Study on Behavior of Concrete by Copper Slag and Quartz Sandas Replacement of Fine Aggregate

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Abstract— Concrete is the most basic and the most essential building material which is used in any construction industry. It is plastic and mouldable when it is in crisp state. How ever gets solid and strong when solidified. Concrete is a building matter collectively composed of water, FA and CA embedded in a harden matrix of materials, which fills up the voids among aggregates and adheres them strongly. Concrete is good in compression but weak in tension, therefore the reinforcements are provided so that the required strength can be achieved in the tension zone. The usage of wastes such as copper slag getting prioritized as additives, by using these wastes in concrete, the strength can be effectively achieved & the problem of disposal of these wastes can be greatly reduced. In the present thesis work, the properties of concrete are thoroughly studied with addition of industrial wastes obtained from copper industries & easily available cheap mineral known as quartz sand. Copper slag which is used in the sand blasting whereas quartz sand is used in glass manufacturing using these material as partial replacement of fine aggregate in M25 grade concrete. The IS codes used in this experimental work are IS 2720-part 3, IS4031 –part 1, IS383 1970, IS 2386 part III-1963. Various proportions of copper slag replacement of fine aggregate & quartz sand replacement were adopted i,e 0%, 20%, 30%, 40%,50% by volume of fine aggregate. The parameters such as strength aspects are examining in this work. The best proportions will be chosen and are compared based on based on the various test results such specific gravity tests compressive strength split tensile strength and flexural strength test. In this project the workability seems to increase with the addition of copper slag and quartz sand. Strength aspects such as compressive, Tensile and flexural strength tests are conducted. The compressive strength for concrete containing 40% of copper slag as partial replacement of fine aggregate for 28 days of curing is 39.40 respectively. Split tensile for 40% copper slag replacement fine aggregate for 28 days of curing is 4.61 respectively. Flexural strength for 40 % copper slag replacement of fine aggregate for 28 days of curing is 4.96, all units are in N/mm2. The compressive strength for concrete containing 40% of quartz sand as partial replacement of fine aggregate for 28 days of curing is 37.47. Split tensile for 40% quartz sand replacement of fine aggregate for 28 days of curing is 4.47. Flexural strength for 40 % quartz sand replacement for 28 days of curing is 4.88, all units are in N/mm2. From the experimental study and comparing of results it is found that the strength such as compressive, split tensile and flexural obtain from optimum replacement percentage of copper slag which is 40% is greater than the strength obtained from optimum replacement percentage of quartz sand which is 40%.

Key words: copper slag (CS), fine aggregate (FA), OPC

I. INTRODUCTION

Concrete is the most basic material which is been used in construction industry since very long time in various fields of construction such as in buildings, bridges, pavements, dams, marine, sanitary structures and many others. Concrete is durable in nature. It is plastic and pliable in nature in its fresh state. Concrete is a building matter mainly composed of water, FA and CA embedded in a harden matrix of material called cement, which fills up the voids among aggregates and adheres them strongly. Concrete is good in compression but weak in tension, therefore the reinforcements are provided so that the required strength can be achieved in the tension zone. The most important component of a concrete is cement. The manufacture of cement causes various environmental and social consequences depending on considerations which are both harmful and are welcomed. Cement industries produce a huge amount of carbon dioxide. The global consumption of natural sand has become very high due to excessive use of concrete. Increased extraction of natural sand from river bed causes many problems like lowering of underground water table, disturbs the aquatic life, disturbs the tectonic plates in the distribution of seismic effects, changes the profile of river beds etc. For the present study we are partially replacing fine aggregate with industrial bi products such as copper slag and easily available mineral known as quartz. The use of industrial wastes gaining importance as additives, because they increase strength, decrease density and most importantly decrease environmental impacts. During the smelting process of copper huge amount of slag residues are produced and require proper disposal. The residue is known as Copper slag and are the major ingredients. As it is used in concrete to enhance the strength. In this work, an extensive study using copper slag has been carried out to investigate strength, workability and durability. The method adopted is relevant to real social needs that is accessible, affordable and empowering. It results to save natural resources. Quartz is the most abundant silica mineral. Pure Quartz is colour less and transparent. It occurs in most igneous and practically all metamorphic and sedimentary rocks. Quartz is mainly made up of silica. The formula for it is SiO2. It has a hardness of 7 on the Mohs scale. The usage of quartz sand and copper slag as a substitute to fine aggregate in concrete reduce the cost of construction and also might increase the strength characteristics of quarts 2 sand and copper slag based concrete. By using copper slag and quartz sand as a construction material the construction would be economical and eco-friendly Using these materials mix design of M25 grade concrete is done using IS code IS102622009 and some basic tests are done on copper slag and quartz sand such as specific gravity and fineness modulus and sieve analysis etc. The IS codes used in this tests are IS 2720-part 3, IS4031 –

part 1, IS383 1970, IS 2386 part III-1963. The strength aspects such as compressive strength, split tensile and flexural strength are calculated for 3,7 and 28 days of curing. The casting of specimens is done using standard molds 150mmx150mmx150mm for determining compressive strength and 150mm x 300mm cylinder is casted for split tensile strength and for determining flexural strengths a beam of size 100mm x100mm x 500mm is casted. For each proportion 3 cubes 3 cylinders and 1 beam is casted and cured for 3, 7 and 28 days. After testing all the specimens, the results are compared and the conclusion is drawn.

II. Literature Review

A. Alnuaimi AS,(2012), "Effects of Copper Slag as a Replacement for Fine Aggregate on the Behavior and Ultimate Strength of Reinforced Concrete Slender Columns", TJER, Vol. 9, No. 2, pp 90-102.

It includes the general research work carried out on concrete, its strength properties with addition of copper slag and quartz mineral sand. Use of copper slag (CS) as a replacement for fine aggregate (FA) in RC slender columns was experimentally investigated in this study. Twenty columns measuring 150 mm x150 mm x 2500 mm were tested for monotonic axial compression load until failure. The concrete mixture included ordinary Portland cement (OPC) cement, fine aggregate, 10 mm coarse aggregate, and CS. The cpercentage of cement, water and coarse aggregate were kept constant within the mixture, while the percentage of CS as a replacement for fine aggregate varied from 0 to 100%. Four 8 mm diameter high yield steel and 6 mm mild steel bars were used as longitudinal and transverse reinforcement, respectively. Five cubes measuring 100 mm x100 mm x100 mm, eight cylinders measuring 150 mm x 300 mm and five prisms measuring 100 mm x 100 mm x 500 mm were cast and tested for each mixture to determine the compressive and tensile strengths of the concrete. The results showed that the replacement of up to 40% of the fine aggregate with CS caused no major changes in concrete strength, column failure load, or measured flexural stiffness (EI). Further increasing the percentage reduced the concrete strength, column failure load, and flexural stiffness (EI), and increased concrete slump and lateral and vertical deflections of the column. The maximum difference in concrete strength between the mixes of 0% CS and 100% CS was 29%, with the difference between the measured/control failure loads between the columns with 0 and 100% CS was 20% the maximum difference in the measured EI between the columns with 0 and 100% CS was 25%. The measured to calculated failure loads of all specimen varied between 91 and -100.02%. The measured steel strains were proportional to the failure loads. It was noted that columns with high percentages of CS (t60%) experienced buckling at earlier stages of loading than those

B. Ariño Antonio M. , Barzin Mobasher,(1999), "Effect of Ground Copper Slag on Strength and Toughness of Cementitious Mixes", ACI Materials Journal, Vol. 96, No. 1, pp 68-7.

Due to exponential growth in the usage of concrete world over, there is a huge demand for natural river sand as construction material. Off late, this excessive consumption of sand led to acute shortage and led to slowing down of construction projects. Hence to protect the natural shore line, a necessity is felt to find suitable replacement material for sand in concrete as concrete is consumed second largest in the world. In this work copper slag which is an industrial waste is used as a replacement material for sand and its effect is studied on the strength of concrete. Also, to improve the strength and ductility, polypropylene fibers are added in the ratios of 0.1%, 0.2%, 0.3% and 0.4% content. The effect of copper slag is investigated by replacing fine aggregate in concrete in the proportions of 10%, 20%, 30%, 40%, 50% 60% and 100%. The results obtained are analyzed and presented.

C. Barnett Stephanie J., Marios N. Soutsos, John H. Bungey, Steve G. Millard,(2007), "FastTrack Construction with Slag Cement Concrete:

Adiabatic Strength Development.The early-age strength development of concrete containing slag cement has been investigated to give guidance for its use in fast-track construction. Measurements of temperature rise under adiabatic conditions have shown that high levels of slag cement-for example, 70% of the total binder - are required to obtain a significant reduction in the peak temperature rise. Despite these temperature rises being lower than those for portland cement mixtures, however, the early-age strength under adiabatic conditions of slag cement concrete can be as high as 250% of the strength of companion cubes cured at 20°C (68 °F). The maturity and, hence, strength development were calculated from the adiabatic temperature histories based on several maturity functions available in the literature. The predicted strength development with age was compared with the experimental results. Maturity functions that take into account the lower ultimate strengths obtained at elevated curing temperatures were found to be better at predicting the strength development.

D. Tarun R. Naik, Viral M. Patel, Dhaval M. Parikh, Mathew P. Tharaniyil, "Utilisation of used quartz sand in concrete", Journal of Materials in Civil Engineering, Vol. 6, No. 2, May, 1994. [5] Foundry Industry Recycling Starts Today (FIRST), quartz sand Sand Facts for Civil Engineers, Federal Highway Administration Environmental Protection Agency Washington, DC; 2004. [6] Han-Young Moon, Yun-Wang Choi, Youg-Kyu Song and Jung-KyuJeon, "Fundamental properties of Mortar and Concrete using waste quartz sand", Journal of the Korea Concrete Institute, Vol.17, No.1, pp.141-147, February 2005. [7] RafatSiddique, Geert de Schutter, Albert Noumowe, "Effect of used-of quartz sand on the mechanical properties of concrete", Elsevier, Construction and Building Materials 23 (2009) 976–980.

This research was conducted to investigate the performance of fresh and hardened concrete containing discarded foundry sands as a replacement of fine aggregate. A control concrete mix was proportioned to achieve a 28-day compressive strength of 38 MPa (5500 psi). Other concrete mixes were proportioned to replace 25% and 35% of regular concrete sand with clean/new foundry sand and used foundry sand by weight. Concrete performance was evaluated with respect to compressive strength, tensile strength and modulus of elasticity. At 28-day age, concrete containing used foundry

sand showed about 20 to 30% lower values than concrete without used foundry sand. But concrete containing 25% and 35% clean/new foundry sand gave almost + c the same compressive strength as that of the control mix.

III. OBJECTIVES & METHODOLOGY

1) To use industrial waste copper slag as a stabilizing material and to solve the problem of waste disposal while finding the optimum replacement level.
2) To use the quartz sand as stabilizing material to reduce the cost of construction.
3) To determine the behavior of concrete by using partial replacement of copper slag and quartz sand in fine aggregate
4) To investigate the strength parameters such as compressive, split tensile and flexural strength for copper slag and quartz sand as a partial replacement for fine aggregate respectively
5) To find out the optimum percentile value of copper slag and quartz sand, and comparing their strength variations to obtain the economical and ecofriendly concret

IV. METHODOLOGY

The materials like Cement, copper slag, quartz sand, natural Sand, Natural Coarse Aggregate, and grade of concrete are selected and their characteristics has been thoroughly analyzed.

The M25 grade of concrete is adopted for the following study. Mix design is done for M25 grade concrete.

The water cement ratio is taken as 0.5 no superplasticizer where added

Using this materials, Design mix is done with required w/c ratio for M25 concrete grade.

Cubes of size 150mm x 150mm x 150mm is casted for determining the compressive strength of concrete containing copper slag and quartz sand for 3,7 and 28 days of curing.

Cylinder of size 300mm x 150mm is casted for determining the split tensile strength of concrete containing copper slag and quartz sand for 3,7 and 28 days of curing.

Prisms of size 100mm x 100mm x 500mm is casted for determining the flexural strength of concrete containing copper slag and quartz sand for 3,7 and 28 days.

The cubes, prisms and cylinders are casted and tested for different mix proportions.

For each proportion 3 cubes, 3 cylinder,1 prism is casted and tested.

The tests are conducted on specimen for 3,7 and 28 days of curing.

The equipment which are used for testing these specimens are mention below 1. Compressive strength machine 2. Flexure testing machine

Optimum value for copper slag & quartz sand by partial replacement for fine aggregate will be determined.

After determining the optimum replacement percentages their respective strengths i.e compressive strength, split tensile strength and flexural strength are compared.

After comparing the strength variation, the economical and eco-friendly concrete is determined.

Finally, with obtained results, they are compared and conclusions are drawn.

Fig. 1: Angular Aggregate

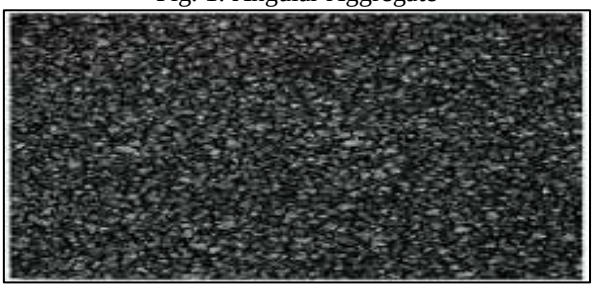

Fig. 2: Copper Slag

V. CONCLUSIONS

On the basis of the experimental investigations made and analysis of the results, following are the conclusions which are made.

1) From the experimental study it has been seen that the preparation of concrete from byproduct and minerals is possible.
2) The byproduct copper slag seems to be brittle and porous in nature, is said on the basis of previous research work and other journals that has been done on copper slag in the past, whereas quartz sand is in the form of short white crystal and it's also porous in nature according to the previous research and other journals that has been done in the past.
3) These material play an important role in improving the workability of concrete.
4) Sieve analysis is done on these materials their particle size distribution falls under ZONE I, which means it can be used as fine material in concrete.
5) From the experimental study on CS & QS concrete it is concluded that compressive strength, split tensile strength, and flexural strength are seemed to be increased continuously at some optimum value and then later decreased.
6) The average values of compressive strength, 20% replacement of copper slag and quartz sand for 28 days curing is 34.07, 33.18 N/mm2 respectively and split tensile strength is 3.95, 3.83 N/mm2 respectively and flexural strength is 4.26, 4.18 N/mm2 respectively.
7) The average values of compressive strength, 30% replacement of copper slag and quartz sand for 28 days curing is 36.29, 35.40 N/mm2 respectively and split tensile strength is 4.34, 4.16 N/mm2 respectively and flexural strength is 4.54, 4.46 N/mm2 respectively.

8) The optimum replacement percentage of copper slag is seeming to be 40%, and the optimum replacement % of QS is also 40 %, but there is a great difference in the respective strengths.
9) The compressive strength for concrete containing 40% of copper slag as partial replacement of fine aggregate for 3,7 and 28 days is 22.07, 25.63 and 39.40 respectively. Split tensile for 40% copper slag replacement fine aggregate for 3,7 and 28 days is 2.77, 3.43 and 4.61 respectively. Flexural strength for 40 % copper slag replacement of fine aggregate for 7 and 28 days is 3.12 and 4.96 all units are in N/mm2.
10) The compressive strength for concrete containing 40% of quartz sand as partial replacement of fine aggregate for 3,7 and 28 days is 21.64, 24.88 and 37.47 respectively. Split tensile for 40% quartz sand replacement of fine aggregate for 3,7 and 28 days is 2.65, 3.36 and 4.47 respectively. Flexural strength for 40 % quartz sand replacement for 7 and 28 days is 3.06 and 4.88 all units are in N/mm2.
11) After comparing the results, it is found that the Compressive strength, split tensile strength, flexural strength, with concrete containing copper slag is greater than the concrete containing quartz sand
12) Hence use of copper slag may lead to greater strength in concrete when compare to quartz sand.
13) The use of byproduct i.e copper slag reduces the cost of construction and also increases the strength of concrete.

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