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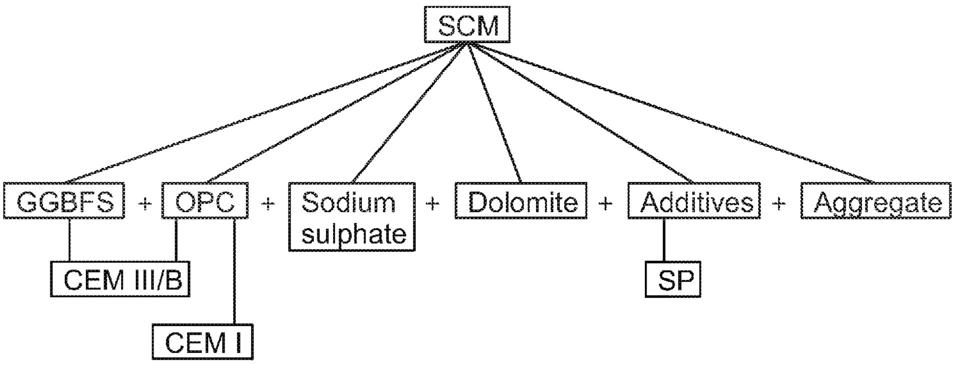

FIG. 3

(57) Abstract: A supplementary cementitious material composition, concrete composition, and method of producing concrete. The supplementary cementitious material composition comprises hydraulic binder composition, aggregate material, activator, and additive materials. The hydraulic binder composition comprises ground granulated blast-furnace slag (GGBFS) and port-land cement (OPC). As an activator is used sodium sulphate (Na_2SO_4). The composition further comprises dolomite ($CaMg(CO_3)_2$).

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HIGH GGBFS CONTAINING CEMENTITIOUS BINDER, CONCRETE AND METHOD

Background of the invention

The invention relates to a new solution for providing a supplementary cementitious material composition which comprises slag based binder material and can replace traditional cements and decrease carbon dioxide emissions of concrete.

More specifically, the invention relates to a hydraulic slag cement composition.

The invention relates also to a concrete composition and method of producing concrete.

The object of the invention is described in more detail in the preambles of independent claims of the application.

Concrete has several excellent properties, such as durability, high compressive strength, low-cost material, and easy maintenance, and it is fire and waterproof. Therefore, concrete is the most used construction material in the world. Traditionally, cement has been the main component of the concrete. Unfortunately, it is estimated that 5 - 8% of carbon dioxide (CO_2) emissions come from the manufacture and use of cement. A large proportion of this emission is due to the use of calcium, which is normally obtained by burning limestone and which is essential for the reaction between cement and water to form concrete. This is why there are massive ongoing scientific projects around the world seeking solutions for lowering the emissions or making concrete and cement totally out of carbon dioxide emissions.

Ordinary portland cement (OPC) is the most comprehensively used cement nowadays. Cement containing this OPC is often called CEM I type cement or portland cement. Considerable research efforts are targeted to find alternative ways of making concrete or similar construction materials more sustainable. Several studies suggest replacing OPC with various supplementary cementitious materials (SCMs) to thereby reduce carbon dioxide emissions. However, the known supplementary cementing materials (SCM) suffer from low early age strength compared to portland cement. Therefore, it has been difficult to implement the new materials in practice.

Documents WO-2018228839-A1, US-2019071354-A1, KR-100948754-B1 and WO-2019077390-A1 disclose some concrete compositions.

Brief description of the invention

The idea of the invention is to provide a new and improved supplementary cementitious material composition and concrete. Further, it is an object to provide a new and improved method of producing concrete.

The characteristic features of the supplementary cementitious material composition according to the invention are set forth in the characterizing part of the first independent claim.

The characteristic features of the concrete composition according to the invention are set forth in the characterizing part of the second independent claim.

The characteristic features of the method according to the invention are set forth in the characterizing part of the third independent claim.

The idea of the proposed solution is to improve properties of slag based hydraulic binder by incorporating dolomite as supplementary cementitious material and using sodium sulphate as an activator. The dolomite can act as a binder material in the disclosed composition.

In the tests performed it was found that the use of dolomite accelerated the hydration process of the hydraulic binder composition and improved thereby early age strength development.

The tests further showed that the use of the sodium sulphate as an activator had a positive impact on the strength properties.

When the compound includes a small amount of portland cement the early strength development is improved.

An advantage of the proposed solution is that incorporation of dolomite as a supplementary cementitious material and sodium sulphate as an activator can improve the early strength development of a slag containing concrete. The early age strength is particularly important as this will control the age at which mould formwork can be removed.

Further, there is a growing demand worldwide to use alternative cementitious materials since they will help reduce the environmental impact of traditional concrete. Since the disclosed solution can solve the problem related to the poor early strength development, then there are no longer obstacles for substituting the OPC with the disclosed environmentally friendlier solution.

The new solution can also reduce costs because cycle time for concrete pouring can be shorted and more effective production of concrete elements and structures is possible.

Summary of some advantages:

- the rapid increase in early strengths enables quick demolding of products,
- improved and rapid early strength properties enable to use the disclosed solution as a binder in ready mix solutions,
- high early and final compressive strengths,
- good workability,
- improved resistance to aggressive chemicals.

Thus, the early age strength problem of the known solutions can be solved by the disclosed solution.

According to an embodiment, the composition contains the ground granulated blast-furnace slag (GGBFS) 10 – 12% by weight and the portland cement (OPC) 4 – 7% by weight.

According to an embodiment, the composition contains dolomite ($CaMg(CO_3)_2$) 1.4 – 1.8% by weight.

According to an embodiment, the composition contains sodium sulphate (Na_2SO_4) 0.6 - 0.8% by weight.

According to an embodiment, the composition contains aggregate material 70 - 73% by weight.

According to an embodiment, the composition contains at least one superplasticizer (SP) 0.5 - 2.0 % by weight of the binder material. The superplasticizer (SP) is serving as at least one additive material in the composition.

According to an embodiment, the composition contains superplasticizer (SP) 1.5 % by weight of the binder material.

According to an embodiment, the composition may in some cases be without any superplasticizer (SP).

According to an embodiment, the composition contains:

the portland cement (OPC) 6,6% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 71% by weight;

the dolomite ($CaMg(CO_3)_2$)1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,8% by weight.

According to an embodiment, the composition contains:

the portland cement (OPC) 4,9% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 72.6% by weight;

the dolomite ($CaMg(CO_3)_2$)1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,2% by weight.

According to an embodiment, the composition contains blast furnace cement CEM III/B comprising the ground granulated blast furnace slag (GGBFS) and the portland cement (OPC) and wherein amount of the ground granulated blast furnace slag (GGBFS) is at least 65% by weight.

According to an embodiment, the composition contains blast furnace cement CEM III/B and CEM I type cement. Thus, the composition contains a blend of two cement types. The GGBFS amount in the binder originates from the CEM III/B. Further, the amount of portland cement originates from the CEM III/B and CEM I type cements.

According to an embodiment, the hydraulic binder composition contains the portland cement (OPC), the ground granulated blast-furnace slag (GGBFS) and the dolomite ($CaMg(CO_3)_2$) and wherein relative proportion of the dolomite ($CaMg(CO_3)_2$) per the hydraulic binder composition is 0.08 – 0.09.

According to an embodiment, relative content of the dolomite per total amount of the binder material is 0.06 – 0.10.

According to an embodiment, grain size of ingredients of the hydraulic binder composition is 100 micrometers or less.

According to an embodiment, the aggregate comprises crushed stone with grain size 0.02 – 16 mm.

According to an embodiment, the aggregate comprises normal sand intended for concretes.

According to an embodiment, water to hydraulic binder ratio is 0.45 – 0.65, typically 0.5 – 0.55.

According to an embodiment, aggregate material to hydraulic binder ratio is 3 – 4.

According to an embodiment, aggregate material to hydraulic binder ratio is 4.

According to an embodiment, the disclosed solution relates also to a concrete composition comprising supplementary cementitious material composition and water. The supplementary cementitious material composition in the concrete is in accordance with the features and embodiments disclosed in this document. Further, relative proportion of water per hydraulic binder composition is 0.45 – 0.65, typically 0.50 – 0,55.

According to an embodiment, the concrete composition has early age compressive strength with 24 hours setting time at least 7 Mpa.

According to an embodiment, the early age strength at 24 hours is at least 12 Mpa. It is typically recommended to delay removing of moulding framework until the concrete surface compressive strength has reached a minimum value of 5 Mpa. Thus, this requirement is fulfilled rapidly. Let it be mentioned that setting time is the time required for stiffening of cement paste to a defined consistency. Indirectly it is related to the initial chemical reaction of cement with water to form stiff compound.

According to an embodiment, the concrete composition has early age compressive strength with 2 days setting time at least 18 Mpa.

According to an embodiment, the concrete composition has ultimate compressive strength at 28 days setting time at least 42 Mpa.

According to an embodiment, the final or ultimate compressive strength is at least 47 Mpa.

According to an embodiment, the concrete composition is ready mix concrete. Then the concrete composition is to be produced at a ready-mix concrete plant and configured to be transported to use sites by means of ready-mix trucks.

According to an embodiment, the concrete composition is casting concrete for concrete prefabrication factory wherein different precast concrete elements are manufactured from the disclosed concrete composition. The precast concrete element may be a wall element, precast slab, hollow-core concrete slab, precast concrete stair, soil reinforcing pile, or concrete railway sleeper, for example.

According to an embodiment, the concrete composition is floor screed for providing a levelled surface for floor finishing materials.

According to an embodiment, the concrete composition is mortar material intended to be used as a glue type material between prefabricated building components, such as bricks and blocks.

According to an embodiment, the disclosed solution relates also to a method of producing concrete comprising supplementary cementitious material composition. The method comprises: mixing in a first step together dry ingredients comprising at least one hydraulic binder composition, at least one aggregate material, and at least one activator material; adding liquid ingredients to a formed dry mix, wherein the liquid ingredients comprise at least superplasticizer (SP) as additive material and water; and mixing in a second step the dry mix and liquid ingredients together. The method further comprises: using as the hydraulic binder composition at least CEM III/B slag cement comprising ground granulated blast-furnace slag (GGBFS) and portland cement (OPC); including dolomite ($CaMg(CO_3)_2$); using sodium sulphate (Na_2SO_4) as the activator; and mixing the dolomite ($CaMg(CO_3)_2$), the CEM III/B slag cement, and the sodium sulphate (Na_2SO_4) activator together for forming the mentioned dry mix.

According to an embodiment, the method further comprises implementing a recipe wherein the concrete comprises the following ingredients:

the portland cement (OPC) 4,9% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 72.6% by weight;

the dolomite ($CaMg(CO_3)_2$) 1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,2% by weight.

According to an embodiment, the method further comprises adding CEM I portland cement 1,6% by weigh and mixing it together with the CEM III/B slag cement with 16,4% by weight to form a blend cement which is used as the hydraulic binder composition.

The above-described embodiments and their features may be combined to provide desired configurations.

Disclosure of some related materials and features

Hydraulic cement

A type of cement that sets quickly and hardens with the addition of water to the finely ground cement is called hydraulic cement.

Early age strength

Early strength development of concrete is essential.

Early strength is particularly important as this will control the age at which formwork can be removed.

It is recommended to delay demoulding until the concrete surface compressive strength has reached a minimum value of 5 MPa. Then the risk of mechanical damage to the moulded structure is minimized. Where the concrete curing temperature is below 20°C then the curing time needs to be increased.

Aggregate

Aggregate is medium-grained particulate material used as a component in concrete and may include sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. The aggregate serves as reinforcement to add strength to the concrete which is a composite material.

Ground granulated blast-furnace slag (GGBFS)

Ground granulated blast-furnace slag, also commonly referred to as slag, is a by-product of steel production. The slag is primarily composed of CaO, SiO_2, aluminium oxide (Al_2O_3), and magnesium oxide (MgO). When used as part of a portland cement concrete, slag reacts with both the water (latent hydraulic reaction) and the hydrated cement paste (pozzolanic reaction), resulting in a more refined micro-structure than that of a plain portland cement. At early exposure ages, concrete containing slag will have a similar to slightly higher diffusion coefficient than in ordinary portland cement concrete, but at ages greater than 90 days, it will have a lower diffusion coefficient.

The main drawback of using cements or combinations that incorporate GGBS is that although the 28-day strength will be similar to that achieved with CEM I alone, the early strength may be significantly reduced.

Granulated slag is created by the very fast cooling of the slag from the blast furnace with a large quantity of water. We call this the granulation process. In the granulation process, the liquid slag is changed into so-called slag sand, a granular product with a grain size of 0 – 2 mm. As a result of this process, the slag also takes on an amorphous structure. Finally, the granulated slag is ground into a fine powder.

Ground-granulated blast furnace slag is highly cementitious and high in calcium silicate hydrates (C-S-H) which is a strength enhancing compound which improves the strength, durability, and appearance of the concrete.

Granulated slag is a raw material for the production of blast furnace cement (CEM III). In combination with Portland cement, ground granulated slag can also be used under certain conditions directly in concrete in combination with Portland cement.

<u>CEM III</u>

CEM III is also known as blast furnace cement (BFC).

Blast furnace cements (CEM III/A, B, C) are based mainly on Portland cement clinker (OPC) and ground granulated blast furnace slag (GGBFS).

There are three different classified types of blast furnace cement, namely CEM III/A, CEM III/B and CEM III/C, wherein the letter indicates amount of slag.

The CEM III/B comprises about 70% GGBS.

CEM I

CEM I is a cement type made of portland cement for concretes.

Dolomite

Dolomite ($CaMg(CO_3)_2$) can be obtained from natural sedimentary rock and it is low cost and environmentally friendly material.

Studies have shown dolomite to improve the properties of cement composite.

Dolomite as an OPC replacement resulted in the greater compressive strength.

Sodium sulphate, Na_2SO_4

Sodium sulfate (also known as sodium sulphate or sulfate of soda) is the inorganic compound with formula Na_2SO_4. The sodium sulfate is solid powder material that is highly soluble in water.

The sodium sulfate can be used as an activator on cement paste.

Superplasticizer (SP)

Superplasticizers, also known as high range water reducers, are additives used in making high strength concrete. By means of superplasticizers water content may be reduced by 30% or more in the production of concrete. Superplasticizers retard the curing of concrete. Their addition to concrete allows the reduction of the water to cement ratio without negatively affecting the workability of the mixture. SPs also improve flow characteristics whereby they enable the production of self-consolidating concrete and high performance concrete. They greatly improve the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases.

Superplasticizers are synthetic polymers. Compounds used as superplasticizers include sulfonated naphthalene formaldehyde condensate, sulfonated melamine formaldehyde condensate, acetone formaldehyde condensate and polycarboxylate ethers.

Some examples of the tests performed

CEMIII/B early strength development was achieved in experiments by making different mix compositions.

Desirable mixes with adequate early age strength were made in small scale (Prismatic samples 40x40x16 mm). Recipes were made by using standard sand as aggregate and water/binder ratio was 0.45-0.5. The most promising results were selected for further experiments and modified based on the application requirements.

Ground granulated blast furnace slag (GGBFS) can be made reactive in highly alkaline conditions by using alkaline materials like NaOH, KOH, Na_2SiO_3. Since CEM III/B contains 70-75% blast furnace slag, the first set of experiments was made by adding different ratios of NaOH + Na_2SiO_3, KOH, NaOH, Na_2SiO_3 to make them alkali activated materials. Some promising results came up from the experiments and the mix composition containing CEM III/B + NaOH + Na_2SiO_3 was selected for large scale mixing.

Metakaolin is a clay mineral that contains a considerable amount of alumina and silicon, and it is usually used as precursor material for geopolymerization. Unfortunately, using metakaolin and the alkaline solution

($NaOH+Na_2SiO_3$) incorporated with CEM III/B could not help to improve the final product's early strength properties.

Limestone is a common filler used in cementitious materials. The effect of using limestone is making a compact structure and strength improvement due to reactive $CaCO_3$ inside. But it was found that in different CEM III/B mixes the limestone cannot help the early strength achievement.

Magnesium oxide (MgO) and calcium oxide (CaO), calcium hydroxide (CaOH) are other precursor materials used for helping reactivity of alkali-activated materials. But it was found that in CEM III/B mixes they cannot support the early strength achievement.

It was also found out that sodium carbonate (Na_2CO_3) and sodium sulfate (Na_2SO_4) and silica fume (SiO_2) cannot improve high early strength for CEM III/B. However, the final strength can be relatively high. Overall, if the early strength is not a target, using 6-10% of binder content with Na_2CO_3 or Na_2SO_4 or SiO_2 may reach to the final strength of 45-55 MPa.

Gypsum ($CaSO_4$) is another precursor material used to improve early age strength properties of cementitious materials. However, use of the gypsum leads to lower final strength for CEM III/B based products.

Prismatic recipes with higher early age strength properties were selected for large-scale mixing. The recipes were calculated and designed for the large-scale mixing and taking into account superplasticizer, aggregate, and curing conditions based on the final product requirements.

Recipe experiment 1:

CEM III/B 11% + CEM I 3% + (Na_2SiO_3 + NaOH) 1-1,2%+ SP 5%

1-day strength	9-10 MPa
28-day strength	28-35 MPa

Recipe experiment 2:

CEM III/B 14% + (Na_2SiO_3 + NaOH)1-1,2% + SP 5%

1-day strength 8-10 MPa
28-day strength 26-32 MPa

Recipe experiment 3:
CEM III/B 14% + CEM I 2% + limestone 2% + dolomite 2% + Na_2SO_4 1% + SP 6%

1-day strength 3-5 MPa
28-day strength 30-32 MPa

Recipe experiment 4:
CEM III/B 12-16% + CEM I 1,5-2% + dolomite 1-2% + Na_2SO_4 1-1,5% + SP 6%

1-day strength 6-13 MPa
28-day strength 35-47 MPa

The recipe experiment 4 was found as the most promising one. In this recipe, commercial CEM III/B was used.

For comparison, it was prepared in the test laboratory self-made CEM III/B containing a blend of pure GGBFS (70%) and CEM I (30%). This blended slag cement was then mixed with the other material content of previous recipe experiment 4. This way mix composition of recipe experiment 5 below was created.

Recipe experiment 5:
GGBFS 11% + CEM I 7% + dolomite 2% + Na_2SO_4 1% + SP 6%

1-day strength 7 MPa
28-day strength 42 MPa

Curing conditions in the tests were temperature 22° C and relative humidity RH 95%.

Another interest is using CEM III/B in pre-casted products, such as in manufacture of piles for soil reinforcing. Therefore, several additional tests were made. In the tests same ingredients were used. The only difference was a greater amount of binder CEM III/B. Because of the greater amount of the binder material, amount of SP was also increased. In addition to, curing conditions were different since higher temperature was used, 40° C and RH 65%.

Recipe experiment 6:
CEM III/B 19% + CEM I 2% + dolomite 2% + Na_2SO_4 1% + SP 8%

1-day strength	20 MPa
28-day strength	45 MPa

In one further test arrangement SP was left out from the previous recipe experiment 6. All the other ingredients and conditions remained the same.

Recipe experiment 7:
CEM III/B 19% + CEM I 2% + dolomite 2% + Na_2SO_4 1%

1-day strength	22 MPa
28-day strength	47 MPa

Some general issues to be mentioned regarding the experiments:

Superplasticizers SP were used for decreasing need of water addition. In tests commercial SP materials was used. When amount of SP was 1,5% of the binder content the amount of added water was able to be limited considerably.

In the tests it was found out that the presence of Na_2SO_4 may improve hydration reaction in both cement and slag content and may cause to make C-S-H content with a dense structure.

Brief description of the figures

Some embodiments of the proposed solution are illustrated in more detail in the following figures, in which

Figures 1 - 3 are schematic and simplified diagrams illustrating some possible supplementary cementitious material compositions,

Figure 4 is a schematic and simplified diagram illustrating manufacturing process of a concrete paste,

Figure 5 is a table showing ingredients and ranges of one possible recipe of the disclosed solution,

Figure 6 is a schematic and simplified diagram illustrating possible concrete products and use cases of the disclosed solution,

Figures 7 and 8 are tables showing ingredients of two possible recipes of the disclosed solution,

Figure 9 is a table showing some relative proportions of different materials in the disclosed solution, and

Figure 10 is a schematic presentation of strength values for two different recipes at different setting times.

For the purpose of clarity, some embodiments of the proposed solutions are illustrated in the figures in a simplified form. The same reference numerals are used in the figures to refer to the same elements and features.

Detailed description of some embodiments

Figure 1 discloses that the disclosed supplementary cementitious material composition SCM may comprise ground granulated blast-furnace slag GGBFS and portland cement OPC which serve as hydraulic binder materials. The composition further comprises sodium sulphate Na_2SO_4 as an activator. The composition is also provided with dolomite ($CaMg(CO_3)_2$). Relative amounts of these ingredients are disclosed above in this document.

Figure 2 further discloses that the supplementary cementitious material SMC may comprise a blending of CEM III/B type slag cement and CEM I type ordinary cement. Then the ground granulated blast-furnace slag GGBFS is originated from the CEM III/B component and the portland cement OPC is originated from both cement types CEM III/B and CEM I.

Figure 3 discloses that the supplementary cementitious material SMC may further comprise one or more additive materials. Typically, superplasticizer SP is needed for controlling amount of water in concrete paste. Further, the composition comprises aggregate material, which may contain natural stone material in different grain sizes, for example. The aggregate material may be natural sand or gravel, or it may be crushed rock material.

Figure 4 discloses a possible manufacturing process of a concrete paste. At first dry material ingredients are added and mixed together in a first mixing phase. Thereafter liquid ingredients are added to the formed dry mix and second mixing is executed. After water is added to the dry mix and the second mixing phase is executed then hydraulic reaction is initiated. The dry matter component and liquid component are mixed properly whereafter the concrete paste is ready for use.

Figure 5 is a table showing ranges in weight percent wt% for amounts of ingredients for a material recipe in accordance with the disclosed solution. Table 1 is a summary of possible ranges disclosed already above in this document.

Figure 6 illustrates that the disclosed solution can be implemented when producing material for ready-mix concrete, casting concrete, floor screed and mortar. Ranges in ingredient proportions and other disclosed material properties and amounts can be adjusted so that needed properties are achieved for different concrete products and use cases.

Figures 7 and 8 show Tables 2 and 3 disclosing ingredients for two different recipes. Figure relates to Recipe A and Figure 8 relates to Recipe B. As can be noted, CEM I and CEM III/B amounts are different in these recipes. In Recipe A there is a blend of both cement types, whereas in Recipe B only CEM III/B is used. In both recipes the used CEM III/B includes 70% GGBFS and 30% CEM I, whereby Recipe A comprises totally GGBFS 11.5 wt% and CEM I 6.6 wt%, whereas Recipe B comprises totally GGBFS 11.5% and CEM I 4.9%.

Because of this difference in binding material contents, slight differences occur in at least some of the other ingredients.

In addition to the listed ingredients in the Tables 2 and 3, there is water so that the total weight percentage is 100%.

Figure 9 shows Table 4 disclosing some relative proportions of different materials in the above mentioned Recipes A and B. Further, possible ranges for the relative amounts are also disclosed.

Figures 7 – 9 summarize and put in more understandable format materials and numerical values disclosed in this document.

Figure 10 presents measured strength values for the mentioned Recipes A and B at different setting times.

The figures and their description are intended only to illustrate the idea of the invention. However, the scope of protection of the invention is defined in the claims of the application.

Claims

1. A supplementary cementitious material (SCM) composition comprising:

hydraulic binder composition;

at least one aggregate material; and

at least one activator;

c h a r a c t e r i z e d in that

the hydraulic binder composition comprises ground granulated blast-furnace slag (GGBFS) and portland cement (OPC);

the mentioned activator is sodium sulphate (Na_2SO_4);

and wherein the hydraulic binder composition further comprises dolomite ($CaMg(CO_3)_2$).

2. The composition according to claim 1, c h a r a c t e r i z e d in that

the composition contains the ground granulated blast-furnace slag (GGBFS) 10 – 12% by weight and the portland cement (OPC) 4 – 7% by weight.

3. The composition according to claim 1 or 2, c h a r a c t e r i z e d in that

the composition contains dolomite ($CaMg(CO_3)_2$) 1.4 – 1.8% by weight.

4. The composition according to any of the preceding claims 1 - 3, c h a r a c t e r i z e d in that

the composition contains sodium sulphate (Na_2SO_4) 0.6 – 0.8% by weight.

5. The composition according to any of the preceding claims 1 - 4, c h a r a c t e r i z e d in that

the composition contains aggregate material 70 – 73% by weight.

6. The composition according to any of the preceding claims 1 - 5, c h a r a c t e r i z e d in that

the composition contains at least one superplasticizer (SP) 0.5 – 2.0 % by weight of the binder material and the superplasticizer (SP) is serving as at least one additive material.

7. The composition according to any of the preceding claims 1 - 6, c h a r a c t e r i z e d in that

the composition contains:

the portland cement (OPC) 6,6% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 71% by weight;

the dolomite ($CaMg(CO_3)_2$)1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,8% by weight.

8. The composition according to any of the preceding claims 1 - 6, c h a r a c t e r i z e d in that

the composition contains:

the portland cement (OPC) 4,9% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 72.6% by weight;

the dolomite ($CaMg(CO_3)_2$)1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,2% by weight.

9. The composition according to any of the preceding claims 1 - 8, c h a r a c t e r i z e d in that

the composition contains blast furnace cement CEM III/B comprising the ground granulated blast furnace slag (GGBFS) and the portland cement (OPC) and wherein amount of the ground granulated blast furnace slag (GGBFS) is at least 65% by weight.

10. The composition according to any of the preceding claims 1 - 9, c h a r a c t e r i z e d in that

the hydraulic binder composition contains the portland cement (OPC), the ground granulated blast-furnace slag (GGBFS) and the dolomite ($CaMg(CO_3)_2$) and wherein relative proportion of the dolomite ($CaMg(CO_3)_2$) per the hydraulic binder composition is 0.06 – 0.10.

11. A concrete composition comprising supplementary cementitious material composition and water;

c h a r a c t e r i z e d in that

the supplementary cementitious material composition is in accordance with any of the preceding claims 1 – 10;

and wherein relative proportion of water per hydraulic binder composition is 0.40 – 0.60.

12. The concrete composition according to claim 11, c h a r a c t e r i z e d in that

the concrete composition has early age compressive strength with 24 hours setting time at least 7 Mpa.

13. The concrete composition according to claim 11 or 12, c h a r a c t e r i z e d in that

the concrete composition has early age compressive strength with 2 days setting time at least 18 Mpa.

14. The concrete composition according to any of the preceding claims 11 - 13, c h a r a c t e r i z e d in that

the concrete composition has ultimate compressive strength at 28 days setting time at least 42 Mpa.

15. The concrete composition according to any of the preceding claims 11 - 14, c h a r a c t e r i z e d in that

the concrete composition is ready mix concrete.

16. A method of producing concrete comprising supplementary cementitious material composition,

wherein the method comprises:

mixing in a first step together dry ingredients comprising at least one hydraulic binder composition, at least one aggregate material, and at least one activator material;

adding liquid ingredients to a formed dry mix, wherein the liquid ingredients comprise at least superplasticizer (SP) as additive material and water;

and mixing in a second step the dry mix and liquid ingredients together;

c h a r a c t e r i z e d by

using as the hydraulic binder composition CEM III/B slag cement comprising ground granulated blast-furnace slag (GGBFS) and portland cement (OPC);

incorporating to the hydraulic binder composition dolomite ($CaMg(CO_3)_2$);

using as the mentioned activator sodium sulphate (Na_2SO_4);

and mixing the dolomite ($CaMg(CO_3)_2$), the CEM III/B slag cement, and the sodium sulphate (Na_2SO_4) activator together for forming the dry mix.

17. The method according to claim 16, c h a r a c t e r i z e d by

implementing a recipe wherein the concrete comprises the following ingredients:

the portland cement (OPC) 4,9% by weight;

the ground granulated blast-furnace slag (GGBFS) 11.5% by weight;

the aggregate 72.6% by weight;

the dolomite ($CaMg(CO_3)_2$) 1,6% by weight;

the sodium sulphate (Na_2SO_4) 0.7% by weight; and

superplasticizer (SP) 6,2% by weight.

18. The method according to claim 16, c h a r a c - t e r i z e d by

adding CEM I portland cement 1,6% by weigh and mixing it together with the CEM III/B slag cement with 16,4% by weight to form a blend cement which is used as the hydraulic binder composition.

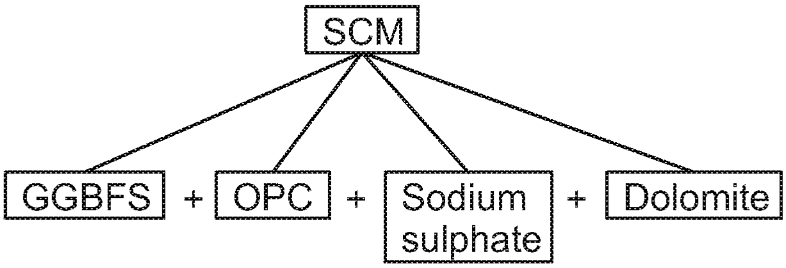

FIG. 1

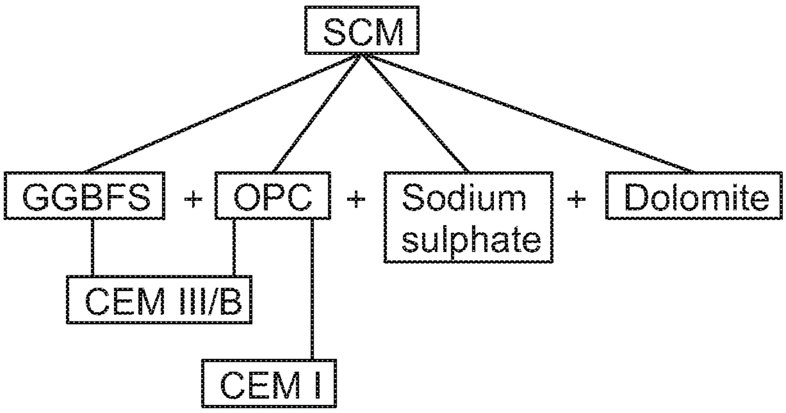

FIG. 2

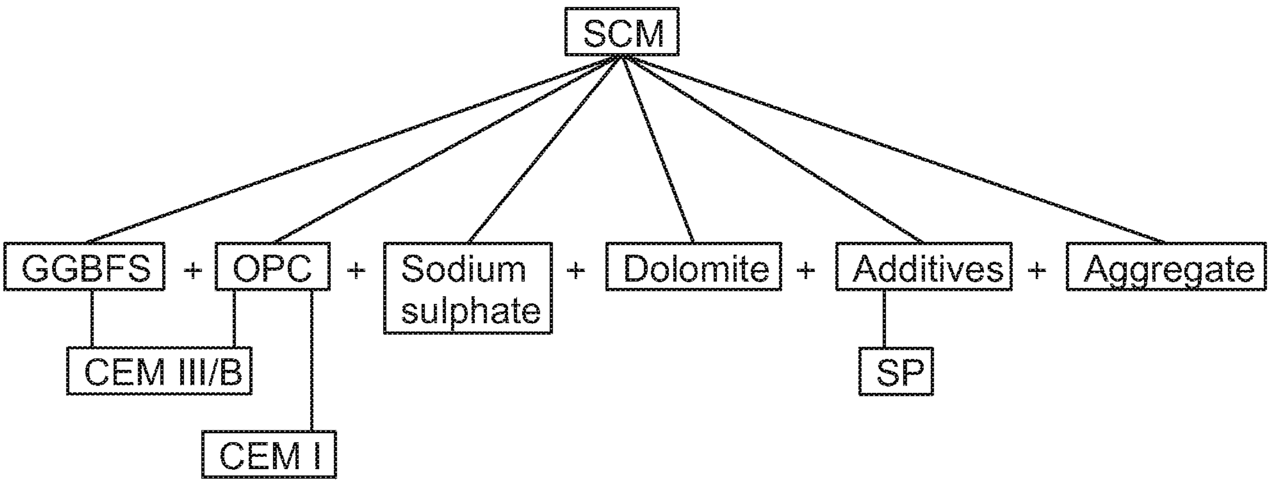

FIG. 3

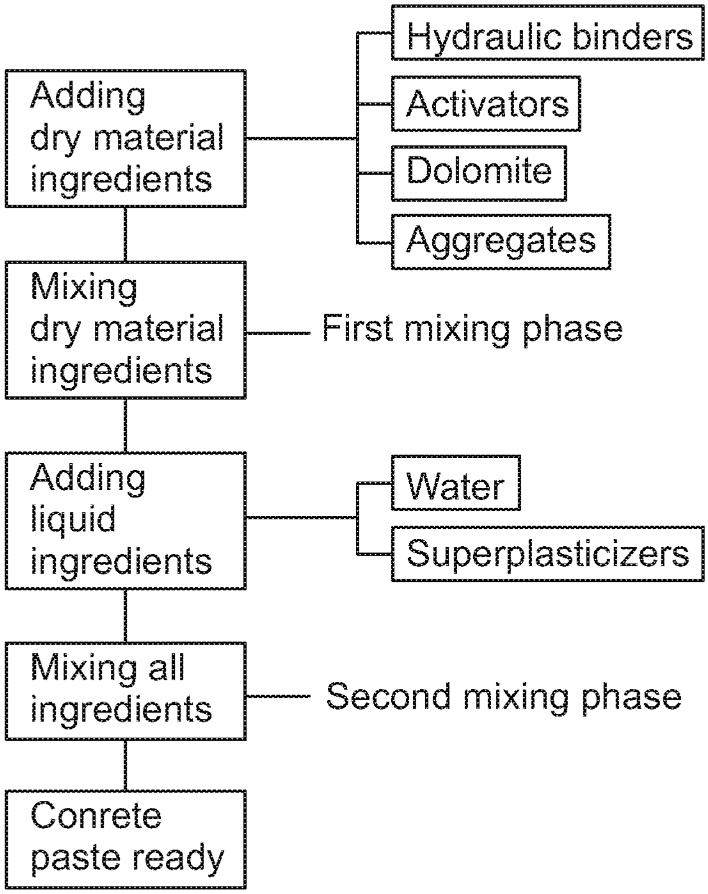

FIG. 4

Table 1	
Material	wt%
OPC	4 - 7
GGBFS	10 - 12
Aggregate	70 - 73
Dolomite	1.4 - 1.8
Sodium sulphite	0.6 - 0.8
Superplasticizer	6 - 8

FIG. 5

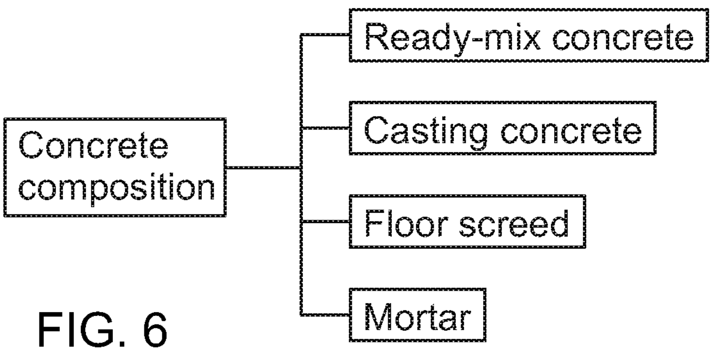

FIG. 6

Table 2 - Recipe A	
Material	wt%
CEM I	1.6
CEM III/B	16.4
Aggregate	71.0
Dolomite	1.6
Sodium sulphite	0.7
Superplasticizer	6.8

FIG. 7

Table 3 - Recipe B	
Material	wt%
CEM I	0.0
CEM III/B	16.5
Aggregate	72.6
Dolomite	1.6
Sodium sulphite	0.7
Superplasticizer	6.2

FIG. 8

Table 4

Ratio	Recipe A	Recipe B	Range
Water/Binder	0.51	0.54	0.45-0.65
Dolomite/Binder	0.08	0.09	0.06-0.10
Na2SO4/Binder	0.04	0.04	0.04-0.045
Additives/Binder	0.20	0.13	0.10-0.20
Aggregate/Binder	4	4	3-4

FIG. 9

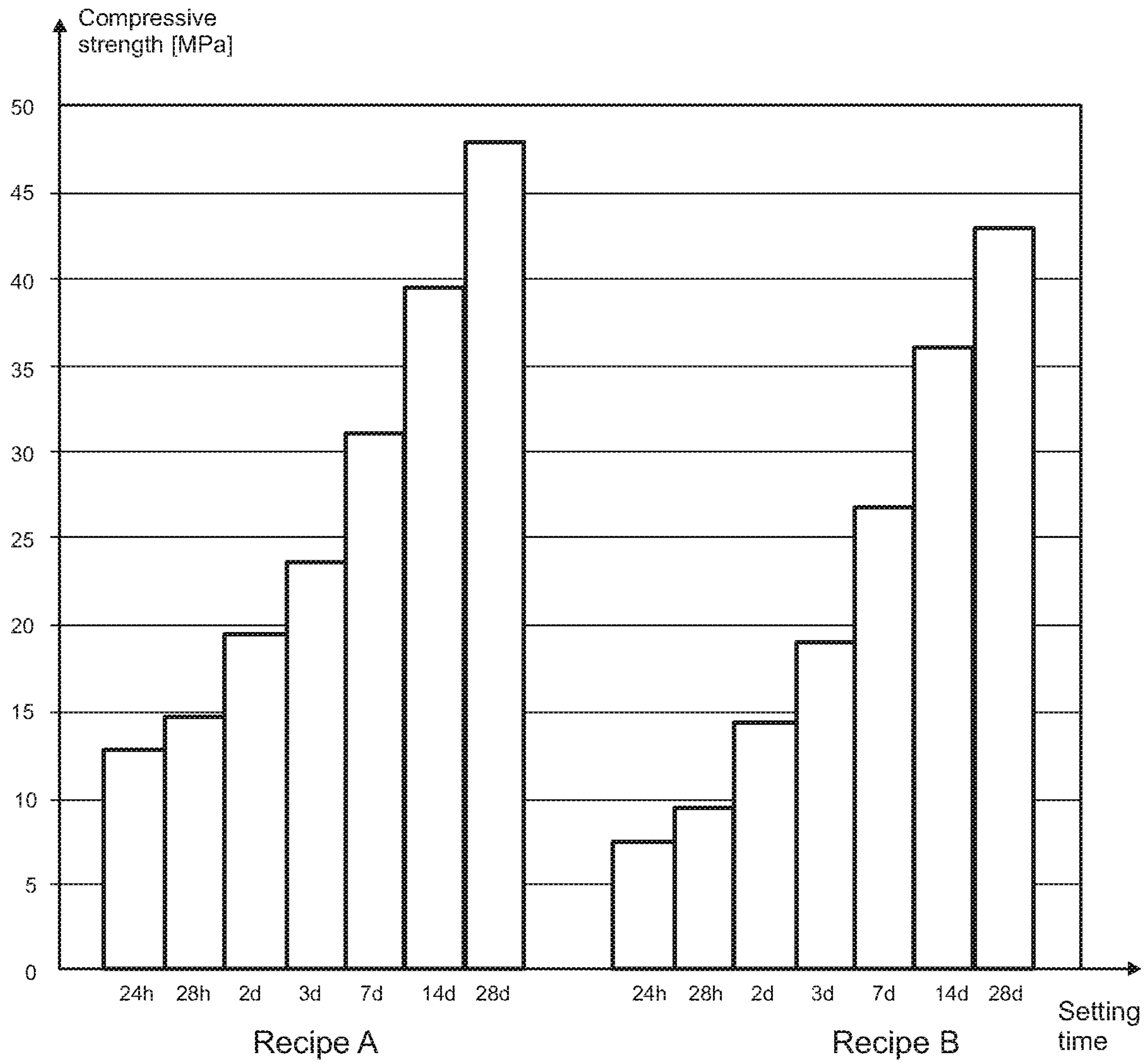

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2024/050267

A. CLASSIFICATION OF SUBJECT MATTER
INV. C04B28/04 C04B28/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 4 082 984 A1 (ECOCEM MAT LIMITED [IE] ET AL.) 2 November 2022 (2022-11-02)	1,4,5, 10-15
Y	paragraphs [0035], [0066], [0075]	9
A	example E1; tables 1,3 claims 1-7	2,3,6-8

Y	WO 2018/228839 A1 (HEIDELBERGCEMENT AG [DE]) 20 December 2018 (2018-12-20) cited in the application	9
A	claims 1-5,9-15	1,16-18

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 August 2024	03/09/2024

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

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International application No
PCT/FI2024/050267

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