DEVELOPMENT OF GEO-POLYMER FLY ASH BRICK EMBEDDED WITH PHASE CHANGE MATERIAL LAID ROOF FOR COOLING OF BUILDINGS

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ABSTRACT

A technology that can be used to store large amounts of heat or cold in a definite volume has been a subject of research. The use of stone or masonry for this purpose in modern buildings can give rise to a number of problems, high cost, excessive mass and undesirable temperature excursions during and following prolonged periods of high and low ambient temperatures. In the present work, it is proposed to develop a geo-polymer fly ash brick embedded with a phase change material laid on walls and roof of a building. The theoretical study is planned to carry out for the prevailing ambient temperature. It is proposed to conduct experiments by constructing two experimental test rooms of small size; the roof of the first room is a simple RCC. The second room is provided with a geo-polymer fly ash brick embedded with phase change material. A comparison between the thermal performances of both the roof is to be done for yielding energy savings and providing thermal comfort in buildings.

Keywords: *Geo-polymer, fly ash brick, ground granulated blast furnace slag (GGBFS), phase change material, Building energy conservation*

1. INTRODUCTION

The newly found alternative method in the construction of bricks is a geo-polymer fly ash brick, which comprises of fly ash, ground granulated blast furnace slag, lime stone dust, rice husk ash, welding flux slag and other waste products.

After developing the geo-polymer fly ash brick, it must bind with Phase Change Material (PCM) ($CaCl_26H_2O$), which will give strength and durability in the construction of walls and roofs and also it is sustainable in the atmospheric conditions. River sand can be replaced with M-sand as fine aggregate. The reported literature is silent about the use of geo-polymer masonry blocks in the construction.

The building model constructed using geo-polymer masonry blocks performed better compared to traditional concrete block. The use of geo-polymer masonry blocks can be recommended for the construction of buildings. Despite the extensive development in the construction industry, bricks and blocks have still remained as the major building units.

The traditional fired bricks still rule supreme since cost consideration is the prime influencing factor in the product choice. About 22 million tones of coal are consumed in the production of burnt bricks apart from 10 million tones of biomass. Clay bricks consume large amount of fertile top soil owing to fast depletion of soil. The alternative to these bricks is compressed cement blocks which have gained popularity recently.

The main drawback of cement blocks is consumption of cement which is deterrent to sustainability. As an alternative to the above products a new technology is developed to manufacture fly ash based geo-polymer compressed blocks. There are several advantages of these blocks. Marginal materials can be used to develop these blocks. No traditional curing methods are adopted and no cement is being used.

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In the present investigation alkali activated fly ash and Ground Granulated Blast Furnace Slag (GGBFS) are used as binder materials in the compressed blocks at ambient and higher temperature. The huge demand from housing industry due to population explosion has entailed the need for sustainable building materials especially bricks.

Researchers have tried to incorporate fly ash, Ground Granulated Blast Furnace Slag (GGBS), lime stone dust, rice husk ash, welding flux slag and other waste products into bricks so as to improve its sustainability. An interesting area of research which has attracted interest of many scholars is geo-polymer binder which utilizes industrial waste products to form sustainable green binders.

As per TERI (2001) report, India produces more than 1400 billion bricks per year using 350 million tons of top soil by burning 24 million tons of coal thereby emitting 42 million tons of CO_2.

In India, it is estimated that by end of 2012, from the total thermal capacity of about 90 coal / lignite based Thermal Power plants, generate ash in the form of fly ash (80-90%) and bottom ash (10-20%) would be of the order of 173 Million Tons (MT) per annum considering 38% ash content in coal as an average and at 80% Plant Load Factor (CEA 2009-10).

It is further estimated that only about 51% of the ash generated found gainful utilization. The fact that economic growth of the nation is generally linked to power availability and given the trend of high proportions of coal based Thermal Power Stations (TPS), fly ash generation is likely to increase in future. It is estimated that coal ash generation will likely to grow over 200 MT by the year 2017. Unless we find more ways to utilize fully this industrial waste, in line with its output, it will greatly endanger the environment.

Hence exploring the possibility of utilizing Bottom Ash (BA) along with fly ash is interesting avenue for research. The term geo-polymer was termed by David Ovits in 1988 to represent mineral polymers. Geo-polymers are chemically similar to zeolite but have amorphous microstructure consisting predominantly of Si and Al atoms.

During the synthesized process, silicon and aluminum atoms are combined to form the building blocks that are chemically and structurally comparable to those binding the natural rocks. Most of the literature in geo-polymer deals with geo-polymer pastes and geo-polymer concrete.

Geo-polymer based binder was patented in USA in 1988 as High Strength Mineral polymer and the binder was prepared using GGBS which replaced cement mortar in precast structural elements. Geo-polymer has advantages like availability of abundant raw materials, quick strength gain, and good durability especially in acidic environment, reduced energy consumption and reduced greenhouse gas emission.

Research into geo-polymer bricks incorporation copper mine tailings, cement kiln, fly ash, metakaolin, red mud, rice husk ash, fly ash and iron making slag and many more have produced promising results.

2. PREPARATION OF BLOCKS

Alkaline activator solution was prepared using sodium hydroxide pellets and sodium silicate solution. These chemicals were dissolved in specified quantity of tap water. The ratio of sodium hydroxide to sodium silicate was 1.5. The solution was prepared at least one day in advance. Fly ash and GGBFS (Ground Granulated Blast Furnace Slag) were mixed in the proportion of 80:20 in dry condition.

Later, fine aggregate was added and mixed again till homogeneous mix was obtained. Alkaline solution was added and mixed to get wet mortar mix. The ratio of fluid–to-binder was maintained at 0.2. The ratio of total binder to aggregate was maintained as 1:1. This mortar mix was used to prepare bricks and blocks. Specified amount of mortar was placed into the mould and static compaction was applied to mould the block/brick.

The bricks/blocks were kept in open air for curing till the age of testing.

NaOH pellets-3

Sodium silicate-2

3/2=1.5

Flyash-80%

GGBFS (Ground Granulated Blast Furnace Slag)-20%

Alkaline solution (fluid)-4

Fly ash + GGBFS (Binder)-20

4/20=0.2

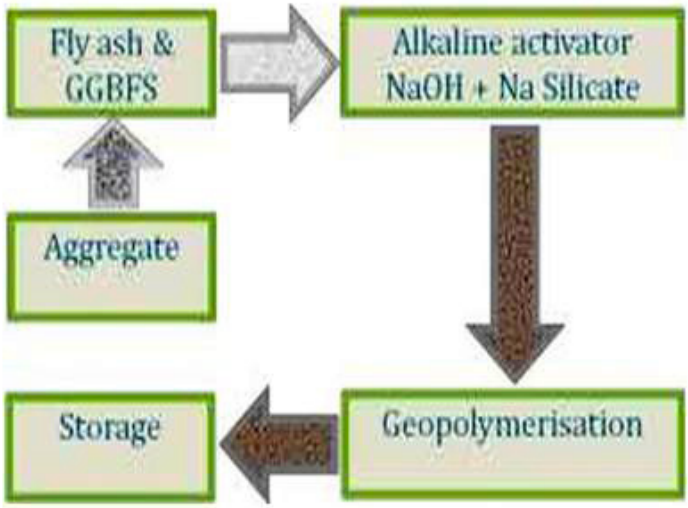

Fig. 1. Preparation of Block

3. GEO-POLYMER BLOCK MASONARY HOUSE

The geo-polymer blocks were used to construct a model building near Doddaballapura, Bangalore-Karnataka. Conventional cement mortar was used as masonry mortar in the construction. The building was kept open to the atmosphere without constructing roof for 18 months as well as without plastering the walls both outside and inside. There was no sign of any deterioration of the walls of the building.

Fig.2. Geo-polymer block model house

4. CONCLUSION

The parameters affecting the performance of PCM embedded fly ash brick laid roof, the economic feasibility, life of phase change material, the energy saving potential, the possible level comfort are evaluated. Finally recommendations and suggestions will be made on the basis of results yielded from simulation and experimental work.

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