ANALYSIS OF GGBS ON PARTIAL REPLACEMENT OF CEMENT IN LIGHT WEIGHT BRICKS

[1]Challa. Nithin Kumar Reddy, [2]Dr.B.Saritha

[1]Research Scholar, Department of Civil Engineering, Bharath Institute of Higher Education and Research,Selaiyur, Chennai, Tamil Nadu 600126, India.

[2]Associate Professor, Department of Civil Engineering, Bharath Institute of Higher Education and Research,Selaiyur, Chennai, Tamil Nadu 600126, India.

1303nithin@gmai.com, sarichaks@gmail.com

ABSTRACT

Cement mortar is used a lot in the construction industry every year, and demand is expected to rise soon. One of the most widely used building materials is cement mortar; Cement is the main component of cement mortar. Cement mortar is increasingly in demand, as a construction material. On the other hand, cement production and use reduces the availability of raw materials (limestone) and pollutes the environment. Every year, portland cement is increasing around the world. As Portland cement production currently contributes to greenhouse gas emissions, additional cementitious and pozzolanic materials are required for cement mortar. Consequently, there is a growing interest, in using industrial waste and byproducts to cut down on the amount of Portland cement which is used. The thermal behavior of partially replacing lightweight cement mortar with GGBS (Ground granulated blast furnace slag) is analyzed by this paper. A building's thermal analysis of lightweight cement mortar can be used as an energy storage system, lowering the demand on the building's auxiliary heating and cooling systems. By adding GGBS (Ground granulated blast furnace slag), which have a high conductivity and high latent heat storage capacity, lightweight cement mortar's heat storage capacity can be improved.

KEY WORDS: Lightweight Cement mortar, Life time, GGBS (Ground granulated blast furnace slag), Test Capability, Performance, Water, Portland cement.

I.INTRODUCTION

With approximately six billion tons produced annually, cement mortar is probably the most widely used building material worldwide. It is only next to water in terms of how much each person consumes. However, the environmental sustainability is at risk because of the harm caused by getting raw materials and releasing CO2 (Carbon Dioxide) when making cement. Researchers were put under tension subsequently to lessen concrete utilization by some degree supplementary concrete with extra materials. These materials might come from nature, waste from an industry, or by-products that don't use as much energy. These materials called pozzolanas which can act like cement when mixed with calcium hydroxide. Fly ash, silica fume, metakaolin, and Ground Granulated Blast furnace Slag (GGBS) are the pozzolanas that are utilized most frequently. This needs to examine the admixtures performance when blended with cement mortar so as to ensure a reduced life cycle cost.

Cement mortar is used a lot in the construction industry every year, and demand is expected to rise soon [1]. Cement mortar is a highly popular construction material, and cement is its main ingredient. From 1.5 billion tons in 1995 to 3.2 billion tons in 2016, the building material demand for cement mortar has steadily increased, cement production is estimated to have grown [2].

However, use of cement reduces the availability of raw materials (limestone) and pollutes the environment. Portland cement production is rising by 9% annually worldwide. The production of Portland concrete, results in the release of around 1.5 billion tons of substances that deplete the ozone layer each year, accounting for approximately 7% of global greenhouse gas emissions. Since the early 1900s, ground slag has been used as a cementitious material in cement mortar. [3]. The focus of this paper is to review the different studies on alternative materials that can partially replace cement, with a particular emphasis on Ground Granulated Blast Slag (GGBS).

Europe has used Blast Furnace Slag (BFS) and Steel Furnace Slag (SFS) as industrial byproducts for nearly 150 years, but in the United States, they have been used for nearly 100 years. For a significant amount of time, Ground Granulated Blast furnace slag (GGBS) has been utilized as a cementitious ingredient in cement mortar and composite cements. Initially, unground Granulated Blast furnace Slag (GBS) was commercially used in brick production. However, its cementitious properties were discovered in the second half of the century, resulting in the production of the first GBS-containing cements by the end of the 19th century. Since in the late 1950s, it has become common practice to add GGBS to the cement mortar mixer together with Portland cement as a separate ground material. In some countries, pure GGBS is referred to as "slag cement."

At the moment, GGBS was used in place of Portland cement on a one-to-one basis by weight. It is used to create durable cement mortar structures when combined with regular Portland cement and/or other pozzolanic materials. In Europe, GGBS is widely used in the United States and Asia (particularly China, India, Japan, and Singapore) to extend buildings' lifespans from fifty to one hundred years due to its superior durability in cement mortar. GGBS is mostly used as an in China to make ready-mixed and site-batched cement mortar, as a substitute for clinker in the production of blended slag and normal cement [4].

At the moment, the adoption of GGBS is directly and fundamentally driven by the benefits of cost reduction. Portland Blast Furnace Cement (PBFC) and High Slag Blast Furnace Cement (HSBFC) are two high-quality slag cements that are enhanced with GGBS. The GGBS content of these cements typically ranges from 30 to 70%. It is also used to make durable cement mortar that can be site-batched or ready-mixed. Alkali-Silica Reaction (ASR) damages are less likely to occur with GGBS, chloride intrusion is less likely to occur with reinforcement corrosion, and chemical and sulfate attacks are less likely to occur.

In addition to the above-mentioned facts, unground GBS can be utilized in cement mortar as a regular weight aggregate. In road construction, it is also used as a base layer material. BFS aggregates, on the other hand, it can only be used for asphalt road bases and sub-bases rather than surface layering, because of their low porosity. The slow rate of cementation is one of the significant benefits of using slag products in stabilized pavement. The pavement material can be reworked in two days after the initial mixing without affecting its final strength, which may vary by depending on the mixer used.

Economic factors include the degree of material fineness, determines how well GBS and GGBS perform in stabilization. It is necessary to strike a balance between the costs of transportation and those of producing a higher-grade GBS and GGBS. Which requires less slag stabilizing binder to achieve the same strength [5]. Alkali Silica Reaction (ASR) can be controlled effectively with GGBS because:
(i) GGBS lowers the cement mortar's alkalinity and consequently the alkali-silica ratio;
ii) The cement mortar's alkalis are less mobility when GGBS is used furthermore.
(iii) Alkali silica response is significantly influenced by free lime in cement mortar, which is reduced by GGBS.

II. LITERATURE SURVEY

Bricks are one of the most widely used building materials worldwide, according to Chinku Alphons Tom and Arya K.C., Alester Joseph Vanreyk, et al. [6]. Natural materials for making conventional bricks are already shortage in many locations. The price of clay rises when demand is rising. The incorporation of waste materials into clay bricks is an alternative strategy for reducing clay consumption. The positive effects of disposing these wastes will be lessened by making use of them. A review on, how bricks can be made from waste materials is presented in this paper. Bricks made from GGBS, paper sludge, and late rite soil have also been reviewed, as it have a wide range of waste materials used in various ways to make them. Bricks' mechanical and physical properties were analysed and discussed.

In their investigation, Samson et al. 7] investigated the thermomechanical properties of a foam cement mortar (FC) made of ground granulated blast furnace slag (MK-GGBS) and blended metakaolin. This FC could be used as self-bearing insulation. The researchers initially focused on determining the binder composition of MK-GGBS FC. In order to determine the ideal ratios of metakaolin, GGBS, and activator for the production of an Alkali-Activated Material (AAM) FC matrix, it looked into 14 distinct paste formulations. For the fresh paste (with an initial setting time of over 180 minutes) and solid materials (with moderate shrinkage and high compressive strength) that would be used in the production of FC, specific requirements were established. Theoptimal mix was used in the production of AAM FC through the gasfoaming procedure. The researchers conducted examinations on various aspects of the AAM FC, including compressive strength, thermal conductivity, density, and porous structure in relation with two main parameters: contents of the surfactant and H2O2. FC density is largely due to the H2O2 content. The FC permeable design is totally dependent on the amount of surfactant and H2O2. The structure of FCs with a high surfactant content is thin, uniform, and porous. The compressive strength of FC is affected by the amount of surfactant present when maintaining a constant density. It was discovered that there exists a specific surfactant content that maximizes the compressive strength of FC while keeping the density constant.

Santosh Kumar Karri et. al. [8] the study's specimens of M20 and M40 cement mortar were cured for 28 and 90 days, respectively, on cement replacement levels of 30%, 40%, and 50%. This measures different properties of cement mortar at 7, 14, and 28 days. At early curing ages, the compressive and tensile strengths of mortar mixes with slag which is decreased. At 7 and 28 days, the specimens' compressive strength increased when 20% cement was replaced. Cement mortar cubes were subjected to exposure to H2SO4 (sulfuric acid) and HCl (hydrochloric acid).

S. Arivalagan.at.al.[9] investigated the effects on the strength and strength efficiency factors of hardened cement mortar of partially replacing cement with 20 percent, 30 percent, and 40 percent GGBS at various ages. The specimens' compressive strength increased at 7 and 28 days after 20 percent cement was replaced. The split tensile and flexural strengths of the cement mortar also showed an increase when 20% of the cement was replaced with GGBS.

Yogendra O. Patil et. al. [10] conducted a study to investigate the effect on cement mortar's compressive and flexural strengths of partially replacing cement with various percentages of GGBS. The tests were carried out at 7, 28, and 90 days, with replacement rates ranging from 0% to 40%. Cement mortar strength was found to be inversely correlated with the proportion of GGBS replacing cement. When OPC is replaced with GGBS, the result shows a slight decrease in compressive and flexural strength of 4 to 6 percent for 90 days of curing—up to 20 % and beyond that, more than 15 %. He came to a conclusion that replacing Ordinary Portland Cement (OPC) with 20% GGBS results in a cost reduction of 14% for cement mortar, considering the current market rate.

III. MATERIALS USED

3.1. Materials

GGBS, water, Ordinary Portland Cement (OPC) are the parts used in this analysis. The materials' physical properties were evaluated.

3.2 GGBS:

The production of GGBS includes submerging molten iron slag from a blast furnace in water or a stream. Its color is off-white. The GGBS is showed in the image (1) below. The use of lightweight aggregate lowers the cement mortar's overall density, which lowers its strength. Cement was replaced with GGBS at its optimal percentage of 40% in order to improve cement mortar's overall strength.

Fig. 1: GGBS

3.3 Cement:

For the purpose of the investigation, grade-53 standard OPC cement from local suppliers was used. The cement had a specific gravity of 3.15, a consistency of about 27%, and an initial setting time of 32 minutes.

3.4 Water:

Potable water is used as per IS 456:2000.

IV. RESULTS & DISCUSSION

The below table (1) shows the parameters comparison for light weight bricks integrated air vents polystyrene in light weight brick and GGBS. In this performance, test capability and life time are given in detail manner.

Table. 1: Comparison of Parameters

S.NO	PARAMETER	INTEGRATING AIR VENTS AND POLYSTYRENE IN LIGHT WEIGHT BRICK	GGBS
1	Performance	81%	96%
2	Test capability	87%	91%
3	Life Time	79%	95%

Comparison of performance and test capability is shown in below figure (2) for integrated air vents and polystyrene in light weight brick and GGBS. Compared with integrated air vents, polystyrene in light weight brick, GGBS improve performance and test capability.

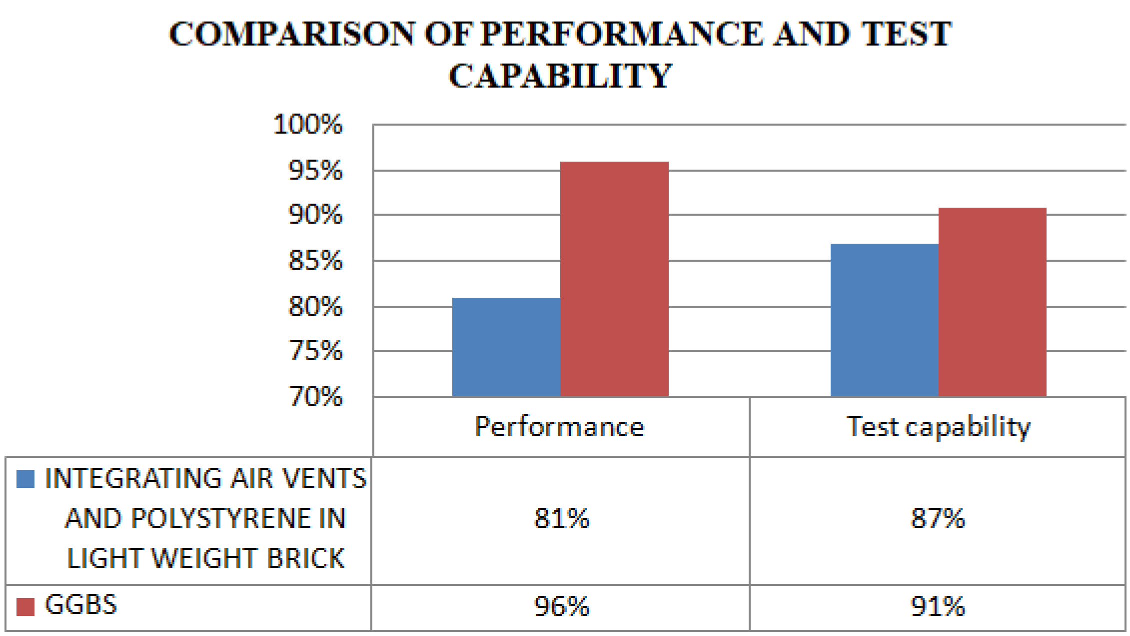

Fig. 2: **Comparison of Performance and Test Capability**

Comparison of life time is shown in below figure (3) for integrated air vents and polystyrene in light weight brick and GGBS. Compared with integrated air vents, polystyrene in light weight brick, GGBS improves life time capability and performance.

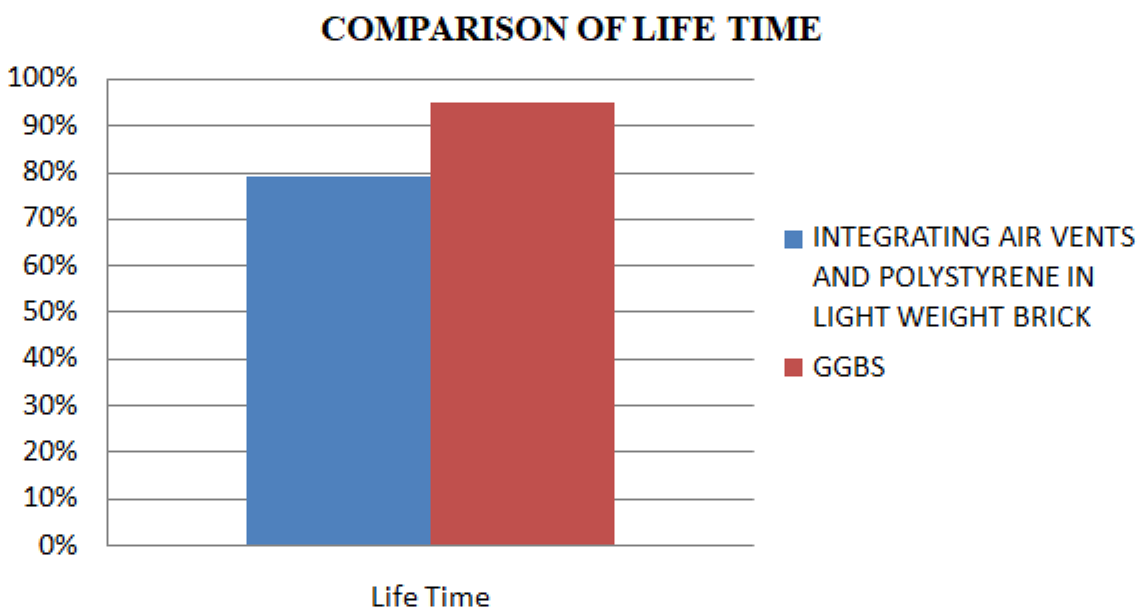

Fig. 3: Comparison Of Life Time

V.CONCLUSION

Alternative cementation materials have the potential to improve not only the economy of construction projects as a whole but also the cement mortar composites themselves. Researchers are looking into new ways to replace cement mortar's components because of this requirement. The use of cement with GGBS replacement has gained significant attention in the cement mortar industry due to several advantages. These include savings in cement usage, energy, and costs, as well as environmental and socioeconomic benefits. It is now widely used in place of traditional cement mortar. The thermal analysis of GGBS when light weight bricks are only partially replaced is the purpose of this paper. In the study, the effectiveness of Ground Granulated Blast furnace Slag (GGBS) in comparison to cement mortar and its strength at various replacement levels were evaluated. From results, it can observe that compare with integrated air vents, polystyrene in light weight brick, GGBS improves life time, test capability and performance.

VI. REFERENCES

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