iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** V **Month of publication:** May 2016

DOI:

www.ijraset.com
IC Value: 13.98

Volume 4 Issue V, May 2016
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Durability Strength Waste Admixed High Strength Concrete

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Abstract--Concrete due to various reasons lacks tensile strength, durability and are more prone to cracks and segregation. In this study, various tests were performed on fresh and hardened concrete containing Copper slag (as a fine aggregate replacement) and Metakaolin and GGBS. The main aim of this project is to study the strength characteristics of concrete by the partial replacement of cement by Metakaolin , GGBS and fine aggregate is partially replaced by copper slag. Various proportions (0%,5%,10%) of Metakaolin and GGBS were partially replaced for cement The percentage addition varies from 20% to 60% at 20% interval for the partial replacement of fine aggregate by copper slag. Sorpitivity test, Porosity test, Acid attack test, Water absorption test were carried out to study the hardened properties of M30 grade concrete to determine the optimum percentage value for which the concrete exhibits higher strength. With that optimum value, the durability properties of concrete can be determined under 28 days curing period.

I. INTRODUCTION

Many countries are witnessing a rapid growth in the construction industry which involves the use of natural resources for the development of the infrastructure. This growth is jeopardized by the lack of natural resources which are depleting world wide, at the same time the generated wastes from the industry are increasing substantially. The sustainable development in construction involves the use of non-conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways for conserving the environment. Many researchers are being done on the possible use of locally available material to partially replace cement in concrete as cement is widely noted to be most expensive constituents of concrete. Cement according to Shetty, is composed primarily of silica and lime, which form the essential cementing compounds tricalcium (C_3S) and dicalcium silicate (C_2S). Any alteration in silica content will invariably affect the strength characteristics of cement.

In recent years, it is becoming more and more difficult to dispose of great quantities of waste materials into the ground. Hence, there is a great need to utilize various industrial waste products in appropriate manner in construction industry to reduce health and environmental problems Admixtures are added to concrete during its preparation, for altering the properties of fresh concrete and to enhance the properties of the hardened concrete. Improvement of concrete by adding chemicals are expensive and therefore require an economic replacement. In this project cement is replaced by Metakaolin and GGBS (Ground Granulated Blast Furnance Slag) and also Fine aggregate is replaced by copper slag to improve the strength of the concrete. The main objective of this study is to evaluate the possibility of using Metakaolin, GGBS and copper slag to enhance the durability properties of concrete at suitable proportions.

II. REVIEW OF LITERATURE

Dinakar P et al (2013),studied the effect of metakaolin content on the properties of high strength concrete. A constant water binder ratio of 0.3 is used. Metakaolin mixes with cement replacement of 5%, 10%, 15% were used. It was observed that 10 % replacement level was the optimum level in terms of compressive strength.In durability tests Metakaolin concretes have exhibited high resistance compared to control and the resistance increases as the Metakaolin percentage increases. The optimum replacement level of OPC by Metakaolin was 10 %, which gave the highest compressive strength in comparison to that of other replacement levels, this was due to the dilution effect of partial cement replacement. The results indicated that the replacement percentage of Metakaolin increases it reduces the water permeability, absorption and chloride permiability.

Saravanan J et al (2014),studied the mechanical properties for cement replacement by metakaolin based concrete. The conventional concrete M30 was made using OPC 53 grade were used and the cement is replaced by metakaolin and flyash. The cement is replaced by metakaolin as a percentage of 5%, 10%, 15%, 20%, 25% and fly ash for all mix 10%. The increase in metakaolin content improves the compressive strength and split tensile strength up to 20% cement replacement. It is concluded that the strength of metakaolin concrete mixes over shoot the strength of OPC.

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Amritpal Kaur et al (2015),studied the strength and durability properties of concrete with partial replacement of cement with metakaolin and marble dust.The partial replacement of cement has been done at 0%,3%,5%,9%,12%,13% with MK (Metakaolin) and 0%,10% (constant) with MP (Marble Powder). Result shows that there is a gain of strength with the addition of MK and MP. The percentage of metakaolin and marple powder increases it decreases the rate of penetration of chloride ions. It is concluded that the Use of Metakaolin and Marble powder give green concrete. Use of MK and MP save our environment, since during the production of MK and MP there is no emission of carbon dioxide.

Sonali K Gadpalliwar et al (2014),studied the partial replacement of cement by ground granulated blast furnace slag (GGBS) & rice husk ash (RHA) and natural sand by quarry sand in concrete.In first phase mix of concrete with replacement of 0%,15%,30%,45%,60%,75%,90% and 100% of quarry sand with natural sand is carried out to determine the optimum percentage of replacement at which maximum compressive strength is achieved. In second phase, cement is partially replaced with GGBS by 10%, 20% and 30%. In phase three, combination of GGBS and RHA is partially replaced with cement. The workability of concrete had been found to be decrease with increase of quarry sand in concrete. The workability of concrete had been found to be decrease with increase of RHA but the GGBS increases the workability of concrete .It showed that combination of GGBS and Rice Husk Ash with QS concrete will be durable as compared to control concrete.

Ramalekshmi M et al (2014),studied the experimental behavior of reinforced concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS).Mix design has been arrived for M25 concrete with replaced by the different ratios of 50%, 60%, 70% & 80% of GGBS slag. Fineness modulus, specific gravity, sieve analysis and bulk density of fine aggregate and coarse aggregate are also found out. GGBS can achieve adequate early-age compressive strength, while maintaining a long-term strength higher than conventional concrete.

Vinayak Awasare et al studied the analysis of strength characteristics of ground granulated blast furnace slag (GGBS) concrete. In this paper the strength characteristics analysis of M20 grade concrete with replacement of cement by GGBS with 20%, 30%, 40% and 50% and compare with plain cement concrete.The maximum compressive strength achieved is 32.59 Mpa at 30% of GGBS replacement and those achieved for 20%, 40%, and 50% of concrete is 31.11Mpa, 30.7Mpa and 27.74Mpa respectively as compare to 29.11 Mpa of strength of plain cement concrete . The flexural strengths achieved are 3.01 Mpa, 3.45 Mpa, 3.58Mpa, 3.44Mpa and 3.12 Mpa a 0%, 20%, 30%, 40%, and 50% for GGBS concrete respectively for M20 grade concrete of OPC cement and crushed sand. This report shows that tensile strength also give good performance for 20%, 30 % and 40% replacement which is more than normal plain concrete.

Reshma Rughooputh et al (2014),studied partial replacement of cement by ground granulated blast furnace slag in concrete. Aim of this work was to investigate the effects of partially replaced Ordinary Portland Cement (OPC) by ground granulated blast furnace slag (GGBS) on the properties of concrete including compressive strength, tensilesplitting strength, flexure, modulus of elasticity, drying shrinkage and initial surface absorption. The partial replacement of OPC with GGBS improves the workability but causes a decrease in the plastic density of the concrete.

Venu malagavelli et al (2010), studied high performance concrete with ground granulated blast furnace slag (GGBS) and robo sand. The cement is partially replaced by granulated blast furnace slag (GGBS) and sand is partially replaced by robo sand. It is found that by the partial replacement of cement with GGBS and sand with ROBO sand helped in improving the strength of the concrete substantially compared to normal mix concrete.If the percentage of Robo sand increased then the compressive strength and tensile strength also increased.

Meenakshi Sudarvizhi S et al (2011), studied the performance of copper slag and ferrous slag as partial replacement of sand in concrete. Six series of concrete mixtures were prepared with different proportions of CS and FS ranging from 0% to 100%. The replacement of sand by copper slag and ferrous slag as a percentage varies from 0%, 20%, 40%, 60%, 80% and 100%.All specimens were cured for 7, 28, 60 & 90 days before compression strength test and splitting tensile test. It is concluded that the percentage of copper slag and ferrous slag increases then the workability also increases.

Leema rose A et al (2015), studied the performance of copper slag on strength and durability properties as partial replacement of fine aggregate in concrete.The fine aggregate is partially replaced with copper slag as a percentage varies from 10%, 20%, 30%, and 40%.It is concluded that addition of copper slag in concrete increases the density of the concrete. The increase in density results in increase of self weight of the concrete.

Binaya Patnaik et al studied the strength and durability properties of copper slag admixed concrete.The sand is partially replaced by copper slag with 0% to 50%.Two different types of Concrete Grade (M20 & M30) were used with different proportions of copper slag replacement (0 to 50%) in the concrete. It is concluded that the High toughness of Copper Slag attributes to Increased

Compressive strength. Due to low water absorption, coarser (in nature than sand) and glassy surface of Copper slag the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture. Acid resistance test showed that the concrete containing copper slag has a low resistance to H2So4 and HCl solution than the control concrete It is also concluded that the Concrete with Copper slag as Partial replacement of Sand shows good resistance to sulphate attack.

Anil K Gupta (2014), This paper deals with the use of Metakaolin which is having good pozolanic activity and is a good material for the production high strength concrete. which is getting popularity because of its positive effect on various properties of concret. The results shows that that optimal performance is achieved by replacing 7% to 15% of the cement with metakaolin. While it is possible to use less, the benefits are not fully realized until at least 10% metakaolin is used. Values of compressive strength of concrete with metakaolin after 28 days can be higher by 20%. Dosage of 15% of metakaolin causes decrease of workability of suspension in time. Increasing amount of percentual proportion of metakaolin in concrete mix seems to require higher dosage of superplasticizer to ensure longer period of workability.

Gurunaathan K et al (2014), studied the effect of mineral admixtures on durability properties of concrete.The cement is partially replaced by Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), Rice Husk Ash (RHA) and Silica Fume (SF) to improve the durability properties of concrete.The combination of rice husk ash and silica fume shows lower result than the control concrete due to inherent chemical reactions. It is concluded that the replacement shows good resistance to sulphate attack, chloride attack and acid attack than the control concrete.

Magudeaswaran P et al (2013), studied the experimental study on durability characteristics of high performance concrete. The cement is partially replaced with fly ash (F) and silica fume (SF). The cement was replaced with 25% F & 12.5% SF, 30% F & 15% SF, 35% F & 17.5% SF. Water cement ratio is kept constant for all mixtures.It was observed that for the increase in the percentage of fly ash and silica fume there was steady increase in the water absorption and alkalinity which significantly indicates the markable change in strength and durability characteristics of concrete.

Deotale R S (2014), studied the replacement of cemet with Ground granulated blast furnace slag and also with Rice husk ash, quary sand is replaced with the natural sand. In first phase mix of M40 grade concrete with replacement of 0%, 15%, 30%, 45%, 60%, 75%, 90% and 100% of quarry sand with natural sand is carried out. In second phase, cement is partially replaced with GGBS by 10%, 20% and 30%. In phase three, combination of GGBS and RHA is partially replaced with cement. It is observed that when natural sand is partially replaced with 60% quarry sand maximum strength is achieved. The composition of 22.5% GGBS + 7.5% RHA with 60% of quarry sand gives good strength results In order to increase the strength cement is replaced by combination of GGBS and RHA. The maximum 28 days split tensile strength was obtained with 30% GGBS replaced with cement.

Srishaila J M (2014), this study investigates the combined effect of Ground Granulated Blast Furnace Slag (GGBS) and Metakaolin on the properties of self compacting concrete. The workability test for acceptance of self compacting concrete like slump test, V-funnel, and L-Box were carried out on fresh concrete. The compressive, split tensile, and flexural strength test of concrete with replaced GGBS plus Metakaolin at 5%,15%and 25% and 3%,6% and9% were examined after curing period of 28 and 56 days and it is found that fresh property results show us that as the percentage of Metakaolin increases the filling and flowing ability of the concrete decreases. The temperature of the concrete increased with the increase in percentage of Metakaolin.

Prince Arulraj (2015), Over 300 million tons of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials poses problems of disposal, health hazards and aesthetic problem. Hypo Sludge (HS) is a waste material produced from paper industry that can used as a cement replacement material in concrete since the lime content in the sludge is large. Copper slag is a waste material produced from copper manufacturing process and this can be used as a replacement material for fine aggregate (sand) since the particle size similar to sand. During the present study, an attempt had been made to study the mechanical properties of concrete in which Hypo sludge and Copper slag were as a replacement material for cement and fine aggregate respectively. Replacement percentage used during this study were 10%, 20% and 30% of Hypo sludge for cement. Fine aggregate was replaced with 30%, 40% and 50% of Copper slag. Compressive strength of cubes were found on 7th, 28th and 56th days. Split tensile strengths of the cylinders were found on 28th and 56th days. Flexural strengths of prism specimens were found on 28th day.It is found that Optimum of 50% replacement of fine aggregate by copper slag shows increase in compressive strength when compared to conventional mix. Optimum of 10% replacement of cement with Hypo sludge and 50% replacement of fine aggregate with Copper slag shows increase in compressive strength compared to other combinations. At 40% replacement of fine aggregate by copper slag shows increase in split strength Optimum of 10% replacement of cement with Hypo sludge and 50% replacement of fine aggregate with Copper slag shows increase in flexural strength compared to conventional mix.

Maya T M (2015), studied the sustainable development in construction involves use of waste materials and by-products to replace

Portland cement and aggregates. The aim of the present study is to evaluate the effect of replacing cement with silica fume and fine aggregate with copper slag. For this research work M30 grade concrete is prepared and is evaluated for fresh concrete properties and hardened concrete properties like compressive strength and flexural strength. Portland cement is replaced with silica fume at 0, 4, 8 and 12 % and fine aggregate is replaced with copper slag at 0, 20, 40 and 60 %. The results show that the use of silica fume and copper slag as replacement material improves mechanical properties of the concrete. Concrete incorporating 40 % copper slag and 8 % silica fume as replacement material shows better performance among all the mixes. Workability of the concrete increases with increase in copper slag percentage and decreases with increase in silica fume percentage. Workability is reduced when silica fume is added to concrete containing copper slag as fine aggregate. When replacement level of silica fume increases all the mechanical properties are increased up to 8% and up to 40% replacement level of copper slag all the mechanical properties are increased.

Srinivasu K (2014), Concrete a widely used construction material, consumes natural resources like lime, aggregates, water. In this content an interest was made by civil engineers to replace the composite concrete material with industrial wastes, agricultural wastes, and waste glass. In this content metakaolin was a pozzolanic material used in wide range in partial replacement of cement in concrete which was treated as economical and also due to its pozzolanic action increasesstrength and durability properties of concrete. In this study he concluded that Use of metakaolin in concrete is of 25% in replacement of cement gave good strength results and durability improvement. Water permeability, absorption was much improved in use of metakaolin which leads to increase in density of concrete. Use of metakaolin in preparing acid resistance concrete such as chloride permeability, sulphate resistance showed good results Improvement in use of metakaolin with silica fume, fly ash and steel fibres showed better results than conventional concrete. Use of metakaolin showed better improvement in flow ability of concrete and cement mortar.

III. RESULTS AND DISCUSSIONS

The study is to make use of industrial wastes such as Metakaolin and GGBS are varied from 5%, 10%, 15% by the weight of cement and copper slag varied from 10%, 20%, 30%, 40%, 50%, 60% by the weight of fine aggregate.Mix design is done for the M30 grade concrete with 0.38 w/c.The combination of mix ratio were taken as 5%, 10%, 15% for each 10%, 20%, 30%, 40%, 50%, 60%. Totally 19 number of mix ratios were taken.Concrete cubes 150 x 150 x 150 mm sizes of 3 no's were tested and there average values were used.

Slag replacement by weight decreases the strength of concretes in short term when compared to control Portland cement concrete. However, in long term, concrete containing slag exhibits a greater final strength than that of control normal Portland cement concrete. When compared to control normal Portland cement concrete, the increase in the water–cementitious material ratio decreases more the strength of concrete having particularly high percentages of slag.

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