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Investigation on Copper Slag Enriched FaL-G Mortar Bricks

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Abstract -*Wastes are unwanted or unusable materials. Reuse of waste generated from industrial activities as building materials appears to be viable solution to problem of pollution and waste disposal. In India it has been estimated that nearly 30% of the daily production turns on waste during the manufacturing, transportation and usage. This paper is deals with the investigation on Copper slag enriched FaL-G mortar blocks by partial or full replacement of fine aggregate and cement respectively. The blocks are produced with different volume fractions of copper slag. The compressive strengths, water absorption, dry density and initial rate of absorption values of the blocks differ upon curing at room temperature for 28 days and moist curing was continued till the respective specimens were tested for 7 days and 28 days compressive strength. Tests are carried out to find the physical and mechanical properties of copper slag enriched FaL-G mortar blocks*

Key Words: Reuse, FaL-G mortar, Copper slag, compressive strength etc

1. INTRODUCTION

The raw materials of concrete consist of cement, sand and crushed aggregates. Partial or complete replacement of these raw materials by waste products may decrease the cost, can reduce the energy consumption and also can reduce environmental pollution. Wastes can be used to produce new products or used as admixture so that natural resources are used more effectively and the accumulation of waste products can be reduced. FaL-G mortar is a combination of fly ash, lime and gypsum as a replacement for cement. Copper slag used as fine aggregates. All the materials used are waste material from various industries and hence it is a method for waste management and is very much economical. The overuse of materials hassled to environmental concerns, depletion of river sand deposits and price increase of materials can also be resolved using this method.

Fly ash is used as filler material and helps in the reduction of void contents in the cement in concrete. The use of fly ash can lead to the reduction in early strength of concrete. The Phosphogypsum can be used with any treatment and so it is titled as untreated, impure or raw Phosphogypsum. Lime forms as evaporates from marine waters and is found collectively with other mineral deposits such as quarts, Sulphur and clays. Lime is a pozzolanic binder known for its very slow setting and progressive strength gain overages.

Copper slag is a by-product obtained during the matte smelting and refining of copper. Currently, about 2600 tons of Copper slag is produced per day and a total accumulation of around 1.5 million tons. 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. Utilization of copper slag in applications such as substitution as aggregates has threefold advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems.

1.1 Literatures on Fly ash bricks

Many investigations have been carried out on the properties of fly ashes by various researchers to study their application as a construction material in various areas of civil Engineering. Some of them are precised below

Niranjan P S, Radhakrishna (2014), studied the properties of the FaL-G bricks is considered. According to this paper FaL-G is the product name derived from a cementations mixture which is composed of Fly ash (Fa), Lime (L) and Gypsum (G). FaL-G mortar is a combination of fly ash, lime and gypsum as a replacement for cement. Quarry dust and sand are used as fine aggregates. The density of the block was less compared to conventional concrete blocks available in markets. The percentage of water absorption was found to be less than 17.56% for all the series against the maximum limit of 20% as per IS 3495-1976.It shows a variation in compressive strength with age of quarry dust. Compressive strength increases with age, and there is at least 70% increment in compressive strength between each age. It is noticed that compressive strength of FaL-G block is higher than the minimum compressive strength required as per IS 1077. The results show that FaL-G blocks can be used for construction. The paper concluded that FaL-G masonry units can effectively replace the conventional masonry units.

Srirama Venkateswara Rao (2014), It deals with the application of FaL-G hollow masonry Blocks in building construction. In this research, FaL-G mortar hollow blocks were made and various properties were studied. FaL-G mortar was made using fly ash, lime and

gypsum as a replacement for cement. Quarry dust and sand are used as fine aggregates. The mix gains strength similar to the hydraulic cement in the presence of water. It is water resistant too. FaL-G mortar prepared using FaL-G as binder and sand as fine aggregate is mixed in the ratio 1:2. The densities of the blocks were observed in the range of 1.507 to 1.654 g/cc and the water absorption obtained varied from 20.6 to 33.6%. The compressive strength obtained was in the range of 1.35 to 6.35 N/mm^2. As the weight of FaL-G blocks is low in the range of 25.1 to 30.9 g, it will reduce the dead weight and material handling cost in multi-storied constructions hence become less. At the age of 120 days FaL-G hollow blocks attained the strength up to 6.35N/mm^2 which can be used as masonry units with adequate modulus of elasticity. They studied about the FaL-G concrete for housing and infrastructure. The FaL-G technology can be used to serve both brick and concrete segments, but FaL-G technology was applicable mostly to brick, except for a very few concrete applications. This paper deals with FaL-G concrete. FaL-G concrete was used in the check dams, ground water tanks, over-head water tanks, housing etc. FaL-G concrete are mostly concentrated in durability point of view. The simple reason behind this is the high cementitious content with low OPC input. When comparing with the cement paste, FaL-G possesses 40-50% of the ordinary Portland cements strength. By providing higher range of FaL-G binder, M-15 and M-20 grade of concrete has developed strength gain which was almost by double between 28-day and 180-day.

Baboo Rai, Sanjay Kumarand Kumar (2014**)**, have studied the effect of fly ash on mortar mixes with quarry dust as fine aggregate, the combined use of quarry rock dust and fly ash exhibited excellent performance due to efficient micro filling ability and pozzolanic activity. The results show that 20% replacement of natural sand by quarry dust will yield the maximum strengths for cement mortar. Further when fly ash is partially replaced with cement from 0 to 30% in mortar with 20% quarry dust, there is an overall increase in strength at 3 days, 7 days, and 28 days of age. The drop in compressive strength due to conversion reaction decreases with increase in fly ash content for a given water to powder ratio. The increase in fly ash content improves the compressive strength, for a given water to powder ratio. It was observed that the decrease in early strength by the addition of fly ash is ameliorated by the addition of quarry dust. Therefore, the results of this study provide a strong recommendation for the combined use of quarry rock dust and fly ash in mortar/concrete manufacturing. Quarry dust qualifies itself as suitable substitute for river sand. However, it is advisable to carry out trial casting with quarry sand proposed to be used, in order to arrive at the water content and mix proportion to suit the required workability levels and strength requirement. Also, it is advisable to remove excess fines of size up to 150 microns by washing.

S. S. Bhadauria, Rajesh and B. Thakare (2006). have analysed that mixture in which cement replaced with five percent Phosphogypsum having almost same standard or normal consistency than that of plain cement and thus water requirement of the cement – Phosphogypsum mix minutely affected. Further replacements of ordinary Portland cement with raw PG seriously affect the consistency. Phosphogypsum in ordinary Portland cement mixes considerably retards setting time but does not contribute to produce unsound cement paste.

K.S. Elango(2017) analysed the physical, mechanical, permeability, porosity, dry density, abrasion resistance and chemical resistance of OPC and FaL-G binder pervious concrete were examined. From the test results, the following conclusions can be drawn. Compressive strength and split tensile strength of control mix (OPC) and FaL-G mix increased with decrease in porosity and increased with density of aggregates. However, OPC has better mechanical strength properties than FaL-G because of enriched bonding between the coarse aggregates. Percentage of wear of pervious concrete. The wet ability of FaL-G binder with coarse aggregate is less compared to OPC binder and this leads to increased void connectivity and void formation and thus helps in increased permeability properties. The relationship studies among various properties confirmed that the aggregate size of 10 mm was found as optimum for FaL-G binder pervious concrete while for control mix with OPC it was 9.5 mm. However, when the FaL-G binder pervious concrete made with aggregate size from 6.3 mm to 12.5 mm, it satisfied the requirements and this made FaL-G binder pervious concrete sustainable in pavement construction. Both OPC and FaL-G binder pervious concrete can be used to enhance the chemical resistance against salt, sulphate and acid environment. In general, FaL-G binder pervious concrete can be suggested for future green project as usage of fly ash and gypsum helps in minimization of waste materials and thus helps in controlling land pollution. Further, FaL-G binder pervious concrete is suggested to be used in areas with less traffic flow and pedestrian path ways

P. R. Kannan Rajkumar (2016) A feasibility study was undertaken on Fly ash-Lime-Gypsum (FaL-G) bricks and Quarry dust-Fly ash-Lime-Gypsum (QuFaL-G) bricks to use as a building element. The bricks of size 220 x 100 x 75mm were casted to study the strength and durability characteristics. Results shows that the compressive strength of FaL-G bricks was 8.2 N/mm2 on the 28th day, which is much higher than the conventional burnt clay bricks (>3.5 N/mm2). The water absorption property of FaL-G brick is lesser than the water absorption of normal good quality burnt clay bricks (20%). Applications/Improvements: In view of the strength and durability characteristics of these bricks, it can be used in place where the fly ash and quarry dust available more in

quantity to solve the consequences of pollution and at the same time to build houses economically by utilizing industrial wastes

Sunil Kumar (2002) A perspective study on fly ash–lime–gypsum bricks and hollow blocks for low cost housing development. Housing is a great problem in today's world. The most basic building material for construction of houses is the usual burnt clay brick. A significant quantity of fuel is utilized in making these bricks. Also, continuous removal of topsoil, in producing conventional bricks, creates environmental problems. A feasibility study was undertaken on the production of fly ash–lime– gypsum (FaL-G) bricks and hollow blocks to solve the problems of housing shortage and at the same time to build houses economically by utilizing industrial wastes. The compressive strength, water absorption, density and durability of these bricks and hollow blocks are investigated. It is observed that these bricks and hollow blocks have sufficient strength for their use in low cost housing development. Tests were also conducted to study the influence of type of curing on the increase in strength and hardening of the bricks and blocks with time. It was observed that the hot water curing leads to a greater degree of hardening and higher strength, earlier compared to ordinary water curing

1.2 Literature Review on Copper Slag as aggregate

Al-Jabri KS, et.al (2011) was to investigate and analyse effect of copper slag as a replacement of sand on the properties of cement mortars and concrete. Specimens were made using copper slag of different proportions yielded comparable or higher compressive strength than that of the control mixture. From this study, its seen that compressive strength of mortars is shows 70% improvement with 50% copper slag substitution in comparison with control mix. when the copper slag content increases there is a slight improvement in density of nearly 5% whereas the workability increased significantly as copper slag percentage increase compared with the control mixture. Copper slag in the range of 40–50% could potentially replace sand in concrete mixtures.

Wei Wuet.al (2011), to investigate and analyse the effect of copper slag (waste material) as a replacement of sand on the properties of high strength concrete and to determine the optimum content of copper slag. The workability and strength characteristics were assessed through a series of tests on proportions by weight replacement of sand from 0% to 100%. The results indicated that the strength of the concrete with less than 40% copper slag replacement was higher strength as compared with control specimen. It was found that copper slag can improve the workability and dynamic behavior of the concrete respectively, but the presence of excess water, the higher fineness and ferric oxide content decrease the compressive, flexural and tensile splitting strength.

Binaya Patnaik (2014) concluded that Copper Slag behaves similar to River Sand, for its use as fine aggregate (partially or in blending) in Concrete mixes. Addition of Copper Slag in Concrete increases the density, thereby the self-weight of Concrete. The results showed that the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture due to the low water absorption, coarser (in nature than sand) and glassy surface of Copper slag, thereby the Strength properties also improved. The Compressive Strength of Concrete is comparable to the control mix up to 40% of Copper Slag substitution, but they decrease with a further increase in Copper Slag contents (due to the increase of free water content in the mix). Compressive Strength of Copper Slag Admixture Concrete, increased due to high toughness of Copper Slag. For longer curing periods (i.e. 90-Days), no detrimental effect (i.e. Strength reversal) was observed, when using Copper Slag. Replacement of Copper Slag as fine aggregate in concrete mixes reduces the cost of concrete production. The utilization of Copper Slag in Concrete production provides additional environmental as well as effective waste management technique for all the related Industries

Khalifa S. Al-Jabri (2011) studied that for cement mortars, all mixtures with different copper slag proportions yielded comparable or higher compressive strength than the strength of the control mixture. There was more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution in comparison with the control mixture. There is almost 5% increase in the concrete density, when copper slag was used as a sand replacement, whereas the workability increased substantially with an increase in copper slag content. This was attributed to the low water absorption and glassy surface of copper slag. The compressive, tensile and flexural strength of concrete were comparable to the control mix using up to 50% copper slag substitution for sand, but they decreased with a further increase in copper slag contents. The surface water absorption of concrete was reduced with up to 40% copper slag replacement for sand. The volume of permeable voids decreased with the replacement of up to 50% copper slag. Copper slag, in the range of 40–50%, could potentially replace sand in concrete mixtures.

M.A.G. dos Anjos et.al (2017) The present work focuses on assessing the viability of applying blasted copper slag, produced during abrasive blasting, as fine aggregate for Portland cement concrete manufacturing, resulting in an alternative and safe disposal method. Leaching assays showed no toxicity for this material. Concrete mixtures were produced, with high aggregate replacement ratios, varying from 0% to 100%. Axial compressive strength, diametrical compressive strength,

elastic modulus, physical indexes and durability were evaluated. Assays showed a significant improvement in workability, with the increase in substitution of fine aggregate. With 80% of replacement, the concrete presented lower levels of water absorption capacity. Axial compressive strength and diametrical compressive strength decreased, with the increase of residue replacement content. The greatest reductions of compressive strength were found when their placement was over 40%. For tensile strength by diametrical compression, the greatest reduction occurred for the concrete with 80% of replacement. After the accelerated aging, results of mechanic properties showed a small reduction of the concrete with blasted copper slag performance, when compared with the reference mixture. Results indicated that the blasted copper slag is a technically viable material for application as fine aggregate for concrete mixtures

2. CONCLUSION

In India it has been estimated that nearly 30% of the daily production goes on waste during the manufacturing, transportation and usage. The practice of dumping and the inadequate management of waste from the various manufacturing sectors had a notable impact on the receiving environment, leading to water, soil, air and noise pollution adding to existing environmental problems. The manufacturing of fly ash bricks using waste materials can minimize the environmental overburden caused by waste deposition on open landfills and would also improve the brick performance at low production cost leading to more sustainable construction.

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