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Research on the Effects of Fly Ash and Silica Fume as Partial Replacements in Self-Compacting Concrete

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ABSTRACT

The purpose of this research is to determine how well Fly Ash and Silica Fume (replacement), a mineral additive in concrete, perform in terms of workability, durability, and strength of concrete when combined with cement utilising the open-protocol concrete (OPC) method (53- grade). Recent studies on concrete have shown that by adding admixtures such minerals and chemicals to cement replacement materials, concrete's strength, workability, and durability may be enhanced. Using mineral byproducts like Silica Fume and Fly Ash as supplemental cementing elements has been the focus of the study into making self-compacting concrete. This research analyses the compressive and split tensile strengths of M-30 grade concrete at 7, 14, and 28 days after mixing. In this study, self-compacting concrete was made with OPC replaced by either Fly Ash (15%), Silica Fume (20%), or both (25%) in terms of weight. In order to determine the dramatic impacts of Silica Fume and Fly Ash on the characteristics of concrete, a 1.2% super-plasticizer was added to all of the test specimens. The Concrete samples here underwent a lengthy curing process in water at room temperature

Keywords: Self Compacting Concrete, Fly ash, Silica fume, Fresh Concrete Properties, Hardened Properties, Compressive Strength, Split tensile Strength.

INTRODUCTION

Concrete is the material that is utilised for building the most over the globe. The characteristics of concrete, such as durability, quality, workability, and compactness, are growing in significance as their usage becomes almost obligatory. Vibration is often used in the traditional method of casting concrete to facilitate the movement of the concrete to all corners of the form work, the elimination of trapped air, and the complete encapsulation of the reinforcement [1]. Recently developed super plasticizing admixtures have allowed for the production of self-compacting concrete, which does not need the use of mechanical vibration [2].

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Concrete That Compacts Itself

Self-compacting concrete, also known as self-consolidating concrete, is a concrete mixture that flows easily yet compacts itself. Self- Compacting Concrete (SCC) is a subset of the concrete family that has been called "the most advanced breakthrough in concrete building for some years." Because of the availability of cheaper, lower-skilled labour, it is originally established [3].The cost-effectiveness and usefulness of this SCC have been shown by a number of variables. The need prompted the creation of SCC, and the technology was initially disclosed in 1989. There is also a kind of high performance concrete known as self-compacting concrete, which, unlike conventional concrete, does not need the use of external vibrating equipment in order to achieve a dense, compact finish. Concrete doesn't leak or separate into chunks because of how cohesive it is. Self-compacting concrete requires a low water-to-cement ratio, however chemical admixtures are often used to boost its flowability and workability.

Given that the construction business has environmental effect owing to high consumption of energy, which results in higher release of carbon dioxide, sustainable industrial expansion will affect the cement and concrete sector in a variety of ways (CO_2). Thus, efforts are being made to lessen global warming by substituting mineral admixtures for cement, such as fly ash and silica fumes. Since these admixtures are often industrial waste, they may be properly disposed of when blended with cement[4]. Careful attention is paid to the mix proportioning of SCC. The aggregate size is much smaller than in regular concrete, hence vibratory compaction is not necessary. Self-Compatibility may be achieved by using a paste or mortar with a high deformability and by ensuring that the SCC remains homogeneous (i.e., not separated) throughout transport and placement. The following are some of the most important factors that contributed to the emergence of SCC:

- One, to cut down on building time.
- Second, to guarantee the building is compact
- To reduce or get rid of vibration-based noise.
- Specified Conditions for Certification (B.SCC Requirements)
- To be practical, SCC has to have the following three features:
- The Capacity to Be Filled
- With its self-weight, SCC should be able to entirely fill the formwork's voids.
- Aptitude for Success
- No segregation or leakage of SCC should occur even via small gaps like those between reinforcing bars. The ability of SCC should remain homogeneous during transportation and placing.

Substantial Cost Reduction

The synergy of SCC's highly superior parts results in a potent combination with many positive outcomes. As you can see, it has a number of benefits. Lessens the amount of work and noise generated by vibrations when laying concrete. Access to sophisticated forms and the ability to fill them out. A consistent thickness of the concrete layer in regions with closely spaced rebar.

We can pump concrete quickly [6]. The need for rubbing and repairing the surface is lessened as a result. Effortlessly enhances the visual quality of output. It has cut down on the amount of time and effort required for building. Utilizing transport and mixing resources to their fullest potential.

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What SCC Can't Do
It is more difficult to produce SCC than regular concrete, and it has various drawbacks, some of which have already been mentioned.

A change, however little, in the defining features of an SCC blend may serve as an early warning signal for quality assurance. At extremely low W/C (0.3) ratio, the rheology of SCC is more sensitive to variations of even 1% in moisture content in the fine aggregate. There has to be a lot of trial batches for an SCC to be developed. After a successful batch has been mixed, further trials will be needed to determine how much each ingredient contributes to the final product [7]. As a result of the larger dose of chemical admixtures required to produce SCC, its initial monetary outlay exceeds that of more commonly used concrete.

The purpose of the research
Self-compacting concrete's characteristics will be investigated in order to determine the impact of Fly Ash and Silica Fume (SCC).

In order to: • Determine the ideal proportions of Fly Ash and Silica Fume for use in Self-Compacting Concrete (SCC)

To calculate the rate of increase in toughened parameters such as compressive strength and split tensile strength as a percentage.

Partial substitution of cement with Fly Ash in three different percentages (15, 20, and 25%) and Silica Fume in three different percentages (6, 9, and 12) is studied for its effects on the concrete's fresh and hardened qualities (i.e., compressive strength, split tensile strength).

PROPERTIES OF MATERIALS III.
All-Purpose Cement, Fine Aggregate, Coarse Aggregate, Fly Ash, Silica Fume, and Super Plasticizer are utilised in this project.
Cement
Cement of the 53rd grade of Ordinary Portland Cement (OPC) was utilised for the KPC, meeting all of IS

Micro silica, also known as condensed silica fume, is an extremely tiny form of silica. Slag with a high glass content and high reactivity generated by controlled granulation is the basis of this carefully processed product. In addition to being more refined than OPC in concrete, silica fume possesses low absorption and denser packing properties as a result of its distinctive chemistry and ultra-fine particle size (Smaller particles of silica fume nestling between the OPC grains). In most cases, this material will seem somewhat greyish white. It shares silica fume granules' chemical and physical characteristics [8].

First, we have the Super Plasticizer, Conplast SP430.
The admixture Conplast Sp430. It is a dark liquid that may be immediately dispersed in water; it is a

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sulphonated naphthalene polymer and it is utilised as a super plasticizer. It is precisely developed to generate high-quality concrete with low permeability while using a little amount of water. In this project, the amount of Conplast utilised is 1.2% of the volume of the cement.

METHODOLOGY

The purpose of this experimental research is to learn more about the characteristics of SCC by partly replacing it with varying amounts of fly ash and silica fume. Different trail mixes are done using variable amounts of cement, fine aggregate, coarse aggregate, water, and super plasticizer to get the best possible SCC. Once the Optimal Mix design is obtained, nine mixes are produced by substituting fly for cement at 15, 20, and 25%, with silica fume added at 6%, 9%, and 12% of the cement's mass, respectively. There are two stages to the experimental programme [9]. In the first stage, several concrete tests (such as the slump flow, L-box, J-ring, V-funnel, and U-box tests) are carried out to evaluate the material's fresh workability.

The second stage involves moulding new concrete into cubes and cylinders. After curing in water for 7, 14, 28 days, the samples are put through a battery of mechanical property tests (compressive strength and split tensile strength). In addition, an acid test is performed to determine how long-lasting the qualities [10].

SCC MIX DESIGN

Create a conventional concrete mixture with the desired compressive strength of 30 MPa. Changing the cement paste or fine-tuning the aggregates, or both, may be necessary. The literature study indicates that a 25% fly ash content, together with 6%, 9%, and 12% silica fume, is the sweet spot. The standard concrete recipe calls for 25% fly ash and between 6% and 12% silica fume. This allows for a direct comparison between conventional concrete and self-compacting concrete with regards to the optimal replacement amount and the percent increase in compressive strength. Mix ratios for traditional concrete trail mixes A M30 (1: 1.180: 2.132) Number of Fly Ash Content in Tons of Cement 550: 649.37: 1172.97: 165.1: 1.180: 2.132 SCC/EFNARC

Recommendations

SCC mix EFNARC specifies a few criteria to change the intended trail mixes in. You may list them as follows:
First, a volume ratio of 0.80 to 1.10 of water to powder.
Powder density of between 400 and 600 kilogrammes (1,600 to 1,800 pounds) per cubic metre.
Third, coarse aggregate makes up between 28 and 35% of the total volume of the mixture.
In the fourth place, the ratio of water to cement is determined by standards set out in EN 206. The average moisture level is below 200 l/m3.
Fifth, the sand helps keep the amount of everything else in check.

Experimentation Scheme
Each batch of mix is made by adjusting the amounts of cement, fine aggregate, coarse aggregate, water, and super plasticizer.

SCC-Relevant Properties of Fresh Concrete:

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The features of SCC in its raw form are its defining feature. The SCC MIX layout primarily prioritises vibration-free operation under load. ability to maintain homogeneity without segregation of aggregates and flow through obstructed reinforcing bars under its own weight.

STATE-OF-THE-ART SCC TESTS

Slump Flow Test & T50: The slump test is the most widely used technique for gauging the consistency of concrete, and it may be carried out either in a laboratory or on the actual construction site.

The filling capacity of SCC may be determined using this test. The slump diameter is determined by pouring the SCC sample into the cone. T50 slump time is the period between when the cone is lowered and when the concrete has flowed to a diameter of 500mm, both of which are measures of how quickly the concrete can be moved. For increased self-weight in filling a form, a larger slump flow value is required. The slump flow test requires a metallic cone-shaped mould with the following interior dimensions and a 900mm x 900mm sheet as its primary components.
The bottom has a 20cm diameter.
Inside dia. : 10cm
A 30 centimetre height
Method of Examination: 1. Position the clean base plate in a level and even surface.

Center the cone on the base plate's 200 mm diameter circle, then use the disc's weight to hold it there. Without tamping or vibrating, fill the cone with the test sample from the bucket. It's important to separate any concrete that's still on the base plate and knock off any excess concrete from the top of the cone. Be sure the surface you're testing on is neither too damp nor too dry. There must be no dry spots on the base plate, and any water overflow must be diverted.

After a short break (no more than 20 seconds for cleaning and inspection of the moist state of the test surface), the cone is lifted at right angles to the base plate so that the concrete can flow out freely without being blocked by the cone, and the stopwatch is started when the cone is in free contact with the base plate.

The clock should be stopped when the leading edge of the concrete first contacts the circle (with a diameter of 50 cm) that has been previously designated. The

The T50 value is the stopwatch reading that is recorded. When the concrete flow stops, the test is complete.

Using the ruler, determine the leading biggest dia of the flow spread (d max), as well as the dia at right angles to it (d perp) (reading to nearest 4 mm).

This is a test designed to measure how well and how quickly SCC flows when there are no obstacles in its path. This finding provides insight on the filling capacity of SCC.

The V-Funnel RT Test

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The filling ability (flow ability) of concrete with aggregate no larger than 20 mm in size may be measured using a V-funnel test. About 12 litres of concrete is poured into the funnel. The time it takes to trickle down may be calculated.

Once the 5 minutes are over, the concrete may be poured into the funnel. There will be a substantial delay in the flow of the concrete if it displays signs of segregation.

Supplies: V-funnel, 12-liter bucket, trowel, scoop, and stopwatch
The test requires around 12 litres of concrete. Place the V-shaped funnel firmly on the ground.

Dampen the funnel's inner lining. You should leave the drain open so that any water that accumulates may drain out. Submit a bucket beneath the trap door and secure the door. Don't compress or tamp the concrete in, just fill the whole contraption. Break away from the ground's even surface. The concrete may be timed by opening the trap door and timing how long it takes to fall. Put the time it takes to empty into the log. Viewed from above, the light will allow for a definitive verdict. The whole process of the exam takes no more than 5 minutes.

L-Box evaluation
By measuring how much reinforcement is able to obstruct the concrete's flow, this test may provide insight into the durability of your construction.Percentage of obstruction. Time limit for the whole exam is 5 minutes.

Capacity to Pass = H2/H1
According to EFNARC, the ideal range for the Passing Ability rating is between 0.8 and 1.
This experiment calls for around 14 litres of concrete. Before closing the sliding gate, be sure it can be opened easily. Wet the interior down and drain any excess water. Pour concrete into the device's vertical chamber. Don't touch it for a full minute. Raise the sloping gate and let the concrete pour into the lower level. When the concrete reaches the 200 mm and 400 mm markers, start the stop watch simultaneously and jot down the times. The height H2/H1 is the value at which the concrete stops flowing.

The concrete mixture is cast into the appropriate moulds for the samples. All of the samples were made in accordance with Indian norm IS 516: 1959. After being cast, cubes and cylinders are submerged in water to cure.

Treatment of Specimens
When the time for relaxation is over. Cubes, cylinders, and other shapes were removed from the specimen moulds. Curing times in water range from 7 days to 28 days for various specimens.

Mechanical Properties
Numerous experiments are performed on SCC mix to ascertain its mechanical qualities.
The two most common types of testing are the compression and split tensile tests.
These inferences are supported by the findings of the present investigation.
The Workability and Mechanical properties of SCC will be influenced by the proportion of Fly ash

and Silica fumes used in the mixture.
All nine mixtures were found to be within the acceptable range established by the EFNARC.
Compressive strength increases with extended curing time. When specimens are cured for 28 days, they exhibit greater compressive strength.

Fly ash with a silica fume content of 6% has the highest compressive strength and split tensile strength.

REFERENCES

1. Santos, S., Da Silva, P. R., & De Brito, J. (2019). Self-compacting concrete with recycled aggregates–a literature review. *Journal of Building Engineering*, *22*, 349-371
2. Adesina, A., & Awoyera, P. (2019). Overview of trends in the application of waste materials in self-compacting concrete production. *SN Applied Sciences*, *1*(9), 1-18.
3. Sandhu, R. K., & Siddique, R. (2017). Influence of rice husk ash (RHA) on the properties of self-compacting concrete: A review. *Construction and Building Materials*, *153*, 751-764.
4. Asteris, P. G., & Kolovos, K. G. (2019). Self-compacting concrete strength prediction using surrogate models. *Neural Computing and Applications*, *31*(1), 409-424.
5. Yaman, M. A., Abd Elaty, M., & Taman, M. (2017). Predicting the ingredients of self compacting concrete using artificial neural network. *Alexandria Engineering Journal*, *56*(4), 523-532.
6. Fediuk, R. S., Lesovik, V. S., Svintsov, A. P., Mochalov, A. V., Kulichkov, S. V., Stoyushko, N. Y., ... & Timokhin, R. A. (2018). Self-compacting concrete using pretreatmented rice husk ash. *Magazine of Civil Engineering*, (3 (79)), 66-76.
7. Aslani, F., Hamidi, F., & Ma, Q. (2019). Fire performance of heavyweight self-compacting concrete and heavyweight high strength concrete. *Materials*, *12*(5), 822.
8. Aarthi, K., & Arunachalam, K. (2018). Durability studies on fibre reinforced self compacting concrete with sustainable wastes. *Journal of Cleaner Production*, *174*, 247-255.
9. Sasanipour, H., Aslani, F., & Taherinezhad, J. (2019). Effect of silica fume on durability of self-compacting concrete made with waste recycled concrete aggregates. *Construction and Building Materials*, *227*, 116598.
10. Raisi, E. M., Amiri, J. V., & Davoodi, M. R. (2018). Mechanical performance of self-compacting concrete incorporating rice husk ash. *Construction and Building Materials*, *177*, 148-157.