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Experimental Study on Concrete Using Admixture Metakaolin, Copper Slag on M30 Grade Concrete A Review

Pradeep Kumar Tiwari[1], Afzal Khan[2]
P.G. Scholar[1], Assistant Professor[2]
Department of Civil Engineering, MITS Bhopal, Madhya Pradesh, India

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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 research 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 the present study copper slag is that by product which is used in replacement with sand without disturbing properties of concrete with respect to strength, workability, and other mechanical properties.

Keywords : Self compacting concrete, Admixture, Copper slag, Durability, Strength

I. INTRODUCTION

Now a day major problems faced by civil engineers is construct durable concrete structure. For making durable concrete structures, proper and sufficient compaction is necessary. For normal or conventional concrete compaction is done by vibrators. In case of highly congested reinforcement, it is very difficult to compact the concrete and if over vibration is done then it causes segregation in concrete. For such structure, concrete which can easily flow is required. Self Compacting Concrete (SCC) is the concrete which settles and get compacted by its own weight. SCC was proposed by Okamura in 1986 for Japan. Later on lots of researchers are working on flowability, strength and durability performance of the concrete.

SCC is the concrete which meets the special performance and uniformity requirements which cannot be always obtained by conventional concrete, normal mixing and curing practices. SCC consists of different engineered materials like cement, sand, aggregate, admixtures. Chemical admixtures were used for care of specific requirements such as strength, high workability, less permeability, high flow ability, durability, resistance to stresses, and resistance to segregation.

Copper slag is a by-product obtained during the production of copper metal, which can be used as pozzolana in the production of cementing materials. The raw copper slag had particle sizes ranging from micrometers to larger than 1 cm in diameter. Industrial sludge is generated at a rate of 100 metric tons/day, from a copper slag recycling plant. An attempt is made to produce more economical and durable concrete using industrial byproducts i.e. copper slag. Technically copper slag is used to improve the strength and the durability of concrete. Hence, aim of our project is to check the behavior of conventional concrete under the influence of copper slag which is normally available in market now days. The effect of copper slag on conventional concrete and SCC were studied.

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste or utilized in different applications.

Fig 1 Copper Slag

II. Review of Literature Summary

Purva Parekh and Kishan Vekariya (2022) research paper evaluated the Durability of High Strength Concrete (HSC) containing Metakaolin (MK) as a partially replacement of cement, Copper Slag (CS) as a partially replacement of fine aggregate and Silica Fume (SF) as a mineral admixture.

Results stated that compression strength of the concrete increases when the percentage of replacement up to 15%, then after compressive strength decreases. The acid attack test result show that it is good to resist for acid and corrosion relative to normal concrete. The incorporation of metakaolin, copper slag and silica fume is excellent improvement in compressive strength and durability. The presence of silica fume as a mineral admixture shows excellent results to enhance mechanical and durability properties of concrete. Use of copper slag as a partially replacement of fine aggregate gives good result on durability.

E Lalith Prakash et.al (2021) in the research paper, the mineral admixtures such as fly ash and Ground Granulated Blast furnace Slag (GGBS) were added to the concrete containing fine aggregates which was partially substituted with copper slag. Test experiments were designed using Response Surface Method (RSM) to obtain the various trial proportions. Three factors such as Copper Slag, GGBS, and Fly Ash were considered. The levels were 20%, 30%, and 40% for copper slag; 20%, 35%, and 50% for GGBS; and 15%, 25%, and 35% for Fly ash. Test were performed on each trial proportion to study the compressive strength , split tensile strength, chloride penetration and sorptivity properties.

Results stated that there was considerable improvement in the performance of the copper slag concrete at the optimum dosage of GGBS and fly ash. It was found that the concrete mix in which the river sand is replaced with 20% of copper slag and cement replaced with GGBS and Fly Ash by 50% and 15% respectively, perform better in the strength, permeability, and porosity characteristics.

R. Jeyamahima et.al (2020) objective of the research was to investigate the strength and durability properties of M70 grade of concrete to analyze the properties of concrete containing copper slag as partial replacement of fine aggregate and mineral admixture as partial replacement of cement in the concrete mix design. Copper slag content has been 40% as a replacement of fine aggregate and silica fume 5%,10%,15% & 20% and GGBS 5%,10%,15% & 20% as a replacement of cement respectively.

The test results indicated that the strength properties of concrete were improved having copper slag as a partial replacement of fine aggregate (40%) and Silica fume & GGBS as partial replacement of cement (up to 15%). It was further observed that the use of copper slag and mineral admixture in concrete has shown considerable increase in strength and reduction of cost when compared with normal concrete.

P. Satish Reddy and D. Rajitha (2020) objective of the research paper was to investigate the mechanical properties such as compressive strength test, droop test,spilt pliable test, flexural quality test, basic analysis and antacid test toward the finish of 7 and 28 days of restoring by halfway supplanting concrete by fly debris, silica smolder, metakoalin and by copper slag under typical relieving with compound admixture.

In instance of various blends Of percent substitute of mineral admixtures gives the most extreme compressive power for M80 grade concrete in 89.3 Mpa with substitution of concrete by methods for 15% fly Ash and 5% Metakaolin Mineral admixtures comprising of Fly debris, miniaturized scale silica, metakaolin and Slag likewise make commitments viably for achieving high force. In elite solid blend plan, the water concrete proportion is embraced low. It is important to keep up super plasticizers for required usefulness. At the point when the level of mineral admixtures in the blend builds super plasticizer rate additionally increments for getting of required quality.

Vignesh Kumar.B et.al (2020) objective of the research paper was to investigate the strength and durability properties of M70 concrete containing copper slag as partial replacement of fine aggregate and mineral admixture as partial replacement of cement in the concrete mix design. Copper slag content was 40% as a replacement of fine aggregate and silica fume 5%,10%,15% & 20% and GGBS 5%,10%,15% & 20% as a replacement of cement respectively. The results were analyzed to study the strength test and durability test.

The test results stated 40% replacement of fine aggregate as copper slag gives them more strength. And silica fume & GGBS as partial replacement of cement (up to 15%). It was observed that the use of copper slag and mineral admixture in concrete has shown a considerable increase in strength and reduction of the cost when compared with normal concrete.

A.Mohideen Abdul Kader Refai and Dr. P. Oliver Jayaprakash (2019) research paper focused on replacing fine aggregate in concrete to improve the strength. An effort was made to replace fine aggregate with copper slag and styrene butadiene in proportions on trial and error basis by keeping water-cement ratio as 0.36 to attain the optimum strength. For high strength concretes produced in C50/C60 designs, Styrene Butadiene Copolymer (SBR) in different ratios by weight (Control (0%), 1%, 3%, 5% and 8%) was used instead of cement and strength properties were investigated.

The optimum mix proportion for fine aggregate was 70% Copper slag, 10% Styrene butadiene and 20% sand. The addition of copper slag enhances the compressive and tensile behavior only up to certain extent. There was reduction in the strength due to the water content. The butadiene incorporation results in

reduction in strength of the specimen. The incorporation of copper slag and styrene butadiene in proper proportion enhanced the flexural behavior of the concrete.

P. Priyadharshini and R. Sakthivel (2019) reserach paper aimed to investigate partial replacement of sand by copper slag and the strength variations observed by the incorporation of glass fibres and compared with the strength properties of control mix SCC. Mix proportioning was done for M30 SCC and Self Compactability was checked by various flow tests of slump flow test, J-ring test, U-box, V-funnel and L-Box. Sand was replaced with copper slag in proportions of 0%, 20%,30%,40%,50%,60%,with constant proportion of glass fibre i.e.,by0.1% by volume of concrete.

Compressive strength increases when the % of copper slag increases. High toughness of copper slag attributes to the increased compressive strength. Maximum percentage increase in compressive strength is 27.73 %. When copper slag % is greater 50%, there is a reduction in compressive strength. This is due to the increased voids and increased free water content. Flexural strength increases when the % of copper slag increases. Copper slag admixed concrete shows higher energy absorption values and this is attributed to the ductile nature of copper slag admixed beams. Maximum percentage increase in flexural strength is 43.28%. Split tensile strength increases when the % of copper slag increases. Glass fibre across the splitting section is effective in resisting the splitting of cylinder. Maximum percentage increase in split tensile strength is 45.74 %.

C Manikandan et.al (2018) objective of research paper was to study the strength and durability properties of M 70 grade concrete containing copper slag as partial replacement of fine aggregate and mineral admixture as partial replacement of cement in the concrete mix design. Copper slag content was 40% as a replacement of fine aggregate and silica fume 5%,10%,15% & 20% and GGBS 5%,10%,15% & 20% as a replacement of cement respectively. Strength test and durability test was conducted on concrete cubes for analytical results. Results stated that 40% replacement of fine aggregate as copper slag gives the more strength. And Silica fume &GGBS as partial replacement of cement (up to 15%). The use of copper slag and mineral admixture in concrete stated considerable increase in strength and reduction of cost when compared with normal concrete.

Jebastina Rolex.M et.al (2018) research paper dealt with the effects of supplementary cementitious materials in concrete by incorporating fly ash and copper slag with a water binder ratio of 0.45.

The use of copper slag experimentally found that it reduces the amount of water content required for the concrete mix. Since the self-weight of the copper slag is comparatively higher than sand and hence it increases the strength of the concrete. It is found that the compressive strength of concrete decreases as the percentage of fly ash increases. The mix ratio 90% replacement of copper slag with fine aggregate and 20% replacement of fly ash with cement gave better result.

Megha Patel and Dr. Piyush J. Patel (2018) author analyzed the effect of copper slag as a mineral admixture on the properties of self compacting concrete. In the experimental analysis, copper slag was used as by product in replacement with sand without disturbing properties of concrete with respect to strength, workability, and other mechanical properties. Cubes were casted for conventional concrete and concrete with copper slag replacement with fine aggregate of 10%, 20%, 30%. All specimens were demoulded after 24 hours and kept under curing tank and tested after 7 days, 14 days 28 days and 60 days.

Conclusion stated that flow ability of mortar was directly influenced by the composition of the concrete. Especially sand content influences the flow spread by affecting the free water in mortar mixer. By using copper slag the reuse of the industrial by-product will be beneficial for environment. And replacing it with sand will also prevent the reduction in mean sea level as the river sand is replaced. By replacing copper slag in the self compacting concrete the required strength of concrete is meeting up to 30% replacement as per results.

Md. Arshad Hussain and M. Muzaffar Ahmed (2017) research paper analyzed physical properties of cement, aggregates, Silica Fume and copper slag were examined. In the second phase, M30 grade of concrete was used to perform the effective replacement of copper slag with fine aggregate by replacement levels of 0%, 25%, 50% and 75% and the behaviour of fresh and hardened properties of concrete was carried out. Cement was replaced by Silica Fume for 5%, 10% and 15% were used in the concrete by weight of cement and analzyed on parameters of compressive strength, split tensile strength, workability test and durability on concrete containing copper slag and micro silica as partial replacement of sand and cement respectively.
Results concluded that cube compressive strength, split tensile strength and Flexural Strength of concrete had higher strength for 25% replacement of copper slag with 10% Silica Fume. Copper slag replacement at 50% & 75% with Silica Fume showed a marginal variation in cube compressive strength, Split tensile strength and Flexural Strength.

Jinson Markose and Sreeja S (2017) control mix is casted for M25 grade and the Fly Ash as cement replacement in range of 10%, 20% and 30% by weight of cement and the Copper Slag as fine aggregate replacement in 20%, 30%, 40% and 50% by weight of fine aggregate and the cubes are tested for compressive strength.
The optimum replacement of fine aggregate with copper slag was found to be 40%, and to reduce cost of construction. Durability study stated that loss of strength of 20% cement replacing fly ash less compared to conventional concrete.

A. Anbarasan et.al (2016) research paper presented the experimental behaviour of concrete with partial and fully replacement of copper slag and partial replacement of cement by Fly Ash and its compare with controlled cubes. Fine Aggregates are replaced by copper slag for various percentages 20%, 40%, 60%, 80% and 100% and cement with additionally used material of Fly Ash for various percentage 25%, 50%, 75% and 100% and PVA Fibre for ratio 0.8%, 1.0%, 1.2%, 1.4%, 1.6% was used in combination and the strength was determined. The compressive strength and Flexural strength of hardened concrete with various replacements was done.

The compressive strength of the cube is attained in the proportion of 125% of fly ash, and 40% replacement of copper slag and 1.0% PVA fiber and it shows the overall strength of the cube at 28 days is more than the conventional concrete 64.20%, while the normal concrete is about 58.02 only. While in case of flexural strength 5.94 is attained and this is greater than the conventional concrete is about 3.9.

Dinesh S (2016) research paper presented an experimental study of M50 grade concrete where cement and fine aggregate was partially and fully replaced with fly ash and copper slag and it's compared with controlled specimens. Replacement of copper slag by weight of fine Aggregates in various percentages such as 10%, 20%, 30%, 40% up to 100% does not have any adverse effect on strength. Fly Ash of about 0.4% is replaced by weight of cement and strength properties of concrete was compared. The compressive strength and Flexural strength test, split

tensile strength of hardened concrete with various replacements was investigated.

Results stated that 30% replacement of sand with copper slag and 40% replacement of weight of cement with fly ash significantly increase the compressive strength of concrete mixtures.

K.Sundarayamini et.al (2016) research paper investigated the effect of copper slag as partial replacement of cement in various percentages ranging from 0% to 15%, on physical properties such as consistency, initial setting time, final setting time, slump, compressive and tensile strength are investigated. The durability properties was determined by conducting water absorption test and deterioration test on control, acid and sulphate medium whereas the corrosion behaviour of the admixed concrete was analyzed using time to cracking and potential test.

Irrespective of acid and sulphate medium, the percentage weight loss and loss of compressive strength is lower in 10 % replacement whereas in 15% replacement percentage loss is higher when compared to control specimens. In potential time behaviour of both normal and aggressive environment conditions, the potential of the replaced concretes rebar exhibit slightly lower potential value than control concrete. Hence results concluded that 10% replacement of waste material does not affect the durability of concrete.

S.Sujitha et.al (2016) research paper investigated 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 was conducted to analyze the hardened properties of M30 grade concrete to determine the optimum percentage value for which the concrete exhibits higher strength under 28 days curing period.

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.

III.CONCLUSION

Here author illustrated that percentage of Copper Slag in concrete mix increases, the workability of concrete increases. This is because copper slag is unable to absorb the water in large proportion.

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