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A Study on Cost Analysis of Low Fines Self Compacted Concrete of M30 Grade by Replacing Cement with GGBS Upto 50 Percentage

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Abstract:

Low Fines Self-Compacting Concrete (SCC)has gained wide spread application in the construction industry, where its advantages are easily verified and put to a profitable use. But the picture is quite different in the day to day concrete where SCC use is still quite low. Generally, when the concrete producer has to produce a SCC, the strength is over designed for the application. This is due to the high fines content necessary to achieve the necessary stability of the SCC. These fines are usually provided by cement and Pozzolanic materials that are readily available at the plant. The excess cement and fines content adds to the production costs.

The reduction of the total fines content would lead to a decrease in the unit cost of the concrete, as long as the SCC properties are maintained. This paper is about preparing a mix of Low Fines SCC by replacing the cement with GGBS without losing the properties of SCC by using a new chemical admixture which is a hyper plasticizer having in built viscosity modifying agent . In this experimental work mix is prepared with low fines attained properties of SCC by replacing cement with 50% of GGBS and proved to be more economical compared to conventional vibrating concrete and also creating green environment by replacing cement with GGBS which is also an industry waste.

I. Introduction:

The use of Self-Compacting Concrete (SCC) as an “everyday” concrete in the construction Industry is still limited and focused on certain specific applications. The introduction of Smart Dynamic Construction, an innovative technology able to provide the benefits of the traditionally vibrated concrete along with those of SCC including ease of production with enough robustness for everyday use in a cost effective way, can contribute to expand the use of SCC in the Construction Industry. Along these lines, these concretes provide high mechanical and durability performance, as well as, the required fresh properties. Nevertheless, the statistics of European Ready Mix Concrete Organization (ERMCO) reveal that the mechanical requirements of the “everyday” concrete are significantly lower than those provided by “standard” SCC. Along these lines, SCC is usually supplied with excess in the mechanical and durability requirements in order to fulfill the fresh requirements implying higher cost of SCC than CVC. This is one of the most important reasons of the limited use of SCC in Ready Mixed Industry although not the only one. Among these reasons, one of the most important is the technical difficulties for preparing, with existing materials, robust SCC with low content of fines (cement + filler), even using Viscosity Modifying Admixtures (VMA) currently available in the market.[2].

On the other hand, the characteristics of locally-available materials (i.e., cement, aggregates and filler) for SCC production are, not always, the most appropriate and, consequently, a lot of laboratory work is needed in order to adjust the mix design with the aim of obtaining stable concrete. Also, variations in the moisture content of the aggregates and, especially, of the filler significantly influence the stability of the SCC, implying several adjustments in the mix design.[1]. Additionally, the use of extra fines (filler) implies, sometimes, new silos along with further control of the concrete in the plant. Therefore, this, along with the high contents of cement usually used, lead to an increase in production costs. Consequently, the use of SCC as an "every-day concrete" is, nowadays, difficult especially in the case of the Construction Industry. [3].

Along these lines, the development of the Self Compacted Concrete (SCC) concept, by means of an innovative VMAs that allows designing concrete with self-compacted properties without incorporating extra fines (filler) and, consequently, having a total content of fines (cement + filler) in the range of 350–420 kg/m^3, providing the required stability in the concrete. The use of this new family of VMAs called Rheo-MATRIX, along with super plasticizers especially designed for SCC, leads to an improvement in the cost-effectiveness of the concrete that can contribute to expand the use of SCC in the Construction Industry.[5].

The objectives and scope of the present work are **:**
To develop mix-designs for low fines self compacting concrete by adopting the trial and error method of designing mixes. Identify application areas for low fines, mid range SCC in commercial structures. This project explores the feasibility of using low fines in a mix i.e. a way to optimize the amount of fines content and still achieve SCC properties. The study focuses on comparison of fresh/hardened properties of SCC with varying amounts of the fines trying out various options amongst the fines available in Bangalore like the Slag, Micro Silica, and Pulverized fly ash etc.

The comparison is done amongst various mixes on the basis of their flows and strengths. Test results substantiate the feasibility to develop low cost SCC using low fines. Cost analysis showed that the cost of ingredients of a specific SCC mix is 19.15 percent less than that of the control concrete commercially available.[7].

Fig.1.&2.

II. Review of Literature:

In the paper definition of self-compacted concrete and some advantages over conventional concrete are covered. This chapter is an extension for the first chapter which covers the theory of self compacted concrete with Pozzolanic materials in detail, influence of admixture, tests on SCC, the review of recently published journals.[6,7,&8]. The workability of SCC and its rheological properties are manifested in three ways as given below:

i. Filling ability
ii. Passing ability
iii. Stability (Segregation resistance)

Filling ability:

SCC must flow into forms and around obstacles such as reinforcing steel under only the force of gravity. This does not mean that all SCC is self-leveling, however.

Passing Ability (Resistance to Blocking):

SCC must pass through various obstacles and fill open spaces in the formwork without blockage due to aggregates being restricted from passing through narrow openings. Typical aggregate size to opening size relationships are at least 1:2, such that, for example, a 12.5 mm maximum nominal size aggregate would require a 20 mm or larger opening

.

Stability (Segregation Resistance):

SCC must have dynamic stability by remaining homogenous throughout mixing, transportation, placing, and have static stability during finishing and curing. A concrete mix can only be classified as self-compacted concrete if the requirements for all the above three characteristics are fulfilled.

Dr. S.C. Maitiand Raj K Agarwal, NBM & CW Journals, (2007) have experimented on using chemical and mineral admixtures that develops mechanical properties. They have used super-plasticizer and viscosity modifying agent, that resulted in improving strength properties and reduction of water in the mix and they suggested the percentage of fine aggregate and coarse aggregate should not be more than 55% and 45%, by weight of total aggregate.

V.V.Karjinni, Shrishail B. Anadinni and Dada S. Patil, (2008) studied the variation of general properties of SCC by using Super-plastisizer (HRWRA), Viscosity Modifying Admixture (VMA), Fly Ash, silica fume and met kaolin as mineral admixtures. It is found that flow of concrete is increased by using mineral admixtures.

Tahir kemalerdem, Kamal H khayat, and Ammaryahia, (2009) Correlated Rheology of self compacted concrete to corresponding concrete equivalent mortar with mineral admixtures. They found good rheological properties with mineral admixtures.

P.T. Santosh Kumar, (2009) has studied the effect of Water / cement ratio and aggregates and there affects on strength properties and workability of SCC and suggested that Coarse aggregate of size 10mm, 12.5mm, 16mm and not more than 20mm is suitable for economical SCC. Selcukturkel & Ali kandemir, (2009) have determined the Fresh and hardened properties of SCC made with different aggregate and mineral admixtures.

Aggelos S. Georgiadis, Kosmas K .Sideris, Nikolaos S. Anagnostopoulos, (2009) have researched on properties of SCC produced with lime stone filler or VMA.

S. Girish, R.V. Ranganath and Jagadish Vengala, (2010) have researched on influence of powder and paste on flow properties of SCC and indicated that flow properties of SCC will increase with in paste volume.

Rafat Siddique, (2010) has investigated onProperties of self-compacted concrete containing class F-fly ash and indicated that mixes that are prepared with fly-ash range of 15% to 35% given a very good results on self-compatibility parameters (slump flow, J-ring, V-funnel, L-box, U-box), strength properties (compressive and split tensile strength), and durability properties (deicing salt surface scaling, carbonation and rapid chlorine penetration resistance).

Nadar Ghafoori & Mary Barfield, (2010) have studied on Effects of hauling time on Air – Entrained self compacted concrete, Khurana. R.S., Magarotto, R. and Moro, (2010) have improved the concept of Self Compacted Concrete: an innovative approach for the construction industry'. Rashid Jaffrey, Roberta Magarotto& Joana Roncero, (2010) have developed on Self Compacted Concrete using fines lower than 380 kg/m^3 is feasible by means of an innovative Viscosity Modifying Admixture called Rheo MATRIX.

Many research studies have been made over the SCC properties and its feasibility and found that limited study is done on low fines SCC mix with 50% replacement of cement by GGBS and its properties. It is observed that, use mineral admixtures 25% to 50 % as per IS 456, Amend No3 ANNEX J (Self Compacted Concrete) ,J-3 sub heading , b paragraph. This project explores the feasibility of using low fines in a mix by replacing 50% cement with GGBS i.e. a way to optimize the amount of fines content and cost, and still achieve SCC properties.

The study focuses on comparison of fresh/hardened properties of Low Fines SCC, with varying amounts of the fines trying out various options. The comparison is done amongst various mixes on the basis of their flows and strengths.Test results substantiate the feasibility to develop low cost SCC using low fines. Cost analysis showed that the cost of ingredients of a specific SCC mix is 16 percent less than that of the control conventional concrete commercially available.

III.MIXTURE DESIGN:

The workability of SCC is higher than degree of workability mentioned in IS 456:2000.

i. Size of coarse aggregates 20mm of 40% & 10mm 60% of the total coarse aggregate proportion calculated in Mix design procedure.
ii. Percentage coarse aggregates should be 58% of total volume of concrete.

Here the mix design procedure has been carried in reference with EFNARC guide lines.[9&10].

The modifications which are needed:
Smart Dynamic Concrete shall be obtained by adding cementations material and use of New Generation Hyper plasticizer Master Glenium SKY 8631.

Following shall be the design requirements: Characteristic 28 days compressive strength -30 Mpa

Maximum aggregate size-20mm.

Initial Flow-Min 600- 650 mm.

Flow at the time of Placing/Pouring(EFNARC SF 1) – Min 550-650mm.

Maximum water/ Cementations ratio -0.36-0.40

Cement (OPC) + GGBS-380-420Kg/m^3

Hyper plasticizer (Master Glenium SKY 8631)- 0.9 to1.4% (weight of cementations content).

Actual mix proportion to be used will be determined by trial mix design at the site conditions. Test samples shall be made in accordance with IS: 1199, tested as per IS: 516 and analyzed as per IS: 456.

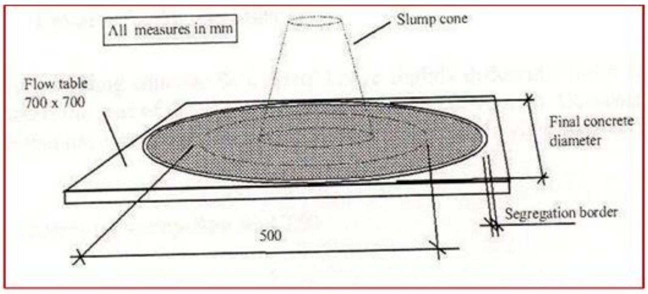

Fig. 3. Shows the typical arrangement of the apparatus.

IV. Material Characterization:

As seen in earlier study, there are many tests performed to determine various properties of SCC. At present, there are no standards American Standard Testing Manual (ASTM) or American Association of State Highway & Transport Officials (AASHTO) procedures or standard test methods available to characterize the properties of SCC. ASTM Committee C09 on Concrete and Concrete Aggregates met with various constituencies such as concrete producers, engineers, transportation officials, manufactures etc. to discuss SCC admixture standards. A subcommittee (C09.47) was created to review specific standard requirements for such mix agents, and scope for a basic standard.[16].

Master-Glenium SKY 8631 is a ready-to-use liquid which is dispensed into the concrete together with the mixing water. The plasticizing effect and water reduction are higher if the admixture is added to the damp concrete after 50 to 70% of the mixing water has been added. The addition of Master-Glenium SKY 8631 to dry aggregate or cement is not recommended. Automatic dispensers are available. Thorough mixing is essential and a minimum mixing cycle, after the addition of the Master-Glenium SKY 8631, of 60 seconds for forced action mixers is recommended.[14 & 15].

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Optimum dosage of MasterGlenium SKY 8631 should be determined with trial mixes. As a guide, a dosage range of 300 ml to 1200ml per 100kg of cementations material is normally recommended. Because of variations in concrete materials, job site conditions, and/or applications, dosages outside of the recommended range may be required.

V. Test on Low fines Self-Compacted Concrete (SCC):

SCC must possess following three characteristics to meet its stated workability requirements i.e. Filling ability, Passing ability and Segregation resistance: For the concrete to possess adequate **Filling ability**, the inter particle friction of the materials must be reduced. This can be achieved by reducing the surface tension and optimizing the packing of fine particles. Resistance to segregation can be improved by minimizing the free water to avoid bleeding and by making the liquid phase more viscous to enhance suspension of particles. Viscosity modifying agents (VMA) and/or higher fine content have been used to accomplish higher viscosity. In addition to the above workability requirements, the concrete must also possess adequate strength, durability and bleeding resistance.[12].

Workability (Rheology) Tests:

There is no single test that can adequately measure the three workability requirements mentioned above and hence it necessitates multiple testing. At the time of writing this report, there were no standardized tests method or equipment adopted by ASTM. Below is a list of test methods for workability properties of SCC that has been employed in the past. These equipments and test method have been employed by many researchers and agencies to investigate SCC rheology in past with good experience and success.[11].

Slump-Flow Test:

Slump-flow tests are used to determine flow ability and stability of self Consolidating concrete. The equipment consists of one slump cone and one flow table (Figure 1). A concentric diameter of 500 mm is marked on the table. The slump cone is filled with concrete while pressing the slump cone to the table. Next, the slump cone is lifted vertically and time measurement is started. Time for the concrete diameter to reach 500mm (T50) is recorded, which is less than or equal to 2 seconds. When the concrete has stopped flowing, the final diameter (D-final) of the concrete and if necessary any Segregation border at the concrete periphery is measured.

VI. MECHANICAL CHARACTERISTICS OF SDC:

The compressive strength of concrete is determined from laboratory tests conducted on cubes. The results of the tests conducted on various aspects of SCC are presented. For workability of fresh SCC conducted Slump Board test for various proportions of materials of SCC.[15].

Fig.4. The flow and strength of Concrete.

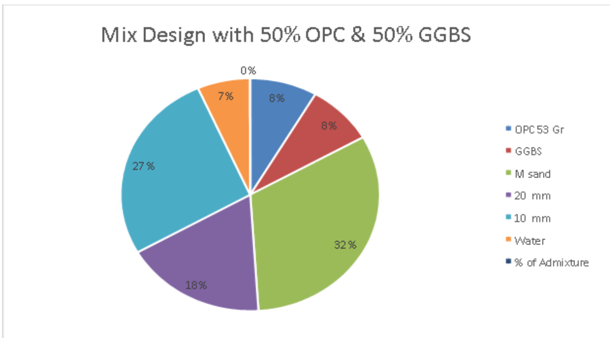

Fig.5. Mix Design with 50% OPC & 50%GGBS

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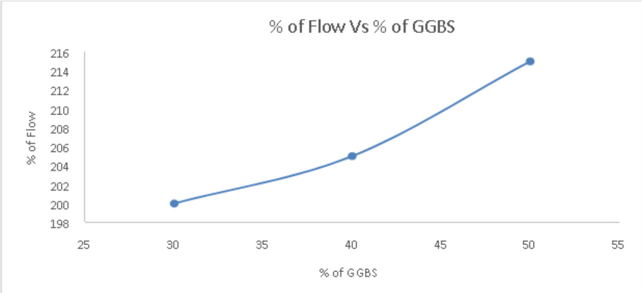

Fig.6. % of Flow Vs of GGBS.

VII.COST ANALYSIS:

Self Compacted Concrete has been limited by high material costs particularly cement, to specialized applications. Conventional applications of 25–30 MPa concrete range, has not been cost effective due to the high fines content required to produce self compacted concrete. The use of a new generation Viscosity Modifying Admixture, called RheoMATRIX increases the scope of applying the Self Compacted Concrete for conventional concrete applications, with all the benefits associated with this new innovation. Now self compacted concrete can be produced with a lower requirement for total fines. This concrete, Called Self-Compacted Concrete, can contribute to significantly expand the use of Self-Compacted Concrete in the Ready-Mixed Concrete Industry. This eliminates the extra costs related to fines and reduction of the binder content to the required strength class.(***i.e.*** less cement or use of a lower grade cement or more supplementary cement materials).

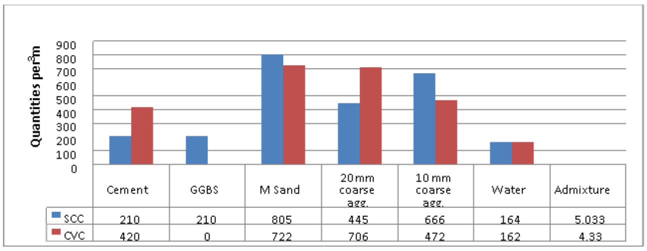

Fig.7.Mix Comparison SCC Vs CVC.

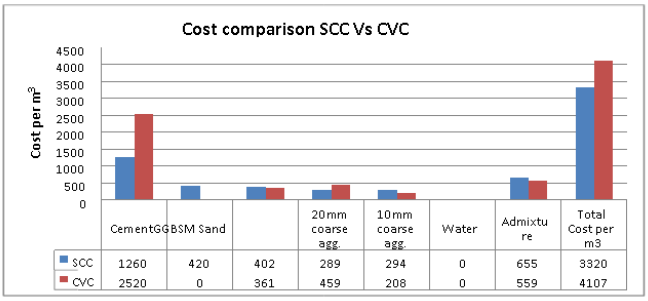

Fig.8.Cost comparison.

VIII. Conclusion and Future Work:

From the trial mixes Mix 2, Mix 4 & Mix 6finally concludes that a cementations range of 420 kg/m^3, with an admixture of 1.2% is giving a slump flow of 630mm. By looking at the mechanical characteristics like compressive strengths, achieved results are feasible for M30 grade of concrete. On studying the economical analysis of both SCC and CVC, there is an amount of Rs 786/- for m^3 of concrete can be saved with SCC over CVC. As seen from the above study, it is observed that the percentage of silicon dioxide (i.e. 35.50 %) in GGBS is more and found that the strength attained in Mix 6 which contain 50% GGBS is more. From the trial mixes, it can be adopted that the SCC in construction industry which is reliable in cost aspects compared to CVC. Experiments can be encouraged with replacement of GGBS with Fly Ash and combination of both. Without exceeding the cost we can further improve Mechanical Characteristics by using another type of admixture. There is a scope to study on the durability and health monitoring system for SCC.

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