary mixer, a powder premix was continuously introduced at a flow rate of 1 kg/min. The powder premix was composed of:

- gypsum hemi-hydrate from the Ottmarsheim factory (France) so that the water to plaster ratio is 0.58; and
- 1 g Ball milled accelerator (BMA, see above) per kg of gypsum hemihydrate.

[0101] The following liquid ingredients were also introduced into the mixer:

- 410 g/min of water;
- 57 g/min of a solution of sodium polyacrylate (Coatex TP1431EXP: fluidizing agent obtained from Coatex), the solution being a 1/10th dilution of the commercial solution, so that the weight concentration in active material is 0.3% relative to the gypsum hemihydrate;
- 50 g/min of a blend of natural product with proteins in solution (Plastretard L: retarder supplied by Sicit, Vincenza Chiampo, Italy) containing 6 g per kg of the initial commercial solution;
- 50 g/min of a solution of K_2SO_4 obtained from Riedal de Haën containing 100 g per kg of active material.

[0102] The K_2SO_4 aims at providing acceleration of the final set and hardening.

[0103] The W/P ratio was 0.58. A strength reinforcement solution could be added if necessary. When a slump test was performed (with a 50-mm height and a 60-mm width ring), the diameter of the slump was between 205 and 240 mm. The setting time was comprised between 6.5 minutes and 7.5 minutes (based on the knife test), otherwise it could be adjusted by varying the quantity of Plastretard. If the Gilmore test indicated a setting time of less than 9 minutes, K_2SO_4 could be adjusted accordingly.

[0104] The slurry thus prepared exited the primary mixer and was continuously transferred to the top of a cylindrical tank having a 20 mm diameter and a 200 mm height. The slurry was then continuously pumped at the bottom of the tank at a flow rate of 1 Umin in a tube so that the amount of material in the tank remained constant. The average passing time in the tank was less than 5 seconds and the residence time distribution was narrow (95% of the slurry leaved the tank less than 10 seconds after entering the tank), as was measured by dyes concentration evolution techniques.

[0105] A solution of Glucopon 215 CS UP (containing 64% of alkylpolyglycoside surfactant) obtained from Cognis, prepared with 400 g of Glucopon and 600 g of water, was continuously injected into the circulation tube of the primary slurry by an injection pump (flow rate: 13 g/min). The concentration in active material is thus about 0.3% by weight relatively to the gypsum hemihydrate.

[0106] The primary slurry then entered a Mondomix® air mixer (secondary mixer) rotating at 300-500 rpm (400-450 rpm being preferred), where air was introduced at a flow rate of 2.5 Umin so that foaming took place. After the exit of the air mixer, the foamed slurry was deposited on a liner where it was allowed to set after the addition of a second liner on the top. The distance between the air mixer and the liner was less than 10 cm and the direction of the deposition was horizontal.

[0107] The liner used was FF 0.55/6 supplied by Johns Manville. This liner is a nonwoven glass mat of 8 μm fibers adhered together by 20 g/m^2 of a blend of acrylic and polyvinyl alcohol polymers.

Example 3 : partition having a single laver fast on each side of a frame

[0108] A frame used is a 36 mm tracks in the form of a U installed horizontally on the top and the bottom of a partition. Vertically the frame used is a 34.8 mm studs in the form of a C studs, arranged in the tracks at 600-mm centres.One each side of C studs were fixed one boards, a 18 mm gypsum porous boards obtained according to example 1 with a minimum surface mass of 6.7 kg/m^2. The said boards were fixed vertically and parallel to the studs with 35-mm screws at 300mm centers on each side of the framing. A 2.3 mm thick plaster coating with a surface mass of 3.6 kg/m^2 was applied in surface being the most outer layer to the cavity. The total thickness of the partition was 76.6 mm. The working thickness Tw was equal to 72 mm and the apparent thickness Ta was equal to 34.8 mm.

[0109] The system according to invention had been compared to traditional partition made with 12.5 mm standard plasterboards and where the cavity was filled with 45 mm glass wool. The total thickness of the partition was 72 mm and the surface mass of each side was 9.2 kg/m^2. The standard plasterboards were fixed vertically and parallel to a 46 mm studs in the form of a C studs with 35-mm screws at 300mm centres on each side of the framing. The working thickness Tw was equal to 48 mm and the apparent thickness Ta was equal to 48 mm.

[0110] The airborne sound insulation performance of two partitions were measured in conformity to the standard EN ISO 140-3 ("Measurement of sound insulation in buildings and of building elements, part 3, Laboratory measurement of airborne sound insulation of building elements" and gave a airborne sound reduction rating of Rw+C 38 dB for the partition with the said porous gypsum and Rw+C 36 dB for the traditional partition with glass wool inside the cavity. The airborne sound reduction rating was calculated in accordance to the standard EN ISO 717-1 ("Rating of sound insulation in buildings and pf building elements, Part 1 airborne sound insulation").

[0111] The resistance to fire was evaluated in accordance to the standard 1363-1 ("Fire resistance tests - Part 1: General requirements »). The traditional system with glass wool inside the cavity gave a Fire insulation and Fire Integrity (EI) of 30 minutes in accordance to the standard EN 1364-1 ("Fire resistance tests for non-load bearing elements. Part 1 Walls). The partition with the said porous gypsum obtained an EI of 60 minutes.

Example 4 partition having a single laver fast on each side of a frame

[0112] A frame used is a 36 mm tracks in the form of a U installed horizontally on the top and the bottom of the partition. Vertically a frame used is a 34.8 mm studs in the form of a C studs, arranged in the tracks at 600-mm centres. One each side of C studs were fixed one boards, a 25 mm gypsum porous boards obtain according to example 2 with a minimum mass of 9.9 kg/m^2. The said boards were fixed vertically and parallel to the studs with 35-mm screws at 300mm centres on each side of the framing. A 1 mm thick plaster coating for surface mass of 1,1 kg/m^2 was applied in surface being the most outer layer to the cavity. The total thickness of the partition was 88 mm. The working thickness Tw was equal to 86 mm and the apparent thickness Ta was equal to 36 mm.

[0113] The airborne sound insulation performance of the partitions were measured in conformity to the standard EN ISO 140-3 ("Measurement of sound insulation in buildings and of building elements, part 3, Laboratory measurement of airborne sound insulation of building elements" and gave a airborne sound reduction rating of Rw+C 41 dB for the partition with the said porous gypsum. The airborne sound reduction rating was calculated in accordance to the standard EN ISO 717-1 ("Rating of sound insulation in buildings and pf building elements, Part 1 airborne sound insulation").

Example 5 partition having a double laver fast on each side of a frame

[0114] A frame used is a 36 mm tracks in the form of a U installed horizontally on the top and the bottom of the partition. Vertically a frame used is a 34.8 mm studs in the form of a C studs, arranged in the tracks at 600-mm centres. One each side of C studs were fixed one boards, a 18 mm gypsum porous boards obtain according to example 1 with a minimum mass of 6.7 kg/m^2. The said boards were fixed vertically and parallel to the studs with 35-mm screws at 600mm centres on each side of the framing. A second layer of a 12.5 mm dense plasterboards with a minimum surface mass of 12.3 kg/m^2 and a Young modulus between 3 to 7 Gpa. The dense boards were fixed vertically and parallel to the studs with 55-mm screws at 300mm centers on each side of the framing. The total thickness of the partition was 97 mm. The working thickness Tw was equal to 72 mm and the apparent thickness Ta was equal to 34.8 mm.

[0115] The system according to invention had been compared to traditional partition made two layers of a12.5 mm standard plasterboards and where the cavity was filled with 45 mm glass wool. The total thickness of the partition was 98 mm and the surface mass of each side was 18.4 kg/m^2. The standard plasterboards were fixed vertically and parallel to a 46 mm studs in the form of a C studs with 35-mm screws at 600mm centres on each side of the framing for the first layer and at 300mm centers on each side of the framing for the second layer. The working thickness Tw equal to 46 mm and the apparent thickness Ta equal to 46 mm.

[0116] The airborne sound insulation performance of two partitions were measured in conformity to the standard EN ISO 140-3 ("Measurement of sound insulation in buildings and of building elements, part 3, Laboratory measurement of airborne sound insulation of building elements" and gave a airborne sound reduction rating of Rw+C 45 dB for the partition with the said porous gypsum and Rw+C 45 dB for the traditional partition with glass wool inside the cavity. The airborne sound reduction rating was calculated in accordance to the standard EN ISO 717-1 ("Rating of sound insulation in buildings and pf building elements, Part 1 airborne sound insulation").

[0117] The resistance to fire was evaluated in accordance to the standard 1363-1 ("Fire resistance tests - Part 1: General requirements »). The traditional system with glass wool inside the cavity gave a Fire insulation and Fire Integrity (EI) of 60 minutes in accordance to the standard EN 1364-1 ("Fire resistance tests for non-load bearing elements. Part 1 Walls). The partition with the said porous gypsum obtained an EI of 90 minutes.

Example 6 partition having a double layer fast on each side of a frame

[0118] A frame used is a 36 mm tracks in the form of a U installed horizontally on the top and the bottom of the partition. Vertically a frame used is a 34.8 mm studs in the form of a C studs, arranged in the tracks at 600-mm centres. One each side of C studs were fixed one boards, a 25 mm gypsum porous boards obtain according to example 2 with a minimum mass of 9.5 kg/m^2. The said boards were fixed vertically and parallel to the studs with 35-mm screws at 600mm centers on each side of the framing. A second layer of a 10 mm dense plasterboards with a minimum surface mass of 11.8 kg/m^2 and a E modulus between 3 to 7 Gpa. The dense boards were fixed vertically and parallel to the studs with 55-mm screws at 300mm centers on each side of the framing. The total thickness of the partition was 106 mm. The working thickness Tw was equal to 86 mm and the apparent thickness Ta equal to 34.8 mm.

[0119] The airborne sound insulation performance of two partitions were measured in conformity to the standard EN ISO 140-3 ("Measurement of sound insulation in buildings and of building elements, part 3, Laboratory measurement of airborne sound insulation of building elements" and gave a airborne sound reduction rating of Rw+C 47 dB for the partition with the said porous gypsum.The airborne sound reduction rating was calculated in accordance to the standard EN ISO 717-1 ("Rating of sound insulation in buildings and pf building elements, Part 1 airborne sound insulation").

Claims

1. An insulating system having a multi layer panel on each side of a frame or on one side of a frame, wherein the said panel comprises

   - at least one airtight material; and
   - at least one cementitious porous material being the most inner layer to cavity, having a porosity from 80 to 95 %, percentage in volume of air voids and water voids, and having a density from 150 to 450 kg / m^3.

2. An insulating system according to claim 1, the said cementitious porous material having a Young Modulus in flexion from 0,1 GPa to 10 GPa.

3. An insulating system according to claim 1, the said cementitious porous material having a compressive strength of at least 0,3 MPa.

4. An insulating system according to claim 1, the said cementitious porous material having a minimum thickness of 10 mm.

5. An insulating system according to claim 1, the said cementitious porous material having a flow resistivity between 10 000 and 3 000 000 N.s.m^{-4};

6. An insulating system according to claim 1, with a working thickness of the cavity (Tw) determined as follow :

   $Tw \geq 1.4\ Ta$
   with Ta being the apparent thickness of the cavity.

7. An insulating system according to claim 1, the said cementitious porous material being a gypsum porous material.

8. An insulating system according to claim 7, the said gypsum porous material being a composition comprising at least

   - a set hydraulic binder; and
   - a foaming agent
   and having
   - a porosity ≥ 80% percentage in volume of air voids and water voids;
   - a flow resistivity between 10 000 and 3 000 000 N.s.m^{-4};
   - a tortuosity between 1.2 and 3.4;
   - a viscous characteristic length between 10 μm and 60 μm;
   - a thermal characteristic length between 60 μm and 1000 μm.

9. An insulating system according to claim 1, the said system being airtight.

10. An insulating system having a multi layer panel on each side of a frame according to claim 1, the said system being a partition.

11. An insulating system according to claim 10, the said system being an acoustic insulating partition.

12. An insulating system according to claim 10, the said system being an fire-resistant insulating partition.

13. An insulating system having a multi layer panel on one side of a frame according to claim 1, the said system being a ceiling or a lining.

Figure 1

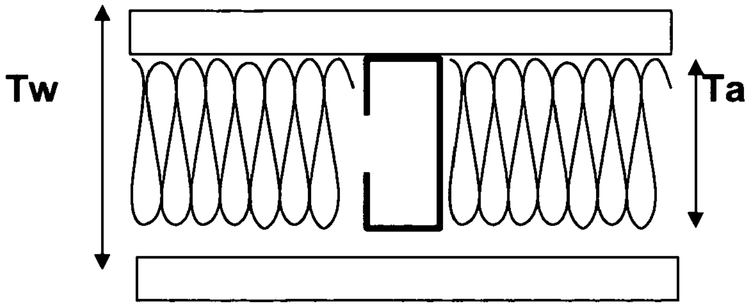


Figure 2

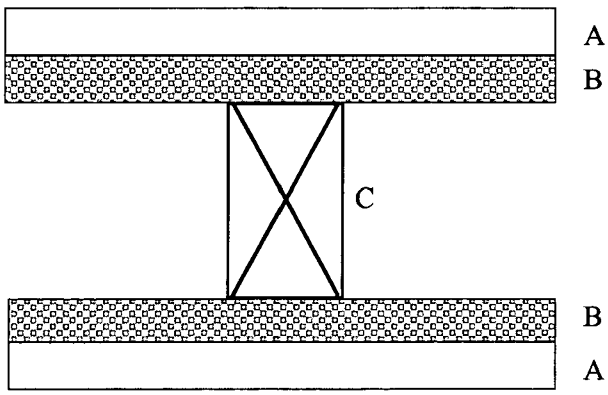


Figure 3

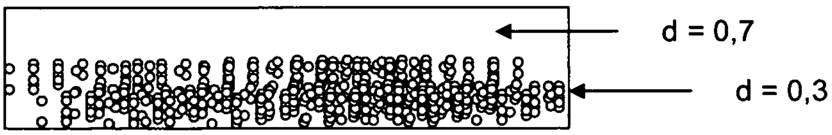
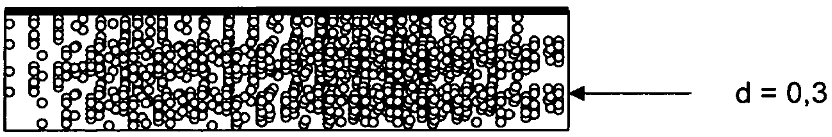


Figure 4



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EUROPEAN SEARCH REPORT

Application Number
EP 09 35 6039

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 November 2009	Rosborough, John

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