

Composition for the production of concrete, in particular porous lightweight concrete and high-performance concrete, of mortar, self-levelling screed and filler, and methods for their manufacture and uses

5 Technical Field of the Invention

The present invention relates to a composition for the production of concrete, in particular porous lightweight concrete and high-performance concrete, mortar, in particular 3D printing mortar, self-levelling screed and filler, as well as a method for the manufacture of this composition and its use. The
10 concrete is in particular porous lightweight concrete, also referred to as foam concrete. The composition of the composition is in particular individually adaptable to the ambient temperatures of the composition. Likewise, in the methods according to the invention for the manufacture of these compositions, the quantities of the individual components are in particular
15 individually adapted to the ambient temperatures.

Prior Art

The compositions known from the prior art generally do not take into account the outdoor temperatures prevailing on the construction site and the ambient
20 temperatures prevailing within a building's shell.

It was therefore an object of the present invention to provide a composition for which this is possible, as well as a method for its manufacture.

25 Furthermore, conventional porous lightweight concrete has a maximum wet density of 500 kg/m³. It was therefore a further object of the invention to provide a porous lightweight concrete having a wet density of up to 1250 kg/m³.

30 Description of the Invention

This object is achieved by a composition for the production of concrete, in particular for the production of high-performance concrete and porous

lightweight concrete, of mortar, in particular of 3D printing mortar, of self-levelling screed or of filler, comprising the following components:

- i) a pulverous main component selected from CEM I cement, CEM II cement, sand, quartz sand and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand and mixtures thereof;
- ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
- iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents;
- iv) at least one liquid ancillary component selected from retarders, liquefiers and shrinkage reducers;
- v) optionally, at least one liquid foaming agent; and
- vi) water;

wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total weight of cement in the composition; and

wherein the composition has a wet density in the range of from 100 to 1250 kg/m³ for porous lightweight concrete, a wet density in the range of from 1900 to 2600 kg/m³ for concrete including high-performance concrete, a wet density in the range of from 1800 to 2200 kg/m³ for 3D printing mortar, a wet density in the range of from 2000 to 2400 kg/m³ for self-levelling screed and a wet density in the range of from 1800 to 2200 kg/m³ for filler;

with the proviso that the pulverous main component i) for the composition for the production of porous lightweight concrete is selected from CEM I cement, CEM II cement and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement and mixtures thereof.

This means that, in contrast to mortar, in particular 3D printing mortar, self-levelling screed and filler, the composition for the production of porous lightweight concrete contains no sand or quartz sand.

- 5 The invention is therefore directed to a composition for the production of porous lightweight concrete comprising the following components:
- i) a pulverous main component selected from CEM I cement, CEM II cement and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement and mixtures thereof;
 - 10 ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
 - iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents;
 - iv) at least one liquid ancillary component selected from retarders and
 - 15 liquefiers;
 - v) at least one liquid foaming agent; and
 - vi) water;

wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total weight of cement in the composition; and

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wherein the composition has a wet density in the range of from 100 to 1250 kg/m³.

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In particularly preferred embodiments, the porous lightweight concrete according to the invention may additionally comprise the following further components:

- The optional further second ancillary component iii) may be selected
- 30 from glass fibres, iron oxide powders and coloring agents, as well as graphite powder, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl

acetates, poly(ethylene-vinyl acetate)s and poly(organo)siloxanes (so-called silicones).

The composition for the production of concrete, in contrast to the

- 5 composition for the production of porous lightweight concrete, contains no foaming agent.

The invention is therefore also directed to a composition for the production of concrete, including high-performance concrete, comprising the following

10 components:

- i) a pulverous main component selected from CEM I cement, CEM II cement, sand, quartz sand and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand and mixtures thereof;
- 15 ii) optionally, a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
- iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents;
- iv) at least one liquid ancillary component selected from retarders and
- 20 liquefiers; and
- vi) water;

wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total weight of

25 cement in the composition; and

wherein the composition has a wet density in the range of from 1900 to 2600 kg/m³.

- 30 A particular feature of the compositions according to the invention is that the composition thereof can in each case be individually adapted to the ambient temperatures of the respective composition.

In this context, the further second ancillary component iii) may additionally be selected from graphite powders, fly ashes, silicon dioxides, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(organo)siloxanes (so-called
5 silicones).

The invention also relates to a composition for the production of mortar, in particular 3D printing mortar, comprising the following components:

- i) a pulverous main component selected from CEM I cement, CEM II cement,
10 sand, quartz sand, and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand, and mixtures thereof;
- ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement, and mixtures thereof;
- 15 iii) optionally,, a further second ancillary component selected from glass fibres, iron oxide powders, and coloring agents;
- iv) at least one liquid ancillary component selected from the group of retarders and shrinkage reducers; and
- vi) water;

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wherein the quantity of retarder is in the range of from 0.05 to 2.00 weight-%, based on the total weight of cement in the composition; and

wherein the composition has a wet density in the range of from 1800 to 2200
25 kg/m³.

In this context, the further second ancillary component iii) may additionally be selected from graphite powders, fly ash, silicon dioxides, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl
30 acetates, poly(ethylene-vinyl acetate)s, and poly(organo)siloxanes (so-called silicones). In particular, it is selected from glass fibres, iron oxide powders and

coloring agents, as well as poly(organo)siloxanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s, and polyurethanes.

The invention further relates to a composition for the production of self-

5 levelling screed, comprising the following components:

i) a pulverous main component selected from CEM I cement, CEM II cement, sand, quartz sand, and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand, and mixtures thereof;

10 ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement, and mixtures thereof;

iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders, and coloring agents;

iv) at least one liquid ancillary component selected from retarders and

15 liquefiers; and

vi) water;

wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total weight of

20 cement in the composition; and

wherein the composition has a wet density in the range of from 2000 to 2400 kg/m³.

25 In this context, the further second ancillary component iii) may additionally be selected from graphite powders, fly ash, silicon dioxides, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s, and poly(organo)siloxanes (so-called silicones). In particular, it is selected from glass fibres, iron oxide powders and

30 coloring agents, as well as poly(organo)siloxanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s, and polyurethanes.

The invention further relates to a composition for the production of filler, comprising the following components:

- i) a pulverous main component selected from CEM I cement, CEM II cement, sand, quartz sand, and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand, and mixtures thereof;
 - ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement, and mixtures thereof;
 - iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders, and coloring agents;
 - iv) at least one liquid ancillary component selected from retarders and liquefiers; and
 - vi) water;
- wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total weight of cement in the composition; and

wherein the composition has a wet density in the range of from 1800 to 2200 kg/m³.

In this context, the further second ancillary component iii) may additionally be selected from graphite powders, fly ash, silicon dioxides, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s, and poly(organo)siloxanes (so-called silicones). In particular, it is selected from glass fibres, iron oxide powders and coloring agents, as well as poly(organo)siloxanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s, and polyurethanes.

The wet density is also referred to as bulk density.

The distinctive feature of the composition according to the invention is that it can be produced in situ at an ambient temperature of the composition of from 0°C to 50°C, and/or that the individual quantities of the liquid ancillary components iv) are adapted to the ambient temperatures of the

5 composition, and/or that the individual quantities of the liquid components iv) can be metered with an accuracy of at least 5% of the total quantity used, preferably at least 2% of the total quantity used, more preferably at least 1% of the total quantity used. This applies both to the liquefier(s) and to the retarder(s).

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The term "cement" herein encompasses the pulverous main component and the first pulverous ancillary component, insofar as these are cement, i.e. the term "cement" encompasses CEM I cement, CEM II cement, CSA cement, calcium aluminate cement, and mixtures thereof. In particular, the term

15 "cement" encompasses 52.5 R cement, 42.5 R cement, 32.5 R cement, CSA cement, calcium aluminate cement, and mixtures thereof.

In a preferred embodiment of the compositions according to the invention, components i) to v) account for at least 90 weight-% of all components

20 present in the compositions according to the invention, excluding water. That means, based on the total weight of the components i) to v), a maximum of 10 weight-%, preferably a maximum of 7 weight-%, more preferably a

maximum of 5 weight-%, of further components may be present. Such further components include, for example, fly ash, lime (CaO , $\text{Ca}(\text{OH})_2$, CaCO_3),

25 limestone powder, pozzolans, kaolin, silica, in particular SiO_2 , hydroxyapatite ($\text{Ca}_5[\text{OH}/(\text{PO}_4)_3]$), tricalcium phosphate, gypsum, sand, tuff, trass, rock

powder, silica dust, silica suspension, blast furnace slag powder, limestone

powder, quartz powder, and further additives known to the skilled person for concrete, in particular for aerated lightweight concrete, for mortar, for 3D

30 printing mortar, for self-levelling screed, or for filler.

In a further preferred embodiment of the compositions according to the invention, the composition contains no components other than components i) to vi).

- 5 The individual components are now described in detail below.

The so-called common cements and their requirements are described in DIN EN 197-1. CEM I cements have a clinker content of at least 95%, whereas CEM II cements may contain up to 20% auxiliary components. R cements are
 10 cements that have high early strength and rapid strength development. 42.5 R cement, also known under the term "CEM II cement" or "A-S 42.5 R cement", is a cement of strength class 42.5 R which may be produced by jointly grinding Portland cement clinker, blast-furnace slag and gypsum. Instead of blast-furnace slag, other latent hydraulic constituents, such as fly
 15 ash or pozzolans, may be included. 52.5 R cement, also referred to as "CEM I 52.5 R cement", is a cement of strength class 52.5 R which is produced by grinding Portland cement clinker and gypsum. Portland cements are based on calcium silicates, whereas CSA cements are based on calcium sulfoaluminates and the raw materials limestone, bauxite and gypsum.

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Clay cement is described in DIN EN 14647. Clay is the term for aluminum oxide. Clay cement may, for example, be produced by slow cooling of melts having a monocalcium aluminate composition or by sintering correspondingly composed raw material mixtures of limestone and the
 25 aluminum ore bauxite (also as white cement). In contrast to silicate cements, it consists essentially of monocalcium aluminate (CA), for which reason the term *calcium aluminate cement* is also commonly used. Essential constituents in more lime-rich clay cements are $C_{12}A_7$ and, in more lime-poor grades, CA_2 . The SiO_2 content is either bound as C_2S or as C_2AS (gehlenite). The
 30 solidification and hardening are based on the formation of calcium aluminate hydrates, whereas silicate cements harden by forming calcium silicate hydrates (CSH). Clay cement hydrates considerably faster than

Portland cement, binds approximately twice as much water and releases virtually no Ca(OH)_2 . Clay-rich clinker is a slag with a high clay content that has been finely ground. Commercially, calcium aluminate cement is available, for example, under the term "Ciment Fondu".

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In a preferred embodiment, the pulverous main component i) is 52.5 R cement or 42.5 R cement, or a mixture thereof, preferably the pulverous main component i) is 52.5 R cement, and the first pulverous ancillary component ii) is CSA cement or calcium aluminate cement, or a mixture thereof, preferably
 10 the first pulverous ancillary component ii) is CSA cement, in particular when the composition is a composition for the production of porous lightweight concrete.

In a further preferred embodiment, the weight ratio of component i) to
 15 component ii) is in the range of from 10 : 1 to 1 : 1, preferably in a range of from 5 : 1 to 1.2 : 1, and more preferably in a range of from 4 : 1 to 1.3 : 1, preferably when component i) is CEM I cement and component ii) is CSA cement, more preferably when component i) is 52.5 R cement and component ii) is CSA cement.

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When a composition for the production of porous lightweight concrete is used, in which the component i) is CEM I cement, in particular 52.5 R cement, and the component ii) is CSA cement, their processability may be extended to outdoor temperatures of -10°C , when the CSA cement is at least partially
 25 replaced by calcium aluminate cement, preferably when the CSA cement is replaced in the range of from 30 to 70 weight-%, more preferably in the range of from 20 to 80 weight-%, most preferably in the range of from 10 to 100 weight-%, by calcium aluminate cement.

30 The same effect can also be achieved in compositions for the production of self-levelling screed, of 3D printing mortar or of filler, when the CSA cement is at least partially replaced by calcium aluminate cement, preferably when

the CSA cement is replaced in the range of from 30 to 70 weight-%, more preferably in the range of from 20 to 80 weight-%, and most preferably in the range of from 10 to 100 weight-%, by calcium aluminate cement.

- 5 If the composition is a composition for the production of porous lightweight concrete, the total quantity of cement in kilogram in the composition is preferably in the range of from 35 to 80%, preferably in the range of from 40 to 75%, of the wet density expressed in kg/m³.
- 10 The cement content in porous lightweight concrete, based on the total weight of the composition, is preferably in the range of from 42 kg per 100 kg of composition at a wet density of 100 kg/m³ to 920 kg per 1250 kg of composition at a wet density of 1250 kg/m³.
- 15 Sand is a naturally occurring unconsolidated sediment composed predominantly of mineral grains having a particle size of 0.063 to 2 mm. The term "sand" is not dependent on its mineral composition. However, most sands consist predominantly of quartz grains. Especially such quartz sand is an important raw material for the construction industry and is also used in the
- 20 compositions according to the invention for the production of self-levelling screed, 3D printing mortar and filler.

- The composition for the production of 3D printing mortar preferably has a weight ratio of sand to the total quantity of cement in the range of from 3 : 1
- 25 to 1.5 : 1, more preferably in the range of from 2.8 : 1 to 2.0 : 1, most preferably in the range of from 2.6 : 1 to 2.2 : 1. The cement used is preferably a mixture of CEM I cement and CSA cement or a mixture of CEM II cement and CSA cement, more preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement or a mixture of 32.5 R
 - 30 cement and CSA cement, most preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement, wherein the

CSA cement can be replaced by calcium aluminate cement in an amount of 50-100 weight-%.

The composition for the production of filler preferably has a weight ratio of sand to the total quantity of cement in the range of from 2.5 : 1 to 1.0 : 1, more preferably in the range of from 2.0 : 1 to 1.2 : 1, most preferably in the range of from 1.8 : 1 to 1.3 : 1. The cement used is preferably a mixture of CEM I cement and CSA cement or a mixture of CEM II cement and CSA cement, more preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement or a mixture of 32.5 R cement and CSA cement, most preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement, wherein the CSA cement can be replaced by calcium aluminate cement in an amount of 50-100 weight-%. A certain proportion of the cement can also be replaced by fillers known to the person skilled in the art, in particular a proportion of up to 30 weight-%, preferably a proportion in the range of from 5 to 15 weight-%, based on the total weight of the cement.

The composition for the production of self-levelling screed preferably has a weight ratio of sand to the total quantity of cement in the range of from 4 : 1 to 2.0 : 1, more preferably in the range of from 3.5 : 1 to 2.2 : 1, most preferably in the range of from 3.0 : 1 to 2.4 : 1. The cement used is preferably a mixture of CEM I cement and CSA cement or a mixture of CEM II cement and CSA cement, more preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement or a mixture of 32.5 R cement and CSA cement, most preferably a mixture of 52.5 R cement and CSA cement or a mixture of 42.5 R cement and CSA cement, wherein the CSA cement can be replaced by calcium aluminate cement in an amount of 50-100 weight-%.

The second pulverous ancillary component iii) is in particular selected from glass fibres, iron oxide powders, and coloring agents, which are described in more detail below.

- 5 As glass fibres in particular alkali-resistant glass fibres are used. These can in particular replace the asbestos used previously. Even at a glass fibre content of 0.4 volume-%, the service properties of, for example, concrete, in particular of porous lightweight concrete, are significantly improved, since crack formation is reduced. Glass fibres are in particular added in order to produce structural components with special requirements with regard to impermeability, such as, for example, self-levelling screed. Since glass fibre does not rust, no minimum concrete cover or minimum porous lightweight concrete cover is required for structural components having a glass fibre content of 2.5 to 5 volume-% and containing no further metallic reinforcement, so that the minimum thickness can be reduced to a few millimeters, and thus extremely filigree shapes can be produced.

The quantity of glass fibre is preferably in the range of from 0.1 to 1.5 weight-%, based on the total quantity of sand and cement, more preferably in the range of from 0.2 to 1.2 weight-%, most preferably in the range of from 0.3 to 1.05 weight-%.

The iron oxide powder comprises both artificially produced iron oxide pigments and iron oxide powders obtained by grinding corresponding iron ores such as, for example, hematite, limonite, goethite or magnetite. The term "iron oxide powder" furthermore comprises iron oxide red, also called Mars red, which consists of Fe_2O_3 , iron oxide yellow, also called Mars yellow, which is composed of $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ or FeOOH , as well as iron oxide black, also called Mars black, which predominantly contains Fe_3O_4 .

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Any coloring substance known to the person skilled in the art can be used as the coloring agent which is suitable for coloring, preferably permanently

coloring, concrete, in particular porous lightweight concrete, mortar, in particular 3D printing mortar, self-levelling screed and filler, such as, for example, earth colours. Earth colours are inorganic pigments. They are obtained by grinding coloured minerals or mineral mixtures. In individual cases, the colour can be changed by firing. Thus, yellow ochre becomes red when heated. Frequently used earth colours are ochre, green earth, red ochre, terra di Siena, umber, chalk and cinnabar. The iron oxide pigments and the other coloring agents can also be metered in liquid form, in particular as an aqueous suspension.

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The total quantity of iron oxide powders and coloring agents is preferably in the range of from 0.5 to 7 weight-%, based on the quantity of R cement, that is, based on the quantity of 52.5 R cement or 42.5 R cement, more preferably in the range of from 0.8 to 6 weight-%, most preferably in the range of from 1 to 5 weight-%. The iron oxide can also be used as an aqueous dispersion as described, for example, in paragraphs [0013] and [0014] of DE 603 11 180 T2. The coloring agents can likewise be used as an aqueous dispersion.

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The second pulverous ancillary component iii) can in particular additionally be selected from graphite powder, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(organo)siloxanes, which are described in more detail below.

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The graphite powder is used in the compositions according to the invention in particular in a quantity in the range of from 1 to 20 or 1 to 15, preferably in the range of from 5 to 15 or 5 to 12 weight-%, more preferably in the range of from 8 to 12 weight-%, most preferably about 10 weight-%, based on the total weight of cement.

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Fly ash is understood to mean silica-rich or lime-rich, dust-like combustion residues from pulverised coal that are produced during the cleaning of flue

gases from steam generators in coal-fired power plants. Certain fly ashes are suitable as concrete additives, which contain at least two thirds vitreous particles and consist essentially of reactive silicon dioxide SiO_2 and aluminum oxide Al_2O_3 as well as small proportions of iron oxide Fe_2O_3 and other oxides.

- 5 The proportion of reactive calcium oxide CaO should generally be below 5 weight-%, and the proportion of reactive silicon dioxide SiO_2 must be at least 25 weight-%. Further details are regulated in DIN EN 450 "Fly ash for concrete".

- 10 The fly ash is used in the compositions according to the invention in particular in a quantity in the range of from 1 to 10 weight-%, preferably in the range of from 2 to 7 weight-%, more preferably in the range of from 3 to 5 weight-%, based on the total weight of cement.

Non-limiting examples of plastic fibres are polypropylene fibres.

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- The plastic fibres, in particular polypropylene fibres, are used in the compositions according to the invention in particular in a quantity in the range of from 0.01 to 5 weight-%, preferably in the range of from 0.05 to 3 weight-%, more preferably in the range of from 0.1 to 1 weight-%, most
20 preferably about 0.3 weight-%, based on the total weight of the composition. In particular, polypropylene fibres having a length of 6, 9, 12, 16, 18 or 19 mm are used. The compressive load of the product obtained therewith, in particular of the porous lightweight concrete, is thereby increased, as are the tensile strength and the modulus of elasticity. Compressive loads of 400 MPa
25 are possible, a tensile strength of 300 N per mm^2 and/or a modulus of elasticity of 4000 N per mm^2 .

- The graphite powder, fly ash, silicon dioxide, quartz powder, basalt and plastic fibres are preferably admixed to the cement, while the accelerators,
30 viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(organo)siloxanes are preferably metered into the water.

It is also possible to admix the polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and/or poly(organo)siloxanes during foam production for the production of porous lightweight concrete to the water used for foam production. In this case, they are preferably added to the

5 water in a quantity in the range of from 0.5 to 10 weight-%, more preferably in a quantity in the range of from 1.0 to 5.0 weight-%, based on the weight of the water.

Conventional hardening accelerators are used as accelerators, such as those

10 commercially available, for example, from Mapei S.P.A., Italy, under the name DYNAMON HAA.

Conventional viscosity modifiers are used as viscosity modifiers, such as those commercially available, for example, from Mapei S.P.A., Italy, under the

15 name VISCOSTAR 3K.

Suitable poly(organo)siloxanes (so-called silicones) are, for example, the so-called SILRES® powders, which are commercially available from Wacker Chemie AG (Munich, Germany). A preferred poly(organo)siloxane is, for

20 example, SILRES® Powder A, which is commercially available from Wacker Chemie AG. However, liquid poly(organo)siloxanes can also be used.

Likewise, silane-based additives can also be used, such as those marketed by the Chinese company Henan Botai Chemical Building Material Co., Ltd. for example under the trademark BOTAI HP-70. These additives contribute to the

25 hydrophobisation of the concrete or of the porous lightweight concrete. The same effect can also be achieved by corresponding polyurethanes, polyvinyl acetates and poly(ethylene-vinyl acetate)s known to the person skilled in the art.

The poly(organo)siloxane is used in the compositions according to the invention in particular in a quantity preferably in the range of from 0.001 to 2.0 weight-%, preferably in the range of from 0.01 to 1.0 weight-%, more

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preferably in the range of from 0.05 to 0.5 weight-%, most preferably in the range of from 0.2 to 0.4 weight-%, based on the total weight of the pulverous components of the composition and based on the total weight of cement, respectively. The same preferred quantities also apply to the polyurethanes,
 5 polyvinyl acetates and poly(ethylene-vinyl acetate)s.

The poly(organo)siloxane is usually admixed directly to the water in the required quantity, preferably in a quantity in the range of from 0.5 to 5 weight-%, more preferably in a quantity in the range of from 1.0 to 4 weight-%, most
 10 preferably in a quantity in the range of from 1.5 to 3.0 weight-%, based on the weight of the water, or as a 10% aqueous solution, in order to ensure homogeneous mixing in the composition because of the small quantity used. By adding at least one poly(organo)siloxane, an elastic product is obtained, such as, for example, an elastic porous lightweight concrete. The same effect
 15 can also be achieved with polyurethanes, polyvinyl acetates and/or poly(ethylene-vinyl acetate)s known to the person skilled in the art for this purpose.

In the preferred embodiments disclosed above of the composition according
 20 to the invention for porous lightweight concrete, in which the pulverous main component i) is 52.5 R cement or 42.5 R cement or a mixture thereof and the first pulverous ancillary component ii) is CSA cement or calcium aluminate cement or a mixture thereof, graphite powder is preferably admixed. The quantity of graphite powder in this embodiment is advantageously in the
 25 range of from 1 to 20 weight-%, preferably in the range of from 5 to 15 weight-%, more preferably in the range of from 8 to 12 weight-%, most preferably about 10 weight-%, based on the total quantity of 52.5 R cement, 42.5 R cement or a mixture thereof.

30 The composition for the production of concrete, 3D printing mortar, self-levelling screed and filler can also preferably contain the graphite powder, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerator, viscosity

modifier, polyurethane, polyvinyl acetate, poly(ethylene-vinyl acetate) and/or poly(organo)siloxane in the quantities indicated above.

5 The at least one liquid ancillary component iv) is selected from retarders and liquefiers. The at least one liquid ancillary component iv) can preferably be metered with an accuracy of 2-3%.

10 According to DIN EN 934-2, retarders are concrete additives, in particular also for porous lightweight concrete, which extend the time until the beginning of the transition of the mixture from the plastic state to the solid state. Retarders are compounds that can bind calcium ions as chelates.

15 Examples of retarders are phosphonic acid derivatives having hydroxy or amino groups as disclosed, for example, on page 2, lines 40-49 of DE 40 38 147, hydroxycarboxylic acids and their salts, such as salicylic, citric, lactic, gluconic, tartaric, muconic and glucoheptanoic acid; polycarboxylic acids and their salts, such as maleic, fumaric, itaconic, malonic, succinic and phthalic acid, as well as polymaleic, polyfumaric, polyacrylic and polymethacrylic acids, preferably with low molecular weight; antioxidants
20 such as ascorbic acid and isoascorbic acid; polymers such as sulphonic acid-containing acrylic polymers and polyhydroxysilanes, preferably with low molecular weight; aldoses and ketoses, respectively, such as sugars and corn syrup, as well as lignosulphonates such as calcium lignosulphonate.
Furthermore, inorganic (phosphates, borates) or organic (EDTA, NTA)
25 complexing agents and zeolites are suitable. In the compositions according to the invention, retarders are used which are liquid at a temperature of from -3 to +50°C. Particularly preferred retarders are citric acid, tartaric acid and acetic acid, and mixtures thereof, as well as retarders commercially available from the company Mapei S.P.A., Italy. Most particularly preferred is Mapetard
30 VZ/Mapetard D from the company Mapei S.P.A., Italy. Mapetard SD2000 and Mapetard D, both likewise from the company Mapei S.P.A., Italy, can also be used as retarders.

The quantity of retarder is added as a function of the temperature.

Depending on the composition, retarder is preferably used in a quantity of from 0.05 to 0.55 weight-% at an outside temperature of 0°C on the

5 construction site. Depending on the composition, particularly preferably either 0.1 or 0.5 weight-% of retarder, based on the total weight of cement, is added to the composition at an outside temperature of 0°C. Preferably, with each temperature increase of 1 K, 0.02 weight-% more retarder is added, so that, depending on the composition, either 1.1 or 1.5 weight-% retarder is
10 added at 50°C. This means that the quantity of retarder is preferably in the range of from 0.1 to 1.5 weight-%, based on the total weight of cement. As a result, processing of the composition can take place within approximately the same period of time irrespective of the outside temperature.

15 Examples of liquefiers are plasticizers such as the products of the reaction of polycarbonate polymers with monofunctional polyethers, as disclosed, for example, in WO 2011/076655 of Mapei S.P.A. Mapefluid R440 from the company Mapei S.P.A., Italy, is preferably used as liquefier.

20 The quantity of liquefier depends on the wet density. In general, less liquefier is added at higher wet densities. More liquefier is added in compositions having high flowability. Preferably, the liquefier is added in a quantity of from 0.4 to 1.7 weight-% at a wet density in the range of from 100 to 400 kg/m³, in a quantity of from 0.2 to 1.2 weight-% at a wet density in the range of from 400
25 to 800 kg/m³, and in a quantity of from 0.2 to 0.9 weight-% at a wet density in the range of from 800 to 1250 kg/m³; more preferably, the liquefier is added in a quantity of from 0.45 to 1.6 weight-% at a wet density in the range of from 100 to 400 kg/m³, in a quantity of from 0.25 to 1.1 weight-% at a wet density in the range of from 400 to 800 kg/m³, and in a quantity of from 0.25 to 0.8
30 weight-% at a wet density in the range of from 800 to 1250 kg/m³; most preferably, the liquefier is added in a quantity of from 0.5 to 1.5 weight-% at a wet density in the range of from 100 to 400 kg/m³, in a quantity of from 0.3 to

1.0 weight-% at a wet density in the range of from 400 to 800 kg/m³, and in a quantity of from 0.3 to 0.75 weight-% at a wet density in the range of from 800 to 1250 kg/m³.

- 5 In some compositions, the liquefier also depends on the outside temperature at which the composition is processed. Here, as with the retarder, starting from an initial value which depends on the composition and its intended use, 0.02 weight-% more liquefier is added for each temperature increase of 1 K.
- 10 It is a distinctive feature of the method for the manufacture of the composition described further below that the retarder and the liquefier can be metered with an accuracy of 0.02 weight-%, wherein the deviation depending on the metering pump is only 2-3% of this value.
- 15 Examples of liquid foaming agents v) are organic surfactants, which are in particular liquid at a temperature in the range of from -3 to 50°C. Such products are marketed, for example, by the companies Mapei S.P.A. (Italy) and Sika AG (Switzerland) under the trade names Mapeair LA/L and Sika® Lightcrete-400. Mapeair LA/L from the company Mapei S.P.A., Italy, is
20 preferably used as the foaming agent.

The quantity of liquid foaming agent is in particular in the range of from 10 to 50 g per 1 liter of water, preferably in the range of from 20 to 40 g per 1 liter of water, more preferably in the range of from 25 to 35 g per 1 liter of water,
25 most preferably in the range of from 28 to 32 g per 1 liter of water. Here too, metering can be carried out with an accuracy of 2-3%.

The quantity of the individual components i) to vi) can be metered very accurately. Thus, in outdoor applications it is possible to adapt the
30 composition of the concrete, in particular of the porous lightweight concrete, of the mortar, in particular of the 3D printing mortar, the self-levelling screed and the filler, to the environmental conditions by mixing the individual

components with water available on site. Therefore, by determining the moisture content of the environment, the water content as well as the metering of the required individual components can be optimized accordingly. Depending on the outside temperature and the ambient
 5 temperature, the quantity of individual components is also metered and thus adapted to the outside and ambient conditions.

In the composition according to the invention, the weight ratio of water to cement is preferably in the range of from 0.2 : 1 to 0.6 : 1. For concrete, in
 10 particular for porous lightweight concrete, the weight ratio of water to cement is preferably in the range of from 0.2 : 1 to 0.4 : 1, whereas for self-levelling screed, 3D printing mortar or filler it is preferably in the range of from 0.3 : 1 to 0.55 : 1.

15 By the individual metering of the single components, it is possible to adjust various parameters such as setting behavior, flow behavior and bulk density as desired by the customer.

The features of the preferred embodiments mentioned above, including the
 20 preferred quantities, can be combined with one another as desired in one composition and are also encompassed by the present invention.

Preferred embodiments of the composition according to the invention

In a preferred embodiment of a composition according to the invention for
 25 the production of concrete, in particular for the production of porous lightweight concrete, the pulverous main component i) is 52.5 R cement and the first pulverous ancillary component ii) is CSA cement. The weight ratio of component i) to component ii) is herein preferably in the range of from 4 : 1 to 1.3 : 1. The quantity of retarder is preferably in the range of from 0.1 to 1.5
 30 weight-%, based on the total weight of cement. The liquefier is preferably added in a quantity of from 0.5 to 1.5 weight-% at a wet density in the range of from 100 to 400 kg/m³, in a quantity of from 0.3 to 1.0 weight-% at a wet

density in the range of from 400 to 800 kg/m³, and in a quantity of from 0.3 to 0.75 weight-% at a wet density in the range of from 800 to 1250 kg/m³. The quantity of liquid foaming agent is preferably in the range of from 25 to 35 g per 1 liter of water, more preferably in the range of from 28 to 32 g per 1 liter of water.

If porous lightweight concrete cubes having a nominal edge length of 150 mm are produced from this preferred composition with different wet densities, they exhibit the following properties:

Tabelle 0:

Wet density [kg/m ³]	Compressive strength after 7 days [N/mm ²]	Compressive strength after 14 days [N/mm ²]	Compressive strength after 28 days [N/mm ²]	Preferred compressive strength after 28 days [N/mm ²]
200	0.1	0.1	0.1	0.06-0.14
250	0.2	0.3	0.3	0.16-0.34
300	0.3	0.4	0.4	0.26-0.44
400	1.0	1.0	1.0	0.6-1.4
500	1.8	1.9	2.0	1.5-2.5
600	3.0	2.8	3.0	2.5-3.5
700	3.1	3.5	3.3	3.0-4.0
800	4.3	5.3	5.1	4.0-5.8
900	5.9	5.9	6.0	5.0-6.5
1000	7.1	7.0	7.5	6.6-8.0

The present invention is also directed to a method for the manufacture of the composition according to the invention, comprising the following steps:

a) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and water to form an aqueous mixture;

b) optionally introducing the at least one liquid foaming agent v) into water and mixing it with air to produce foam;
 c) introducing the further components i), ii) and iii) into a first mixer, preferably via individual, separate metering pumps, and mixing them with the aqueous
 5 mixture produced in step a) to form a slurry;
 d) further mixing the slurry produced in step c) in a second mixer, optionally whilst adding the foam produced in step c), to the composition;
 e) removing the composition from the second mixer;
 wherein the quantities of the components i) to iv) are in particular individually
 10 adapted to the ambient temperatures.

Preferably, steps a) to e) are carried out continuously, more preferably steps a) and b) are carried out continuously at the same time. However, it is also possible to carry out steps a) to e) batchwise.

15 If the composition according to the invention is a composition for the production of porous lightweight concrete, step b) is carried out, and the further mixing in step d) is carried out whilst adding the foam produced in step c).

20 The method for the manufacture of the composition according to the invention for the production of porous lightweight concrete therefore comprises the following steps:

a) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and
 25 water to form an aqueous mixture;
 b) introducing the at least one liquid foaming agent v) into water and mixing it with air to produce foam;
 c) introducing the further components i), ii) and iii) into a first mixer, preferably
 30 via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a slurry;

- d) further mixing the slurry produced in step c) in a second mixer whilst adding the foam produced in step c), to the composition;
- e) removing the composition from the second mixer.

- 5 Herein, the quantities of the components i) to iv) are in particular individually adapted to the ambient temperatures.

- The method for the manufacture of the composition according to the invention for the production of mortar, in particular 3D printing mortar, self-levelling screed and filler, therefore comprises the following steps:
- 10 a) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and water to form an aqueous mixture;
 - c) introducing the further components i), ii) and iii) into a first mixer, preferably 15 via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a slurry;
 - d) further mixing the slurry produced in step c) in a second mixer to form the composition;
 - e) removing the composition from the second mixer.

20

Here too, the quantities of the components i) to iv) are in particular individually adapted to the ambient temperatures.

- The method for the manufacture of the composition according to the invention for the production of concrete comprises the following steps:
- 25 A) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and water to form an aqueous mixture;
 - B) introducing the further components i), ii) and iii) into a first mixer, preferably 30 via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a slurry;
 - C) further mixing the slurry produced in step c) in a second mixer;

D) removing the composition from the second mixer;
wherein the quantities of the components i) to iv) are in particular individually adapted to the ambient temperatures.

5 Steps b), c) and d) are now explained in more detail:

Step b): The production of the foam from the at least one liquid foaming agent and water is preferably carried out in a foam generator in which the at least one liquid foaming agent and the water are mixed together whilst
10 adding air. In particular, the foam can also be produced in a device as described in NL-A 9302111.

Step c): The introduction of the components i), ii) and iii) into the first mixer, preferably into a continuous mixer, is preferably carried out via a rotary valve
15 into a pump funnel and subsequent transport via a downstream screw conveyor. The rotary valve is advantageously equipped with two probes in order to be able to meter the quantities of the components i), ii) and iii). Thus, one probe switches off the rotary valve when a certain upper filling level is reached, and another probe switches the rotary valve on again when a
20 certain lower filling level is fallen below.

The mixing of the components i), ii) and iii) with the aqueous mixture produced in step a) to a slurry is preferably carried out in a mortar mixing pump as described in WO 2004/080676 for the production of concrete slurry.

25

The slurry produced in step c) is preferably a homogeneous, thixotropic mass.

Step d): The slurry produced in step c) is preferably pumped via a hose to a second mixer, preferably a static mixer, wherein the hose preferably
30 comprises a T-piece between the pump outlet and the second mixer through which the foam produced in step b) is optionally admixed. Alternatively, the pump outlet can also comprise a foam injection device. Particularly

preferably, the further mixing of the slurry and the foam is carried out not only in one, but in two static mixers connected in series. Instead of a static mixer, an electric mixer can also be used.

- 5 The features of the preferred embodiments mentioned above can be combined with one another as desired in a method and are also encompassed by the present invention.

10 If the composition according to the invention manufactured in this way is dried, concrete, in particular porous lightweight concrete, self-levelling screed, 3D printing mortar and filler are thereby obtained. In other words, the present invention also comprises the use of the dried composition according to the invention as concrete, in particular as porous lightweight concrete, as self-levelling screed, 3D printing mortar or filler.

15

The invention will now be described in more detail by means of the following non-limiting examples.

Examples

20

The following examples use Mapeair LA/L as the foaming agent, Mapetard VZ as the retarder, Mapefluid R440 as the liquefier, DYNAMON HAA as the accelerator and Viscostar 3K as the viscosity modifier. All five substances are commercially available from the company Mapei S.P.A., Italy. SILRES®

- 25 Powder A, which is commercially available from Wacker Chemie AG, is used as the poly(organo)siloxane.

30 In the following examples a specific water-cement ratio is mostly given. In order to reduce the quantity of water, an attempt will be made to lower this ratio. This means that the following examples can generally also be carried out at lower water-cement ratios. Such variations and modifications are also encompassed by the present invention.

Examples 1–3: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement

The composition of exemplary porous lightweight concretes according to the present invention is shown in Table 1.

The quantity of liquefier given in Table 1, based on the total weight of cement, is metered to water. The liquefier quantity is independent of temperature. The quantity of retarder is temperature-dependent and is also metered to the water in the quantity given in Table 1. This permits processing of the porous lightweight concrete over a period of approximately 30 to 120 minutes.

Foam is produced from water and the foaming agent. The quantity of water is set out in Table 1. The quantity of foaming agent is 30 g per 1 liter of water, corresponding to approximately 1.5 kg per m³ of water.

A cement mixture of 52.5 R cement and CSA cement is used in the weight ratio given in Table 1. Depending on the wet density, the total cement content ranges from approximately 42 kg per 100 kg of composition at a wet density of 100 kg/m³ up to approximately 920 kg per 1250 kg of composition at a wet density of 1250 kg/m³. That means, the total quantity of cement in kilograms is within a range of approximately 42% to 73.6% of the wet density in kg/m³.

Depending on the desired wet density, the aforementioned total quantity of cement is mixed with water containing the liquefier and retarder in the quantities given in Table 1, preferably in a screw conveyor, to produce a slurry. The weight ratio of water to cement is herein in the range from 0.20 : 1 to 0.33 : 1.

This slurry is subsequently mixed with the foam downstream of the screw conveyor to the composition according to the invention, wherein the weight ratio of water to cement is ideally 0.35. Depending on the desired bulk density, more or less foam is admixed. The homogenization of the mixture is then carried out in a static mixer arranged downstream of the screw conveyor. Preferably the mixing is carried out in two static mixers connected in series. Thereby the composition for the production of porous lightweight concrete is obtained having a wet density in the range of from 100 to 1250 kg/m³.

Examples 4–6: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement

Table 2 contains further examples of porous lightweight concrete according to the invention. The manufacture is carried out analogous to the manufacture described for the examples 1–3. In contrast to the examples 1–3, more liquefier is used in the compositions according to the examples 4–6. The total cement content again is, depending on the wet density, in a range of from 42 kg at a wet density of 100 kg/m³ to approximately 920 kg at a wet density of 1250 kg/m³. That means, the total cement quantity in kg is in a range of from 42 to 73.6% of the wet density in kg/m³.

Examples 1A–6A: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement

Examples 1–6 are modified such that the quantity of CSA cement is calculated not on the basis of the quantity of 52.5 R cement, but on the clinker content thereof, which is 87 weight-%. Consequently, in the examples 1A–6A more CSA cement is used than in the examples 1–6.

Examples 7–30: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement

The manufacture is carried out analogous to the manufacture described for the examples 1–3. The relevant parameters and conditions are shown in Table 3.

- 5 The quantity of water required for producing 1 m³ of foam, expressed in kilograms, corresponds to the value of the wet density in kg/m³ minus 50 kg/m³. The weight ratio of retarder to cement [%] is 0.1 to 1.1 for a temperature of 0°C and 50°C, wherein an additional 0.1 weight-% of retarder is added for each temperature difference of 5 K.

10

The weight ratio of 52.5 R cement to CSA cement is 2.33. Thus, for example 70 kg of 52.5 R cement and 30 kg of CSA cement are used.

Examples 7A–30A: Manufacture of porous lightweight concrete using 52.5 R

and calcium aluminate cement

The CSA cement in the examples 7–30 is replaced by calcium aluminate cement from the company Hamitech AG or by Ciment Fondu® from the company LAFARGE ZEMENT.

Examples 31–54: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement

The manufacture is carried out analogous to the manufacture described for the examples 1–3. The corresponding parameters and conditions can be found in **Table 4**. Here, however, the retarder quantity is adapted to an

- 25 accuracy of 1K; i.e. starting from a quantity of 0.1 weight-% of retarder, based on the total weight of cement, at 0°C, an additional 0.02 weight-% of retarder is added up to a temperature of 50°C.

The quantity of water required for producing 1 m³ of foam, expressed in kilograms, corresponds to the value of the wet density in kg/m³ minus 50 kg/m³.

30

In contrast to the examples 7–30, the quantity of CSA cement is here calculated on the clinker content (approximately 87 weight-%) in the 52.5 R cement. That means, the weight ratio of the clinker in the 52.5 R cement to CSA cement is 2.33 : 1.

5

Examples 31A–54A: Manufacture of porous lightweight concrete using 52.5 R cement, CSA cement and clay cement

Compared with the examples 31–54, calcium aluminate cement from the company Hamitech AG or Ciment Fondu® from the company LAFARGE ZEMENT was additionally used, wherein the weight ratio of the clinker in the 52.5 R cement to CSA cement to calcium aluminate cement/Ciment Fondu® is 7.7 : 3.8 : 1.

10

Examples 55–78: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement without liquefier

15

The manufacture is carried out analogous to the manufacture described for the examples 1–3. The corresponding parameters and conditions can be found in **Table 5**.

20

In contrast to the examples 7–30 and 31–54, the following porous lightweight concrete examples 55–78 contain no liquefier. In addition, more water than in the examples 7–54 is used for foam production, namely the quantity of water in kilograms for producing 1 m³ of foam corresponds to the value of the wet density in kg/m³.

25

Exactly as in the examples 31–54 (Table 4), the quantity of retarder is adapted to an accuracy of 1 K; however, more retarder is used, namely starting from a quantity of 0.5 weight-% of retarder, based on the total weight of cement, at 0°C, an additional 0.02 weight-% of retarder is added up to a temperature of 50°C. The weight ratio of 52.5 R cement to CSA cement is 2.33 : 1.

30

Examples 55A–78A: Manufacture of porous lightweight concrete using 52.5 R cement, CSA cement and clay cement without liquefier

In the examples 55–78, the CSA cement was partially replaced by clay cement; the weight ratio of 52.5 R cement to CSA cement to clay cement is

5 7.7 : 3.8 : 1.

Examples 79–92: Manufacture of porous lightweight concrete using 52.5 R cement and CSA cement without liquefier

In contrast to the examples 55–78, the quantity of CSA cement is here calculated on the clinker content (87 weight-%) in the 52.5 R cement. That means, the weight ratio of the clinker in the 52.5 R cement to CSA cement is

10 2.33 : 1.

Examples 79A–92A: Manufacture of porous lightweight concrete using 52.5 R cement, CSA cement and clay cement without liquefier

In contrast to the examples 55A–78A, the quantity of CSA cement and clay cement is here calculated on the clinker content (87 weight-%) in the 52.5 R cement. That means, the weight ratio of the clinker in the 52.5 R cement to CSA cement to clay cement is 7.7 : 3.8 : 1.

20

Examples 93–98: Manufacture of fireproof porous lightweight concrete

Instead of a mixture of 52.5 R cement and CSA cement, a mixture of 52.5 R cement, CSA cement and a calcium aluminate clinker such as Ciment Fondu® is used here in the weight ratio 6.66 : 1 : 1. Further conditions can be found in **Tables 6 and 7**.

25

Otherwise, the manufacture is carried out as described under the examples 1–3. The quantity of foaming agent is 30 g per 1 liter of water.

30 The weight ratio of water to the total quantity of cement in the composition, i.e. the mixture of cement, liquefier, retarder, water and foam after mixing, is in the range of from 0.20 to 0.35. The quantity of water for producing 1 m³ of

foam, expressed in kilograms, corresponds in example 94 to the value of the wet density in kg/m^3 and in the examples 93 and 95–98 to the value of the wet density in kg/m^3 minus 50 kg/m^3 .

5 **Examples 99–104: Manufacture of porous lightweight concrete processable at outdoor temperatures down to -3°C**

In order to be able to process the composition also at lower ambient temperatures, a part of the CSA cement is replaced by clay-rich clinker. The manufacture is carried out analogous to the manufacture of the

10 compositions according to the invention according to the examples 1–3. Further details can be found in **Tables 8 and 9**.

At a wet density above 400 kg/m^3 , processing can even be carried out at an ambient temperature below 0°C , preferably at -3°C .

15

The quantity of water for producing 1 m^3 of foam, expressed in kilograms, corresponds to the value of the wet density in kg/m^3 minus 50 kg/m^3 . The quantity of foaming agent is 30 g per 1 liter of water.

20 **Example 1*: Measurement of the Compressive Strength of porous lightweight concrete according to the invention**

From compositions for the production of porous lightweight concrete manufactured according to Example 1, cubes having a nominal edge length of 150 mm are produced in accordance with standard SN EN 12390-3. These

25 are stored either in a humidity room at $20^\circ\text{C} \pm 2^\circ\text{C}$ and a relative humidity $\geq 95\%$ or covered with plastic film at 20°C until measurement. The compressive strength is determined after 7, 14 and 28 days, respectively. The results can be found in Tables I and II below. The values given are in each case the average values from three measurements.

30

Tabelle I

Example	Wet density [kg/m ³]	Compressive strength after 7 days [N/mm ²]	Compressive strength after 14 days [N/mm ²]	Compressive strength after 28 days [N/mm ²]
1	200	0.1	0.1	0.1
1	250	0.2	0.3	0.3
1	300	0.3	0.4	0.4
1	400	1.0	1.0	1.0
1	500	1.8	1.9	2.0
1	600	3.0	2.8	3.0
1	700	3.1	3.5	3.3
1	800	4.3	5.3	5.1
1	900	5.9	5.9	6.0
1	1000	7.1	7.0	7.5

Examples 105–111: Manufacture of 3D printing mortar

The examples are summarized in **Table 10**.

- 5 3D printing mortar contains neither a liquefier nor a foaming agent.

The retarder is metered to 281 liters of water in the quantity given in Table 10.

- 10 The metering is carried out temperature-dependent. This permits processing of the 3D printing mortar mass over a period of 1 to 30 minutes, depending on the print length.

- 15 Sand and cement are mixed together in the weight ratio given in Table 10. As sand, either fire-dried quartz sand or crushed sand having a grain size of 0 to 1 mm can be used. As cement, a mixture of 52.5 R cement and CSA cement (Examples 105–107 and 110–111) or a mixture of 42.5 R cement and CSA cement (Examples 108–109) is used in the weight ratio given in Table 10. In the examples 110 and 111, one-half and the complete quantity, respectively, of the CSA cement has been replaced by clay cement.

In the examples 106 and 107, pulverous glass fibre and in the examples 108 and 109 additionally iron oxide powder and/or pulverous coloring agent, respectively in the quantity given in Table 10, are added to the sand-cement mixture, and this mixture of pulverous components is then mixed with water, wherein the weight ratio of water to cement is in the range of from 0.1 to 0.50 : 1, that means, 9.8 to 15.75 liters of water are mixed with a total cement quantity of 28–30 kg. The aqueous mixture containing the retarder is then added to the aqueous sand-cement mixture, which optionally additionally contains glass fibre (Examples 106, 107) or iron oxide powder and/or coloring agent (Examples 108, 109), respectively. Depending on the iron oxide used, either a white 3D printing mortar (Example 108) or a black 3D printing mortar (Example 109) is obtained. By mixing the 3D printing mortar mass is obtained, the wet density of which is, depending on the composition, in the range of from 1800 to 2200 kg/m³. The mixing of the components can be accelerated by using preheated water, in particular water preheated to a temperature in the range of from 6 to 50°C. Shrinkage reduction during curing is 1 volume-%.

Examples 112–116: Manufacture of self-levelling screed

The examples are summarized in **Table 11**.

20

Self-levelling screed differs essentially from 3D printing mortar in that liquefier is contained in the mixture.

1 weight-% of liquefier, based on the total weight of cement, is metered to water, as is the retarder separately therefrom. The quantity of retarder is temperature-dependent: At 0°C 0.1 weight-% of retarder, based on the total weight of cement, is metered to water. For each temperature increase of 5 K, an additional 0.1 weight-% of retarder is added, such that at a temperature of 50°C, 1.1 weight-% of retarder, based on the total weight of cement, is metered to water. This permits processing of the self-levelling screed over a period of 15 to 100 minutes, 15 to 50 minutes.

30

In each case 73 kg of sand are mixed with 27 kg of cement, such that the weight ratio of sand to cement is 2.70 : 1. It is also possible to use mixtures wherein the weight ratio of sand to cement is in the range from 4 : 1 to 2 : 1. As sand, either fire-dried quartz sand or crushed sand having a grain size of 0.1 to 0.5 mm, 0.5 to 1.25 mm, 1.25 to 4 mm can be used. As cement a mixture of 52.5 R cement and CSA cement (Examples 112, 113, 114, 116) or a mixture of 42.5 R cement and CSA cement (Example 115) is used, wherein the weight ratio of 52.5 R cement or 42.5 R cement to CSA cement is 2.33 : 1. Alternatively, 32.5 R cement could also be used.

10

In the examples 113 and 114 additionally pulverous glass fibre and in the examples 115 and 116 additionally iron oxide powder and/or pulverous coloring agent in the quantity given in Table 11 are added to the sand-cement mixture, and this mixture of pulverous components is then mixed with water, wherein the weight ratio of water to cement is in the range of from 0.4 to 0.55 : 1, that means, 16.8 to 25.2 liters of water are mixed with a total cement quantity of 40 kg. Depending on the iron oxide used, either a white self-levelling screed (Example 115) or a black self-levelling screed (Example 116) is obtained. The aqueous mixture containing the retarder and the liquefier is then added to the aqueous sand-cement mixture, which optionally additionally contains glass fibre (Examples 113, 114) or iron oxide powder and/or coloring agent (Examples 115, 116), in order to obtain the self-levelling screed, the wet density of which is 2000–2200 kg/m³. Shrinkage reduction of the self-levelling screed during curing is 1 volume-%. The self-levelling screed can be installed in a thickness of 10–100 mm. From 20 mm onwards it is installed on a separating layer, and from 30 mm onwards as a floating screed.

25

Examples 117–122: Manufacture of Filler

The examples are summarized in **Table 12**.

30

2 weight-% of liquefier, based on the total weight of cement, are metered to water. The quantity of retarder is temperature-dependent: 0.1 weight-% of

retarder, based on the total weight of cement, are metered to water at 0°C. For each temperature increase of 5 K, an additional 0.1 weight-% of retarder is added, such that at a temperature of 50°C 1.1 weight-% of retarder, based on the total weight of cement, are metered to water. This permits processing
5 of the filler over a period of up to 30 minutes.

In each case 60 kg of sand are mixed with 40 kg of cement, such that the weight ratio of sand to cement is 1.5 : 1. As sand, either fire-dried quartz sand or crushed sand having a grain size of 0 to 0.5 mm can be used. As cement, a
10 mixture of 52.5 R cement and CSA cement (Examples 117, 118, 119) or a mixture of 42.5 R cement and CSA cement (Examples 120, 121, 122) is used, wherein the weight ratio of 52.5 R cement or 42.5 R cement to CSA cement is 2.33 : 1.

15 In the examples 118 and 119 an additional 0.5 weight-% and 1 weight-%, respectively, of pulverous glass fibre and in the examples 120, 121 and 122 an additional 5 weight-%, 1 weight-% and 1 weight-%, respectively, of iron oxide powder and/or pulverous coloring agent are added to the sand-cement mixture. Depending on the iron oxide used, either a white filler (Example 120)
20 or a black filler (Example 121) is obtained. The mixture of the pulverous components is advantageously prepared beforehand in the factory. This mixture of pulverous components is then mixed with water, wherein the weight ratio of water to cement is in the range of from 0.35 to 0.45 : 1, that means, 14.0 to 18.2 liters of water are mixed with a total cement quantity of
25 40 kg. The aqueous mixture containing the retarder and the liquefier is then added to the aqueous sand-cement mixture, which optionally additionally contains glass fibre (Examples 118, 119) or iron oxide powder and/or coloring agent (Examples 120, 121, 122). Thereby the filler is obtained, the wet density of which is 1900–2000 kg/m³. Shrinkage reduction of the filler during curing is 1
30 volume-%.

Examples 123–128: Manufacture of porous lightweight concrete containing fly ash, graphite powder and polyvinyl acetate or poly(organo)siloxane

The composition for the production of porous lightweight concrete can be manufactured with a wet density of 100 kg/m³ to 1200 or 1250 kg/m³. The pulverous main component is 52.5 R cement, the pulverous ancillary components are CSA cement and calcium aluminate cement (= clay-rich clinker), and the further ancillary components are fly ash, graphite powder and polyvinyl acetate. The graphite powder provides an electromagnetic shielding effect of building elements produced therefrom. The fly ash fills the air inclusions of the concrete better and thus provides a higher degree of compaction. The polyvinyl acetate provides an increase of the plastic properties.

The manufacture is carried out as follows:

The quantity of liquefier given in Table 13, based on the total weight of cement, is metered to water. The quantity of retarder, where present, is likewise metered to water in the quantity given in Table 1. This permits processing of the porous lightweight concrete over a period of 30 to 120 minutes.

Furthermore, the polyvinyl acetate is added to the cement as a 2 weight-% aqueous solution.

Foam is produced from water and the foaming agent. The quantity of water for producing 1 m³ of foam, expressed in kilograms, corresponds to the value of the wet density in kg/m³ minus 52.5 kg/m³. The quantity of foaming agent is 30 g per 1 liter of water, i.e. 1.5 kg per 1 m³ of water.

As cement a mixture of 52.5 R cement, CSA cement and calcium aluminate cement is used in the weight ratio given in Table 1. The total quantity of cement is, depending on the wet density, between 42 kg per 100 kg of composition at a wet density of 100 kg/m³ and 937.5 kg per 1250 kg of

composition at a wet density of 1250 kg/m^3 , i.e. the total quantity of cement in kilograms is in the range of 42% to 75% of the wet density in kg/m^3 .

Furthermore, fly ash and graphite powder are admixed to the cement in the quantities given. In order to avoid the risk of possible separation of the small quantity of polyvinyl acetate in the cement mixture, the polyvinyl acetate is added to the water and mixed with a high-performance mixer. Preferably a 10% aqueous solution is first prepared from the polyvinyl acetate in order to permit even more accurate metering into water.

Depending on the desired wet density, the above-mentioned total quantity of cement including fly ash and graphite powder is mixed with the water containing the liquefier, the retarder and the polyvinyl acetate in the quantities given in Table 1, preferably in a screw conveyor, to a slurry. The weight ratio of water to cement is herein in the range from 0.20 : 1 to 0.33 : 1.

This slurry is subsequently mixed with the foam downstream of the screw conveyor to the composition according to the invention, wherein the weight ratio of water to cement is ideally 0.35. Depending on the desired bulk density, more or less foam is admixed. The homogenization of the mixture is then carried out in the static mixer arranged downstream of the screw conveyor. Preferably the mixing is carried out in two static mixers connected in series. Thereby the composition for the production of porous lightweight concrete is obtained having a wet density of $100\text{--}1200 \text{ kg/m}^3$ or $100\text{--}1250 \text{ kg/m}^3$, respectively.

Further details, such as the weight ratios of the components, can be found in **Table 13.**

At a wet density above 400 kg/m^3 , processing can even be carried out at an ambient temperature below 0°C , preferably at -3°C

Examples 129–134: Manufacture of porous lightweight concrete containing graphite powder

The manufacture is carried out analogous to the manufacture described for the examples 123–128. In contrast thereto, the compositions according to the
5 examples 129–134 contain neither polyvinyl acetate nor fly ash.

Foam is produced from water and foaming agent. For the examples 129 and 131–134, the quantity of water for producing 1 m³ of foam, expressed in kilograms, corresponds to the wet density value in kg/m³ minus 50 kg/m³. In
10 Example 130 the quantity of water for producing 1 m³ of foam, expressed in kilograms, corresponds to the wet density value itself in kg/m³. The quantity of foaming agent is 30 g per 1 liter of water, i.e. approximately 1.5 kg per 1 m³ of water.

15 Further details concerning the type and quantity of the individual components can be found in Table 14.

Examples 135–137: Manufacture of porous lightweight concrete containing graphite powder

20 The manufacture is carried out analogous to the examples 129–134. In the examples 135–137, however, the quantity of retarder is adjusted very precisely to the outdoor temperature.

Foam is produced from water and foaming agent. The quantity of water for
25 producing 1 m³ of foam, expressed in kilograms, corresponds in the examples 135 and 136 to the value of the wet density in kg/m³ minus 50 kg/m³, and in Example 137 it corresponds to the value of the wet density in kg/m³. The quantity of foaming agent is 30 g per 1 liter of water, i.e. 1.5 kg per 1 m³ of water.

30 Further details such as the type and quantities of the components can be found in Table 15.

Examples 138–143: Manufacture of porous lightweight concrete containing poly(organo)siloxanes and, optionally, silicon dioxide

The manufacture is carried out analogous to the examples 123–128, except
5 that the examples 138–140 contain silicon dioxide instead of fly ash.

Foam is produced from water and foaming agent. The quantity of water for
producing 1 m³ of foam, expressed in kilograms, corresponds to the value of
the wet density in kg/m³ minus 50 kg/m³. The quantity of foaming agent is 30 g
10 per 1 liter of water, i.e. 1.5 kg per 1 m³ of water.

Further details such as the type and quantities of the components can be
found in Tables 16 and 17.

Example 144: Manufacture of porous lightweight concrete containing a poly(organo)siloxane and silicon dioxide

The details regarding the type and quantity of the components can be found
in Table 18. The manufacture is carried out analogous to the examples 123–
128. The quantity of water for producing 1 m³ of foam, expressed in kilograms,
20 corresponds to the value of the wet density in kg/m³ minus 50 kg/m³. The
quantity of foaming agent is 30 g per 1 liter of water, i.e. 1.5 kg per 1 m³ of
water.

Examples 145–146: Manufacture of porous lightweight concrete containing a poly(organo)siloxane

The details regarding the type and quantity of the components can be found
in Table 19. The manufacture is carried out analogous to the examples 123–
128. In Example 145 the quantity of water for producing 1 m³ of foam,
expressed in kilograms, corresponds to the value of the wet density in kg/m³
30 minus 50 kg/m³; in Example 146 it corresponds to the value of the wet density
in kg/m³. The quantity of foaming agent is 30 g per 1 liter of water, i.e. 1.5 kg
per 1 m³ of water.

Examples 147–153: Manufacture of 3D printing mortar

The details regarding the type and quantity of the components can be found in Tables 21-22.

5

The manufacture of the compositions according to the examples 147–153 is carried out analogous to the manufacture of the compositions according to the examples 105–111. Here silicon dioxide SiO_2 is mixed into the sand-cement mixture and the poly(organo)siloxane is added to the water. Preferably a 10% aqueous solution is first prepared from the poly(organo)siloxane in order to permit even more accurate metering into the water.

10

The examples 147–149 describe 3D printing mortars containing silicon dioxide and poly(organo)siloxane. The formulations are suitable for processing over a broad temperature range and may be adapted even for sub-zero ambient temperatures through appropriate adjustment of the retarder and cement system.

15

The examples 150 and 151 additionally comprise glass fibres, which improve crack resistance and mechanical stability of the printed structures.

20

The examples 152 and 153 comprise iron oxide pigments and/or coloring agents. Depending on the pigment employed, white or black architectural 3D printing mortar compositions can be obtained. ,

Examples 154–158: Manufacture of a Composition for the production of 3D printing mortar using pre-tempered water

25

The details regarding the type and quantity of the components are shown in Table 23.

The manufacture of the compositions according to the examples 154–158 is carried out analogous to the manufacture of the compositions according to the examples 105–111. Here the shrinkage reducer is usually added to the water.

30

Examples 159–160: Manufacture of concrete: Table 25

The details regarding the type and quantity of the components are shown in Table 24.

- 5 The liquefier, the accelerator, the viscosity modifier and, where present, the poly(organo)siloxane are introduced independently of one another into water, preferably via a metering pump, and mixed with water to an aqueous mixture.
- 10 The sand, the cement, the silicon dioxide or the quartz powder/basalt and the polypropylene fibres are introduced into a first mixer, preferably via individual, separate metering pumps, and mixed with the aqueous mixture containing the liquefier, the accelerator, the viscosity modifier and, where present, the poly(organo)siloxane to a slurry. The slurry is then further mixed in
- 15 a second mixer and removed therefrom.

Example 161: Manufacture of concrete

The details regarding the type and quantity of the components are shown in Table 25.

20

The manufacture of the composition according to Example 161 is carried out analogous to the manufacture of the compositions according to the examples 159–160.

Examples 162–165: Manufacture of high-performance concrete

The details regarding the type and quantity of the components are shown in Table 26.

- 25 The manufacture of the compositions according to the examples 162–165 is
- 30 carried out analogous to the manufacture of the compositions according to the examples 159–160.

Example 166: Manufacture of a composition for an elastic porous lightweight concrete

The manufacture is carried out analogous to the examples 141–143.

- 5 Foam is produced from water and the foaming agent. The quantity of water for producing 1 m³ of foam, expressed in kilograms, corresponds to the value of the wet density in kg/m³ minus 50 kg/m³. The quantity of foaming agent is 30 g per 1 liter of water, i.e. 1.5 kg per 1 m³ of water. In addition, 2 weight-% of poly(ethylene-vinyl acetate), based on the total weight of the foam, are
- 10 added to the foam. The composition thereby obtained is highly elastic.

Further details such as the type and quantities of the components are shown in Table 27.

Examples 1–3: Manufacture of porous lightweight concrete: Table 1

Example/ Components and parameters	Special properties	Wet density [kg/m³]	Quantity of wa- ter for foam production [kg water per 1 m³ of foam]	Weight ra- tio of 52.5 R cement to CSA ce- ment	Weight ratio of re- tarder to cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
1	—	100– 1250	Wet density value in kg/m ³ – 50 kg/m ³	2.33	0.1–1.1 for a tempera- ture of 0 to 50°C, whereby for a tempera- ture difference of 5 K, 0.1 weight-% more is added	0.5 at a wet density of 100–799 kg/m ³ ; 0.3 at a wet density of 800–1250 kg/m ³
2	Stable on a slope of up to 3%	100– 1250	Wet density value in kg/m ³ – 50 kg/m ³	3.85	0.5–1.5 for a tempera- ture range of 0 to 50°C, whereby 0.1 weight-% more of re- tarder is added for every 5 K difference in temperature	—
3	Highly flowable	100– 1250	Wet density in kg/m ³ – 50 kg/m ³	2.33	0.1–1.1 for a tempera- ture of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K	1.5 at a wet density of 100–399 kg/m ³ ; 1.0 at a wet density of

						temperature difference	400–799 kg/m ³ ; 0.75 at a wet density of 800–1200 kg/m ³
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Examples 4–6: Manufacture of porous lightweight concrete: Table 2

Example/ Component s and parameters	Proper ties	Wet density [kg/m ³]	Quantity of wa- ter for foam production [kg water per 1 m ³ of foam]	Weight ra- tio of ce- ment 52.5 R to CSA cement	Weight ratio of re- tarder to cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
4		100– 1200	Wet density in kg/m ³ – 50 kg/m ³	3.85	0.1–1.1 for a temper- ature range of 0 to 50°C, whereby 0.1 weight-% more re- tarder is added for every 5 K tempera- ture difference	0.5–1.5 for a temper- ature range of 0 to 50°C, whereby an additional 0.1 weight- % of retarder is added for every 5 K temperature differ- ence
5		100– 1200	Wet density in kg/m ³ – 50 kg/m ³	2.33	0.1–1.1 for a temper- ature of 0 to 50°C, whereby 0.1 weight- % more retarder is added for every 5 K temperature differ- ence	1.5 at a wet density of 100–399 kg/m ³ ; 1.0 at a wet density of 400–749 kg/m ³ ; 0.75 at a wet density of 750–1200 kg/m ³

6		100–1200	Wet density value in kg/m ³ – 50 kg/m ³	2.33	0.5–1.5 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K temperature difference	–
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Examples 7–30: Manufacture of porous lightweight concrete: Table 3

Example/ Components and parameters	Wet density [kg/m ³]	Total weight of cement in kg [% of the quantity of water in kg per 1 m ³ of foam]	Weight ratio of water to ce- ment	Quantity of liquefier [weight ratio to total weight of ce- ment in %]
7	100	84	0.2	0.5
8	150	82.5	0.2	0.5
9	200	83.3	0.2	0.5
10	250	83.1	0.2	0.5
11	300	83.4	0.2	0.5
12	350	83.4	0.2	0.5
13	400	83.4	0.2	0.5
14	450	83.0	0.2	0.5
15	500	81.7	0.22	0.5
16	550	80.9	0.23	0.5
17	600	80.2	0.235	0.5
18	650	79.6	0.245	0.5
19	700	79.6	0.252	0.5
20	750	79.1	0.259	0.5
21	800	78.6	0.265	0.3

22	850	78.1	0.27	0.3
23	900	77.7	0.275	0.3
24	950	77.4	0.275	0.3
25	1000	77.2	0.282	0.3
26	1050	77.1	0.285	0.3
27	1100	76.8	0.287	0.3
28	1150	76.8	0.291	0.3
29	1200	76.6	0.293	0.3
30	1250	76.6	0.295	0.3

Examples 31–54, 31A–54A and 31B–54B: Manufacture of porous lightweight concrete: Table 4

Example/ Components and parameters	Wet density [kg/m³]	Total weight of cement in kg [% of the quantity of water in kg per 1 m³ of foam]	Quantity of liquefier [weight ratio to total weight of cement in %]
31	100	82	1.5
32	150	82.5	1.5
33	200	82	1.5
34	250	81.9	1.5
35	300	82.2	1.5
36	350	81.9	1.5
37	400	82.3	1.0
38	450	82.4	1.0
39	500	81.1	1.0
40	550	80.4	1.0
41	600	79.7	1.0
42	650	79.3	1.0
43	700	79.6	1.0

44		750	78.5		1.0	
45		800	78.2		0.75	
46		850	77.9		0.75	
47		900	77.7		0.75	
48		950	77.7		0.75	
49		1000	77.5		0.75	
50		1050	77.0		0.75	
51		1100	76.8		0.75	
52		1150	76.7		0.75	
53		1200	76.5		0.75	
54		1250	76.4		0.75	

Examples 55–78: Manufacture of porous lightweight concrete: Table 5

Components and parameters / Example	Wet density [kg/m ³]	Total weight of cement in kg [% of wet density in kg/m ³]
55	100	42.0
56	150	55.0
57	200	62.0
58	250	66.1
59	300	69.0
60	350	71.0
61	400	72.2
62	450	73.5
63	500	73.3
64	550	73.3
65	600	73.7
66	650	73.6
67	700	73.6
68	750	73.6
69	800	73.6
70	850	73.6
71	900	73.6
72	950	73.8
73	1000	73.6
74	1050	73.6
75	1100	73.6
76	1150	73.6
77	1200	73.5
78	1250	73.6

Examples 93–95: Manufacture of porous lightweight concrete: Table 6

Example/ Components and parameters	Properties	Wet density [kg/m³]	Weight ratio of retarder to total weight of cement [%]	Quantity of liquefier [weight ra- tio to total weight of cement in %]
93	Can be pro- cessed down to - 5°C; fire- proof	100–1250	0.1–1.1 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, an additional 0.1 weight-% of retarder is added	0.5
94	Stable on a slope of up to 3%	100–1250	0.5–1.5 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, an additional 0.1 weight-% of retarder is added	—
95	Highly flowable	100–1250	0.1–1.1 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, an additional 0.1 weight-% of retarder is added	1.5 at a wet density of 100–399 kg/m³; 1.0 at a wet density of 400–849 kg/m³; 0.75 at a wet density of 850–1250 kg/m³

Examples 96–98: Manufacture of porous lightweight concrete: Table 7

Example/ Components and parameters	Properties	Wet density [kg/m ³]	Total weight of cement in kg	Weight ratio of 52.5 R cement to CSA ce- ment to clay-rich clinker	Weight ratio of re- tarder to cement [%]	Quantity of liq- uefier [weight ratio to total weight of ce- ment in %]
96	Higher stabil- ity of the ce- ment mix- ture	100– 1200	76.7–84.0% of the quantity of water for the foam in kg	6.66 : 1 : 1	0.1–1.1 for a temper- ature of 0 to 50°C, whereby for a tem- perature difference of 5 K, an additional 0.1 weight-% of re- tarder is added	0.5
97	flowable	100– 1250	76.7–84.0% of the quantity of water for the foam in kg	6.66 : 1 : 1	0.1–1.1 for a temper- ature of 0 to 50°C, whereby for a tem- perature difference of 5 K, an additional 0.1 weight-% of re- tarder is added	1.5 at a wet density of 100– 399 kg/m ³ ; 1.0 at a wet density of 400–749 kg/m ³ ; 0.75 at a wet density of 750–1250 kg/m ³
98	Can be pro- cessed de- spite a slope of 3–5%	100– 1250		6.66 : 1 : 1	0.5–1.5 for a temper- ature of 0 to 50°C, whereby for a tem- perature difference of 5 K, an additional	—

						0.1 weight-% of re-tarder is added	
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Examples 99–101: Manufacture of porous lightweight concrete at outdoor temperatures down to –3°C: Table 8

Example/ Components and parameters	Properties	Wet density [kg/m³]	Weight ratio of water to total weight of cement	Weight ratio of 52.5 R cement to CSA ce- ment to clay- rich clinker	Weight ratio of re- tarder to total weight of cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
99	Can be pro- cessed down to –5°C; fire- proof	100– 1250	0.28	7.7 : 2 : 1	0.5 at a wet density of 100–349 kg/m³, 0.4 at a wet density of 350–849 kg/m³, 0.3 at a wet density of 850–1250 kg/m³	0.5 at a wet density of 100–349 kg/m³, 0.4 at a wet density of 350– 849 kg/m³, 0.3 at a wet density of 850–1250 kg/m³
100	Stable on a slope of up to 3%	100– 1250	0.28	7.7 : 2 : 1	1.5 at a wet density of 100–399 kg/m³; 1.0 at a wet density of 400–899 kg/m³; 0.75 at a wet den- sity of 900–1250 kg/m³	—
101	Highly flowable	100– 1250	0.28	7.7 : 2 : 1	0.1–1.1 for a tem- perature of 0 to 50°C, whereby 0.1 weight-% more re- tarder is added for	1.5 at a wet density of 100–449 kg/m³; 1.0 at a wet density of 450– 849 kg/m³; 0.75 at a wet density of 850– 1250 kg/m³

						each 5 K temperature difference	
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Examples 112–116: Manufacture of self-levelling screed: Table 11

Example/ Components and parameters	Properties	Quantity of glass fibre [kg] per 100 kg of sand-cement mixture	Quantity of iron oxide powder [% of the quantity of 42.5 R cement in kg]
112	—	—	—
113	—	0.35	—
114	—	0.7	—
115	grindable	—	1
116	grindable	—	1

Examples 102–104: Manufacture of porous lightweight concrete at outdoor temperatures down to –3°C: Table 9

Example/ Components and parameters	Wet density [kg/m ³]	Total weight of cement in kg [% of wet density in kg/m ³]	Weight ra- tio of Ce- ment 52.5 R to CSA ce- ment	Weight ratio of retarder to cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
102	100– 1200	42	7.7 : 3.8 : 1	0.1–1.1 for a tempera- ture of 0 to 50°C, whereby for every 5 K temperature difference, an additional 0.1 weight- % of retarder is added	0.5 at a temperature of 0°C to 50°C
103	100– 1250	42	7.7 : 3.8 : 1	0.1–1.1 for a tempera- ture range of 0 to 50°C, whereby for every 5 K temperature difference, an additional 0.1 weight- % of retarder is added	Temperature-independ- ent: 1.5 at a wet density of 100–399 kg/m ³ ; 1.0 at a wet density of 400–749 kg/m ³ ; 0.75 at a wet den- sity of 750–1250 kg/m ³
104	100– 1250		7.7 : 3.8 : 1	0.5–1.5 for a tempera- ture of 0 to 50°C, whereby for every 5 K temperature difference, an additional 0.1 weight- % of retarder is added	—

Examples 105–111: Manufacture of 3D printing mortar: Table 10

Example and properties/components and parameters	Wet density [kg/m ³]	Quantity of sand with a grain size of 0–1 mm [kg relative to 100 kg of 3D printing mortar]	Weight ratio of sand to cement [kg/kg]	Weight ratio of 52.5 R cement to CSA cement	Weight ratio of retarder to cement [%]	Quantity of glass fibre [kg] per 100 kg of 3D printing mortar	Quantity of iron oxide powder [% of the quantity of 42.5 R cement in kg]
105	1900–2100	72	2.57 : 1	2.33 : 1	At temperatures up to 24°C 0; at 25°C 0.01; at 30°C 0.02; at 35°C 0.8; at 40°C 0.9; at 45°C 1; at 50°C 1.1.	—	—
106	2000–2200	70	2.3 : 1	2.33 : 1	0.1–1.1 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, 0.1 weight-%	0.35	—

107	1800– 2200	70	2.3 : 1	2.33 : 1	more retarder is added	0.7	—
					0.1–1.1 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, 0.1 weight-% more retarder is added	—	1
108	2000– 2200	70	2.3 : 1	2.33 : 1 (42.5 R ce- ment is used in- stead of 52.5 R ce- ment)	0.1–1.1 for a temperature of 0 to 50°C, whereby for a temperature difference of 5 K, 0.1 weight-% more retarder is added	—	1
109	2000– 2200	70	2.3 : 1	2.33 : 1 (42.5 R ce- ment is used in- stead of	0.1–1.1 for a temperature e of 0 to 50°C, whereby for a temperature difference of	—	1

					52.5 R cement)	5 K, 0.1 weight-% more retarder is added			
110 Processable at -5°C.	1900–2100	72		2.57 : 1	2.33, whereby half of the CSA cement is replaced by clay cement	0.1–1.2 for a temperature range of -5°C to 50°C, whereby for a temperature difference of 5 K, 0.1 weight-% more retarder is added	—	—	—
111 Processable at -10°C.	1900–2100	72		2.57 : 1	2.33, whereby the CSA cement is replaced by clay cement	0 at -10°C, 0.05 at -5°C; 0.1–1.1 for a temperature range of 0 to 50°C, whereby for a temperature difference of 5 K, 0.1 weight-% more retarder is added	—	—	—

Examples 117–122: Manufacture of filler: Table 12

Example/ Components and parameters	Thickness to which the filler can be processed [mm]	Quantity of glass fibre [kg] per 100 kg of sand and cement	Quantity of iron oxide powder or coloring agent [% of the quantity of 42.5 R cement in kg]
117	1–50	—	—
118	2–60	0.5	—
119	2–70	1	—
120	5–50	—	5
121	5–50	—	1
122	5–50	—	1

Examples 123–128: Manufacture of porous lightweight concrete containing fly ash, graphite powder and optionally poly(organo)siloxane: Table 13

Example	Properties	Wet density / total weight of cement relative to the wet density	Weight ratio of water to total weight of cement	Weight ratio of cement 52.5 R to fly ash to CSA cement to clay-rich clinker to graphite powder [kg : kg : kg]	Quantity of polyvinyl acetate or poly(organo)siloxane, relative to the total weight of 52.5 R cement, CSA cement, clay-rich clinker, fly ash and graphite powder	Weight ratio of retarder to total weight of cement [%]	Quantity of liquefier [weight ratio to the total weight of cement in %]
123	Electromagnetically shielding	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ – (42%) – 937.5 kg	0.263	7.692 : 2 : 1.154 : 1.154 : 1 (at a wet density of 100 kg/m ³) to 8.696 : 2 :	Polyvinyl acetate: 0.32 weight-% (at a wet density of 100 kg/m ³) to 0.41	–	0.5 at 20°C

124	Electromagnetically shielding and stable on a slope of up to 3%	at a wet density of 1250 kg/m ³ (75%)	0.244 (at a wet density of 100 kg/m ³) to 0.263 (at a wet density of 1250 kg/m ³)	1.304 : 1.304 : 1 (at a wet density of 1250 kg/m ³)	weight-% (at a wet density of 1250 kg/m ³)	—	0.5 at 20°C
125	Electromagnetically shielding and highly flowable	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) to 937.5 kg at a wet density of 1250 kg/m ³ (75%)	0.244 (at a wet density of 100 kg/m ³) to 0.263 (at a wet density of 1250 kg/m ³)	8.7 : 2 : 1.3 : 1.3 : 1	Polyvinyl acetate: 0.28 weight-% (at a wet density of 100 kg/m ³) to 0.41 weight-% (at a wet density of 1250 kg/m ³)	0.5 at 20°C	0.5 at 20°C

126	Electromagnetically shielding	density of 1250 kg/m ³ (75%)	1250 kg/m ³)	10: 2.3 : 1.2747 : 1.2747 : 1	(at a wet density of 1250 kg/m ³)	—	0.1–1.1 for a temperature of 0 to 50°C, whereby for every 5 K difference in temperature, an additional 0.1 weight-% of liquefier is added
127	Electromagnetically shielding and highly flowable	100–1200 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 882.0 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35 (constant for all wet densities from 100 kg/m ³ to 1250 kg/m ³)	10: 2.3 : 1.5 : 1.5 : 1	Poly(siloxane) weight-% (at a wet density of 100 kg/m ³) to 0.33 weight-% (at a wet density of 1200 kg/m ³)	—	0.1–1.1 for a temperature of 0 to 50°C, whereby for every 5 K difference in temperature, an additional 0.1 weight-% of weight-% of

128	Electromagnetically shielding and stable on a slope of up to 3%	kg/m ³ (73.5%) 100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35 (constant for all wet densities from 100 kg/m ³ to 1250 kg/m ³)	10: 2.3 : 1.2747 : 1.2747 : 1	1250 kg/m ³)	0.5–1.5 for a temperature range of 0 to 50°C, whereby for every 5 K temperature difference 0.1 weight-% more of retarder is added	liquefier is added At a wet density up to 1249 kg/m ³ : 0.1–1.1 for a temperature of 0 to 50°C, whereby for every 5 K temperature difference, an additional 0.1 weight-% of liquefier is added; at a wet density of 1250 kg/m ³ : no addition of liquefier
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Examples 129–134: Manufacture of porous lightweight concrete containing fly ash and graphite powder: Table 14

Example	Properties	Wet density / total weight of cement relative to the wet density	Weight ratio of water to total weight of cement	Weight ratio of 52.5 R cement to CSA cement to clay-rich clinker to graphite powder [kg : kg : kg : kg]	Weight ratio of retarder to total weight of cement [%]	Quantity of liquidifier [weight ratio to total weight of cement in %]
129		100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	7.69 : 1.15 : 1.15 : 1	0.5 (20°C)	0.5 (20°C)
130	Electromagnetically shielding and stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg at a wet	0.35	7.69 : 1.15 : 1.15 : 1	0.9 (20°C)	–

133	highly flowable	1200 kg/m ³ (73.5%)	0.35	7.69 : 1.15 : 1.15 : 1	weight-% of re- tarder is added 0.1–1.1 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K tem- perature differ- ence	1.5 at a wet density of 100 to 399 kg/m ³ ; 1.0 at a wet density of 400 to 749 kg/m ³ ; 0.75 at a wet density of 750 to 1200 kg/m ³
134	stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 921.25 kg at a wet density of 1250 kg/m ³ (73.7%)	0.35	7.69 : 1.15 : 1.15 : 1	0.5–1.5 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K tem- perature differ- ence	—

Examples 135–137: Manufacture of porous lightweight concrete containing graphite powder: Table 15

Example	Properties	Wet density / total weight of cement rel- ative to the wet density	Weight ratio of water to total weight of cement	Weight ratio of 52.5 R ce- ment to CSA cement to clay-rich clinker to graphite powder [kg : kg : kg : kg]	Weight ratio of retarder to total weight of ce- ment [%]	Quantity of liquefier [weight ra- tio to total weight of cement in %]
135	Electromagnetically shielding	100–1250 kg/m ³ / 42 kg at a wet den- sity of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	7.69 : 2 : 1 : 1.07	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.02 weight-% more retarder is added for each 1 K temperature difference	0.5 at a wet density of 100 to 799 kg/m ³ ; 0.3 at a wet density of 800 to 1250 kg/m ³
136	Electromagnetically shielding and highly flowable	100–1250 kg/m ³ / 42 kg at a wet den- sity of 100 kg/m ³ (42%) – 918.75 kg at a wet density of	0.35	7.69 : 2 : 1 : 1.07	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.02 weight-% more retarder is added for each	1.5 at a wet density of 100 to 399 kg/m ³ ; 1.0 at a wet density

			1250 kg/m ³ (73.5%)			1 K temperature difference	of 400 to 799 kg/m ³ ; 0.75 at a wet density of 800 to 1250 kg/m ³
137	Electromagnetically shielding and stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	7.69 : 2 : 1 : 1.07	0.5–1.5 for a temperature of 0 to 50°C, whereby 0.02 weight-% more retarder is added for each 1 K temperature difference	—	

Examples 138–140: Manufacture of porous lightweight concrete containing silicon dioxide and poly(organo)siloxanes: Table 16

Example	Properties	Wet density / total weight of cement + SiO ₂ relative to the wet density	Weight ratio of water to total weight of cement + SiO ₂	Weight ratio of 52.5 R cement to CSA cement to clay-rich clinker to SiO ₂ [kg : kg : kg : kg]	Quantity of poly(organo)siloxane (based on the total weight of cement + SiO ₂ , i.e. weight of 52.5 R cement + weight of CSA	Weight ratio of retarder to the total weight of cement + SiO ₂ [%]	Quantity of liquefier [weight ratio to the total weight of cement + SiO ₂ in %]
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138	Particularly suitable for tropical climates	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 900 kg at a wet density of 1250 kg/m ³ (72%)	0.35 at a wet density of 100 kg/m ³ to 0.41 at a wet density of 1250 kg/m ³	From 7.69 : 1.15 : 1.15 : 1 at a wet density of 100 kg/m ³ to 7.04 : 1.06 : 1.06 : 1 at a wet density of 650 kg/m ³ to 7.04 : 1.06 : 1.06 : 1 at a wet density of 1250 kg/m ³	cement + weight of clay-rich clinker + weight of SiO ₂ 0.27 weight-%	0.5	0.5
139	stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	6.94 : 1.04 : 1.04 : 1 at a wet density of 100 kg/m ³ to 7.67 : 1.15 : 1.15 : 1 at a wet density of 1250 kg/m ³	0.27 weight-%	0.9	0.5

140	Highly flowable	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	6.94 : 1.04 : 1.04 : 1 at a wet density of 100 kg/m ³ to 7.67 : 1.15 : 1.15 : 1 at a wet density of 1250 kg/m ³	0.27 weight-%	0.5	1.5 at a wet density of 100 to 399 kg/m ³ ; 1.0 at a wet density of 400 to 799 kg/m ³ ; 0.75 at a wet density of 800 to 1250 kg/m ³
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Examples 141–143: Manufacture of porous lightweight concrete containing poly(organo)siloxanes: Table 17

Example	Properties	Wet density / total weight of cement relative to the wet density	Weight ratio of water to total weight of cement	Weight ratio of 52.5 R cement to CSA cement to clay-rich clinker [kg : kg]	Quantity of poly(organo)siloxane (based on the total weight of cement, i.e. weight of 52.5 R cement + weight of CSA cement +	Weight ratio of retarder to total weight of cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
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141		100–1200 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 882.0 kg at a wet density of 1200 kg/m ³ (73.5%)	0.35	6.67 : 1 : 1	weight of clay-rich clinker 0.29 weight-% at a wet density of 100 kg/m ³ to 0.3 weight-% at a wet density of 1200 kg/m ³	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K temperature difference	0.5
142	highly flowable	100–1200 kg/m ³ / constant 42%: 42 kg at a wet density of 100 kg/m ³ (42%) – 525.0 kg at a wet density of 1250 kg/m ³ (42%)	0.35	6.67 : 1 : 1	0.3 weight-%	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K difference in temperature	1.5 at a wet density of 100 to 399 kg/m ³ ; 1.0 at a wet density of 400 to 749 kg/m ³ ; 0.75 at a wet density of 750 to 1200 kg/m ³

143	stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 921.25 kg at a wet density of 1250 kg/m ³ (73.7%)	0.35	6.67 : 1 : 1	0.3 weight-%	0.5–1.5 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for every 5 K temperature difference	—
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Example 144: Manufacture of porous lightweight concrete containing a poly(organo)siloxane and SiO₂: Table**18**

Example	Properties	Wet density / total weight of cement + SiO ₂ relative to the wet density	Weight ratio of water to total weight of cement + SiO ₂	Weight ratio of 52.5 R cement to CSA cement to clay-rich clinker to SiO ₂ [kg : kg : kg : kg]	Quantity of poly(organo)siloxane (relative to the total weight of cement + SiO ₂ , i.e. weight of 52.5 R cement + weight of CSA cement + weight of clay-rich clinker + weight of SiO ₂	Weight ratio of retarder to total weight of cement + SiO ₂ [%]	Quantity of liquefier [weight ratio to the total weight of cement + SiO ₂ in %]
144		100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	6.99 : 1.05 : 1.05 : 1 at a wet density of 100 kg/m ³ to 7.69 : 1.15 : 1.15 : 1 at a wet density of 1250 kg/m ³	0.26 weight-% at a wet density of 100 kg/m ³ to 0.28 weight-% at a wet density of 1250 kg/m ³	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.02 weight-% more retarder is added for each 1 K temperature difference	0.5

Examples 145–146: Manufacture of porous lightweight concrete containing a poly(organo)siloxane: Table 19

Example	Properties	Wet density / total weight of cement relative to the wet density	Weight ratio of water to total cement	Weight ratio of 52.5 R cement to CSA cement to clay-rich clinker [kg : kg]	Quantity of poly(organo)siloxane – relative to the total weight of cement	Weight ratio of retarder to total weight of cement [%]	Quantity of liquefier [weight ratio to total weight of cement in %]
145	highly flowable	100–1250 kg/m ³ / 42 kg at a wet density of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	7.69 : 2.01 : 1	0.3 weight-%	0.1–1.1 for a temperature range of 0 to 50°C, whereby 0.02 weight-% more retarder is added for every 1 K difference in temperature	1.5 at a wet density of 100 to 399 kg/m ³ ; 1.0 at a wet density of 400 to 799 kg/m ³ ; 0.75 at a wet density of 800 to 1250 kg/m ³

146	stable on a slope of up to 3%	100–1250 kg/m ³ / 42 kg density of 100 kg/m ³ (42%) – 918.8 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	7.74 : 2.03 : 1 at a wet density of 100 kg/m ³ to 7.69 : 2.01 : 1 at a wet density of 1250 kg/m ³	0.24 weight-% at a wet density of 100 kg/m ³ to 0.42 weight-% at a wet density of 1250 kg/m ³	0.5–1.5 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for every 5 K temperature difference	—
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Examples 147–153: Manufacture of 3D printing mortar: Tables 20, 21 and 22

Example 147-49: 3D printing mortar with silicon dioxide and a poly(organo)siloxane – Table 20

Example and properties	Wet density [kg/m ³]	Quantity of sand with a grain size of 0–1 mm [kg based on 100 kg total weight of sand and cement]	Weight ratio of sand to cement [kg/kg]	Weight ratio of 52.5 R cement to CSA cement	Weight ratio of retarder to cement [weight-%]	Quantity of SiO ₂ [kg] per 100 kg total weight of sand and cement	Quantity of poly(organo)siloxane [kg] per 100 kg total weight of sand and cement
147	1900–2100	72	2.57 : 1	2.33 : 1	0.1–1.1 for a temperature	10	0.168

								range of 0 to 50°C, whereby 0.1 weight-% more retarder is added for every 5 K difference in temperature			
148		1900–2100	72			2.57 : 1	4.66 : 1	0.1–1.1 for a temperature range of –5°C to 50°C, whereby 0.1 weight-% more retarder is added for each 5 K temperature difference	–	0.1554	
149		1900–2100	72			2.57 : 1	2.33 : 1	0 at –10°C; 0.05 at –5°C; then 0.1–1.1 for a temperature range of 0°C to 50°C, whereby 0.1	–	0.168	

							weight-% more retarder is added for each 5 K tem- perature dif- ference		
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Examples 150–151: 3D printing mortar containing a poly(organo)siloxane – Table 21

Example and properties	Wet density [kg/m³]	Quantity of sand with a grain size of 0–1 mm [kg per 100 kg of 3D print- ing mortar]	Weight ratio of sand to cement [kg/kg]	Weight ra- tio of 52.5 R cement to CSA ce- ment	Weight ratio of retarder to cement [%]	Quantity of poly(or- gano)si- loxane [kg] per 100 kg total weight of sand and cement	Quantity of glass fibre [kg] per 100 kg of 3D printing mortar
150	2000– 2200	70	2.33 : 1	2.33 : 1	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for	0.18	0.35

							each 5 K temperature difference		
151		1800–2200	70		2.33 : 1	2.33 : 1	0.1–1.1 for a temperature of 0 to 50°C whereby 0.1 weight-% more retarder is added for each 5 K temperature difference	0.18	0.7

Examples 152–153: Manufacture of 3D printing mortar: Table 22

Example and properties	Wet density [kg/m ³]	Quantity of sand with a grain size of 0–1 mm [kg per 100 kg of 3D printing mortar]	Weight ratio of sand to cement [kg/kg]	Weight ratio of 52.5 R cement to CSA cement	Weight ratio of retarder to cement [%]	Quantity of poly(or)ganosiloxane [kg] per 100 kg total weight of sand and cement	Quantity of iron oxide powder [% of the quantity of 42.5 R cement in kg]

152	2000–2200	70	2.33 : 1	2.33 : 1 (42.5 R cement is used instead of 52.5 R cement, so-called white cement)	0.1–1.1 for a temperature of 0 to 50°C, whereby for every 5 K temperature difference 0.1 weight-% more retarder is added	0.18	1
153	2000–2200	70	2.33 : 1	2.33 : 1 (42.5 R cement is used instead of 52.5 R cement, so-called white cement)	0.1–1.1 for a temperature of 0 to 50°C, whereby 0.1 weight-% more retarder is added for every 5 K difference in temperature	0.18	1

Examples 154–158: Manufacture of a composition for the production of 3D printing mortar using pre-tempered water – Table 23

Example	Weight ratio of water to cement / wet density [kg/m³]	Components and their quantities, based on 100 kg of the total	Retarder and its quantity, based on 100 kg of the total 3D printing mortar composition
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154 3D printing mortar	0.40–0.55 / 1900–2100	3D printing mortar composition Sand (0–1 mm): 72 kg; 52.5R cement: 19.6 kg; CSA cement: 8.4 kg; Optional: shrinkage reducer: 0.196 kg	If the water temperature is brought to 10°C, 15°C, 20°C, 25°C or 30°C in advance, the setting time is delayed by 9, 8, 7, 6 or 5 minutes respectively. Thereafter, the setting time can be extended by one minute at a time by adding 0.02 weight-% of retarder per minute, based on the total weight of cement. This means that to extend the setting time to 22 minutes at a water temperature of 10°C, 0.26 weight-% of retarder, based on the total weight of cement, must be added after 9 minutes.
155 3D Printing Mortar Fibre	0.40–0.55 / 1900–2100	Sand (0–1 mm): 72 kg; 52.5R cement: 19.6 kg; CSA cement: 8.4 kg; Glass fibres: 0.35 kg; Optional: shrinkage reducer: 0.196 kg	If the water temperature is brought to 10°C, 15°C, 20°C, 25°C or 30°C in advance, the setting time is delayed by 9, 8, 7, 6 or 5 minutes respectively. Thereafter, the setting time can be extended by one minute at a time by adding 0.02 weight-% of retarder per minute, based on the total weight of cement. This means that to extend the setting time to 22 minutes at a water temperature of 10°C, 0.26 weight-% of retarder, based on the total weight of cement, must be added after 9 minutes.
156 3D Printing Mortar Fibre	0.40–0.55 / 1900–2100	Sand (0–1 mm): 72 kg; 52.5R cement: 19.6 kg; CSA cement: 8.4 kg; Glass fibres: 0.7 kg;	If the water temperature is brought to 10°C, 15°C, 20°C, 25°C or 30°C in advance, the setting time is delayed by 9, 8, 7, 6 and 5 minutes, respectively.

			optional: shrinkage reducer: 0.196 kg	Thereafter, the setting time can be extended by one minute at a time by adding 0.02 weight-% of retarder per minute, based on the total weight of cement. This means that to extend the setting time to 22 minutes at a water temperature of 10°C, 0.26 weight-% of retarder, based on the total weight of cement, must be added after 9 minutes.
157 3D Printing Mortar White	0.40–0.55 / 1900–2100	Sand (0–1 mm): 72 kg; 52.5R cement: 19.6 kg; CSA cement: 8.4 kg; Iron oxide powder: 0.112 kg or 1 weight-% based on the weight of water; optional: glass fibres: 0.35 kg; optional: shrinkage reducer: 0.196 kg		If the water temperature is brought to 10°C, 15°C, 20°C, 25°C or 30°C in advance, the setting time is delayed by 9, 8, 7, 6 and 5 minutes, respectively. Thereafter, the setting time can be extended by one minute at a time by adding 0.02 weight-% of retarder per minute, based on the total weight of cement. This means that to extend the setting time to 22 minutes at a water temperature of 10°C, 0.26 weight-% of retarder, based on the total weight of cement, must be added after 9 minutes.
158 3D printing mortar black	0.40–0.55 / 1900–2100	Sand (0–1 mm): 72 kg; 52.5R cement: 19.6 kg; CSA cement: 8.4 kg; Iron oxide powder: 0.112 kg or 1 weight-% based on the quantity of water; optional: glass fibres: 0.35 kg;		If the water temperature is brought to 10°C, 15°C, 20°C, 25°C or 30°C in advance, the setting time is delayed by 9, 8, 7, 6 or 5 minutes respectively. Thereafter, the setting time can be extended by one minute at a time by adding 0.02 weight-% of retarder per minute, based on the total weight of cement. This means that, at a water temperature of 10°C, to extend the setting time to 22 minutes, 0.26 weight-% of

		optional: shrinkage re- ducer: 0.196 kg	retarder, based on the total weight of cement, must be added after 9 minutes.
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Examples 159–160: Manufacture of concrete: Table 24

Example	159	160
Wet density	2200–2400 kg/m ³	2200–2400 kg/m ³
Weight ratio of water to cement	0.21–0.23	0.21–0.23
Components and their quantities, based on 100 kg of the total concrete composition	Sand (2–8 mm): 26.6 kg; Sand (0.4 mm): 26.6 kg; 52.5 R cement: 30 kg; Liquefier: 0.665 kg; Silicium dioxide (0.1 mm): 16.5 kg; Accelerator (temperature-dependent): 0.798 kg at 0°C to 0.266 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.	Sand (0–2 mm): 37 kg; Sand (0.05–0.03 mm): 22 kg; 52.5 R cement: 30 kg; Quartz powder/basalt (0.018–0.03 mm): 11 kg; Liquefier: 0.75 kg; Poly(organo)siloxane: 0.0207 kg; Accelerator (temperature-dependent): 0.9 kg at 0°C to 0.3 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.

Example 161: Manufacture of concrete: Table 25

Example	161
Wet density	1900–2600 kg/m ³ ; preferably 2200–2400 kg/m ³
Weight ratio of water to cement	0.21–0.23
Components and their quantities, based on 100 kg of the total concrete composition	Sand (2–8 mm): 26.6 kg; Sand (0.4 mm): 22.0 kg; 52.5 R cement: 30 kg; Liquefier: 0.665 kg; Silicium dioxide (0.1 mm): 11.0 kg; Accelerator (temperature-dependent): 0.798 kg at 0°C to 0.266 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.

Examples 162–165: Manufacture of high-performance concrete: Table 26

Example	Wet density kg/m ³	Weight ratio of water to cement	Components and their quantities, based on 100 kg of the total concrete composition
162	1900–2100 kg/m ³	0.21–0.23	Sand (0–2 mm): 37 kg; Sand (0.05–0.03 mm): 22 kg; 52.5 R cement: 30 kg; Silicium dioxide (0.018–0.03 mm): 11 kg; Liquefier: 0.925 kg; Accelerator (temperature-dependent): 1.11 kg at 0°C to 0.37 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.
163	1900–2100 kg/m ³	0.21–0.23	Sand (0–2 mm): 33 kg; Sand (0.05–0.03 mm): 19 kg; 52.5 R cement: 30 kg; Silicium dioxide (0.018–0.03 mm): 9.5 kg; Liquefier: 0.75 kg; Poly(organo)siloxane: 0.0207 kg; Accelerator (temperature-dependent): 0.9 kg at 0°C to 0.3 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.
164	1900–2100 kg/m ³	0.21–0.23	Sand (0–2 mm): 32 kg; Sand (0.05–0.03 mm): 19 kg; 52.5 R cement: 30 kg; Silicium dioxide (0.018–0.03 mm): 9.0 kg; Graphite powder: 3.0 kg;

			Liquefier: 0.75 kg; Poly(organo)siloxane: 0.126 kg; Accelerator (temperature-dependent): 0.9 kg at 0°C to 0.3 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.
165	1900–2100 kg/m ³	0.21–0.23	Sand (0–2 mm): 32 kg; Sand (0.05–0.03 mm): 19 kg; 52.5 R cement: 30 kg; Silicium dioxide (0.018–0.03 mm): 9.0 kg; Graphite powder: 3.0 kg; Liquefier: 0.75 kg; Poly(organo)siloxane: 0.183 kg; Accelerator (temperature-dependent): 0.189 kg at 0°C to 0.063 kg at 50°C; Viscosity modifier: 0.125 kg; Polypropylene fibres (18 mm): 0.3 kg.

Example 166: Manufacture of the composition for the production of lightweight elastic aerated concrete: Table

27

Example	Properties	Wet density / Total weight of cement rela- tive to wet density	Weight ratio of water to total weight of cement	Weight ratio of 52.5 R ce- ment to CSA ce- ment to clay-rich clinker [kg : kg : kg]	Quantity of poly(or- gano)siloxane – relative to the total weight of ce- ment	Weight ratio of retarder to total weight of cement [weight-%]	Quantity of liquefier [weight ra- tio to total weight of cement in %]
166	elastic	100–1250 kg/m ³ / 42 kg at a wet den- sity of 100 kg/m ³ (42%) – 918.75 kg at a wet density of 1250 kg/m ³ (73.5%)	0.35	6.67 : 1 : 1	0.29 weight-% at a wet den- sity of 100 kg/m ³ to 0.30 weight-% at a wet density of 1250 kg/m ³	0.5 at 20°C	0.5 at 20°C

Claims

1. A composition for the production of porous lightweight concrete comprising the following components:
 - 5 i) a pulverous main component selected from CEM I cement, CEM II cement, and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, and mixtures thereof;
 - ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
 - 10 iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents, as well as graphite powder, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(or-
 - 15 gano)siloxanes;
 - iv) at least one liquid ancillary component selected from retarders and liquefiers;
 - v) at least one liquid foaming agent; and
 - vi) water;

20

wherein the composition of the composition is, in particular, individually adaptable to the ambient temperatures of the composition,

wherein the quantity of liquefier and/or the quantity of retarder is in each
 25 case in the range of from 0.05 to 2.00 weight-%, based on the total weight of cement in the composition, and

wherein the composition has a wet density in the range of from 100 to 1250 kg/m³.

2. The composition according to claim 1, wherein the pulverous main component i) is 52.5 R cement or 42.5 R cement or a mixture thereof, preferably wherein the pulverous main component i) is 52.5 R cement, and wherein the first pulverous ancillary component ii) is CSA cement or calcium aluminate cement or a mixture thereof, preferably wherein the first pulverous ancillary component ii) is CSA cement.

3. The composition according to claim 1 and/or claim 2, wherein the weight ratio of component i) to component ii) is in the range of from 10 : 1 to 1 : 1, preferably in the range of from 5 : 1 to 1.2 : 1, more preferably in the range of from 4 : 1 to 1.3 : 1, preferably when the component i) is CEM I cement and the component ii) is CSA cement, more preferably when the component i) is 52.5 R cement and the component ii) is CSA cement.

4. The composition according to claim 2 and/or claim 3, wherein the CSA cement is at least partially replaced by calcium aluminate cement, wherein preferably the CSA cement is replaced by calcium aluminate cement in a range of from 30 to 70 weight-%, more preferably in a range of from 40 to 60 weight-%, most preferably in a range of from 45 to 55 weight-%.

5. The composition according to one or more of the preceding claims, wherein the liquid foaming agent v) is in a quantity in the range of from 10 to 50 g per 1 liter of water, preferably in a quantity in the range of from 20 to 40 g per 1 liter of water, more preferably in a quantity in the range of from 25 to 35 g per 1 liter of water, most preferably in a quantity in the range of from 28 to 32 g per 1 liter of water.

6. The composition according to one or more of the preceding claims, wherein the quantity of the retarder is in the range of from 0.1 to 1.5 weight-%, based on the total weight of cement.

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7. The composition according to one or more of the preceding claims, wherein the weight ratio of water to cement is in the range of from 0.2 : 1 to 0.6 : 1.

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8. The composition according to one or more of the preceding claims, wherein the weight ratio of water to cement is in the range of from 0.2 : 1 to 0.4 : 1.

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9. A method for the manufacture of the composition according to one or more of the preceding claims, comprising the following steps:

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a) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and water to form an aqueous mixture;

b) introducing the at least one liquid foaming agent v) into water and mixing it with air to produce foam;

c) introducing the further components i), ii) and iii) into a first mixer, preferably via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a

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slurry;

d) further mixing the slurry produced in step c) in a second mixer whilst adding the foam produced in step c), to the composition;

e) removing the composition from the second mixer;

wherein the quantities of the components i) to iv) are, in particular, individually adapted to the ambient temperatures.

10. The method according to claim 9, wherein steps a) to e) are carried out continuously.

11. Porous lightweight concrete produced by drying a composition according to one or more of claims 1 to 8.

12. Use of a dried composition according to one or more of claims 1 to 8 as porous lightweight concrete.

13. A composition for the production of self-levelling screed, 3D printing mortar or filler, comprising the following components:

- i) a pulverous main component selected from CEM I cement, CEM II cement, sand, quartz sand and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement, sand, quartz sand and mixtures thereof;
- ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
- iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents, as well as graphite powders, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes, polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(organo)siloxanes;
- iv) at least one liquid ancillary component selected from retarders, liquefiers and shrinkage reducers; and
- vi) water;

wherein the composition of the composition is, in particular, individually adaptable to the ambient temperatures of the composition, wherein the quantity of liquefier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total

5 weight of cement in the composition, and

wherein the composition has a wet density in the range of 1800 to 2200 kg/m³ for 3D printing mortar, a wet density in the range of 2000 to 2200 kg/m³ for self-levelling screed and a wet density in the range of 1900 to 2000 kg/m³ for filler.

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14. The composition according to claim 13, wherein the quantity of retarder is in the range of from 0.1 to 1.5 weight-%, based on the total weight of cement.

15 15. The composition according to claim 13 or claim 14, wherein the weight ratio of water to cement is in the range of from 0.2 : 1 to 0.6 : 1, preferably in the range of from 0.3 : 1 to 0.55 : 1.

20 16. A method for the manufacture of the composition for the production of self-levelling screed, 3D printing mortar or filler according to one or more of claims 13 to 15, comprising the following steps:

a) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component
25 and water to form an aqueous mixture;

c) introducing the further components i), ii) and iii) into a first mixer, preferably via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a slurry;

d) further mixing the slurry produced in step c) in a second mixer to form the composition; and

e) removing the composition from the second mixer;

wherein the quantities of components i) to iv) are, in particular, individually adapted to the ambient temperatures.

17. The method according to claim 16, wherein steps a), c), d) and e) are carried out continuously.

18. Self-levelling screed, 3D printing mortar and filler produced by drying a composition according to one or more of claims 13 to 15.

19. Use of a dried composition according to one or more of claims 13 to 15 as self-levelling screed, 3D printing mortar or filler.

20. A composition for the production of concrete, comprising the following components:

- i) a pulverous main component selected from CEM I cement, CEM II cement and mixtures thereof, preferably selected from 52.5 R cement, 42.5 R cement, 32.5 R cement and mixtures thereof;
- ii) a further first pulverous ancillary component selected from CSA cement, calcium aluminate cement and mixtures thereof;
- iii) optionally, a further second ancillary component selected from glass fibres, iron oxide powders and coloring agents, as well as graphite powders, fly ash, silicon dioxide, quartz powder, basalt, plastic fibres, accelerators, viscosity modifiers, polyurethanes,

polyvinyl acetates, poly(ethylene-vinyl acetate)s and poly(organosiloxanes);

iv) at least one liquid ancillary component selected from retarders and liquifiers; and

5 (vi) water;

wherein the composition of the composition is, in particular, individually adaptable to the ambient temperatures of the composition,

wherein the quantity of liquifier and/or the quantity of retarder is in each case in the range of from 0.05 to 2.00 weight-%, based on the total

10 weight of cement in the composition; and

wherein the composition has a wet density in the range of from 1900 to 2600 kg/m³, preferably in the range of 2000 to 2500 kg/m³, more preferably in the range of 2200 to 2400 kg/m³.

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21. A method for the manufacture of the composition for the production of concrete according to claim 20, comprising the following steps:

20 A) introducing the at least one liquid ancillary component iv) into water, preferably via a metering pump, and mixing this ancillary component and water to form an aqueous mixture;

B) introducing the further components i), ii) and iii) into a first mixer, preferably via individual, separate metering pumps, and mixing them with the aqueous mixture produced in step a) to form a

25 slurry;

C) further mixing the slurry produced in step c) in a second mixer; and

D) removing the composition from the second mixer;

wherein the quantities of components i) to iv) are, in particular, individually adapted to the ambient temperatures.

22. Concrete produced by drying a composition according to claim
5 20.

23. Use of a dried composition according to claim 22 as concrete.

24. The composition according to any one of claims 1 to 8, 13 to 15 and
10 20, wherein the composition can be produced in situ at an ambient temperature of the composition of 0°C to 50°C, and/or the individual quantities of the liquid ancillary components iv) are adapted to the ambient temperatures of the composition and/or the individual quantities of the liquid ancillary components iv) can be accurately metered to a measurement accuracy of at least 5% of the total quantity used, preferably of
15 at least 2% of the total quantity used, and more preferably of at least 1% of the total quantity used.