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An Experimental Investigation on Hybrid Geopolymer bricks by using Fly Ash, GGBS, Silica Fume and Kadapa Slab powder

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Abstract:

Brick is the oldest building material. It is a standard sized weight bearing unit. The earliest bricks were dried which are formed from clay or mud. During 2007 the new fly ash bricks were created using by products from coal plants. A sustainable development is an important task to the cement industry. To avoid cement as a huge construction material to reduce the environmental issues, replaced with Fly ash, GGBS, Silica fume, Kadapa slab powder. For bonding polymers, limited water content is used. Hence, resulting hybrid geo-polymer brick with multi-material combination is effective. In this experimental approach, initially we were considered 75% and 25% Fly ash and GGBS respectively as a base and then varied silica fume and kadapa slab powder ranging from 2 to 5% in GGBS. Mechanical properties of the materials are giving effective values to replace. Through compressive strength results we can find optimum proportions based on silica fume and kadapa slab powder.

Keywords — **Fly-ash, GGBS, Silica fume, Compressive strength, Kadapa slab powder**

I. INTRODUCTION

A brick is building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units lay in mortar. A brick can be composed of clay-bearing soil, sand, and lime, or concrete materials. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities. Two basic categories of bricks are red and non- red bricks. Fired bricks are one of the longest-lasting and strongest building materials, sometimes referred to as artificial stone, and have been used since circa 5000 BC. Air-dried bricks, also known as mud bricks, have a history older than red bricks, and have an additional ingredient of a mechanical binder such as straw. Initially in 7000 BC sun-dried mud bricks were introduced, it was later determined that kiln-dried clay bricks were more weather-resistant and helped in climate control by absorbing heat during the day and releasing it at night. The ancient Romans used mobile kilns to introduce red clay brick throughout their empire. Fired clay brick spread from Italy to Northern Germany during the 12th century, beginning the brick Gothic period of architecture. Bricks are laid in courses and numerous patterns known as bonds, collectively known as brick work, and may be laid in various kinds of mortar to hold the bricks together to make a durable structure.

A. Fly ash brick (FAB)

It is a building material, especially masonry units, containing class C fly ash and water. Owing to the high concentration of calcium oxide in class C fly ash, the brick is described as "self-cementing". The manufacturing method saves energy, reduces mercury pollution, and costs 20% less than traditional clay brick manufacturing. As per IS1702-1992 the strength of fly ash brick manufactured with the above compositions is normally of the order of 7.5N/mm2to 10N/mm2. Main ingredients include fly ash, water, quicklime or lime sludge, cement, aluminum powder and gypsum. Gypsum acts as a long term strength gainer. The chemical reaction due to the aluminium paste provides AAC its distinct porous structure, lightness, and insulation properties, completely different compared to other lightweight concrete materials. The finished product is a lighter Block - less than 40% the weight of conventional Bricks, while providing the similar strengths. The specific gravity stays around 0.6 to 0.65. This is one single most USP of the AAC blocks, because by using these blocks in structural buildings, the builder saves around 30 to 35 % of structural steel, and concrete, as these blocks reduce the dead load on the building significantly. There are three important ingredients of fly ash which affect the strength i.e. Loss on Ignition, Fineness and Calcium content.

B. Silica Fume

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous silicon dioxide. The individual particles are extremely small, approximately 1/100th the size of an average cement particle. The calcinations of ($CaCO_2$) to produce 1 ton of Portland cement releases 0.53 tons of (CO_2) into the atmosphere and, if the energy used in the production of Portland cement is carbon fuel. So we were decided to reduce the usage of Portland cement, by that we thought the concept of hybrid geo-polymer brick. In this we will go for total replacement of cement by fly ash, GGBS, silica fume and Kadapa slab powder. Now it's time to create new sustainable material for brick by fly ash and GGBS polymers-sodium hydroxide, sodium silicate respectively. Analyzing cement fly ash brick cost, and will try to achieve economy. Geo-polymer also known as "inorganic polymer" has emerged as a green binder with wide potentials for manufacturing sustainable materials for environmental, refractory and construction applications.

C. Ingredients required

- Geo-polymer source materials such as Fly ash, GGBS, silica fume, Kadapa slab powder.
- Aggregate system consisting of fine and coarse aggregate.
- Sodium silicate and sodium hydroxide.

D. Salient Features of Geo-Polymer brick

- Geo-polymer brick reduced (CO_2) emissions of geo-polymer cements make them a good alternative to ordinary Portland cement.
- The mechanical behaviour of Geo-polymer brick is higher normal fly ash brick.
- Durability property of Geo-polymer brick is higher than the normal fly ash brick.
- Geo-polymer brick is Eco-Friendly.
- Water absorption property is lesser than the normal fly ash brick.

E. Objectives

- To make a brick without using cement and by using geo-polymers.
- To study the different strength properties of geo-polymer brick with percentage replacement of GGBS, silica fume and Kadapa slab powder.
- To evaluate the optimum mix proportion of Geo-polymer bricks with fly ash replaced in various percentages by GGBS, silica fume and Kadapa slab powder.
- To compare the cost variation of geo polymer concrete with normal concrete.

II. MATERIALS

A. Fly Ash

Fly ash is a fine powder recovered from the gases of burning coal during the generation of electricity, which is a pollutant material and it causes effects in environment. These micron-sized earth elements consist primarily of silica, alumina and iron. Fly ash improves considerably the performance of binder paste and increases the bonding action with aggregate and reinforcement. The properties of fly ash may vary considerably according to several factors such as the geographical origin of the source coal, conditions during combustion and sampling position within the power plant. The major elemental constituents of fly ash are Si, Al, Fe, Ca, C, Mg, K, Na, S, Ti, P and Mn. Certain trace elements, including As, Mo, Se, Cd and Zn, are primarily associated with particle surfaces. The most abundant species in fly ash extracts are inorganic ions derived from Ca, Na, Mg, K, Fe, S and C. The use of fly ash in concrete is economical and modifies the properties of concrete in both the fresh and hardened states with improvements to workability, strength, abrasion, heat evolution, shrinkage and reduces water reducing admixture demands. It increases the packing density of the cementations system, thus creating a less permeable structure.

B. Silica fume

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. Silica fume can be obtained as a bi-product in the industries where silicon metal or Ferro silicon alloys are produced. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Silicon metal and alloys were produced from electric furnaces. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide ($SiO2$). The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

C. Kadapa slab powder

The comprehensive range of Kadapa Black stone Natural offered by us are quite impervious and hard. These Natural Kadapa Black stone are used for cladding and flooring purposes as the stone is more resistant than most other sedimentary rocks. Available in easy to cut into blocks, these stones are also long-lasting and can also withstand any exposure.

D. Ground Granulated Blast Furnace Slag

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Ground granulated blast furnace slag comprises mainly of calcium oxide, silicon dioxide, aluminum oxide, magnesium oxide. It has the same main chemical constituents as ordinary Portland cement but in different proportions.

E. Aggregates

In the absence of the usage of proper alternative aggregates becoming possible in the near future, the concrete industry globally will consume 8-12 billion tons annually of natural aggregates after the year 2010. Aggregates are inert granular materials such as sand, gravel or crushed stone, constitute an essential ingredient in concrete. Good concrete mix aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other ne materials that could cause the deterioration of the concrete. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75 mm sieve. Coarse aggregates are particles retained in 4.75 mm sieve.

1) Coarse aggregate

The coarse aggregate from a local crushing granite stone of angular type having 6 mm minimum size well graded aggregate according to IS-383 is used in this investigation. The coarse aggregate procured from quarry was sieved through 12.5mm, 10mm and 4.75mm sieves.

2) Fine aggregate

The sand obtained through all the sieves (i.e.4.75mm, 2.36mm, 1.18mm, 600mm, 300mm, and 150mm). Sand retained on each sieve was filled in different bags and stacked separately for use.

F. Alkaline activators (or) Polymers

The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. The NaOH solids were dissolved in water to make the solution. The mass of NaOH solids in a solution depends on the concentration of the solution and is expressed in terms of Molar (M). NaOH solution with a concentration of 8 M consisted of 8 x 40 = 320 grams of NaOH solids (in flake or pellet form) per litre of the solution, where 40 is the molecular weight of NaOH. The mass of NaOH solids was measured as 262 grams per kg of NaOH solution of 8M concentration. Similarly, the mass of NaOH solids per kg of the solution for 14M concentration was measured as 404 grams and for 16M mass of NaOH solid is 444 grams.

G. Water (H2O)

The main reason of using water in this experiment is, in general normal fly ash bricks get the strength due to the formation of C-S-H gel it forms due to the mixing of cement, sand and water. But the geo-polymer brick get the strength due to the formation of N-A-S-H gel it forms due to the mixing of polymers, fly ash and water. So without water the N-A-S-H gel doesn't forms.

H. Test on materials

1) Specific Gravity of Materials

Specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene which does not recent with cement is used. Apparatus used are Specific gravity bottle, balance, weight box, cement, kerosene.

- Weigh the empty Specific gravity bottle (W1)
- Weigh the bottle filled with distilled water (W2)
- Weigh the bottle filled with kerosene (W3)
- Pour some of the kerosene out and introduce a weighed quantity of material into the bottle. Roll the bottle gently in the inclined position until no further air bubbles rise to the surface. Fill the bottle to the top with kerosene and weigh it in grams (W4)
- Weight of material in grams (W5)

TABLE I
SPECIFIC GRAVITY OF MATERIALS

Specific Gravity of Materials	*Materials*	*Percentage of Specific gravity*
1	Fly ash	2.20
2	Silica fume	2.20
3	Kadapa Slab	2.75
4	NaOH	1.4
5	Na2SiO3	1.15

2) Specific Gravity of Fine Aggregate

A balance of capacity not less than 3kg, readable and accurate to 0.5gm and of such a type as to permit the weighing of the vessel containing the aggregate and water.

- Weigh the empty pycnometer = W1gms.
- Take 2/3 of fine aggregate in pycnometer and weigh it =W2gms.
- Weight of pycnometer + 2/3 of aggregate + water =W3gms
- Pour water into the pycnometer and weigh it = W4 gms
- Weight of pycnometer (W1) = 610gms.
- Weight of Pycnometer with sand (W2) =1540gms.
- Weight of Pycnometer with sand and water (W3) = 2016gms.
- Weight of Pycnometer with water (W4) = 1498gms.

Specific Gravity

$= (\omega 2 - \omega 1) / [(\omega 4 - \omega 1) - (\omega 3 - \omega 2)] = 2.50$

3) Specific Gravity of Coarse Aggregate

- Weigh the empty pycnometer = W1gms
- Weigh the pycnometer with coarse aggregate = W2gms.
- Weight of pycnometer +Aggregate + Water = W3gms.
- Weight of full of water with pycnometer = W4gms.
- Weight of pycnometer (W1) = 610gms
- Weight of Pycnometer with coarse aggregate (W2) = 1666gms
- Weight of Pycnometer with coarse aggregate and water (W3) = 2184gms
- Weight of Pycnometer with water (W4) = 1498gms

Specific Gravity

$= (\omega 2 - \omega 1) / [(\omega 4 - \omega 1) - (\omega 3 - \omega 2)] = 2.50$

III. METHODOLOGY

As per IS provisions only M20 grade mix design has to be preferred for bricks. We have investigated the proportions of the materials being used in many of the nearby industries in manufacturing bricks; we have kept-in the same things into practice by following M20 mix design.

A. Mix design for M20 grade concrete

- Characteristic mean strength Ft = Fck + KS

  Ft = 20 + 1.65(4)

  Ft = 26.6 N/mm2
- As per IS-10262, For 10mm size aggregate W/C = 0.5 Nearly for 6mm size aggregate W/C = 0.58
- As per IS-10262-2009, amount of water is to be added W = 180 lit (or) kg/m3
- Weight of cement

  W/C = 0.58

  180/C = 0.58 [W = 180 lit (or) kg/m3]

  C = 310.344 kg/m3

  Take the weight of cement as 330 kg/m3
- Volume of aggregate (Va)

  Vol. of cement (Vc) = weight / density = 330 / 3510 = 0.105 m3

  Vol. of water (Vw) = weight / density = 180 / 1000 = 0.180 m3

  Total vol. of concrete = 1 m3

  Va + Vc + Vw = 1

  Va + 0.105 + 0.180 = 1

  Va = 1 - 0.105 - 0.180 = 0.715 m3
- 6mm size crushed aggregate, as per IS-10262

  Vol. of coarse aggregate = 30% of Va = 0.3(0.715) = 0.2145 m3 Vol. of ne aggregate = 70% of Va = 0.7(0.715) = 0.5005m3

  Weight of coarse aggregate = volume * density = 0.2145 * 2800 = 600 kg/m3

  Weight of ne aggregate = volume * density = 0.5005 * 2500 = 1250 kg/m3

  Total weight of concrete = 330 + 180 + 600 + 1250 = 2360 kg/m3

TABLE III
MIX PROPORTION

Mix Proportion				
	Binder	*Fine Aggregate*	*Coarse Aggregate*	*Water / Cement*
1	1	3.79	1.82	0.58

B. Proportion

TABLE IIIII
PROPORTION TABLE

Proportion			
	Fly ash	*GGBS*	*Silica Fume*
1	75%	25%	0%

- Weight of cement = 330 kg/m3

  Here Cement is totally replaced by Fly ash and GGBS with 75% and 25% respectively. Weight of fly ash = 0.75 * 330 = 247.5 kg/m3 Weight of GGBS = 0.25 * 330 = 82.5kg/m3
- Weight of water = 180 kg/m3

  Here water is totally replaced by chemicals which are NaOH and Na2SiO3 with 1:2.5 proportions.

  Weight of NaOH = 51.42 lit (or) kg/m3

  Weight of Na2SiO3 = 128.58 lit (or) kg/m3
- Total vol. of concrete = 1m3

  Vol. of y ash = weight / density = 247.5 / 2200 = 0.112 m3

  Vol. of GGBS = weight / density = 82.5 / 2850 = 0.0289 m3

  Vol. of NaOH = weight / density = 51.42 / 1400 = 0.0367m3

  Vol. of Na2SiO3 = weight / density = 128.58 / 1150 = 0.1118m3 Vc = Vol. of fly ash (Vf) + Vol. of GGBS (Vg)

  Vw = vol. of NaOH (Vnh) + Vol. of Na2SiO3 (Vns)

  Va + Vf + Vg + Vnh + Vns = 1

  Va + 0.112 + 0.0289 + 0.0367 + 0.1118 = 1

  Va = 0.7106 m3 4. For 6mm size crushed aggregate, as per IS-10262

  Vol. of coarse aggregate = 30% of Va = 0.3 * 0.7106 = 0.21318 m3

  Vol. of ne aggregate = 70% of Va = 0.7 * 0.7106 = 0.49742m3

  Weight of coarse aggregate = volume * density = 0.21318 * 2800 = 597 kg/m3 Weight of ne aggregate = volume * density = 0.49742 * 2500 = 1243 kg/m3

Total weight of concrete = 330 + 180 + 597 + 1243 = 2350kg/m3

C. Mix Proportions and quantity of materials for Geo polymer brick

The laboratory program conducted in this investigation focused on three optimum mixes and these were designated with the different materials used. The concentration of NaOH used in the experimentation was based on the review of previous research (Hardjito and Rangan 2005). Accordingly, the performances of geo-polymer brick specimens made with 8M of NaOH are evaluated. The ratio of sodium silicate solution-to-sodium hydroxide solution was fixed as 2.5. The quantity of different materials used to prepare the geo-polymer bricks of standard sized 19 X 9 X 9 cm.

D. Mixing

For mixing of mortar to prepare bricks, rst collect the materials with required quantities for different proportions. Take a tray of suitable size for mixing of mortar in that first take coarse aggregate then take ne aggregate with required quantities mixed both properly, on other side mix different mineral admixtures which are used for different mixes. Combine those aggregates and mineral admixtures in one tray and mixed both properly with the addition of polymers of W/C=0.58.

E. Casting

For casting of bricks, it is important to x the basic dimensions of mould. As per IS456-2000 the standard dimensions of a brick is 19X9X9 cm. So prepare a mould with required dimensions with by using timber or steel. In this we have prepared a mould with timber which is having the dimensions of 19X9X9 cm. First, apply the grease to the inner sides of the mould. The thoroughly mixed mortar is poured into the mould as three layers, for to compact each layer gives 25 blows by using tamping rod. Finally, finish the surface by using strike o bar.

Fig. 1 Mould used for Casting of Bricks

F. Demoulding

Demould the bricks after it sets hard. For checking purpose whether it is sets or not just scratch the surface with finger nail and observe there is no mark on the surface which results its sets hard. Immediately after demoulding, the specimens were marked by their respective identification mark/numbers.

G. Curing

Geo-polymer brick doesn't require water curing, which requires air curing. So after demoulding of geo-polymer brick we have placed it into open atmosphere for 3 days or 7 days, because it gains its maximum strength in 7 days.

Fig. 2 Bricks after Demoulding

H. Testing

For important laboratory test which is conducting on brick is compressive strength test, for which requires the CTM (Compressive Test Machine) apparatus. So we have initially conducted the compressive strength test on geo-polymer brick. Based on this compressive stress value we have decided the optimum proportions.

Fig. 3 Brick at maximum load

IV. EXPERIMENTATION AND RESULTS

Bricks are undoubtedly amongst the most commonly used construction materials anywhere. Incidentally, concrete is regarded as the most used construction material in the world in terms of weight or volume according to some estimates. Knowing a few simple yet important quality related details as well as about few quality tests on this widely used construction material (i.e. brick) can be beneficial not only to civil engineers or construction personnel but also to any individual planning to build a house that would consume bricks galore. The quality related tests, to be discussed herein, are based on Indian standards. That may exude a bit of technical favor but, in actuality, these are quite simple tests. Bricks of different varieties are available in the market such as clay bricks, cement bricks, fly ash bricks and so on. However, the most commonly used and readily available type is the clay brick. The details and quality tests to be discussed in this submit are on hybrid geo-polymer brick which is same for the clay brick. Two quite common and sticky issues concerning bricks are dampness and efflorescence. Once these problems begin showing up in an already completed structure or in any brickwork it is quite difficult to shake them o and they could prove to be quite a headache in the years to come. The easy way out is to go for quality bricks that are capable of withstanding these problems which can be seen in many buildings in many places.

A. *Crushing Strength or Compressive Strength Test on Bricks*

Compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. This test is done to know the compressive strength of brick. It is also called crushing strength of brick. Generally, 3 specimens of bricks are taken to laboratory for testing and tested one by one. In this test a brick specimen is put on crushing machine and applied pressure till it breaks. After placing the brick in compression testing machine, apply load on it until brick breaks. Note down the value of failure load and find out the crushing strength value of brick. As per IS1702-1992 the minimum crushing strength of brick is 3.50 N/mm2.If it is less than 3.50 N/mm2, then it is not useful for construction purpose.

Brick has good compressive strength which makes it popular in construction world. The compressive strength of brick can vary from 3 N/mm2 to 40 N/mm2and size and shape of brick. But brick masonry wall strength isn't only depending on brick strength. It also depends on mortar strength, bond quality between mortar and bricks. Bond quality is depends on many things. Such as brick textures, mortar quality, absorption and workmanship. So, the brick masonry wall strength may not be same as the brick strength. Geo-polymer bricks were prepared, tested and compared with ordinary bricks. The compressive strength of geo-polymer mortar cubes is influenced by the wet-mixing time.

TABLE IV
LIST OF THE DIFFERENT PROPORTIONS OF MATERIALS

S. NO	Fly ash	GG BS	Silica fume	Kadapa Slab powder	Compressive stress at 3days (N/mm^2)	Compressive stress at 7days (N/mm^2)
1	70%	20%	5%	0%	1.7	2.1
2	75%	25%	0%	0%	8.5	9.4
3	75%	25%	0%	0%	8.6	9.6
4	75%	22%	3%	0%	9.1	10.3
5	75%	23%	2%	0%	8.9	9.9
6	75%	22%	0%	3%	8.6	9.7
7	75%	23%	0%	2%	6.1	7.8
8	75%	20%	0%	5%	7.6	8.1
9	75%	22%	0%	3%	8.4	9.5
10	75%	23%	0%	2%	6.5	7.4

The optimum proportions based on their compressive stresses and which are tabulated below.

TABLE V
OPTIMUM PROPORTIONS

S. NO	Fly ash	GGBS	Silica fume	Kadapa slab powder	Compressive stress at 3days (N/mm^2)	Compressive stress at 7days (N/mm^2)
1	75%	25%	0%	0%	8.6	9.8
2	75%	22%	3%	0%	9.1	10.3
3	75%	22%	0%	3%	8.4	9.5

1) Graphical representation

The above three proportions are the optimum proportions that we get in this project. Where the percentage of fly ash was taken as constant i.e. 75%, GGBS is varies from 22% - 25% and the silica fume and Kadapa slab powder are used as 3% and 3% respectively. The compressive stresses of those three proportions are graphically shown in the figure.

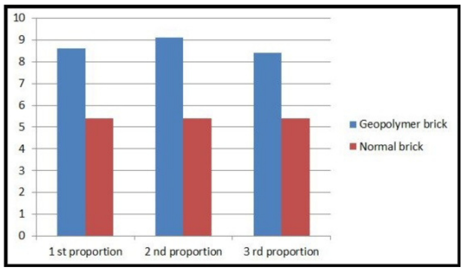

Fig. 4 Compressive Strength at 3 days

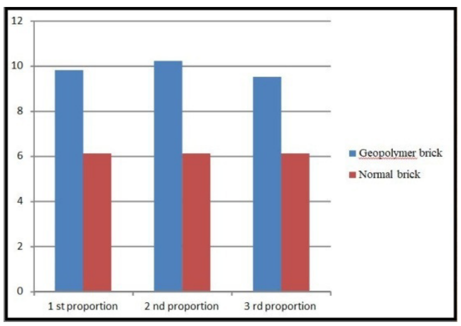

Fig. 5 Compressive Strength at 7 days

B. Absorption test on Bricks

Absorption test is conducted on brick to find out the amount of moisture content absorbed by brick under extreme conditions. In this test, sample dry bricks are taken and weighed. After weighing these bricks are placed in water with full immersing for a period of 24 hours. Then weigh the wet brick and note down its value. The difference between dry and wet brick weights will give the amount of water absorption. For a good quality brick, the amount of water absorption should not exceed 20% of weight of dry brick. Upon calculating the same for each of the 2 bricks the average is found out which is considered as the water absorption capacity for the bricks. The water absorption capacity of first class bricks should not exceed 20% when calculated as described above. The same for 2nd and 3rd class bricks are not to exceed 22% and 25% respectively. For any superior quality brickwork, first class bricks only are recommended while 2nd and 3rd class clay bricks are advised for moderate to low quality work. For my project the water absorption test details and results are shown below.

TABLE VI
WATER ABSORPTION OPTIMUM PROPORTIONS

S. N O	Fly ash	GGBS	Silica fume	Kadapa slab powder	Avg% of water absorption for 2 bricks
1	75%	25%	0%	0%	6
2	75%	22%	3%	0%	6.6
3	75%	22%	0%	3%	5.7

1) Graphical representation

We were conducting the water absorption tests on bricks which are prepared by those three optimum proportions shown above and the results of those are graphically shown in below given figure.

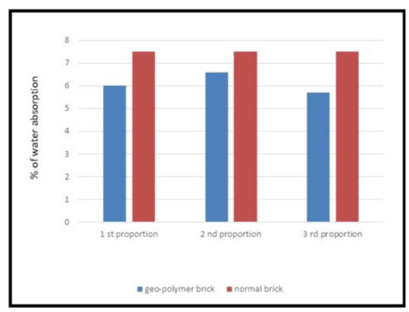

Fig. 6 Optimum Absorption Proportions

C. Hardness test on Bricks

A good brick should resist scratches against sharp things. In this test a scratch is made on brick surface with a hard thing. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick.

D. Shape and Size Test on Bricks

Shape and size of bricks are very important consideration. All bricks used for construction should be of same size. The shape of bricks should be purely rectangular with sharp edges. Standard brick size consists length x breadth x height as 19cmx9cmx9cm. to perform this test, select 20 bricks randomly from brick group and stack them along its length , breadth and height and compare. So, if all bricks similar size then they are qualified for construction work. We have designed the bricks for 19X9X9 shape and checked.

E. Soundness Test

In this test two bricks are held by both hands and struck with one another. If the bricks give clear metallic ringing sound and don't break, then those are good quality bricks.

F. Structure Test

In this test a brick is broken or a broken brick is collected and closely observed. If there are any flows, cracks or holes present on that broken face then that isn't good quality brick.

G. Efflorescence Test

Conventional bricks may contain some amount of alkaline substance in them. However, the greater the presence of such content the greater the risk of efflorescence which appear in the surfaces of bricks as ne whitish layers (deposits). A simple test as described below can serve the purpose easily. Five randomly picked clean bricks are placed together on their ends in a pan so that there are gaps among the bricks as well as between the bricks and the outer edges of the pan. Cold distilled water is then poured in the pan such that the depth of water is at least one inch. That is, at least one inch of the bricks must be under water. The pan is then kept under observation in a well-ventilated room at room temperature. As soon as the entire water in the pan gets exhausted distilled water is poured again exactly as described above and kept as it was until the whole water disappears again due to evaporation and suction by the bricks. The bricks are then examined for efflorescence. If no or negligible whitish salty formation is observed, efflorescence is considered as "nil". Similarly, efflorescence is considered as "slight" if 10% or less of the brick surface only is covered with the salty substance. The same is regarded as "moderate" if 50% of the surface is affected by the whitish salty deposit but without formation of crakes. Efflorescence is considered as "heavy" in case 50% of the surface is affected by whitish powdery deposit simultaneously with cracking of the surface.

V. COST ANALYSIS

In general, the normal fly ash bricks with 85% fly ash and 15% cement are sold by Rs. 7/- each based on that we are analyzing the cost of one geo-polymer brick. Generally, the cost of NaOH is Rs.100/- per kg. We can prepare this 1kg of powder into 3 lit of solution with 8M; in this experiment every brick wants 80ml of NaOH solution. Then by using 1 lit of NaOH solution we can prepare nearly 13 bricks. Similarly, by using 1kg of NaOH, we can prepare nearly 40 bricks. Then the cost of NaOH in one brick is 100/40 = Rs. 2.5/-. Similarly, the cost of Na2SiO3 is Rs. 15/- per kg. We can prepare this 1kg of powder into 8ltr of solution; in this experiment every brick wants 200ml of solution. Then by using 1lit of (Na2SiO3) solution we can prepare nearly 5 bricks. Similarly, by using 1kg of(Na2SiO3), we can prepare nearly 40 bricks. So the cost of(Na2SiO3) in one brick is 15/40 = Rs. 0.375/-.

Similarly, the cost of silica fume is Rs. 18/- per kg. In this experiment each brick wants 50g of silica fume, so by using 1kg of silica fume we can prepare 20 bricks. Then the cost of silica fume in one brick is 18/20 = Rs.0.9/-.

All the other materials are waste materials which are available at free cost, but the transportation cost and labor cost are additional. Based on normal fly ash brick analysis the labor and transportation costs are Rs. 1/- and Rs. 0.5/- respectively. Finally, the cost of a geo-polymer brick = Rs.2.5 + Rs.0.375 + Rs.0.9 + Rs.1.5 = Rs.5.275/-.

VI. CONCLUSIONS

When compared to normal fly ash brick the hybrid geo-polymer brick having better properties and we can achieve the better economy also. The materials which are used in this investigation are the waste materials and by using these materials in different proportions we were prepared nearly 60 cubes based on their compressive stress we can select the optimum proportions which are:

Firstly, we have decided the optimum proportions of fly ash and GGBS i.e. 75% and 25% and the obtained strength is 9.8 (N/mm2). So we can take this as the optimum proportion. Similarly, we will go for an another new material i.e. Silica fume with same 1 to 5% along with fly ash as 75%, GGBS as 20 to 24% .In this for one proportion we get the compressive stress of 10.3(N/mm2) at 7days this is the max stress that we expected, so we can take it as the optimum proportion and that proportion is fly ash 75%, GGBS 22%, silica fume 3%.

Finally, we will go for an another new material i.e. Kadapa slab powder with the same 1 to 5% along with fly ash as 75%, GGBS as 20 to 24%. In this for one proportion we get the compressive stress of 9.5(N/mm2) at 7days this is also a better result that we expected, so we can take it as the optimum proportion and that proportion is fly ash 75%, GGBS 22%, Kadapa slab powder 3%. From the above optimum results, we can achieve better economy and sustainability in the growth of brick culture.

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