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STUDY ON PARTIAL REPLACEMENT OF CEMENT BY SILICA FUME AND FINE AGGREGATE BY STEEL SLAG

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Abstract - Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. The construction industry is the largest consumer of natural resources which led to depletion of good quality natural sand. These situations led to us explore alternative materials and granulated slag a waste industrial byproduct is one such material identified for utilization of it as replacement of natural sand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is **M40** grade concrete with partial replacement of cement by silica fume and fine aggregate by steel slag by 0, 2.5, 5, 7.5, 10, 12.5%. This project presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 7 and 28 days. Expecting the test results will indicate that use of Silica fume and steel slag in concrete has improved the performance of concrete in strength.

Key Words: Silica fume, Steel slag, Cement.

INTRODUCTION

Concrete used in construction are the most widely used material on earth after water. Many aspects of our daily life depend indirectly or directly on concrete. Concrete is a mix prepared by using various constituents like aggregates, water, cement etc. Concrete is different among major construction materials because it is designed specifically for particular civil engineering projects.. Design and construction of the nation's infrastructure critically depends up on concrete. The volume of concrete is composed of almost three quarter of aggregates. In future the availability natural aggregates get reduced. 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 Greenhouse 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 by silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement It becomes difficult to meet the global demand of concrete, so it is becoming more challenging task to find suitable alternatives to natural aggregates for preparing concrete. The steel slag generated from the conversion of iron to steel is poured into beds and slowly cooled under ambient conditions. The slag of crystalline structure is formed and hard lump slag is produced which can subsequently be crushed and screened. The crushing and screening of materials produces the aggregate is known as Steel Slag Aggregate (SSA).

OBJECTIVES

1) To carryout detailed characterizations of silica fume and steel slag based on the Literature review and theoretical studies.

2) To study the effects on workability due to the addition of silica fume and steel slag in various proportions.

3) To fix the silica fume and steel slag content based on the comparing results of six different volume fractions (0, 2.5%, 5% , 7.5%, 10% and 12.5%).

4) To study the behavior of Reinforced Concrete beams with replacement of silica fume and steel slag in optimum percentage.

LITERATURE REVIEW

GENERAL

In this chapter, an elaborate discussion is made regarding works done so far in this area as literature review. Replacement of silica fume and steel slag in different ratio,. In concrete with their behavior were studied. The review is about the replacement of cement and fine aggregate by silica fume and steel slag.

PARTIAL REPLACEMENT OF SILICA FUME AND STEEL SLAG

When silica fume percentage increases. The normal consistency increases about 40% when silica fume percentage increases from 0% to 20%.The optimum 7 and 28-day compressive strength and flexural strength. When compared to other mix the loss in weight and compressive strength percentage was found to be reduced by 2.23 and 7.69 when the cement was replaced by 10% of Silica fume[2].

As the SF concrete is more compact and thereby more durable in nature and hence with some degree of quality control. Moreover with 10% of cement replaced by silica fume, the characteristic strength of higher grade of cement concrete namely M25 is achieved only by using the M20 grade designed mix proportion and consequently this SF concrete can certainly be used as a supplement to M20 grade normal concrete with at least 4% of cost reduction [3].

From the study it has been observed that maximum compressive strength (both cube and cylinder) is noted for 10% replacement of cement with silica fume and the values are higher by 19.6% and 16.82% respectively than those of the normal concrete for cube and cylinder. where as split tensile strength and flexural strength of the SF concrete (3.61N/mm2 and 4.93N/mm2 respectively) are increased by about 38.58% and 21.13% respectively over those (2.6 N/mm2 and 4.07 N/mm2 respectively) of the normal concrete when 10% of cement is replaced by SF. [10].

The compressive strength has increased with increase in silica fume content, his increase is due to the pozzolanic action and binder formation of silica fume with cement. The decrease in strength beyond 10% silica fume may be due brittle behavior of concrete due to presence of extra binder. With further addition of quarry dust in addition to silica fume has increased its strength due to good bond formation due to rocky structure of quarry dust. The optimum replacement level was SF 10% + QD 30% [5].

Compressive strength increases by replacing sand by Steel slag up to 30 % but it get further reduced when percent increased to 40 %. The increase in compressive strength up to certain amount may be due to the fact that steel slag Further by adding Metakaolin (10%) to mix, strength increases as compared to previous mixes which only steel slag as replacement, Steel slag, fly ash and Metakaolin forms a stronger adhesive bond which increases the strength [11].

The maximum compressive strength value occurs at 25% slag ratio and declines beyond the 25% replacement ratio. The slight improvement in strength may be due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the particles and cement matrix. In almost all replacement ratios the flexural strength increased by the increase in slag ratio.which support the notion that in the case of slag utilization, the compressive and flexural strength do not correspond to each other [6].

Compressive Strength Reading at 7, 14, 28 and 50 days are higher than with the use as partial substitution of steel slag by sand with the level of 10, 20, and 30%,lower than 40% of steel slag show up particularly in association with other creation block shape cases. The increment in compressive strength of M 25 is noted 31.47% for 7 days curing 20% for 14 days curing 18% for 28 days while at 40% a slight decrement of 4.2% noted for 7 days and 3.4 % for 28 days of curing as compared to 30% 2. The increment in flexural strength test is about 36.7% for 28 days curing for M 25 grade of concrete and 24.7% for 28 days [1].

MATERIALS TO BE USED

INGREDIENTS OF CONCRETE

Concrete is a construction material composed of Portland cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. The cement and water form a paste which hardens by chemical reaction into a strong, stone like mass. The inert materials are called aggregate, and for economy no more cement paste is used than in necessary to coat all the aggregate surfaces and fill all the voids. The concrete paste is plastic and easily moulded into any form or trowel to produce a smooth surface. Hardening begins immediately, but precautions are taken, usually by covering, to avoid rapid loss of moisture since the presence of water is necessary to continue the chemical reaction and increases the strength. Too much water, however, produces a concrete that is more porous and weaker.

CEMENT

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource. Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as non-hydraulic or hydraulic respectively, depending on the ability of the cement to set in the presence of water.

FINE AGGREGATE

Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. Coarse aggregate form the main matrix of the concrete, where as fine aggregate form the miller matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension.

COARSE AGGREGATE

While the finished product is uniform and strong, concrete is made of many components, but is mostly made up of materials known as coarse aggregates. Coarse aggregates have a wide variety of construction applications because they resemble standard rock particles, as opposed to fine aggregate, which more closely resembles sand. Coarse aggregates are an integral part of many construction applications, sometimes used on their own, such as a granular base placed under a slab or pavement, or as a component in a mixture, such as asphalt or concrete mixtures. Coarse aggregates are generally categorized as rock larger than a standard No. 4 sieve (3/16 inches) and less than 2 inches.

WATER

Water is an important ingredient of concrete as it actively participates in chemical reactions with cement to form the hydration product, calcium-silicate- hydrate (C-S-H) gel. The strength of the cement concrete depends mainly from the binding action of the hydrate cement paste gel. A higher water binder (w/b) ratio will decrease the strength, durability, water tightness and other related properties of concrete. The water used for making concrete should be from desirable salts that may react with cement. Silts and suspended particles are undesirable as they interfere with setting, hardening and bond characteristics. Algae in mixing water may cause marked reduction in strength of concrete either by combining with cement to reduce the bond or by causing large amount of air entrainment in concrete.

SILICA FUME

Silica fume, also known as micro silica, polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete the biggest drawback to exploring the properties of silica fume was a lack of material with which to experiment. Early research used an expensive additive called fumed silica, an amorphous form of silica made by combustion of silicon tetrachloride in a hydrogen-oxygen flame. Silica fume on the other hand, is a very fine pozzolanic, amorphous material, a by-product of the production of elemental silicon or ferrosilicon alloys in electric arc furnaces.

STEEL SLAG

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. The large volumes of industrial by-products and secondary materials are need of hour to produce concrete incorporating materials due to depletion of natural sand resources and strong demand for concrete. In this context fine steel slag material is used as alternative material in replacement for natural fine sand. The steel slag generated from the conversion of iron to steel is poured into beds and slowly cooled under ambient conditions. The slag of crystalline structure is formed and hard lump slag is produced which can subsequently be crushed and screened. The crushing and screening of materials produces the aggregate is known as Steel Slag Aggregate (SSA).

EFFECT OF STEEL SLAG AND SILICA FUME IN CONCRETE

The effect of silica fume in concrete is that of filler, which because of its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. The results indicate that for conventional concrete, the partial replacement of fine and coarse aggregates by steel slag improves the compressive, tensile and flexural strength. The mass loss in cubes after immersion in acids is found to be very low.

WORK TO BE CONTINUED

- The basic properties of cement, fine aggregate, coarse aggregate, silica fume and steel slag should be found out.
- The workability test for concrete such as Slump test, Flow test, Vee Bee apparatus test, Compaction factor test should be found out with and without adding of silica fume and steel slag.
- Further, the results of mechanical properties of concrete should be done and compared with conventional concrete.

CONCLUSION

The Silica fume and steel slag increase the strength of concrete, during and after the finishing. The ultimate load carrying capacity of reinforced concrete beam is higher than that of controlled concrete beams. Addition of silica fume and steel slag expected to be high strength at

service load in the design mix concrete as compared to Controlled reinforced concrete beams. Replaced concrete exhibit high strength and durability at ultimate load. The presence of silica fume and steel slag in reinforced concrete may improve the ductility performance of concrete because of higher bond and anchorage.

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