Brief description of the invention

After long and laborious research and testing, the inventors have successfully selected a particular class of bio-sourced aggregates of plant origin, suitable for constructing a hardened insulation layer, combined with at least one wall, for forming an improved construction system for buildings that meets the above and other objectives.

Summary

A first aspect of the present disclosure therefore relates to a multilayer and insulating construction system for a building, characterized in that

a) this system comprises at least one wall associated with at least one hardened insulation layer,

b) the maximum thickness of the hardened insulation layer is between 1 cm and 60 cm,

c) the hardened insulation has a Bulk Density (BD) in kg/m^3 that is less than or equal to 450; 300; 250; 200; 150; 100; and more preferably between 50 and 300; 150 and 250;

d) this hardened insulation layer is prepared by mixing, with water, a dry composition (d) comprising:

-A- at least one binder including:

- -Al- at least one hydraulic or air binder;
- -A2- possibly at least one water retention agent;
- -A3- possibly at least one surfactant;

-B- at least one bio-sourced aggregate based on sunflower stalk and/or corn stalk and/or rape stalk, having a Bulk Density (BD) in kg/m^3 that is less than 110; preferably between 10 and 80 wherein a percentage of stalk pith in the bio-sourced aggregate is (as % weight on a dry basis and in increasing order of preference) > 15; ≥ 20; ≥ 30; ≥ 40; ≥ 50; ≥ 60; ≥ 70; ≥ 80; ≥ 90; ≥ 95; ≥ 99;

e) this composition having a ratio of A/B [mass of dry binder -A- in kg] / [mass of dry filler -B- in kg] comprised between – by increasing order of preference – 1 and 15; l and 10; 1 and 8; 1 and 6.

It is to the credit of the inventors that they have successfully developed this bio-sourced, insulating, lightweight, and ductile construction system for buildings.

Not wanting to be constrained by current theory, this advantageous construction system was able to be obtained by counter-intuitively choosing a particular bio-sourced aggregate -B- and combining this component B with a binder A, in suitable quantities and in a manner that would obtain a hardened insulation having a BD within a given range.

Advantageously, this construction system is in the form of prefabricated members intended to be assembled on site for the construction of the building or is manufactured on site

for the construction of the building.

In one example, this construction system is in the form of unitary masonry members, preferably standardized and prefabricated, intended to be assembled on site for the construction of the building or parts of the building, preferably walls.

Preferably, the hardened insulation layer is interposed between the associated wall and at least one other wall and/or at least one layer of a material different from the hardened insulation, this other wall and/or this layer possibly being a finishing wall or a finishing layer.

According to the first aspect, the percentage of stalk pith in the bio-sourced aggregate is (as % weight on a dry basis and in increasing order of preference) > 15; ≥ 20; ≥ 30; ≥ 40; ≥ 50; ≥ 60; ≥ 70; ≥ 80; ≥ 90; ≥ 95; ≥ 99.

The construction system according to the present disclosure may be an External Thermal Insulation system – ETI – or an Internal Thermal Insulation system – ITI.

According to an example, the present disclosure relates to unitary masonry members, in particular those referred to above, preferably standardized and prefabricated, and intended to be assembled on site for the construction of the building or parts of the building, preferably walls,

characterized in that

a) each member comprises at least one wall associated with at least one hardened insulation layer,
b) the maximum thickness of the hardened insulation layer is between 1 and 60 cm,
c) the hardened insulation has a Bulk Density (BD) in kg/m^3 that is less than or equal to 450; 300; 250; 200; 150; 100; and more preferably between 50 and 300; 150 and 250;
d) this hardened insulation layer is prepared by mixing, with water, a dry composition (d) comprising:
    -A- at least one binder including:
        · -Al- at least one hydraulic or air binder;
        · -A2- possibly at least one water retention agent;
        · -A3- possibly at least one surfactant;
    -B- at least one biosourced aggregate based on sunflower stalk and/or corn stalk and/or rape stalk, having a Bulk Density (BD) in kg/m^3 that is less than 110; preferably between 10 and 80;
e) this composition having a ratio of A/B [mass of dry binder -A- in kg] / [mass of dry filler -B- in kg] comprised between – in increasing order of preference – 1 and 15; l and 10; 1 and 8; 1 and 6.

According to another example, the invention relates to a dry composition (d) which is particularly useful in the system according to the invention, containing at least one bio-sourced aggregate B based on sunflower stalks and/or corn stalks and/or rape stalks having a Bulk Density (BD) in kg/m^3 that is less than 110; preferably between 10 and 80; the BD being defined according to method M1.

After mixing with water, this dry composition can form a wet composition suitable for use in conventional processes of the construction trades, namely pumping, spraying onto a vertical, inclined, or even horizontal (on the floor or raised) substrate, casting in a mold or

formwork or pouring to create a screed on a floor, and doing so without losing the desired insulating character of the insulation layer comprised in the construction system according to the invention.

According to another example, the present disclosure relates to a kit separately comprising packaging containing a bio-sourced aggregate B as referred to above and packaging containing a binder A as referred to above, as well as instructions for using the kit to manufacture hardened insulation layers, in the construction system according to the invention.

Another aspect of the invention relates to a method for manufacturing the construction system according to the first aspect, characterized in that it consists essentially of:

(i) mixing the binder A, the bio-sourced aggregate B, and the water, the water and the aggregate B preferably being premixed, the binder A then being incorporated into the premix so obtained in order to obtain a wet hardenable composition; preferably in a mass ratio of water to A comprised between 0.8 and 5, preferably between 1 and 4, more preferably between 1.5 and 3.5;

(ii) shaping the wet composition to obtain a layer;

(iii) allowing this layer to dry in order to obtain a hardened insulation layer.

Definitions

Throughout this present description, any use of the singular indiscriminately denotes the singular or the plural.

The definitions given below as examples may be used in interpreting the present description:

- "*construction system*":
  - A structure that is prefabricated or manufactured on site by application of the wet composition of concrete or mortar, onto horizontal surfaces by spreading, onto vertical surfaces by spraying,
  - A structure that is prefabricated or manufactured on site by pouring and casting this wet composition in molds or formwork;
  - Or unitary construction members for buildings, such as cinder blocks, quarry stone, bricks, concrete blocks, etc., these members being generally standardized and prefabricated and intended for the construction of walls, ceilings, or floors.

- "*dry composition*": a mixture of biosourced powders and aggregates which may contain powdered aggregates of inorganic origin, intended to be mixed with water in order to obtain a hardened insulation after drying and curing.

The powders and in particular the bio-sourced aggregates covered by the term "*dry composition*" may contain residual amounts of water which do not affect the properties of the "*dry composition*", for example its flow properties, or the properties of the hardened insulation, for example its durability.

The designation "*dry composition*" is defined here in contrast to the designation "*wet composition*" which refers to the composition obtained by mixing the "*dry composition*" with water.

- "*stalk*" means the stem or stalk of the plant constituting the raw material of the bio-sourced aggregates, this stalk consisting of the skin and a core formed by the pith. The appended FIG. 8 shows a cross-sectional view of a sunflower stalk T in

the left photo. The darker peripheral part is the skin (E) and the lighter central part is the pith (M).

- "*pith*" of the "*stalk*": core of the stalk, having a BD that is less than 60 kg/m^3.
- "*skin*" of the "*stalk*": consisting of everything that is not pith in the stalk, the skin has a BD > 110 kg/m^3.
- "*pith particles*": non-acicular (roughly spherical) or acicular particles having a BD < 60 kg/m^3. The photo on the right in FIG. 8 and the left side of the photo of FIG. 9 show particles of sunflower pith. The right side of FIG. 9 shows non-acicular particles of corn pith. FIG. 10B shows acicular particles of rape pith.
- "*skin particles*": acicular particles (rods) having a BD > 110 kg/m^3. The appended FIG. 8 shows sunflower skin particles in the center photo. The appended FIG. 10A shows rape skin particles.
- "*stalk particles*" comprise skin particles (rods) and pith particles.
- The particle "*size*" of the bio-sourced filler (B) corresponds to the largest of the three dimensions of each particle.
- "*complete pass-through particle size*": 100% of the aggregates are smaller than the sieve.
- "*mortar*" or "concrete" indiscriminately refers to a dry or wet or hardened mixture of one or more organic and/or inorganic binders, fillers of inorganic and/or plant origin, and possibly fillers and/or additives and/or admixtures;
- "*insulating*" mortar: refers to a T grade mortar, "mortar for thermal insulation coating" according to EN 998-1 or a concrete forming a layer for which the thermal conductivity λ, measured after *complete drying* according to the hot plate method, reference NF EN 12664, is less than or equal to – in W/mK and in increasing order of preference – 0.2; 0.15; 0.12; 0.1; 0.08; 0.07;
- "*complete drying*" means stabilization of the mass of the hardened mortar at plus or minus 3%, over 24 hours, for a storage at 50% relative humidity;
- A particulate filler has a size less than or equal to X mm if its d90 is less than or equal to X mm; The term "d90" refers in this description to the particle size criterion where 90% of the particles are smaller than "*d90*". The particle size is measured by sieving according to the EN 12192-1 standard;
- "*about*" or "substantially" means within plus or minus 10%, or even plus or minus 5%, relative to the unit of measurement used;
- "*polymer*" indiscriminately means "*homopolymer*" and "*copolymer*" and/or a mixture of polymers;
- "*between Z1 and Z2*" means that one and/or other of the end values Z1, Z2 is or is not included in the interval [Z1, Z2].
- "wall" being understood as comprising ceilings and floors.

CLAIMS

1. Multilayer and insulating construction system for a building, characterized in that
   a) this system comprises at least one wall associated with at least one hardened insulation layer,
   b) the maximum thickness of the hardened insulation layer is between 1 cm and 60 cm,
   c) the hardened insulation has a Bulk Density (BD) in kg/m^3 that is less than or equal to 450; 300; 250; 200; 150; 100; and more preferably between 50 and 300; 150 and 250;
   d) this hardened insulation layer is prepared by mixing, with water, a dry composition (d) comprising:
      -A- at least one binder including:
         · -Al- at least one hydraulic or air binder;
         · -A2- possibly at least one water retention agent;
         · -A3- possibly at least one surfactant;
      -B- at least one bio-sourced aggregate based on sunflower stalk and/or corn stalk and/or rape stalk, having a Bulk Density (BD) in kg/m^3 that is less than 110; preferably between 10 and 80 wherein a percentage of stalk pith in the bio-sourced aggregate is (as % weight on a dry basis and in increasing order of preference) > 15; ≥ 20; ≥ 30; ≥ 40; ≥ 50; ≥ 60; ≥ 70; ≥ 80; ≥ 90; ≥ 95; ≥ 99;
   e) this composition having a ratio of A/B [mass of dry binder -A- in kg] / [mass of dry filler -B- in kg] comprised between – by increasing order of preference – 1 and 15; l and 10; 1 and 8; 1 and 6.

2. System according to claim 1, wherein it is in the form of prefabricated members intended to be assembled on site for the construction of the building or is manufactured on site for the construction of the building.

3. System according to claim 1, wherein it is in the form of unitary masonry members, preferably standardized and prefabricated, intended to be assembled on site for the construction of the building or parts of the building, preferably walls.

4. System according to at least one of the preceding claims, wherein the hardened insulation layer is interposed between the associated wall and at least one other wall and/or at least one other layer of a material different from the hardened insulation, this other wall and/or this other layer possibly being a finishing wall or a finishing layer.

5. System according to claim 1 or 2, wherein the hardened insulation layer has a thermal conductivity λ that is less than 0.09 W/mK; preferably less than or equal to 0.085 W/mK.

6. System according to claim 1 or 2, wherein the bio-based aggregate consists of stalk particles which have a complete pass-through particle size in the largest dimension of said particles (in increasing order of preference) ≤15 mm; ≤14 mm; ≤13 mm; ≤12 mm; ≤11 mm.

7. System according to claim 3 or 4, wherein the pith is in the form of particles having a form factor F, defined as the ratio of the largest dimension of the particles to the smallest dimension, such that $F \leq 3$; preferably $F \leq 2.5$.

8. System according to at least one of the preceding claims, wherein the binder Al is selected from the group comprising – ideally consisting of – cements, air lime, hydraulic lime, slags, geopolymers, metakaolins, binders with a high content of cementitious phases rich in alumina, natural pozzolans, sodium silicates, potassium silicates, lithium silicates, organic binders, and mixtures thereof alone or in combination;
the cements being advantageously selected from the group consisting of – ideally composed of – Portland cements, fly ash Portland cements, pozzolanic Portland cements, pyrogenic silica Portland cements, masonry cements, quick-setting natural cements, expanding cements, mixed white cements, colored cements, finely ground cements, lime-pozzolana cements, supersulfated cements, calcium sulfoaluminate (CSA) cements, calcium aluminate cements (CAC), natural cements, lime, and mixtures thereof used alone or in combination.

9. System according to at least one of the preceding claims, wherein the binder A comprises – as % weight/weight on a dry basis and in increasing order of preference:

- -Al- binder: [5 - 95]; [10 - 85]; [15 - 75];
- -A2- water retention agent: [0.1 - 5]; [0.5 - 3]; [0.8 - 2];
- -A3- surfactant [0 - 2]; [0.01 - 1]; [0.05 - 0.5];
- -A4- secondary binder [0 - 85]; [5 - 50]; [7 - 15];
- -A5- inorganic lubricating filler having a particle size d90 that is less than 100µm: [0 - 40]; [0 - 30]; [0 - 20];
- -A6- inorganic spacer filler having a particle size d90 that is greater than or equal to 100µm: [0 - 40]; [0 - 35]; [0 - 30];
- -A7- water-repellent admixture: [0 - 1.5]; [0 - 1]; [0 - 0.5];
- -A8- set retardant admixture: [0 - 3]; [0 - 2]; [0 - 1];
- -A9- set accelerator admixture: [0 - 3]; [0 - 2]; [0 - 1];
- -A10- thickening admixture: [0 - 2]; [0.1 - 1]; [0.2-0.8].

10. System according to at least one of the preceding claims, wherein it is an External Thermal Insulation system -ETI- or an Internal Thermal Insulation system -ITI-.

11. Method for manufacturing the construction system according to at least one of the preceding claims, characterized in that it consists essentially of:

(i) mixing the binder A, the bio-sourced aggregate B, and the water, the water and the aggregate B preferably being premixed, the binder A then being incorporated into the premix so obtained in order to obtain a wet hardenable composition; preferably in a mass ratio of water to A comprised between 0.8 and 5, preferably between 1 and 4, more preferably between 1.5 and 3.5;

(ii) shaping the wet composition to obtain a layer;

(iii) allowing this layer to dry in order to obtain a hardened insulation layer.

12. Method according to claim 11, characterized in that the shaping (ii) is carried out by spraying the wet composition on a substrate formed by a wall of the construction system and/or by pouring into a mold possibly formed by one or more component members of the construction system, this member or at least one of these members being the wall associated with the hardened insulation layer of the construction system.

13. Method according to claim 11 or 12, wherein the shaping (ii) is achieved

- by spraying the wet composition:
  → on a vertical or inclined substrate,
  → or to fill a wood or metal framework structure on site,
  → or to create prefabricated building members;
  or
- by pouring or spraying and spreading the wet composition on a horizontal plane on the floor to create a screed or by spraying the wet composition on a raised horizontal plane to create a ceiling;
  or
- by pouring the wet composition into a formwork to create a wall, to fill between two walls with wet composition, or pouring into a mold to create prefabricated unitary masonry members, in particular blocks, cinder blocks, bricks, or precast wall elements or panels.