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A Review on Water Absorption, Porosity and Sorptivity of Cement Mortar made with Copper Slag and Green Sand as Partial Replacement of Fine Aggregate

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Abstract - Sustainability and resource efficiency are becoming increasing important issues within today's construction industry. The possibility of substituting natural fine aggregate with industrial by-products such as copper slag and green sand offers technical, economic and environmental advantages which are of great importance in the present context of sustainability in the construction sector. This paper deals with the review of literature for copper slag and green sand as partial replacement of fine aggregates on durability properties such as water absorption, porosity and sorptivity of cement mortar.
Keywords— water absorption, porosity, sorptivity, copper slag, green sand, cement mortar

I. INTRODUCTION

In India, there is great demand of aggregates mainly from civil engineering industry, for road and concrete constructions. But nowadays it is a very difficult problem for availability of fine aggregates. So the researchers developed waste management strategies to apply for replacement of fine aggregates for specific needs. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

Copper slag is one of the materials that are considered as a waste material which could have a promising future in the construction industry as partial or full substitute of either cement or aggregates. It is a by- product obtained during the matte smelting and refining of copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. In India copper slag is produced by many industries one of them is Sterlite Industries Ltd (SIL), Tuticorin, Tamil Nadu. It is producing Copper slag during the manufacture of copper metal. Currently, about 2600 tons of Copper slag is produced per day and a total accumulation of around 1.5 million tons. If we are able to use the copper slag in place of natural sand, then we can successively obtain a material to replace the sand, which is eco-friendly and cost effective. Hence there is a growing need to find the alternative solution for the slag management.

Green sand is one of the types of Foundry sand. In foundries, the most commonly used molding media is green sand. Silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity. Addition of carbonaceous material leads to prevent the "burn-on" or fusing of sand onto the casting surface. Green sand also contains trace chemicals such as MgO, K2O, and TiO2.

Cement mortar is a material having tiny spaces through which liquid or air may pass. The durability of mortar depends largely on the movement of water and gas enters and moves through it. After evaporation of excess water in the mortar, voids inside the mortar creates capillaries which are directly related to porosity and permeability of the mortar. Due to incomplete compaction; mortar may consists gel pores & capillary pores, which leads to low strength of mortar. Due to problems associated with the absorption test and permeability test; which are measuring the response of mortar to pressure which is rarely the driving force of fluids entering in to mortar; hence there is a need for another type of test. Such tests should measure the rate of absorption of water by capillary suction; "sorptivity" of unsaturated mortar.

II. LITERATURE REVIEW

T.R. Naik et al. [1] conducted an investigation evaluate the performance of foundry by-products in concrete & masonry products. Based on the test results they concluded that, (a) The addition of foundry sand caused a decrease in concrete workability. (b) Compressive strength of concrete decreased slightly due to the replacement of regular coarse aggregate with foundry slag. However, compressive strength observed for both 50 and 100 percent slag mixes were appropriate for structural uses. (c) The modulus of elasticity of the 100 percent slag mix was the highest of all the three mixes evaluated. (d) All the masonry blocks made with 35 percent new/used foundry sands passed ASTM requirements for compressive strength, absorption and bulk density.

Saveria Monosi et al. [2] investigated the properties of mortars and concretes containing different dosages of used foundry sand (UFS) as partial replacement of sand in both fresh and hardened conditions. According to the obtained test results, they concluded that, (a) UFS reduces the workability when added as natural sand replacement (at same w/c); higher amount of super plasticizer is required in order to maintain the same workability. The control mortar sample with w/c equal to 0.50 requires an addition of 0.5% by cement weight, while mortars containing UFS need an addition up to 1.8%. (b) Fresh mixture unit weight and entrapped air content do not point out any relevant differences with and without foundry sand. (c) Despite the absolute value of compressive strength, the negative influence ascribed to the presence of UFS in reducing the compressive strength seems greater when lower w/c is adopted. Although the absolute value of the compressive strength is high at low w/c ratio, as usual, it achieves negligible advantages when w/c is lower than 0.50.

Amin Salvador Nazer et al. [3] studied the use of copper slag in cement mortar in the chemical, mineralogical and size distribution point of view. (a) They obtained the results showed that the mortars manufactured with copper slag present a higher resistance to compression and flexural than those manufactured with river sand. (b) Mortars manufactured with copper slag presented greater resistance to both compression and bending as compared to mortars manufactured with river sand.

Bipra Gorai et al. [4] studied a review of characteristics and utilization of copper slag. (a) Favourable physico-mechanical and chemical characteristics of copper slag lead to its utilization to prepare various value added products such as cement, fill, ballast, aggregate, etc. (b) Copper slag is evident that judicial utilization of different types of copper slag is of prime importance in the present days industrial waste management. (C) These materials have been found to be possessing superior mechanical properties and they may be of cheaper varieties than the similar conventional material.

Madheswaran C.K et al. [5] investigated use of copper slag as replacement material for river sand in building constructions. (a) Based on the test results, it was observed that specimen with 50% copper slag and 50% sand are more efficient than other specimens and it was recommended that use of copper slag is 50% as replacement of conventional river sand is the most feasible alternative. (b) They concluded the highest compressive strength was with 50% of sand and 50% of copper slag.

Mobasher et al. [6] investigated the effect of copper slag on the hydration of cement when upto 15% of copper slag replaced Portland cement. By X-Ray diffraction and the porosity hydration reactions were examined using mercury intrusion porosimetry and it si found that there is significant increase in the compressive strength for upto 90 days of hydration. A decrease in capillary porosity measured using MIP indicated densification of the microstructure. Addition of copper slag decreased the Fracture properties such as critical stress intensity factor and fracture toughness.

Arino and Mobasher [7] presented the effect of ground copper slag on the strength and fracture of cement-based materials. Portland cement was replacement with ground copper slag up to 15% by mass. By closed-loop controlled compression and three-point bending fracture tests, it is observed that, the compression test utilized a combination of the axial and transverse strains as a control parameter to develop a stable post-peak response. Long-term results showed equal or higher strengths for the GCS specimens without concern for degradation of other properties.

Teik-Thye Luin and Chu [8] studied the feasibility of using spent copper slag as fill material in land reclamation. After conducting many laboratory tests, they finally concluded that the spent copper slag was a good fill material and it can be used as a fill material for land reclamation. The batch leaching test results showed that the concentrations of the regulated heavy metals leached from the material at pH 5.0. They were significantly lower than the maximum concentration for their toxicity limits referred by United States Toxicity Characteristic Leaching Procedure.

III. CONCLUSION

From reviewing the above research papers related to copper slag and green sand relevant conclusions can be made:

A. The addition of foundry sand caused a decrease in cement mortar workability.

B. All the masonry blocks made with 35 percent new/used foundry sands passed ASTM requirements for compressive strength,

absorption and bulk density.

C. Green sand reduces the workability when added as natural sand replacement (at same w/c); higher amount of super plasticizer is required in order to maintain the same workability. The control mortar sample with w/c equal to 0.50 requires an addition of 0.5% by cement weight, while mortars containing green sand need an addition up to 1.8%.

D. Mortars manufactured with copper slag present a higher resistance to compression and flexural than those manufactured with river sand. Mortars manufactured with copper slag presented greater resistance to both compression and bending as compared to mortars manufactured with river sand.

E. Copper slag is evident that judicial utilization of different types of copper slag is of prime importance in the present days industrial waste management.

F. The specimen with 50% copper slag and 50% sand are more efficient than other specimens and it was recommended that use of copper slag is 50% as replacement of conventional river sand is the most feasible alternative.

G. A decrease in capillary porosity measured using MIP indicated densification of the microstructure. Addition of copper slag decreased the Fracture properties such as critical stress intensity factor and fracture toughness.

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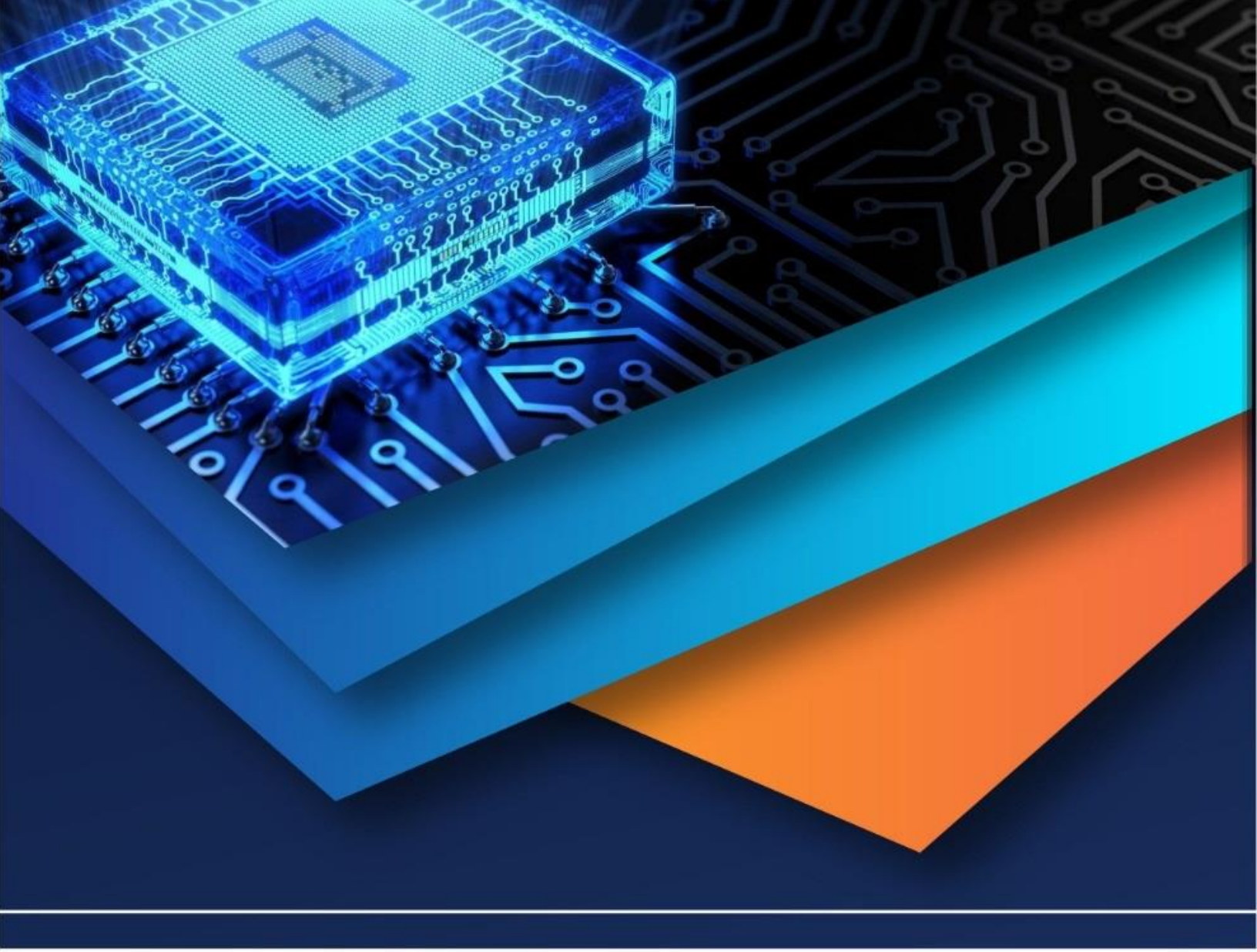

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