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EXPERIMENTAL STUDIES ON DURABILITY ASPECTS OF SELF-COMPACTING CONCRETE USING ALCCOFINE AND BIOCHAR

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Abstract - *In the present day, much research is being done globally to identify a viable cementitious material to take the role of cement. For the purpose of partially or completely substituting cement in concrete, many materials are tested in this order: fly ash, silica fume, GGBS, Metakaolin, Micro materials, Quartz powder, etc. In this paper, a novel ultrafine material named Alccofine and cement made with biobased materials might have lower CO2 emissions. Recently, it has been shown that carbonized biomass, often known as Biochar, is an efficient partial replacement forcement. Here, cement is partially replaced in self-compactingconcrete by substituting 10% of alccofine and 2% of biochar.M30 concrete is designed to examine the durability of alccofine and biochar in concrete. The durability properties were investigated, such as sulphate Attack tests, water absorption tests, and carbonation tests, and were compared with conventional SCC. Results indicated that the compressive strength of self-compacting concrete improved with the incorporation of 10% alccofine and durability properties exhibit superior performance in both alccofine and biochar compared to conventional SCC.*

Key Words: ***Alccofine, Biochar, Sulphate Attack Tests, WaterAbsorption Tests, and Carbonation Tests.***

1.INTRODUCTION

The ash-and-carbon-based, light-weight biochar that remains after biomass is pyrolyzed is known as biochar. The term removal of vibrating equipment, reduced noise, fewer air spaces, shortened time, higher productivity, and enhanced strength and durability. The amount of powder content and the particle size are important aspects of SCC. Costs of production would rise if SCC contained more cement. Considering rapidly expanding industries, many researchers have proposed alternative supplemental cementitious materials (SCMs) or mineral admixtures to attain higher economic value. Alccofine1203 is a high range water reducer that helps concrete work more easily and have greater compressive strength. Biochar is widely considered as effective way of sequestering carbon dioxide. The possibility of using it to enhance the mechanical strength and reduce permeability of cement mortar is explored in this study.

2. ALCCOFINE

Within the concrete industry, Ambuja Cements Limited (ACL) has introduced a novel product. ALCCOFINE 1203 may be a suitable substitute for cement in concrete as an additional cementitious element. process.Alccofine-1203 is a specifically processed product with a high glass content and high reactivity that was created through a carefully monitored granulation process. The principal component of the raw materials is low calcium silicates. Particle size distribution is managed as a result of the processing with other carefully chosen substances (PSD). The calculated blain value using PSD is approximately 12000cm2/gm, which is absolutely extremely fine. Due to its distinct chemistry and ultra- fine particle size, ALCCOFINE-1203 offers lower water content and, depending on the workability, even up to 70% replacement level for concrete performance. Additionally, ALCCOFINE 1203 may be utilized as a super workability aid to enhance flow or as a high range water reducer to enhance compressive strength.

Table -1: Chemical Composition and Physical properties

CHEMICAL ANALYSIS	MASS %	PHYSICAL ANALYSIS	RANGE
CaO	30- 34	Bulk Density	600 -700 kg/m^3
Al_2O_3	18 -25	Surface Area	12000 cm^2/gm
Fe_2O_3	0.8 3.0	Particle Shape	Irregular
SO_3	0.1-0.4	Particle Size,d10	<2mm
MgO	6-10	d50	<5mm

3. BIOCHAR

The ash-and-carbon-based, light-weight biochar that remains after biomass is pyrolyzed is known as biochar. The term "biochar" refers to the solid product created when biomass is thermochemically converted in an oxygen-limited environment.Here coconut shell biochar was used.

4. OBJECTIVE

The main objective of the study is to determine the durability Sulphate Attack Test, Carbonation, Water absorption Test of concrete with control, alccofine and biochar mix and compare the test results.

5. MATERIALS USED

5.1 Cement

Use of Ordinary Portland Cement (OPC) of Grade 53 according to IS specifications is made in this investigation. Table 2 provides cement's characteristics.

Table -2: Properties of OPC 53 grade cement

PROPERTIES	TEST RESULTS	TECHNICAL REERENCES
Specific gravity	3.12	IS4031(PART 11): 1988
Consistency(%)	30	IS4031(PART 4): 1988
Fineness of cement (%)	4.7	IS4031(PART 2): 1996
Initial setting time (minutes)	78	IS4031(PART 5): 1988

5.2 Fine Aggregate

For building, manufactured sand (M-Sand) is an alternative to river sand. M-sand is a product made from hard granite stone that has been crushed. M-Sand is less than 4.75mm in size. River sand is in short supply, hence artificial sand has been employed as an alternative for construction. M-Sand is also used since it is readily available and costs less to transport. Additionally, it is a dust-free material that pollutes very little. Table 3 lists the fine aggregate's characteristics.

Table -3: Properties of Fine Aggregate

PROPERTIES	TEST RESULTS
Specific gravity	2.52
Finess modulus	3.84
Free surfacemoisture	Nil

5.3 Coarse Aggregate

Aggregates with a particle size range of more than 4.75 mm, but typically between 10 and 40 mm in size. Concrete benefits from coarse aggregate's strength, toughness, and hardness qualities as well as its resistance to abrasion. The experimental study's coarse aggregate was 12.5mm in size and conformed to IS 383:1970. Table 4 lists the characteristics of coarse aggregate.

Table -4: Properties of Coarse Aggregate

PROPERTIES	TEST RESULTS	TECHNICAL REFERENCES
Specificgravity	2.69	IS2386(PART 3): Clause2.4.2
Free surface moisture	Nil	IS383(PART 3): 1970
Finenessmodulus	4.25	IS383(PART 3): 1970 table 2

5.4 Alccofine

One of the newest micro-fine materials, Alccofine 1203, is produced in India and has a particle size that is smaller than that of cement, fly ash, silica fume, etc. Due to its efficient particle size distribution, Alccofine 1203 has special characteristics that can affect the performance of concrete in both its fresh and hardened states. The early strength of concrete made with alccofine 1203 is found tobe similar to or greater than that of silica fume. Because alccofine starts the initial chain of events when cement hydrates, this is the reason. Additionally, the alccofine 1203 eats the calcium hydroxide byproduct that is generated during the hydration of cement, increasing the concrete's late-age strength. As a result, it produces additional C-S-H gel that is comparable to that of other pozzolans. Alcofine's calculated particle size distribution(PSD) is roughly 12000 cm^2/g. According to the need, it can be replaced with cement up to a 70% replacement level. Table 5 lists the alccofine 1203's properties.

Fig -1: Alccofine

Table -5: Properties of Alccofine

PROPERTIES	TEST RESULTS
Specific gravity	2.9
Bulk density(kg/m^3)	700-900
Fineness (cm^2/g)	>1200

5.5 Biochar

One of the waste byproducts that has lately received attention is biochar, which could be used in cementitiousand asphaltic composites for infrastructure purposes. It is a carbon-rich solid residue created when municipal solidwaste (MSW) or biomass are thermochemically converted in an oxygen-limited atmosphere. This process is known as pyrolysis and is both energy- and environmentally- friendly. Pyrolysis typically produces less sulphur and nitrogenoxide than standard MSW incineration, which can result in cleaner energy . While being mixed in the reactor, MSW is first prepared by source collection separation, which includes sorting and shredding, and then heated externally using combustion gas from pyrolysis. The colour, weight, size, and mechanical strength of the biomass change simultaneously with the chemical and physical state change during this process, andsyngas, bio-oil, and char develop. The feedstock disintegrates byup to 80% in weight at temperatures about 350°C, and the remaining feedstock then becomes charcoal.

Fig -2: Biochar

6. DURABILITY ASPECTS

The material's resistance to serious deterioration is referred to as durability. The environmental effects of repair and replacement can be minimized with the use of reliable materials. The concrete's endurance and capacity to survive extreme weather conditions are measured by the material's durability qualities. It will help determine how long the structure will be able to last, thus it is crucial. As long as it is un-cracked, durable concrete is comparatively impermeable.

6.1 Durability Test on Concrete

Durability test includes water absorption test and carbonation test. Here, the effectiveness of traditional SCC and the tested specimen were compared through the durabilitytest.

a) Water Absorption Test

One of the elements affecting concrete's durability is moisture infiltration. Due to its porous nature, concrete can produce toxic chemicals and allow water to corrode steel reinforcing. As a result, it should be taken into consideration while determining the concrete's quality. A cube specimen measuring 150 mmx 150 mmx 150 mm was cast and submerged in water for 28 days as part of a water absorption test. The specimens are weighed again at room temperature after being oven-dried for 24 hours at a temperature of 150 C to ensure that the mass is constant.

$$\% \text{ water absorption} = \frac{w1 - w2}{w2} \times 100$$

w1= oven dried weight of specimen

w2 = final weight of specimen

Fig -3: Water Absorption Test

b) Carbonation Test

Carbonation and shrinkage have a direct relationship with the corrosion of steel reinforcement. Carbonation testing is crucial to prevent future corrosion of steel reinforcement and the emergence of shrinkage fractures. The concrete's carbonation depth is measured during this test. A cube-shaped specimen measuring 150 mmx 150 mmx 150 mm was cast. Phenolphthalein is employed as an indication to determine the depth of carbonation; if the tester becomes pink, the specimen is considered to be un-carbonated; otherwise, it is assumed thatthe specimen is carbonated.

c) Sulphate Attack

Sulfate ions attack elements of the cement paste in a process known as sulphate attack on concrete, which is a chemical breakdown mechanism.

7. RESULTS AND DISCUSSION

This section presents the findings of various experiments conducted to evaluate the concrete's durability characteristics.

1) Water Absorption Test

Table 9 shows the percentage of water absorption, which is the difference between the specimen's weightand its oven-dried weight.

Table -6: Water Absorption Test Results

MIX	OVEN DRIED WEIGHT(kg)	WET WEIGHT OF CEMENT(kg)	% WATER ABSORPTION
CS	7.241	7.284	0.59
BIO	7.230	7.311	1.120
ALC	7.324	7.367	0.58

According to the findings of water absorption tests, the specimen of 10% alccofine 1203 absorbs less water than other control specimen.

2) Carbonation Test

Fig -4: Carbonation Test

From figure 3 makes it very evident that the control specimen becomes colorless, showing that it is a carbonated specimen. Alccofine and Biochar are still pink in colour showing that it is an uncarbonated specimen but the carbonation depth is less in alccofine.

3) Sulphate Attack Test

Table -7: Shows the Compressive Strength after Sulphate Attack

MIX	WATER IMMERSION	SULPHATE IMMERSION	REDUC-TION
CS	37.25	34.15	8.3
BIO	38.66	36.2	6.3
ALC	33.01	31.08	5.8

Fig -5: Specimen after Sulphate Attack

8. CONCLUSIONS

The main findings of this investigation are described below.

- Concrete that has alccofine partially replaced with cement performs better in terms of durability than concrete made with the original mix.
- Biochar is partially replaced with cement is a non-carbon concrete. It reduces emissions of CO_2 but in terms of durability, it performs less than a control specimen.
- The water absorption is higher in biochar compared to alccofine
- From the results it can be noted that biochar mix are highly resistant to sulphate attack than alccofine and control mix.

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