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Application of Fly Ash and Brick Dust as a Suitable Materials for Fine Aggregate in Self-Consolidating Concrete

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Abstract

Large-scale efforts are needed for conservation of natural sand whose resources are reducing day by day and legal complications are making it difficult to meet the demand. So, self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. Complex shape of concrete structures and densely arranged bars make it more difficult to use a vibrator. Vibratory compaction is noisy and deleterious to the health of construction workers, as well as an annoyance to people in the neighborhood. In remote areas it is difficult to find skilled workers to carry out the compacting work at construction sites. This paper presents the progress of the research on different harden properties of Self Compacting Concrete using the Ordinary Portland Cement "Ultratek" made and low-calcium fly ash from Birla Glass, Kosamba, Gujarat, as binder materials in making the concrete mixes along with other ingredients locally available. Results indicated increase in workability for all the cases over control concrete. Concrete with fly ash was also found to be about 25% economical when cost per N/mm2 was compared. Based on experimental results correlations are developed to predict Compressive Strength, Flexural strength, cost, Slump and Dry Density for percentage sand replacement with fly ash.

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Introduction

The self-compacting or super workable concrete, also known as self-consolidating concrete is a highly flow able or self-levelling cohesive concrete that can spread readily into place through and around dense reinforcement under its own weight [5,11]. It adequately fills formwork without segregation or bleeding, and without the need for significant vibration. Self-compacting concrete mix has a low yield stress and an increased plastic viscosity. The mix requires minimal force to initiate flow yet have adequate cohesion to\ resist aggregate segregation and excessive bleeding, i.e., coarse aggregate can float in the mortar without segregating [7,9].

The yield stress is reduced by using an advanced synthetic high range water reducing admixture (HRWR), while the viscosity of the paste is increased by using a viscosity modifying admixture (VMA) or by increasing the percentage of fines incorporated into the self-compacting concrete mix design. Modern applications of self-compacting concrete are focused on high performance; better and more reliable quality, dense and uniform surface texture, improved durability, high strength and faster construction. In Japan and Europe, self-compacting concrete technology has been extensively used in bridges, buildings and tunnel construction, where as in USA, used in precast concrete industry, tanks, bridge decks and architectural concretes [8,10,14].

Placement of concrete for the most part requires compaction by vibration in the structures. Self-Compacting concrete has been characterized as 'a profoundly flow able, yet stable concrete that can spread promptly into the right spot and fill the formwork with no compaction and without experiencing any noteworthy separation. Another option suggests self-compacting concrete as 'a flowing concrete without segregation and bleeding, capable of filling spaces and dense reinforcement or out of reach voids without obstacle or blockage'. The composition of SCC must be designed all together not to separate, e.g. to make excessive bleed-water and settle out the coarse division (sedimentation) [10,13]. Air entrainment is additionally workable for SCC to build the concrete's protection from ice or ice defrosting salts. The utilization of SCC in the genuine structure has consistently increased in the current years and presents a brilliant contrasting option to traditional concrete for high-density or complicated reinforced segments and placement in limit molds.

SCC can likewise be pumped from the base of a form or dropped from the top with a suggested greatest fall stature of 6 feet. Marble has been usually utilized as a building material since the old times. The industry's disposal of the marble powder material, comprising of fine powder, today constitutes one of the natural issues far and wide. Marble blocks are cut into smaller pieces so as to give them the coveted smooth shape. Amid the cutting procedure around 25% the first marble mass is lost as dust. In Turkey marble dust is settled by sedimentation and after that dumped away which brings about natural contamination, in addition to forming dust in summer and undermining both farming and general wellbeing. In this way, use of the marble dust in different industrial segments particularly the development, horticulture, glass and paper industries would secure nature.

Objective of the Study

The main objectives set for this research are to compare the mechanical properties of self-compacting concrete with and without using fly ash and brick dust as fine aggregate replacement.The criteria used will be based on 7days, 28-day and 56 days compressive, splitting tensile and flexure strength and of conventional and self-compacting concrete for five Fly ash & Brick dust ratios as a replacement to fine aggregate.

Accordingly, the present study is aimed to develop a concrete with good strength, less porous, so that good durability will be achieved. For this purpose, Brick kiln dust is used as a pozzolanic materials. Precisely; The influence on the strength (*in terms of compressive strength, splitting tensile strength and flexural strength*) with the addition of brick kiln dust *(at various percentage by weight*) as a partial replacement of fine aggregate will be investigated. The influence on the strength (*in terms of compressive strength, splitting tensile strength and flexural strength*) with the addition of Fly Ash *(at various percentage by weight*) as a partial replacement of fine aggregate will be investigated. Experiments for the initial surface absorption characteristics of concrete at different curing ages, have been performed.

Literature Review

The literature indicates that studies on the self-compacting concrete with different mineral admixtures as powder content(filler) and also made comprehensive studies on fresh properties of self-compacting concrete with different percentages of met kaolin and cement kiln dust. The addition of 10 % met kaolin and cement kiln dust itself compacting concrete mixes increases the self-compact ability characteristic like filling ability, passing ability, flowing ability and segregation resistance. It can also be seen that compressive strength, flexural strength, split tensile strength is maximum for10% replacement as compared to 20% and 30%. [7].

The literature indicates that studies on the self-compacting concrete with marble powder and fly ash as mineral admixtures. Many studies proved that 25% replacement of cement with fly ash has optimum results in both fresh and hardened state properties and also economical [5]. The replacement of cement with different mixes proportions of marble powder (0%, 5%, 10%, 15%, 20% and 25%) and 25% fly ash (constant replaced). The positive effect of marble powder 10% and flashy 25% by substitute cement in binder material in self-compacting concrete. In fresh property such as filling ability and passing ability and in hardened property such as compressive strength, flexural strength and split tensile strength shows optimum results for marble powder can be use up to 10% and fly ash 25% [2].

The literature indicates that comparative studies on the self-compacting concrete with marble powder and limestone powder as mineral admixtures. The replacement of cement with different mixes proportions of marble powder and limestone powder (0%, 10%, 20%, 30%, 40% and 50% for both). The mineral admixtures have shown significant performance differences and the highest compressive strength has been obtained for the marble powder mixtures. All the mixtures had satisfactory self-compacting properties in the fresh state. The addition of limestone powder and marble powder had positive effects on the workability [2].

The literature indicates that study on durability characteristics of self-compacting concrete with fly ash as mineral admixture. The durability characteristics like acid resistance, sulphate attack and saturated water absorption test are carried out for different mixes proportions of fly ash at the age of 28, 56 and 90 days. For 30% fly ash replacement, the fresh and hardened properties observed were good as compared to 40% and 50% fly ash replacement [4].

Some studies have shown about the comparison in behavior using PPC and OPC with different proportions of fly ash in the MIX which were taken as 15%, 25%, and 35% in place of cement. For one proportion, a set of 6 cubes was casted and the same was to be tested at 7 days and 28 days for strength. The temperature of sample cubes was kept constant at24°C for the whole period. The mix design was done for M25 grade [6,9].

The W/C ratio was kept constant at 0.45. The proportion offine aggregates to coarse aggregates was kept at 70:30 and maximum size of aggregates was 20 mm. Total powder content was kept at 530 Kg/m3. The quantity of super plasticizer was kept at 450 ml for the samples which was 1% of the total volume. The properties were checked by conducting slump test, J-Ring Test, L-Box Test, V-funnel Test, and U-Box Test with compressive strength test after 7 days and 28 days [1].

Materials and Methods

A. Aggregate

The coarse aggregate chosen for SCC is typically round in shape, well graded and smaller in comparison to typical conventional concrete whose maximum size is 40 mm or more. In general, rounded and smaller aggregate particles not only aid in the flow ability and deformability of the concrete but also prevent segregation. Gradation is an important factor in choosing a coarse aggregate for SCC where reinforcement may be highly congested or the formwork has small dimensions. Gap-graded coarse aggregate promotes segregation to a greater degree than well-graded coarse aggregate. Maximum size of coarse aggregate used in SCC ranges from 10 mm to 20 mm. Aggregates occupy 70% to 80% of the volume of concrete and normally provide concrete with better dimensional stability and wear resistance [3].

B. Sand

All normal concreting sands (less than 0.125 mm) are suitable for SCC and are very important for the rheology of SCC. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation.

C. Cement

The most common cement currently used in construction is type I/II Portland cement. This cement conforms to the strength requirement of a Type I and the C3A content restriction of a Type II. The Blaine fineness is used to quantify the surface area of cement. The surface area provides a direct indication of the cement fineness ranging from 350 to 500 m2/Kg for Type I and Type II cements respectively [12].

Ingredient	% Content
CaO(Lime)	60-67
SiO2 (Silica)	17-25
Al2 O3(Alumina)	3-8
Fe2 O3 (Iron Oxide)	0.5-6
MgO(Magnesia)	0.1-4
Alkalies	0.4-1.3
Sulphur	1-3

D. Super Plasticizer

Super plasticizer is a chemical compound used to increase the workability without adding more water to form a uniform mix. This acts as a lubricant among the materials. In order to increase the workability, the water content is to be increased provided corresponding quantity of cement also added to keep the water cement ratio constant, so that the strength remains the same. The job of SP-430 is to impart a high degree of flow ability and deformability, however high dosages can lead to a high degree of segregation (Ramchandran, and Malhotra). Conplast SP 430 is utilized in this project, which is a product of FOSROC (Manufactured at Bangalore, India) having a specific gravity of 1.22.

E. Water

Potable water is used for mixing and curing.

F. Brick Dust

Brick dust is a waste product obtained from different brick kilns and tile factories. There are numerous brick kilns which have grown over the decade in an unplanned way in different parts of India. Tons of waste products like brick dust or broken pieces or flakes of bricks (brickbat) come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as wasted material.

Conclusion

To increase the stability of fresh concrete using increased amount of fine materials in the mixes. To develop of self-compacting concrete with reduced segregation potential. The latest trend in concrete research is to use industrial by-products in preparing the concrete mixes. The addition of CKD and MP as mineral admixtures in SCC is a step that would gainfully employ these two otherwise waste products whose disposal is an issue in itself. The systematic experimental approach showed that partial replacement of cement with mineral admixture could produce self-compacting concrete with low segregation potential as assessed by the V funnel test. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V funnel, L box, and compressive strength, split tensile and flexure strength tests were carried out to examine the performance of SCC. If we add the mineral admixtures replacement for we can have a better workable concrete. It has been verified, by using the slump flow, L-box test and U-tube tests, that self-compacting concrete(SCC) achieved consistency and self-compatibility under its own weight, without any external vibration or compaction. SCC with mineral admixture exhibited satisfactory results in workability, because of small particle size and more surface area. All the mixtures had satisfactory self-compacting properties in the fresh state. The addition of cement kiln dust and marble powder had positive effects on the workability. It is possible to produce SCC by combined replacement of cement kiln dust and marble powder satisfies the criteria for fresh concrete properties such as slump flow, passing ability, filing ability. As marble powder increase, slump flow of self-compacting concrete is also increase [9,11,13,15]. As marble powder increase, V funnel time of self-compacting concrete is decrease. The optimum compressive strength, split tensile strength and flexural strength of tested concrete specimen's shows up to10% marble powder and 15% cement kiln dust. The percentage loss of compressive strength shows optimum values up to 5%marble powder and 15% cement kiln dust.

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