Effect of Superfines and GGBS on Engineering Properties of Concrete

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Abstract— **This study explores the feasibility and implications of partially replacing cement with alternative materials in concrete production. Concrete is a composite material composed of aggregate bonded together with a fluid cement that cures over time. Cement production, however, also generates most of concrete's greenhouse gas emissions. In this investigation, superfines that is waste material from the rock sand industry is partially replaced in different proportions such as 0%, 2.5%, 5%, 7.5% and 10% along with 10% GGBS in M25 Grade concrete and tested for Workability, Water Absorption, Compressive strength and Split tensile strength. The Durability of concrete was checked by performing Physical Salt Attack Test and Acid Attack Test so as to investigate the effect of Superfines and GGBS on durability of concrete. It was observed that the 5% replacement of cement with superfines and 10% GGBS resulted in an increase in the compressive strength and split tensile strength also follows the same pattern that the 5% replacement of cement with superfines resulted in an increase in strength slightly higher than the nominal concrete. It can be concluded that the superfines from rock sand industry can be used as a partial replacement of cement. It can be cost effective, eco-friendly to use and also the wastes from rock sand industry can be effectively recycled. The Compressive Strength was increased at 9.8% than Conventional Concrete Specimens.**

Index Terms— **Cement, Super fines, Compressive Strength, Split tensile Strength, Mechanical properties, Salt Attack Test, Concrete with Super Fines, GGBS Concrete.**

I. INTRODUCTION

The cement industry is one of the main producers of carbon dioxide, a greenhouse gas. One reason for the high carbon emissions is because cement has to be heated to very high temperatures in order for clinker to form. A major mineral which is of this is alite (Ca_3SiO_5), a mineral in concrete that cures within hours of pouring and is therefore responsible for much of its initial strength.

In the past few years, great emphasis was given on green concrete as it results in sustainable development. Green concrete is implied by application of industrial wastes to reduce consumption of natural resources, save energy and minimize pollution of the environment. So, to minimize the greenhouse gas emissions and other disadvantages of using cement in concrete, there is a need for using alternative materials as a replacement of cement. It may be a partial replacement or a full replacement but replacing cement to any proportion by environmentally friendly and cost-effective cementitious material will be advantageous.

Cement replacement materials are materials that can be used for substituting cement in the production of concrete or other cementitious products. For a material to be used as a cement replacement material, it must possess pozzolanic properties. Pozzolans are a broad class of siliceous and aluminous materials which, in themselves, possess little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide (Ca (OH)2) at ordinary temperature to form compounds possessing cementitious properties.

A. Superfines:

Superfines" in the context of sand industries likely refers to a specific grade or quality of sand that is exceptionally fine in particle size. This type of sand is often used in applications where a very smooth texture or precise grading is required, such as in construction, landscaping, or manufacturing processes like glassmaking or sandblasting. Superfines may have specific properties that make them suitable for certain applications, such as high purity, low moisture content, or uniform particle size distribution.

The utilization of superfines in concrete addresses critical needs in the construction industry, driven by a growing imperative for sustainability and resource efficiency. Superfines, an artificial byproduct, a residue from M-sand processing. Moreover, the incorporation of suprfines aims to enhance the mechanical properties of concrete, improving its compressive strength and durability. As the construction industry seeks greener alternatives, the integration of superfines in concrete represents a significant step toward more sustainable and resource-efficient building practices.

B. GGBS:

GGBFS, also known as ground-granulated blast-furnace slag, is a by-product of manufacturing iron and steel that is created by quenching molten iron slag in water or steam in a blast furnace. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions.

II. METHODOLOGY

A. Objectives:

The Main Objectives of the present investigation are

- The main objective of this work is an experimental investigation on use of industrial waste as a partial replacement of cement in concrete.
- To examine the effectiveness of using superfine as partial replacement of cement by studying strength parameters.
- To use supplementary cementitious materials to produce bricks which is affordable and structural light in weight and which can be used in construction.

B. Materials:

Cement is a binding material used in construction to hold together materials like gravel, sand, and other building materials. It is typically made from a mixture of limestone, clay, and other minerals that are heated at high temperatures to form a hard substance. Cement is a crucial ingredient in concrete, which is the most widely used construction material in the world.

Table 1 – Chemical Composition of Cement

Chemical Composition	Concentration (%)
SiO_2	21.06
CaO	57.98
Al_2O_3	6.10
Fe_2O_3	3.08
MgO	2.74
SO_3..	2.40

Natural River Sand from nearest supplier is used as a Fine Aggregate and Coarse aggregate means the aggregate which is retained on 4.75 mm sieve when it is sieved through 4.75 mm. In this Investigation 20 mm Size aggregates from nearest crusher unit are used as a Coarse Aggregate.

C. Superfines:

In this experimental investigation, the superfines are obtained from the rock sand industry. It is a very fine material which is obtained in the hydro-cycle process while preparing the rock sand using Granite stones. This superfines is being dumped as a waste material. Every week tons of waste (superfines) is being dumped in open area around surroundings of that industry. This industry is located in kawadipalli of Yadadri-Bhuvanagiri district of Telangana. This industries are also present in different parts of our state and also other states. The Physical Properties of Superfines are given in Table 2.

Table 2 – Physical Properties of Superfines

S. No	Properties	Test Results
1	Specific Gravity	3.01
2	Fineness Modulus	2.33
3	Normal Consistency	27.5%

Fig 1 – Superfines at Dumped at Site

Table 3 – Physical Properties of Cement

S. No	Property	Test Results
1	Fineness (%)	97
2	Specific Gravity	3.14
3	Initial Setting Time	65 min
4	Final Setting Time	265 min
5	Normal Consistency	31%

Table 4 – Properties of Fine Aggregate

S. No	Properties	Test Results
1	Fineness Modulus	2.66
2	Specific Gravity	2.63
3	Water Absorption (%)	1.2%
4	Bulk Density	1560 Kg/m^3

Table 5 - Properties of Coarse Aggregate

S. No	Properties		Test Results
1	Specific Gravity		2.64
2	Water Absorption (%)		0.75
3	Bulk Density (Kg/m^3)	Loose	1522.02
		Compacted	1700

III. MIX DESIGN

IS-10262:2019 and IS-456:2000 is the two Standard Codes which are used in the mix design process. The purpose of concrete mix design is to ensure the most optimum proportions of the constituent materials to fulfill the requirement of the structure being built.

Table 6 - Mix Proportions as per IS 10262 - 2019

Material	Quantity (Kg/m^3)
Cement	380 Kg/m^3
GGBS (10%)	38 Kg/m^3
Fine Aggregate	724 Kg/m^3
Coarse Aggregate	1287 Kg/m^3
Water	138 Lit
SP Dosage	1%

IV. RESULTS AND DISCUSSIONS

In this investigation, the strength properties are calculated by the replacement of cement with superfines in different proportions such as 2.5%, 5%, 7.5% and 10% along with the Replacement of 10% GGBS. The Durability of Concrete was investigated by Physical Salt Attack Test under the presence of 5% Sodium Chloride.

A. Workability of Concrete (Slump Cone Test)::

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. The workability of concrete is observed by the Slump Cone method. The Average Slump Values of the concrete are shown in Table 7.

Table 7 - Variation of Slump obtained

Trial Mix	Slump in mm
Trial 1 (0% SF)	68
Trial 2 (2.5% SF)	65
Trial 3 (5% SF)	60
Trial 4 (7.5% SF)	56
Trial 5 (10% SF)	52

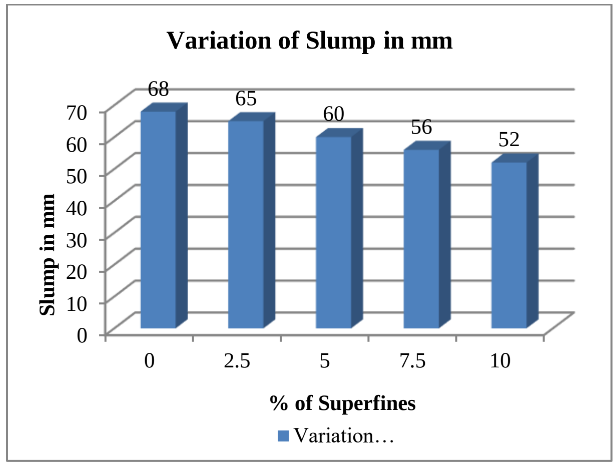

Fig 2 – Variation of Slump of concrete

B. Compressive Strength:

Compressive strength is obtained by applying crushing load on the cube surface. So, it is also called as crushing strength. Compressive strength of concrete is calculated by casting cubes. The test results presented here for compressive strength of 7days and 28 days of testing. The water cured specimens are eliminated from moisture content by surface drying before testing in Compressive Testing Machine.

Table 8 - Compressive Strength of Concrete

Trial Mix	Compressive Strength (Mpa)	
	7 Days	28 Days
Trial 1 (0% SF)	17.2	26.8
Trial 2 (2.5% SF)	16.8	28.6
Trial 3 (5% SF)	17.6	30.5
Trial 4 (7.5% SF)	15.1	27.0
Trial 5 (10% SF)	13.2	23.8

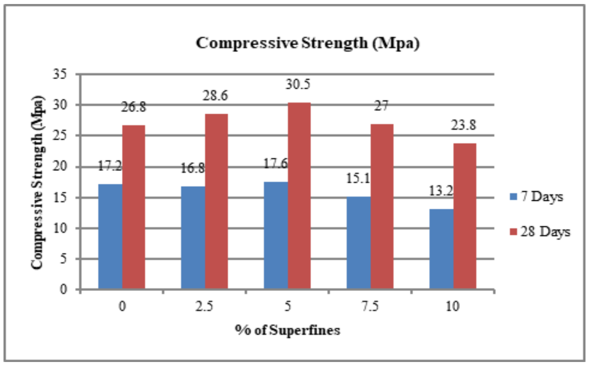

Fig 3 – Compressive Strength of Concrete

B. Split Tensile Strength:

The Split Tensile Strength of concrete can be analyzed by casting Cylinders of Size 200 mm X 100 mm

Table 9 - Split Tensile Strength of Concrete

Trial Mix	Split Tensile Strength (Mpa)	
	7 Days	28 Days
Trial 1 (0% SF)	2.46	2.82
Trial 2 (2.5% SF)	2.42	2.79
Trial 3 (5% SF)	2.54	2.95
Trial 4 (7.5% SF)	2.35	2.71
Trial 5 (10% SF)	2.20	2.64

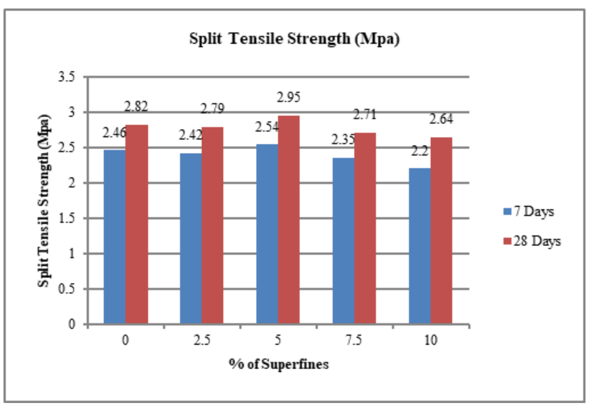

Fig. 4 Split Tensile Strength of concrete

C. Flexural Strength:

The Flexural Strength of concrete can be analyzed by casting Beams of Size 750 mm X 150 mm X 150 mm.

Table 10 - Flexural Strength of Concrete

Trial Mix	Flexural Strength (Mpa)	
	7 Days	28 Days
Trial 1 (0% SF)	2.71	3.10
Trial 2 (2.5% SF)	2.66	3.07
Trial 3 (5% SF)	2.79	3.25
Trial 4 (7.5% SF)	2.59	2.98
Trial 5 (10% SF)	2.42	2.90

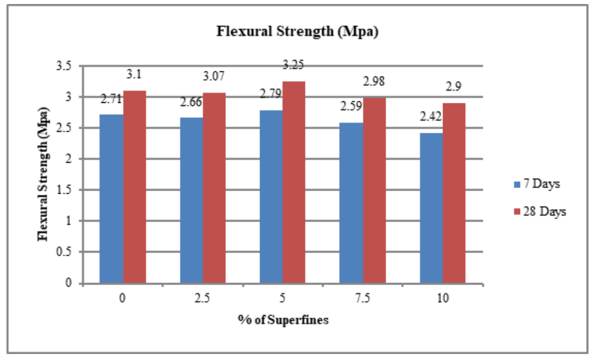

Fig 5 - Variation of Flexural Strength

V. DURABILITY STUDIES

In this experimental work, the Concrete durability Properties are investigated in terms of Physical Salt Attack and Acid Attack Test are carefully observed and the results are tabulated as follows. The Parameters like Percentage Weight Loss and Acid Attack Factor were observed for a dosage of 5% Sodium Chloride in water.

1. Physical Salt Attack Test:

1.1 Salt Attack Factor:

The percentage weight loss of cubes immersed in 5% Sodium Chloride for 28 Days curing have shown below

Table 11 - Physical Salt attack factor immersed in 5% NaCl

Trial Mix	Curing under 5% NaCl	
	After 7days	After 28days
Trail 1	1.51	2.55
Trail 2	1.38	2.47
Trail 3	1.29	2.39
Trail 4	1.33	2.50
Trail 5	1.56	2.73

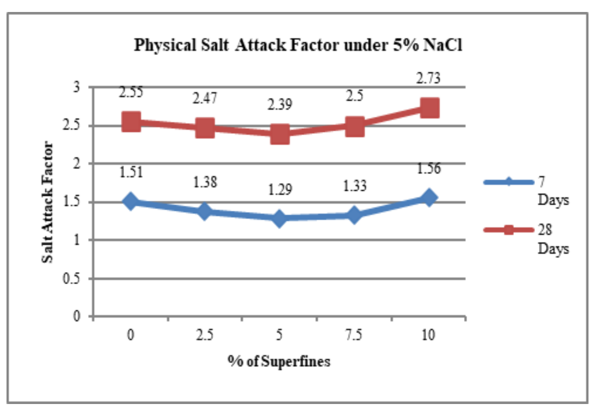

Fig 6 - Percentage of Weight Loss in 5% NaCl

2. Acid Attack Test:

2.1 Acid Attack Factor:

The Physical Salt Attack Factor values immersed in 5% HCl are tabulated as follows

Table 12 - Acid attack factor immersed in 5% HCl

Trial Mix	Curing under 5% HCl	
	After 7days	After 28days
Trail 1	2.87	10.20
Trail 2	2.62	9.88
Trail 3	2.45	9.56
Trail 4	2.53	10.00
Trail 5	2.96	10.92

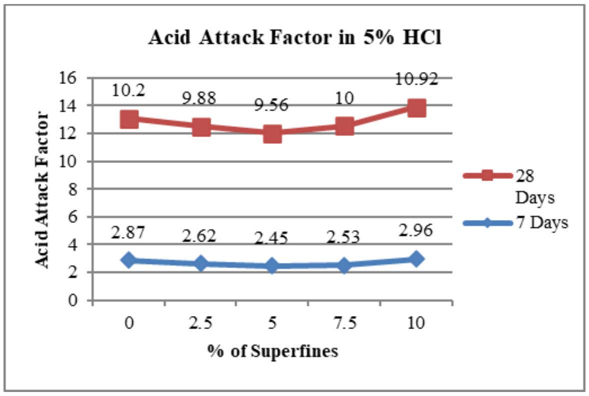

Fig – 7 Acid Attack Factor in 5% HCl

VI. CONCLUSIONS

- ✓ In the present investigation, the fresh and hardened properties are successfully achieved their desired values.
- ✓ The superfines from the rock sand industry are a good replacement material to the cement in concrete.
- ✓ As the percentage of superfines increases beyond 5%, the strength of concrete decreases gradually. So we can effectively use superfines as a partial replacement of cement to certain proportions.
- ✓ As the percentage of superfines increases, the Workability of concrete decreases gradually.
- ✓ Maximum Compressive Strength of 30.5 MPa has occurred for 5% replacement of cement with superfines and 10% GGBS in 28 days test.
- ✓ Maximum Split Tensile Strength of 2.95 MPa has occurred for 5% replacement of cement with superfines and 10% GGBS in 28days test.
- ✓ Maximum Flexural Strength of 3.25 MPa has occurred for 5% replacement of cement with superfines and 10% GGBS in 28days test.
- ✓ The Use of 10% GGBS in Concrete has significantly improved the Strength and durability Properties.
- ✓ The Concrete Mix with 5% Superfines and 10% GGBS has shown better Performance in Durability Studies as it gains minimum percentage of weight loss and Dimension Loss.

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