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Study and Investigate Strength and Durability of Concrete Replaced with Silica Fume and Fly Ash A Review

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ABSTRACT

The last few decades are well thought-out to be the era of the self-compacting concrete and thousands of researches has been carried out. In India, the development of concrete possessing self-compacting properties is still very much in its initial stages. Over the past couple of years, few attempts were made still the cost of production of such concrete is a challenging issue for the present concrete engineers. Hence, in the present study an attempt is done to understand the effect of copper slag as a mineral admixture on the properties of self-compacting concrete. Hence, our attempt is to produce more economical, durable and sustainable SCC using mineral admixture.

In this paper presenting review of literatures

Keywords: Self Compacting Concrete, Admixture, Silica Fume, Fly Ash, Durability Test, Strength Test.

I. INTRODUCTION

Concrete is a most frequently used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-storey buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength, durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of hardened concrete is commonly considered to be an index of its extra properties depending upon a lot of factors e.g. worth and amount of cement water and aggregate batching and mixing placing compaction and curing. The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength called characteristic strength that is specific by designer of the structures. This depends on the quality control measures but there is no doubt that quality control add to the cost of concrete. The level of quality control is often an inexpensive cooperation and depends on the size and type of job now a days engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste material as a partial substitute of cement or as a admixture fly ash, silica fume, steel slag etc are the few examples of these types of materials. These materials are generally by-product from further industries for example fly ash is a waste product from power plants and silica fume is a by-product resulting from decrease of high purity quartz by coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys.

The use of micro silica as a pozzolana material has enhanced in recent years because when mixed in definite proportions it improves the properties of both fresh and hard concrete like durability, strength, permeability and compressive strength, flexural strength and tensile strength.

This section is primarily focus to present summary of research papers from researchers and scholars all around the globe who are constantly working hard towards scaling the properties of concrete for it's different application to come with the most desirable and cost effective product as per the needs to different projects.

II. SURVEY OF LITERATURE

R. R. Parmar and Dr. J. D. Rathod (2022) Durability indices for medium strength concrete containing OPC, silica fume and fly ash in binary and ternary blending are evaluated by testing the specimens at 28 days, 56 days and 90 days. Oxygen permeability, water sorptivity and chloride conductivity tests are conducted to evaluate effectiveness of mineral admixtures in enhancing various transport mechanisms.

It is observed that macroscopic pore structure of the concrete material plays an important role in durability of the concrete instead of compressive strength. Results show that blending of silica fume and fly ash as a part replacement of OPC improvises durability performance which helps to elongate service life of reinforced structures in marine environment.

Vishal Prashar et.al (2022) research paper presented an experimental program to investigate the strength and durability properties of high-strength selfcompacting concrete (HSSCC) with and without steel fibers. Crimped-type steel fibers, fly ash and Alccofine was used as mineral admixtures to fulfil the power requirement. Chemical admixture was used for workability.

Results of plain and fibrous HSSC concrete indicated that steel fiber increases the tensile strength and makes concrete more durable and impermeable. Non destructive testing (NDT) results of concrete were found in good co-relation with actual test results. The results of acid and alkaline resistance test indicate that loss in strength and weight of concrete specimen was more in case of concrete without fibres as compared to fibrous concrete. The acid solution has more severe effect and both RCPT and water absorption test indicated that the concrete has dense matrix and hence very low permeability.

M.D.V.S.Sravani et.al (2021) objective of the research paper was to determine the optimal replacement percentages that can be appropriately used in Indian conditions and find the optimal replacement GGBS with the addition of silica fume in M60 grade concrete with maintaining water cement ratio of 0.32. Different concrete mixtures were prepared and tested with different levels of cement replacement (0 %, 10 %, 20 %, 30% and 40 %) of GGBS with active silica fume as addition (0 %, 5 %, 10 % and 15 % by weight of cement). Experiment was planned to compare 7 days and 28 days the strength parameters of concrete i.e., compressive strength, split tensile strength and flexural strength.

The compressive strength, flexural strength and split tensile strength are increased in combination of partial replacement of cement by GGBS in 30% and addition of silica fume in 10%. The use of Glenium B233 as Superplasticizer at a dosage of 0.3% shows better workability and uniformity in mixing of concrete. It is a good water reducing agent. For M60 grade, maximum compressive strength of 70.66 Mpa, Split tensile strength of 4.4 Mpa and Flexural strength of 7.8 Mpa had occurred for HPC3 i.e., 10% Silica Fume, 30% GGBS. In case of durability the HPC 3 i.e., 10% Silica Fume, 30% GGBS has shown better results in attaining resistance when compared with other trail mixes to resist acid action.

S. M. Ashar et.al (2021) experimental research investigated the effect of silica fume on the fresh and hardened properties of geopolymer concrete such as workability, compressive strength, split tensile strength and flexural strength.
Test results shows that as the percentage of silica fumes was increasing there was an increase till 12% there was increase in all three type of strength but further increment in the percentage of silica fumes leads to the reduction of strength as well as workability and makes the concrete tough to handle.

Yu Bin (2021) Taking pervious concrete with a target porosity of 15% as the research object, the influence of three factors, including the contents of silica fume (mass fraction3%, 5%, 7%), metakaolin (mass fraction 8%, 10%, 12%) and Polypropylene fiber content (volume fraction1%, 2%, 3%), on the mechanical properties, permeability and frost durability of pervious concrete was investigated by utilizing the orthogonal testing method.
The results indicated that the content of silica fume and metakaolin has the most significant influence on the mechanical properties of pervious concrete, the fiber has the most significant influence on the continuous porosity, but the influence on the compressive strength is small. The best mix proportion was obtained, and the silica fume content is 7%, metakaolin content is 10%, and fiber content is 2%. The results of freeze-thaw cycle test of pervious concrete with optimal mix ratio show that the relative dynamic modulus and compressive strength of pervious concrete decrease gradually with the increase of freezing-thawing cycles, and the change rate of mass loss, continuous porosity increases gradually with the increase of freeze-thaw cycles.

C. K Williams et.al (2020) aim of research was to study the strength and durability index of concrete using mineral admixture of C30 grade concrete with the objective to investigate the effect of mineral admixture (Silica Fume) on the strength of concrete produced from cement (OPC). Fifteen cubes were cast in mould with dimension 150mm x 150mm x 150mm. 15 cylindrical samples were cast in mould of dimension 100mm diameter and 50mm height for testing C30 grade concrete. Silica Fume was replaced in the following proportions (5%, 10% 15% and 20%) by weight of cement while mixing concrete and cured for 28 days in water.
Tests carried out on concrete cube samples reveal that maximum strength is attained at 10 percent replacement of cement with silica fume which is considered as optimum SF replacement in the concrete mix. The compressive strength of 10 percent SF replaced mix was 19 percent higher than the conventional mix strength which was found to be 45.6 N/mm2. The discrepancy between the sorpitivity values of control mix and 5% SF replaced concrete mix is found to be less up to 10minutes duration and rise up to 55% for immersing samples for a period of 15 minutes. The maximum rate of water absorption due to capillary suction occurs in 5% SF replaced mix while comparing it with other mixes. The rate of reduction in sorpitivity in control mix and 10% SF replaced mix is similar to that of 15% and 20% silica fume replaced concrete mixes.

P. Ganesh and P. B Krishna (2019) research paper investigated the effect of mineral admixtures on the durability properties of HPC. A control mix without any mineral admixtures having a compressive strength was designed of 60MPa and two other mixes was prepared one by replacing cement by 10% metakaoline and other by replacing cement with 10% metakaoline + 30% fly ash respectively The workability tests were carried out on the fresh mix. Durability properties were determined by conducting sulphate attack test, acid attack test and rapid chloride permeability test.

Results stated that the combined use of silica fume and fly ash improved properties of concrete due to presence of silica fume.The amount of fly ash was not effective alone but it was used effectively with silica fume to produce high strength concrete.Acid attack on high strength concrete with and without mineral admixture is influenced by type of acid even though they may have the same concentration 10%. Hydrochloric acid attack is not severe where as sulphuric acid attack is very severe and significant weight loss and compressive strength loss is recorded.The loss of weight and strength is more in case of immersing in 10% H_2SO_4 compared to HCL. The loss of weight and strength is very less in Na_2SO_4 compared to acids.

P. Narasimha Reddy and J. Ahmed Naqash (2019) research paper presented the mechanical and durability index properties for M30 grade normal concrete (NM) and green concrete (GC). Investigation was carried out to develop a green concrete (GC) by replacing cement with various percentages of alccofine (10, 20, and 30%).

The compressive, splitting tensile and flexural stren gth of green concrete improves upto 20% of cement replaced by alccofine due to the higher specific surf ace area and high pozzolanic activity of alccofine re sulting in high production of C-S-H gel and helps in the formation of compact structure in the concrete th at helps in improving the early strength gaining cap acity of concrete. Water absorption percentage of Green Concrete reduces due to the action of pore filling effect and acceleration of hydration of alccofine particles making the concrete denser and compacted.

V. Gopi and K. Shyam Chamberlin (2019) in the research paper, the optimal percentage of these by-products for partial replacement of cement was analyzed in respect of their resulting concrete's strength properties. For fly-ash, 10%, 15%, 25%, and 35%, of replacement is tried and for silica fume, 0%, 4%, 6%, 8%, and 10%, of replacement is tried to arrive at their optimal replacement to get the desired strength and durability properties of the concrete. Compressive strengths were tested on cubes, split tensile strengths were tested on cylinders and flexural strengths were tested on beams. The specimen's durability properties were tested with sulphate and acid attacks.

Results stated that Workability of concrete increases with increase in percentage of silica fume and fly ash in concrete. The compressive strength reaches its maximum value when cement is replaced with 6% of silica fume and 15% of fly ash. The Split Tensile strength reaches its maximum value when cement is replaced with 6% of silica fume and 15% of fly ash. The flexural strength of composite beam is more than the conventional beam comparatively. The compressive strength of composite concrete (Fly ash + silica fume) attains its optimum value at 15% when compared with the acid attack concrete (NACl and H_2SO_4) for 28 days.

Anjali Prajapati et.al (2017) research paper aimed to study the properties and durability characteristics of fresh and hardened concrete using fly ash, GGBS and replacement of fine aggregate with foundry sand in high performance concrete of M60 grade. Fly ash and GGBS replacement varies from 10% to 30%. Conplast SP430-Sulphonated Naphthalene Polymers as a superplasticizer was used for better workability for high performance concrete. Dosage for superplasticizers was same for all mix proportions. Fine aggregate in different proportions was replaced with foundry sand. Compressive strength, split tensile strength and flexural strength was investigated for all different cases. The HPC mix, grade M60 concrete was designed as per Indian standards "Guide for selecting proportions for high strength concrete with Pozzolana Portland cement and other cementitious materials"

The compressive strength continue to increase as the curing period increase and greatest compressive strength is achieved when mixture content 30% of fine aggregate replaced with foundry sand and 10% GGBS. It was observed that development of tensile strength increase as replacement of sand by 10% of GGBS gives higher strength compared to control mix. In all mix proportion strength gain up is excellent, but 14 days compressive strength is less, and for 28 days strength gain is high because of combination of fly ash and GGBS.

M. Jayagopal and G. P. Lazarus D (2017) The project was increase that percentage of replacement by a suitable waste material. To achieve all the three by products mentioned above are mixed in a proportion of 60%, 30%, 10% of blast furnace slag, fly ash, silica fume respectively. This combination will give better properties like standard cement then the individual replacement of byproducts. Then the cement manufacturing process is adapted for mixture by heating the mixture at a temperature of 1400ºC, the clinker will form then the clinker is crushed and grained to get the fineness of cement. The mixture was tested for standard cement tests like specific gravity, consistency, initial and final setting time, loss on ignition, and chemical composition. The cement in concrete is replaced by obtained mixture by increment of 20% up to 100%. Then the concrete is tested for compression, split tensile, flexural strength test to find the performance of mixture in concrete.

Strength of concrete in compression, tension, and flexure keep on increasing by increase in replacement percentage up to 60% after that it loses its strength gradually. The replacement of cement shall be increased up to 60% to achieve the same strength of conventional concrete with reduction in cost.

R. Malathy (2017) research paper focused on workability, strength, and durability study on M20, M30, and M40 grade concretes replacing 30% of fly ash for cement. The optimum dosage of Spinacea pleracea, Calatropis gigantea, and polyethylene glycol was taken as 0.6%, 0.24%, and 0.3% by weight of cement from the research.

Results revealed that there is a presence of OH ions in the self-curing concrete. This helps in the effective hydration resulting in better durability properties. It was concluded that the vegetative materials added as internal curing agents perform better workability, strength, and durability characteristics in fly ash based concrete of grades M20, M30 and M40, and such biomaterials as internal curing agents can be used for RCC works, pavements, water tanks, pre-stressed concrete structures without curing with fly ash to achieve long term strength with high performance.

S.A. Kagadgar (2017) research paper investigated the influence of alccofine and fly ash as partial replacement of cement in various percentages (Alccofine - 5% replacement to cement content) and (fly ash – 0%, 15%, 30%, 50% & 60% to total cementitious content) on mechanical and durability properties (Permit ion permeability test and corrosion current density) of concrete.

Usage of alccofine and high quantity of fly ash as additional cementitious materials in concrete has resulted in higher workability of concrete. Inclusion of alccofine shows an early strength gaining property whereas fly ash results in gaining strength at later stage. Concrete mixes containing 5% alccofine with 15% fly ash replacement reported greater compressive strength than the other concrete mixes cured in both curing conditions. Durability test conducted at 56 and 150 days indicated that concrete containing higher percentages of fly ash resulted in lower permeability as well lesser corrosion density.

A.Lekhya and Dr. B. Damodar Reddy (2015) research paper evaluated the mechanical and durability properties of M60 grade concrete by replacing 10%, 15% of silica fume and 10%, 20%, 30% of fly ash to cement. 0.5% steel hook fibers are used by volume fraction as admixture for all proportions of HSFRC. Objective of research was to develop M60 grade concrete and to find the effective dosage of silica fume and fly ash and a detailed experimental study on compressive strength at different ages i.e. 3 days, 7 days, 28 days, 56 days, 90 days and split tensile test and flexural strength at the age of 28 days was done. Durability tests like Rapid Chloride Permeability test and Water Absorption test were conducted on casted specimens.

At 10% silica fume and 20% fly ash replacement to cement, split tensile strength were increased up to 60.85% when compared with conventional concrete for 28 days. At 10% silica fume and 20% fly ash replacement to cement, flexural strength were increased up to 38.74% when compared with conventional concrete for 28 days.The addition of silica fume and fly ash as replacement to cement, its normal consistency and initial setting time increases with increase in percentage and final setting time decreases with increase in percentage. The use of mineral admixtures in concrete causes considerable reduction in the volume of large pores at all ages and thereby reduces the permeability of concrete mixes because of its high fineness and formation of C-S-H gel.

Dipali Bharitkar and Jayant Kanase (2015) research paper presented wide-ranging experimental results of a quantitative analysis of the hydration of blended cement pastes with different percentages of calcined coal gangue powder. The concrete cement content was reduced by 20% to 40%. Durability related properties include resistance to sulphate attack and acid rain was enhanced greatly.

Results stated that the use of 20%, to 40% replacement of KG powder instead of cement, has significant effect on compressive strength of concrete over time and will withstand sulfate attack and acid rain. There was no adverse effect of replacement of cement by KG powder in optimum percentage.

K.G.Raveendran et.al (2015) research paper experimentally investigated the effects of mineral admixtures on the water permeability and compressive strength of concretes containing silica fume (SF). The main parameters investigated were M20 grade concrete with partial replacement of cement by silica fume.They were incorporated into concrete at the levels of 0%, 5%, 10%, 15% and 20%. The research presented a detailed experimental study on compressive strength, split tensile strength and flexural strength at an age of 7and 28 days.

Test results indicate that use of silica fume in concrete has improved the performance of concrete in strength at a particular percentage replacement. Although the highest compressive strengths of concrete observed was 10% silica fume mix for ordinary Portland cement and were reduced as the increase in the replacement ratios.

N. Ezhilarasi et.al (2015) research paper dealt with the strength and durability characteristics of high performance concrete using mineral admixtures. Many trials were conducted to find out the optimum mix ratio for the high performance concrete. Test on compressive strength and non-destructive test at 7 and 28 days were conducted.

The optimum replacement of mineral admixtures was found to be C75G5M10S10 .Split Tensile Strength and Flexural Strength and durability characteristics were carried out for conventional and optimum concrete mix to study the properties of concrete with mineral admixtures.

RA. B. Depaa and T. Felix Kala (2015) research paper presented the effects of self-healing on normal concrete by adding small amounts of GGBFS and silica fume to concrete. Silica fume was added to concrete at percent of 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and cement has been replaced with GGBFS by 35% and 55% respectively. The adopted water binder ratio for silica fume and GGBFS mixes was 0.45. M30 mix design was being done as per the Indian Standard Code IS: 10262-1982. The specimens are first tested for compressive strength at 28 days, then 70% and 90% of the compressive load was applied to another set of specimens to generate microcracks for studying the durability properties of the specimens. The strength properties of concrete specimens made using silica fume and GGBFS were tested for compressive strength and the durability properties was investigated using the sorptivity index test. The pre loaded specimens was cured for 28 days and then compressive strength tests and sorptivity index measurements were made at an interval of 14 days.
Results stated that the concrete mix containing cement replaced with 35% GGBFS has given maximum compressive strength value. Further, it was found that when silica fume was added as mineral admixture, the mix has given maximum strength at 12.5% addition of silica fume.

III. CONCLUSION

Here different researches show variations in concrete with different elements and admixtures, here authors shows results with different proportions of materials mixed in concrete shows following observations as:

- Authors examined the utilization of waste material like fly ash in concrete.
- Authors justify the use of other materials in concrete.

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