

CONCRETE COMPOSITION AND METHOD OF PREPARATION

FIELD OF THE INVENTION

The present invention relates to a novel high strength (60 to 100 MPa) concrete composition. The present invention further relates to a process for the preparation of
5 the concrete composition.

BACKGROUND OF THE INVENTION

Articles such as preformed concrete building blocks, roof and floor tiles, paving slabs, structural members, etc. have traditionally been formed from concrete comprising a mixture of cement, such as hydraulic or Portland cement, mineral aggregate, and
10 water, plus various optional additives such as air reducing agents, water reducers, water proofing and possibly other components. These materials are reinforced with reinforcement such as steel bars, wires or fibres. The materials are generally blended in a concrete mixer and the resultant wet mixture is placed and densified in a mould or form to produce a desired shape. Hydration of the cement paste then takes place over
15 a period of time after which the mould or form is removed to form the concrete element. Concrete formed in this manner has reasonable strength and durability in most environments; however the concrete typically takes many days or even weeks to harden to full strength.

Concretes are also often used for non-structural applications. U.S. Pat. No.
20 4,900,359 entitled "Cellular concrete"; U.S. Pat. No. 5,183,505 entitled "Cellular concrete"; and U.S. Pat. No. 6,488,762 entitled "Composition of materials for use in cellular lightweight concrete and methods thereof" relate to concrete for non-structural applications. Lightweight concretes are not very economical on a large manufacturing scale, because the mixture requires a large amount of expensive lightweight
25 aggregates.

EP-A-0931 030 discloses a concrete mixture comprising aggregates, hydraulic binder, and a silica fume having a specific surface area below 200 m² /g.

US Pat. No. 6,008,275 discloses a cementitious mixture comprising low-grade cement, e.g. Ordinary Portland Cement partially replaced with pozzolanic cement containing
30 e.g. fly ash, slag, and natural pozzolans. The cementitious mixture also comprises a polycarboxylate polymer based water reducer and an accelerator.

SUMMARY OF THE INVENTION

According to the present invention there is provided a concrete composition which comprises (i) 20-26% Portland Cement and GGBFS, (ii) 4-12% silica fume; (iii) two types of Polycarboxylate based admixtures (around 2 litres/100kg cementitious material); (iv) water with water to binder ratio of 0.22 to 0.33; (v) 26-32% natural sand blended with/without Washed Copper Slag (WCS) ; and (vi) 35-45% of a 20 mm graded granite stone, blended with/without Recycled Concrete Aggregates (RCA), produced from similar grade of concrete.

According to a further aspect of the present invention there is provided a process for making a concrete mixture comprising (a) providing a concrete composition; (b) mixing the concrete composition in a wet mixer within a RMx plant; (c) controlling the volume of each batch of the mixture of (b) to be in 3-4 m³; (d) loading fine aggregates into the wet mixer, then followed by coarse aggregate and cementitious materials; and (e) finally adding water to the mixture and mixing until a homogeneous mix being formed.

Accordingly, it is an object of the present invention to provide a concrete composition which has high strength (Grade 60 MPa – 100 MPa) which helps to reduce the structural component sizes and therefore the amount of concrete used per building is minimized and thereby reducing the dead load on the foundation.

It is an object of the present invention to provide a concrete composition which is a high strength concrete (Grade 60 MPa – 100 MPa) and has reduction in the amount of reinforcement required, earlier removal of framework and shoring, less deflection of beams and slabs due to high static modulus of elasticity (>32 GPa) and higher long-term durability. The long-term durability is expressed through Rapid Chloride Permeability Test (RCPT, ASTM 1202-12) and resistance to water penetration test (DIN 1048). At 28 days age, RCPT values were below 1000 coulombs and water penetration at 300 kPa pressure and 72 hours exposure was below 15 mm.

Yet still a further object of the present invention is to provide a concrete composition, wherein the concrete has low drying shrinkage (<0.025%) even when compared with conventional Grade 40 concrete; the low shrinkage is achieved by replacement of Ordinary Portland cement by GGBFS (Ground Granulated Blast Furnace Slag) and maintaining very low water-cement ratio (0.22 to 0.33).

Another object of the present invention is to provide a concrete composition, wherein the concrete has low temperature rise (peak temperature < 75°C) as compared to the conventional Grade 40 concrete, and a placement temperature of as low as 25 - 28 deg C, which restricts the peak temperature.

- 5 It is yet another object of the present invention to provide a concrete composition, wherein the concrete allows reduction in the usage of natural resources compared with similar grades of conventional concrete. For example, WCS (Washed Copper Slag) is used as an alternative to natural river sand by an amount of 10% by weight. Another example for natural resource conservation is the addition of RCA (generated from
10 similar grade of concrete) in the mix as a replacement to 20mm natural aggregate 10% by weight.

- Yet a further object of the present invention is to provide a concrete composition, wherein the high strength concrete allows the section size to be reduced by around 45% if the grade of the concrete is increased from grade 40 MPa to 100 MPa. This
15 supports the concept of "Build More Using Less".

Still a further object of the present invention is to provide a concrete composition, wherein the concrete can be used in bridge girders and bridge decks in vehicular bridges and flyovers, encasing steel for composite steel columns and concrete columns and shear walls of high-rise building.

- 20 A further object of the invention is enhanced Fire Rating by adding Polypropylene fibres at a dosage of 1 – 2 kg/m³ of concrete.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a concrete composition that has a unique composition.

- As known from publication, the conventional concrete composition has fine and coarse
25 aggregate, combination of cementitious materials and a blend of chemical admixtures.

- In accordance with the present invention, there is provided a concrete composition, which is a high performance concrete composition comprises in relative parts by weight: (i) 20-26% Portland Cement and GGBFS (ii) 4-12% silica fume; (iii) around 2 litres/100kg cementitious material polycarboxylate based admixtures;(two types) (iv)
30 water with water binder ratio of 0.22 to 0.33; (v) 26-32% natural sand blended

with/without WCS; and (vi) 35-45% of a 20 mm graded granite stone blended with/without RCA.

The cementitious content in accordance with the preferred embodiment of the present invention is a mixture of CEMI, Ground Granulated Blast Furnace Slag (GGBFS) and silica fume (SF). The cementitious content varies from 510 – 670 kg/m³, wherein the amount of GGBFS in the mixture varies from 25 - 35% of the total cementitious material depending on the application. For the high performance concrete composition, GGBFS is added into the mixture (of CEMI and silica fume) so as to reduce the heat of hydration and thereby to control micro cracking during the initial stages of hydration. In the preferred embodiment, fly ash can also be used as an alternative to GGBFS.

In order to control the heat of hydration, the aggregate piles are sprinkled with water a day before the actual casting. The mix water temperature is reduced by addition of ice flakes to ensure that the placement temperature of concrete is brought down in the range of 25-28 deg. C. In the cementitious content, the amount of silica fume varies from 4-12% of the total cementitious material and the silica fume that used has a minimum SiO₂ content of 85% and silica fume can be either obtained from the Ferro-Silicon industry or produced by burning of rice husk. The water-binder ratio varies from 0.22 to 0.33. The lower water content helps to maintain the drying shrinkage below 250 microstrains (0.025%). The amount of aggregate by weight per cubic meter varies between 65-70% by total weight. The proportion of fine aggregate varies from 26 – 32% of the total by weight.

The maximum size of well graded cubical shaped coarse aggregate is 20 mm and its Fineness Modulus (FM) around 7 to 7.5. The coarse aggregates having flakiness index and shape index less than 10% are used. The fine aggregates are below 4mm in maximum size and has silt content less than 3% by mass and conform to medium sand with FM of 2.6 -2.9.

In the preferred embodiment, M-sand generated by crushing of granite rock and processed through Vertical Shaft Impact (VSI) or Conical Crusher is also used as an alternative to natural river sand. It is used as a partial or full replacement of natural river sand. The fines content (<150 micron) of M-sand are below 20% by weight.

In the present invention, the higher concrete grades (Example grade 100) consists of a Polycarboxylate (PC) based admixture added to reduce the mix water content. The admixture is added for dispersing the cement particles to avoid flocculation. The dosage of admixture varies between 1.5 liter to 1 liter per 100 kg of cementitious materials. An additional PC base of admixture is added to obtain the required slump flow and to retain the slump flow for a longer duration of time (2 – 4 hrs). The dosage of this PC based admixture varies between 0.5-1.0 liter per 100 kg of cementitious materials.

For higher grades (Grade 100 MPa) of concrete an additional chemical is added to reduce the entrapped air in the concrete below 1%. The admixture is diluted with potable water in 1:100 proportion before dosing into the mix. All the admixtures are dosed by mixing with the last portion of mix water.

The concrete is mixed in a wet mixer in the RMx plant. The volume of each batch varies from 3 – 4 m³. The fine aggregates are loaded first into the wet mixer followed by coarse aggregate, CEMI/GGBFS and mix water is added in the end. The chemical admixtures are discharged into the last portion of the mix water. The duration of mixing for every m³ of concrete if PC based admixtures are present will be around 2 minutes, otherwise the normal mixing is for a maximum period of 60 seconds/m³ of concrete.

When silica fume is added it is dosed into the wet mixer along with the coarse aggregates and is dry mixed for 1-2 minutes with the coarse aggregates to ensure that the densified silica fume is crushed into smaller fragments.

The moisture content of the fine aggregate is evaluated prior to the batching process and the water content in excess of SSD is deducted from the mix water.

It is well understood that any characteristic described above relating to any embodiment can be used alone, or in combination with other described characteristics, and can also be used in combination with one or more characteristics from any other embodiments, or any combination of any other embodiments.

WHAT IS CLAIMED IS:

1. A high performance concrete composition which comprises in relative parts by weight:
 - i. 20 - 26% by weight of CEMI and GGBFS;
 - 5 ii. 4%-12% by weight of silica fume;
 - iii. two polycarboxylate (PC) based admixture (around 2 litres/100 kg cementitious content) ;
 - iv. water binder ratio of 0.22 to 0.33;
 - v. 26 - 32% by weight of natural sand and 35 - 45% by weight of a 20 mm
 - 10 graded granite stone;
 - vi. a WCS and RCA as a replacement to natural sand and 20mm coarse aggregates respectively by a maximum of 10% by weight; and
 - vii. Polypropylene fibre at a dosage of 1 – 2 kg/m³.
- 15 2. The high performance concrete composition of Claim 1, wherein a mixture of CEMI, Ground Granulated Blast Furnace Slag (GGBFS) and silica fume (SF) form the cementitious content.
3. The high performance concrete composition of Claim 1, wherein the total

20 cementitious content is ranging from 510 - 670 kg/m³.
4. The high performance concrete composition of Claim 1, wherein the dosage of PC based admixture varies between 1.5 liters to 1 litre per 100 kg of cementitious materials and an additional PC based admixture is added to obtain the required slump

25 flow and to retain the slump flow for a longer duration of time (2 – 4 hours).
5. The concrete composition of Claim 2, wherein the amount of GGBFS (Fineness ~ 400m²/kg) in the concrete mixture is ranging from 25 - 35% of the total cementitious material.

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6. The concrete composition of Claim 1, wherein the silica fume is 4 -12% by weight of the total cementitious contents.
7. The concrete composition of Claim 1, further comprising aggregate in an

35 amount ranging from 65-70% by total weight.

8. The concrete composition of Claim 7, wherein the proportion of fine aggregate varies from 26 - 32% of the total aggregate by weight.
- 5 9. The concrete composition of Claim 7, wherein the proportion of Coarse Aggregate varies from 35 - 45% of the total weight of aggregate.
10. A method of fabrication of concrete object employing the concrete composition of Claim 1 comprising the steps of:
 - 10 mixing concrete composition in a wet mixer within a RMx plant; controlling the volume of each batch of the mixture to be in 3 – 4 m³; loading fine aggregates into the wet mixer, followed by coarse aggregate, cement and GGBFS; and finally adding water to the mixture.
 - 15 11. The method of fabrication of concrete object as claimed in Claim 10, further comprising the step of loading CEMI/GGBFS into the mixture prior to adding water to the mixture.
 12. The method of Claim 11, wherein a silica fume is added along with the coarse

20 aggregates.
 13. The method of Claim 12, wherein the silica fume is dry mixed with the coarse aggregates for about 1-2 minutes to ensure that the densified silica fume is crushed into smaller fragments.
 - 25 14. The method of Claim 12, wherein polypropylene fibres are added to the truck mixer at the point of discharge and the mixer drum of the mixer is rotated to its full speed (14 – 18 rpm) for 1 – 2 minute before discharging the concrete.
 - 30 15. A method of making a concrete element of a defined shape using the high performance concrete as set forth in Claim 1, comprising the steps of (a) providing a concrete composition and a mouldable mixture of coarse aggregate, wherein the coarse aggregate varies from 60 - 75% per cubic meter of concrete and the fine aggregate is ranging from 26 - 32% per cubic meter of concrete and a binder, wherein

35 the water-binder ration varies from 0.22 - 0.33; (b) forming the concrete composition

into an element of a defined shape, and (c) curing the element until sufficient strength is achieved.

16. The method of Claim 12, wherein the concrete is either a slump below 220 mm
5 or a slump flow having an average flow diameter as 650 ± 50 mm.

17. The method of Claim 12, wherein the concrete has a permeability that can be
reduced by the addition of an in-situ waterproofing admixture in the form of dry powder
or aqueous solution and the admixture is dosed into the truck mixed at the point of
10 discharge and, necessary adjustment to the mix water is done if the admixture is
water-based.