EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF CONCRETE BY USING SILICA FUME AS PARTIAL REPLACEMENT FOR CEMENT

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Abstract *Concrete is the most versatile material due to the persistent and continuous demands made on concrete, Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials like fly ash, silica fume, granulated blast furnace slag and steel slag etc… The use of large quantity of cement produces increasing co2 emissions and consequence the green house effect.. Generally, Ordinary Portland cement is most commonly used making concrete in construction work. A byproduct silica fume is partially replaced with concrete to improve the durability, strength and mechanical properties of the concrete. A by-product silica fume are increased the strength and durability of the concrete. Silica fume is adding to increase the self-consolidating strength and compressive strength of the concrete.*

In this present an experimental work which carried out by silica fume as an additional material for cement and determine cement for M20 grade of concrete. We are adding silica fume in the concrete to replace 0% to 20% weight of cement at increase of 5% for cubes and cylinders to find out the compressive strength after 7, 14 and 28 days. To determine the split tensile strength after 7days and 28days curing

Keywords: Silica Fume, Ordinary Portland Cement, Compressive Strength, split tensile strength

1. INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage, behaviour as well as the durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete have bred contempt. Strength was stressed without a thought on the durability of structures. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction.

The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Met kaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement.

A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic

materials as cement replacements and the results are encouraging. Addition of silica fume to concrete has many advantages like high strength, durability and reduction in cement production. The optimum silica fume replacement percentage for obtaining maximum 28- days strength of concrete ranged from 10 to 20 % . Cement replacement up to 10% with silica fume leads to increase in compressive strength, for M20 grade of concrete. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete.

Silica fume, also known as microsilica, is a by-product obtained from the production of silicon and ferrosilicon alloys. It consists of very fine particles of amorphous silicon dioxide (SiO2) with a high surface area. Silica fume is often used as an admixture in concrete mixtures due to its unique properties. Its small particle size and large surface area allow it to fill the gaps between cement particles, improving the overall packing density of the concrete mixture. This results in a more homogeneous and dense concrete with reduced porosity. One of the main advantages of using silica fume in concrete is its high reactivity as a pozzolan . Silica fume reacts with calcium hydroxide to produce additional calcium silicate hydrate (C-S-H) gel, which is the main binder in concrete. This reaction leads to increased strength, durability, and reduced permeability in the hardened concrete..It is obtained as a by-product during the production of silicon and ferrosilicon alloys in the smelting process of high-purity quartz with coal or coke in electric arc furnaces. It is produced by reducing high-purity quartz to silicon at very high temperatures, typically up to 2,000ºC. During this process, SiO2 vapors are generated, which then oxidize and condense in the cooler areas of the furnace to form tiny particles of non-crystalline silica. Silica fume particles are extremely fine, with a particle size typically less than 1 micron and an average diameter of about 0.1 microns.

These particles are about 100 times smaller than the average particles found in cement. Due to their small size, silica fume particles have unique properties and can fill the gaps between cement particles, leading to improved strength and durability of concrete when used as an additive. The discovery of silica fume occurred in Oslo, Norway, in 1947 when it was observed during the filtration of exhaust gases from furnaces. Since then, it has been recognized and utilized as a valuable supplementary cementitious material in concrete production, contributing to enhanced performance in terms of strength, permeability, and resistance to chemical attack. Silicon dioxide, also known as silica, is a compound composed of silicon and oxygen atoms. It is a naturally occurring mineral and one of the most abundant substances on Earth. High-quality material commonly used in the cement and concrete industry. Silica fume is a popular material used as a supplementary cementitious material (often referred to as an admixture) in concrete to enhance its strength and durability. It conforms to standards such as AASHTO M 307 or ASTM C 1240, which provide guidelines for its use in construction.

Objectives of the study

The main objective of the proposed work is to study as to how by using mineral admixtures like Marble dust in varying proportions.

1. To provide most economical concrete
2. To minimize the maximum degradation in environment due to cement and safeguard the ozone layer from greenhouse gases
3. To evaluate cost comparison with the conventional concrete.
4. To minimize the disposal techniques as well as disposal problems.
5. To minimize and utilization of waste production.
6. To minimize maximum demand for cement production.
7. To investigate the utilization of silica fume as Supplementary Cementations Materials and increase the Strength of concretes made with different Cement replacement levels

2. LITERATURE REVIEWS

Roz-Ud-Din Nassar[4] et al,(2012) He examined the strength of recycled aggregate concrete containing milled glass as partial replacement for cement. The replacement of milled glass bring favourable changes in the structure of hydrated cement paste. This partial

replacement for cement is estimated effectively overcome the limitations of recycled aggregate through improvement in quality of remnant mortar paste attached to surface of recycled aggregate. Improvement in 56 days strength provides an indirect measure of pozzolanic activity of milled glass waste.

Roz-Ud-Din Nassar[5] et al,(2012) This paper studies the durability of recycled aggregate. concrete containing milled glass as partial replacement for cement. The use of milled waste glass, as partial replacement of cement is estimated to produce significant gains in durability of recycled aggregate concrete. Milled glass was found to suppress alkali-silica reactions. By use of milled waste glass as partial replacement of cement in recycled aggregate concrete results in enhanced durability characteristic such as sorption, chloride permeability and freeze-thaw resistance through improvement in pore system characteristics.

Mud fadhil[6] et al,(2002) This paper studied Workability and Compressive strength of ductile self compacting concrete(DSCC) with various cement replacement materials. It was studied that DSCC with various cement replacement materials was conducted. up to 20% of cement in DSCC was replaced by microwave incinerated rice husk ash(MIRHA), silica fume(SF) and fly ash(FA) in certain ratio. DSCC with replacement 10% MIHRA and 10%fly ash has higher compressive strength without scarifying the self compacting abilities.

3. METHODOLOGY AND MATERIALS

Cement

In this study Ordinary Portland cement of 53 grade (ACC cement) has been procured and has been used.

OPC 53 grade cement

Coarse aggregates

Coarse aggregates are particles more noteworthy that 4.75mm however for the most part go between 9.5mm to 37.5mm in breadth.
In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

20mm and 10mm coarse aggregates

Fine aggregates

Fine aggregates are essentially sands won from the land or the marine condition. Fine aggregates for the most part comprise of normal sand or squashed stone with most particles going through a 4.75mm sifter.

The fine total utilized in this investigation is waterway sand which is gotten from nearby organization and appeared in figure

Fine aggregates

Silica fume:

Silica fume, also referred to as microsilica or condensed silica fume, is another material that is used as an artificial pozzolanic admixture. Condensed silica fume is essencially silicon dioxide in noncrystalline form. It has spherical shape. It is extremely fine with particle size less than 1 micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement

particles. Silica fume has specific surface area of about 20,000 m^2/kg, as against 230 to 300 m^2/kg.

Micro silica is the most commonly used mineral admixture in high strength concrete. It has become the chosen favourites for high strength concrete and is a good pozzolan & can be used in a big way, Adding to the concrete mix will dramatically enhance the workability, strength & impermiability of concrete mixes while making the concrete durable to chemical attacks, abrasion & reinforcement corrosion, increasing the compressive strength. There is a growing demand in the production of concrete mixes, high performance concrete, and high strength, low permeability concrete for use in bridges, marine environment, and nuclear plants.

Silica fume

4. EXPERIMENTAL INVESTIGATION

Mix trials used in this study

The mix design used for this study is **1:2.026:3.18** for M20 grade design mix as per the materials properties

For this study of experimentation we were taken five trials to get the optimum value of strength values which are shown in the below discussions

1. 0% Silica fume : Mix 1
2. 5% Silica fume : Mix 2
3. 10% Silica fume : Mix 3
4. 15% Silica fume : Mix 4
5. 20% Silica fume : Mix 5

Workability of concrete

Slump cone test

The concrete slump test is utilized for the estimation of a property of crisp cement. The test is an exact test that estimates the usefulness of new concrete. All the more explicitly, it gauges consistency between groups. The test is prevalent because of the straightforwardness of contraption utilized and basic system.

Slump cone test

Compaction factor test

The compaction thing is decided because the ratio of the burden of in part compacted concrete to the load of fully compacted concrete and is stated to the closest second decimal point.

Casting of specimens

Casing of cubes and cylinders accomplished for M40 grade self compacting concrete, the blend extent is for which we are throwing 3D shapes for ordinary cement, with the incomplete substitution of cement

Curing of the specimens

The cased specimens were cured for 7, 14, 28 days to check the compressive strength, split tensile strength and flexural strength of concrete.

Test to be conducted on concrete

Compressive strength of concrete

This test was led according to ([9] IS516-1959). The solid shapes of standard size 150x150x150mm were utilized to locate the compressive quality of cement. Examples were put on the bearing surface of CTM, of limit 200T without unconventionality and a uniform rate of stacking connected till the disappointment of the shape. The most extreme burden was noted and the compressive quality ([21] AS Alnuaimi,) was determined

Compressive strength of concrete

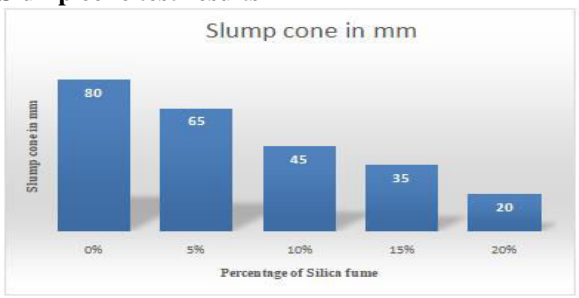
Split tensile strength

This test was led according to IS516-1959. The chambers of standard size 150mmx300mm were utilized discover the quality of cement. Examples are put on the bearing surface of CTM, of limit 200T without unusualness and a uniform rate of stacking is connected till the disappointment of chamber. The greatest burden was noted and the quality was determined. Split elasticity testing Procedure from IS5816-1999: Placing of the example the Testing Machine:

Split tensile strength

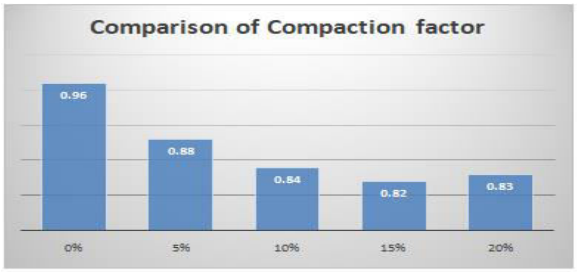
5. RESULTS AND ANALYSIS

Slump cone test results



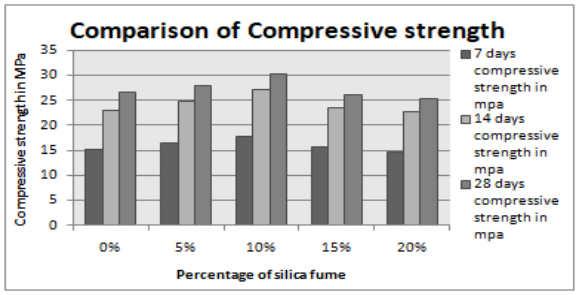
Comparison of slump cone test

Compaction factor test



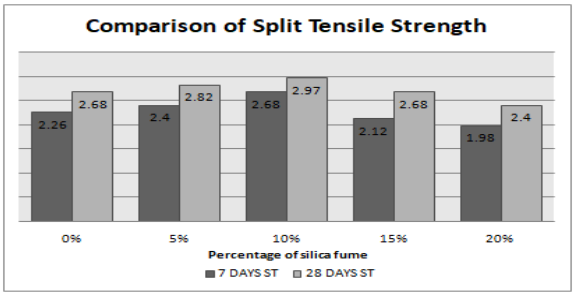
Comparison of compaction factor test

Compressive strength



Comparison of compressive strength

Split tensile strength



Comparison of split tensile strength

6. CONCLUSIONS

The main objective of this project is to evaluate the structural innovative concrete using silica fume as replacement for cement. To assess this, series of laboratory tests were conducted on various concrete mixes by the addition of silica fume. The strength characteristics of silica fume concrete have been studied.

The following conclusions are drawn from the experimental investigations;

1. There is a need for concerted effort to promote the technically sound, environmental safe and economically justified utilization of silica fume.
2. A number of researches and projects on high levels utilization of silica fume have been carried out in many parts of the world.
3. Because of the extreme fineness and high silica content, silica fume is a very effective pozzolanic material.
4. Consistency of cement depends upon its fineness. Silica fume is having greater fineness than cement and greater surface area so the consistency increases greatly, when silica fume percentage increases.
5. The Slump value decreases when the silica fume was added in M20 Grade concrete from 0% to 20%.
6. By using silica fume the compaction factor value is decreasing from 0% silica fume to 15% silica fume and gradually increases for 20% silica fume.
7. Concrete mixes containing 10% silica fume have shown an increase in compressive strength when compared to control mix for 7days, 14days and 28 days curing period.
8. Concrete mixes containing 10% silica fume, have shown an increase in split tensile strength when compared to control mix for 7days and 28 days curing period.

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