EXPERIMENTAL STUDY ON USING SILICA FUME IN CONCRETE

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ABSTRACT: Concrete is the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials. Nowadays, most concrete mixture contains supplementary cementitious material which forms part of the cementitious component. To design high strength concrete good quality aggregates is also required. Steel slag is an industrial byproduct obtained from the steel manufacturing industry. This can be used as aggregate in concrete. It is currently used as aggregate in hot mix asphalt surface applications, but there is a need for some additional work to determine the feasibility of utilizing this industrial byproduct more wisely as a replacement for both fine and coarse aggregates in a conventional concrete mixture. Replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits. Steel slag aggregate generally exhibit a propensity to expand because of the presence of free lime and magnesium oxides hence steel slag aggregates are not used in concrete making. Proper weathering treatment and use of pozzolanic materials like silica fume with steel slag is reported to reduce the expansion of the concrete. However, all these materials have certain shortfalls but a proper combination of them can compensate each other’s drawbacks which may result in a good matrix product with enhance overall quality.

In the present work a series of tests were carried out to make comparative studies of various mechanical properties of concrete mixes prepared by using ACC brand Slag cement, Fly ash cement and their blend (in 1:1 proportion). These binder mixes are modified by 10% and 20% of silica fume in replacement. The fine aggregate used is natural sand comply to zone II as per IS 383-1982. The coarse aggregate used is steel making slag of 20 mm down size. The ingredients are mixed in 1: 1.5: 3 proportions. The properties studied are 7days, 28days and 56 days compressive strengths, flexural strength, porosity, capillary absorption.

Keywords: Silica Fume, Steel Stag, Compressive Strength, Flexure Strength, Porosity, Capillary

I INTRODUCTION

Concrete is a blend of cement, sand, coarse total and water. Its prosperity lies in its adaptability as can be intended to withstand harshest conditions while going up against the most moving structures. Designers and researchers are further attempting to build its breaking points with the assistance of inventive substance admixtures and different supplementary cementitious materials SCMs. Early SCMs comprised of normal, promptly accessible materials like volcanic slag or diatomaceous earth. The building wonders like Roman reservoir conduits, the Coliseum are cases of this strategy utilized by Greeks and Romans. These days, most solid blend contains SCMs which are basically by items or waste materials from other mechanical procedures.
SUPPLEMENTARYCEMENTITIOUS

MATERIAL: More recently, strict environmental – pollution controls and regulations have produced an increase in the industrial wastes and sub graded byproducts which can be used as SCMs such as fly ash, silica fume, ground granulated blast furnace slag etc. The use of SCMs in concrete constructions not only prevent these materials to check the pollution but also to enhance the properties of concrete in fresh and hydrated states.

MATERIALS AND METHODOLOGY:

MATERIALS:

Silica Fume: Silica fume is a by-item in the decrease of high-virtue quartz with coke in electric circular segment heaters in the creation of silicon and ferrosilicon compounds. Silica rage comprises of fine particles with a surface territory on the request of 215,280 ft²/lb (20,000 m²/kg) when measured by nitrogen adsorption strategies, with particles roughly one hundredth the extent of the normal bond. Because of its outrageous fineness and high silica content, silica fume is an extremely powerful Pozzolanic material molecule. Silica fume is added to Portland bond cement to enhance its properties, specifically its compressive quality, bond quality, and scraped area resistance. These upgrades comes from both the mechanical changes coming about because of expansion of a fine powder to the bond glue blend and from the Pozzolanic responses between the silica smoke and free calcium hydroxide in the glue.

Steel Slag: The Steel slag, a by-result of steel making, is delivered amid the partition of liquid steel from contaminations in steel making heaters. This can be utilized as total in concrete. Steel slag total by and large display an inclination to grow on account of the nearness of free lime and magnesium oxides that have not responded with the silicate structure and that can hydrated and extend in damp conditions. This conceivably sweeping nature (volume switches up to 10 percent or more inferable from the hydration of calcium and magnesium oxides) could cause troubles with items containing steel slag, and is one motivation behind why steel slag total are not utilized as a part of solid development.

METHODOLOGY:

TEST PROCEDURE: The Experimental programme was carried out in two stages.

Stage 1: Experimental works were conducted on mortar mixes by using different binder mix modified with different percentages of silica fume.

Stage 2: Experimental works were conducted on steel slag concrete mixes by using different binder mix modified with different percentages of silica fume.

LABORATORY TEST CONDUCTED:

Compressive Strength Test:
For each set six standard cubes were cast to determine 7-days, 28 day and 56 days compressive strength after curing. Also nine no. of cube was casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086–1982.

Capillary absorption Test:
For each set six standard cubes were cast to determine 7-days, 28 day and 56 days compressive strength after curing. Also nine no. of cube was casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086-1982.

Test Procedure:
1) The specimen was dried in oven at about 1050C until constant mass was obtained.
2) Specimen was cool down to room temperature for 6hr.
3) The sides of the specimen were coated with paraffin to achieve unidirectional flow.
4) The specimen was exposed to water on one face by placing it on slightly raised seat (about 5 mm) on a pan filled with water.
5) The water on the pan was maintained about 5mm above the base of the specimen during the experiment as shown in the figure below.
6) The weight of the specimen was measured at 15 min and 30 min. intervals.
7) The capillary absorption coefficient (k) was calculated by using formula:

\[ k = \frac{Q}{A} \sqrt{t} \]

Where, Q is amount of water absorbed

**Porosity Test:**
Two cylindrical specimen of size 65 mm dia and 100 mm height for each mix were cast for porosity test after 7 days and 28 day of curing. This indirectly measures the durability of the mortar matrices

**Test Procedure:**
1) The specimen was dried in oven at about 1000C until constant mass Wdry was obtained.
2) The specimens were placed in a desiccators filled with distilled water under vacuum for 3 hrs.
3) Weight of the saturated specimen Wsat in distilled water is taken.
4) The specimens are taken out and its weight is taken in air i.e. Wwat
5) The vacuum saturated porosity is calculated by the formula:

\[ P = \frac{(W_{sat} - W_{dry})}{(W_{sat} - W_{wat})} \times 100 \]

Where, P = vacuum saturation porosity (%)
Wsat = the weight in air of saturated sample
Wwat = the weight in water of saturated sample
Wdry = the weight of oven dried sample

**RESULTS AND DISCUSSIONS:**

**EXPERIMENTAL STUDY ON MORTAR:** Here we arranged mortar with proportion 1:3 from various sorts of bond + silica fume substitution as folio blend and sand as fine total. At that point its physical properties like fine retention consistency, compressive quality and porosity was anticipated. These test outcomes both in unthinkable shape and graphical introduction are given underneath.

**Normal Consistency for Mortar:** Typical consistency of various folio blends was resolved utilizing the accompanying methodology alluding to IS 4031: section 4 (1988):
- 300 gm of test coarser than 150 micron strainer is taken.
- Approximate rate of water was added to the specimen and was blended completely for 2-3 minutes.
- Paste was put in the vicat’s shape and was kept under the needle of vicat’s mechanical assembly.
- Needle was discharged rapidly in the wake of making it touch the surface of the example.
- Check was made whether the perusing was coming in the middle of 5-7 mm or not and same process was rehashed if not.
- The rate of water with which the above condition is fulfilled is called normal consistency.

**Flexural Test:**
The flexural strength of steel slag concrete at 28 days and 56 days is given below

<table>
<thead>
<tr>
<th>Type of cement</th>
<th>% of SF replaced</th>
<th>28 days (N/mm²)</th>
<th>56 days (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>By vol cement (BC)</td>
<td>0</td>
<td>6.87</td>
<td>6.25</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6.80</td>
<td>5.44</td>
</tr>
<tr>
<td>Slag cement (SC)</td>
<td>0</td>
<td>7.25</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6.4</td>
<td>3.25</td>
</tr>
<tr>
<td>Slag and By vol cement blend (SBC)</td>
<td>0</td>
<td>7.25</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6.4</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>4.75</td>
<td>3.075</td>
</tr>
</tbody>
</table>
CONCLUSION:

From the present study the following conclusions are drawn:

- Consideration of silica seethe enhances the quality of various sorts of fastener blend by making them denser.
• Expansion of silica seethe enhances the early quality pick up of fly powder concrete while it builds the later age quality of slag bond.

• The equivalent mix of slag and fly powder concretes enhances general quality advancement at any stage.

• Expansion of silica smoke to any cover blend diminishes fine ingestion and porosity since fine particles of silica seethe responds with lime show in concrete and frame hydrates artist and crystalline in organization.

• The slender assimilation and porosity diminishes with increment dosage up to 20% swap of silica seethe for mortar.

• Expansion of silica smoke to the solid containing steel slag as coarse total lessens the quality of cement at any age.

• This is because of the arrangement of voids amid blending and compacting the solid blend in vibration table since silica fume makes the blend sticky or more strong which don't permit the entangled air to get away. The utilization of needle vibrator may limit this issue.

• The most essential reason of diminishment in quality is because of antacid total response between folio framework and the steel slag utilized as coarse total. By nature bond glue is soluble. The nearness of salts Na2O, K2O in the steel slag makes the solid more soluble. At the point when silica seethe is added to the solid, silica exhibit in the silica fume respond with the soluble bases and lime and frame a gel which hurt the bond amongst total and the folio framework. This abatement is more noticeable with higher dosage of silica fume.

• Blend of fly fiery debris bond and silica fume makes the solid more firm or sticky than the solid containing slag concrete and silica seethe causing development of more voids with fly fiery remains bond. Consequently the solid blends containing fly fiery debris and silica seethe indicate higher fine assimilation and porosity than concrete blends containing slag bond and silica rage.

• The aggregate substitution of normal coarse total by steel slag is not prescribed in concrete. An incomplete supplanting with fly fiery remains bond may create high quality cement with appropriately treated steel slag.

• The steel slag ought to be appropriately treated by stock heaping it in open for no less than one year to permit the free CaO and MgO to hydrate and in this way to lessen the extension in later age.

• An exhaustive concoction examination of the steel slag is prescribed to discover the nearness of antacids which may antagonistically influence to the bond between cover framework and the total.

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