International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 03, March-2019

EXPERIMENTAL INVESTIGATION ON SUSTAINABLE STABILIZED BUILDING BLOCKS WITHOUT CEMENT STABILIZER

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Abstract - In the growing concern of awareness regarding sustainable building material, Stabilized sustainable building blocks gives the view of energy efficient, cost reduction, environmental friendly materials and overall contribution of the sustainable development. Above to this it is eco-friendly bricks which save environmental damage caused by cement based fly ash bricks which release enormous amount of carbon di-oxide in environment, which is almost equal to the production of cement. In the present investigation a stabilized sustainable building block specimen is cast using fly ash, clay, river sand and chemical stabilizer. Some of the chemical stabilizers available for making the blocks are Di-Ammonium Phosphate, Ammonium Phosphate, Polyvinyl Alcohol (PVA), Starch, Dextrin, etc.,. Di-Ammonium Phosphate and Ammonium Phosphate chemical stabilizer are eco-friendly and easily available when compared to the above mentioned chemical stabilizer, hence the blocks are made by using it. The blocks are made by varying mix composition of clay, fly ash and river sand as 1:1:2 and 1:2:1 with addition of gypsum about 0.5%and 1% and chemical stabilizer are in ratios of to dry weight of fly ash and clay as 2.5%, 5%, 7.5%, 10% and 12.5% respectively. The brick specimens are cast using standard brick mould of size 19cm x 9cm x 9cm and are compacted using table vibrator. Totally 32 specimens are casted. The cast specimens are cured by air curing and tested for the compressive strength and the results are obtained.

Keywords: Fly ash, Bottom ash, River sand, Chemical stabilizer, Compressive strength test, Water absorption test, Initial rate of absorption test and Efflorescence test.

I. INTRODUCTION

The history of civilization is synonymous to the history of masonry. The provision of good quality housing is recognized as an important responsibility for the welfare of people in many countries. For this reason, the building materials based on sustainable resources are often used.

Fly ash is a light coal dust coming out with the gases of coal-fired boilers. The particle size of fly ash varies from one sub-micron to several micrometers and mineral admixture, inert material and good Pozzolanic properties. The huge burning of low quality Indian coal results into generation of various by-products like bottom ash, boiler slag and fly ash. Primarily the fly ash particles consist of Silica and Alumina; carbon and oxides of iron, calcium, magnesium, sulphur, titanium etc. being the secondary ingredients. Fly ash, the after-burnt tiny coal dust is a by-product of the thermal power plants, property of which is dependent on the nature of the coal. The primary effect of fly ash production is the generation of a number of problems, mainly because of its minute size, non-reactive nature, presence of toxic elements and huge production. With the rise of need of more and more power, the production-amount of fly ash has no immediate chance of decline until the alternate power-generation methods are formulated and brought to function. The 'fly ash mission' aims at innovation of various biological and non-biological utilization procedures, which encompasses a spectrum of workers from road research engineers to forest research scientists. The effect of fly ash in ecosystems, especially on the plants, has drawn up deep attention of the environmentalists during the last few decades.

II. RESEARCH SIGNIFICANCE

This paper deals about the mechanical properties such as compressive strength with effects of the use of clay and fly ash with a chemical admixture in building blocks respectively. The mix composition consist of cementitious materials like Fly Ash provides substantial advantages over mixtures containing only Portland or blended cement which gives excellent resistance to water absorption. Ensuring the proportional use of various mix composition in a manner that positively develops not only strength but also improves the overall durability of the building blocks is still a focus for research

studies. As an added advantage, the fly ash are a better replacement for cement to reduce the cost and green house disposals it also proves to create a better evolution in the construction industry as well. It also helps in the reduction of environmental pollution.

III. TEST PROGRAMME

The blocks are made by varying mix composition of clay, fly ash and river sand as 1:1:2 and 1:2:1 with addition of gypsum about 0.5%and 1% and chemical stabilizer are in ratios of to dry weight of fly ash and clay as 2.5%, 5%, 7.5%, 10% and 12.5% respectively. The brick specimens are cast using standard brick mould of size 19cm x 9cm x 9cm and are compacted using table vibrator. Totally 32 specimens are casted. The cast specimens are cured by air curing and tested for the compressive strength and the results are obtained.

IV. MATERIALS AND MIX SPECIFICATION

Fly ash of Class F type was obtained from Mettur thermal power station is used as binder whereas clay(black cotton soil) collected from nearby field and the river sand is used as filler to get strength to the brick. Natural sand is used as fine aggregate and potable water is used. The materials such as fly ash, clay, river sand and chemical stabilizer were blended together in 40 different ratios and tests were conducted on these varying mix composition. Before that various lab test are carried out to determine the material properties such as fineness, bulk density, specific gravity through 45µm sieve test, standard proctor test and sieve analysis test respectively. The schematic diagram for making of brick blocks are shown in given flow diagram below.

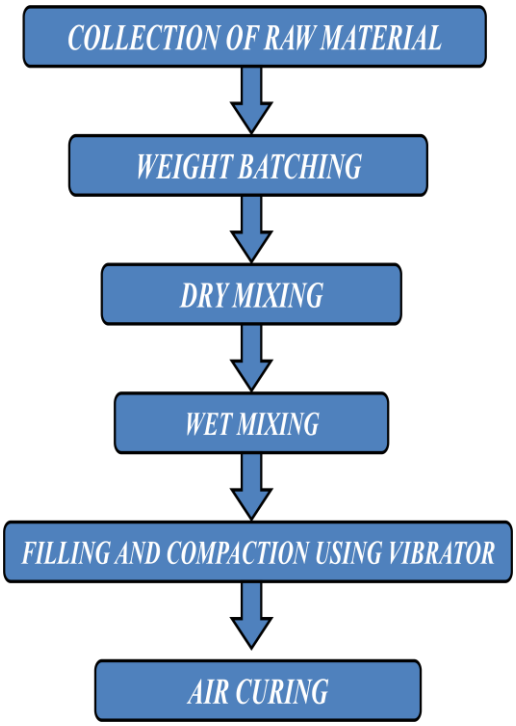


Fig.1 Casting methodology for brick to be tested

The variations in the blend per mix for 40 combinations are given in the table below.

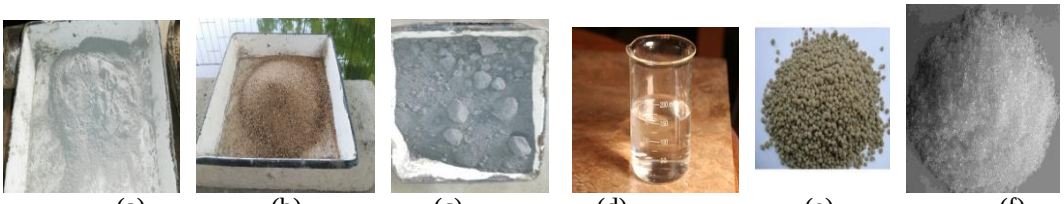
TABLE 1 MIX COMPOSITION FOR DI-AMMONIUM PHOSPHATE

Specimen	% of content combined			% of chemicals w.r.t. water	
	Clay %	Fly ash %	River sand %	Di ammonium phosphate %	$CaSO_4$ %
1	25	25	50	2.5	0.5
2				5	
3				7.5	
4				10	
5				12.5	
6				2.5	1
7				5	
8				7.5	
9				10	
10				12.5	
11	50	25	25	2.5	0.5
12				5	
13				7.5	
14				10	
15				12.5	
16				2.5	1
17				5	
18				7.5	
19				10	
20				12.5	

TABLE 2 MIX COMPOSITION FOR AMMONIUM PHOSPHATE

Specimen	% of content combined			% of chemicals w.r.t. water	
	Clay %	Fly ash %	River sand %	Ammonium phosphate %	$CaSO_4$ %
21	25	25	50	2.5	0.5
22				5	
23				7.5	
24				10	
25				12.5	
26				2.5	1
27				5	
28				7.5	
29				10	
30				12.5	
31	25	25	50	2.5	0.5
32				5	
33				7.5	
34				10	
35				12.5	
36				2.5	1
37				5	
38				7.5	
39				10	
40				12.5	

Table 1 shows that mix composition for Di-Ammonium Phosphate(DAP) (chemical stabilizer) with clay, fly ash and river sand with ratio of 1:1:2, with addition of gypsum 0.5% and 1% the dry weight clay and fly ash. The mix compositions are taken volumetric proportion. Using bulk density calculated from the lab experiments for fly ash, clay and river sand are 1.45g/cc, 1.52g/cc and 1.68g/cc respectively was used to determine the quantity of material required. Same procedure is repeated for calculating another mix composition for Ammonium Phosphate (chemical stabilizer) as shown in Table 2.Material required for casting of bricks are shown given below.



(a) (b) (c) (d) (e) (f)

Fig.2 Materials used for casting bricks

a.) Fly ash b.) River sand c.) Clay d.) Potable water e.) DAP f.) Ammonium Phosphate

V. CASTING OF BRICK SPECIMEN

A. Collection of Raw Material

The material used for casting brick specimens such as fly ash, clay, river sand, potable water and chemical stabilizer are taken from different source. Fly ash of class F type were bought from retailers in RMC plant with minimum lime content, clay(black cotton soil) collected from nearby field and the river sand is used as filler to get strength to the brick. River sand of zone II was used to increase its strength properties from construction sites nearby. Potable water

used was of pH 7 to be maintained. Chemical binders Di-Ammonium Phosphate and Ammonium phosphate were used to increase its binding properties Rs 21 per Kg and Rs100 per Kg repectively. The various lab tests were carried out on material to determine its material properties such as specific gravity, fineness, bulk density and fineness modulus etc,.

B. Batching of Raw Material

The material used for casting brick specimen can be batching by two methods volume batching and weight batching. In my project I am using weight batching method but the mix proportion were in the form of volumetric proportion shown in Table 1 and Table 2.Extra 20% is considered for loose and wastage in casting.

C. Mixing of Raw Materials

Mixing is of two types hand mixing or machine mixing. Machine mixing are more efficient than hand mixing because in machine mixing the materials are mixed properly than that of hand mixing. In my casting procedure I am using hand mixing method to mix the material used to be casting brick because of very low quantity to be mixed. Machine mixing are more efficient for large quantities only. Hand mixing can be done with wet mixing followed by dry mixing. First we have to mix the materials such as fly ash, clay and river sand properly and the water with chemical binders (DAP & AP) are heated and mixed with water and then added to the dry mix and then mix thoroughly to get proper paste form to be casted brick specimen.

D. Moulding and Compaction

Before compaction process to be done mould has to be prepared. For determining compressive strength of brick blocks standard size of 19cm x 9cm x 9cm are used. Before filling the mould with brick paste mould has to be applied with oil to get out specimen safely after hardening. There are two methods we can compact the mortar paste in the mould, machine compaction and hand compaction. Needle vibrator and Table vibrator are used for machine compaction method. Wired clay bricks are manufactured with machine compaction by applying high pressure to remove the excess air inside the paste to get high strength. Hand compaction methods can also be used for compaction but the only disadvantage it cannot produce over large scale but it also have very low strength compare to that of table vibrator method which more efficient. In these castings I am using table vibrator to compact mortar paste.

E. Curing

After compacting, the mould has to be kept for at least one day to harden after that mould is kept open in air for at least 14 days to harden it by removing moisture in that specimen.

(a) (b) (c) d) (e)

Fig.3 Casting of fly ash brick mortar cube specimen

a.) Batching b.) Dry mixing c.) Wet mixing d.) Compaction e.) Air curing

VI. EXPERIMENTAL INVESTIGATIONS

A. Compressive Strength Test

The Classical Method by crushing specimens in the compressive testing machine is to obtain the compressive strength as the test result. The compressive strength value for brick specimen is usually obtained experimentally by means of a compressive test. The bearing surfaces of the testing machine was wiped clean and again the surface of the specimen was cleaned from sand and other materials which may come in contact with the compression plates. While placing the specimen in the machine care was taken such that the load was applied to opposite sides of the specimen as cast and not to the top and bottom. The axis of the specimen was carefully aligned with the center of thrust of the spherically seated plate. As the spherically seated block is brought to bear on the specimen, movable portion was rotated gently by hand so that uniform seating was obtained. The maximum load applied to the specimen was recorded and failure is noted. The following fig shows the compressive strength test conducted on specimens.

The measured compressive strength of the specimen was calculated by the following equation.

$$\textbf{Compressive strength} = \frac{P}{A} \quad N/mm^2$$

Where,

P = Ultimate load in N.

A = Area of specimen in mm^2.

Fig.4 Compressive Strength Test on Brick Specimen

B. Durability Test for Brick

1) Water Absorption Test

The water absorption test was conducted as per IS: 3495 (Part2):1992 - Methods of Tests of Burnt Clay Building Bricks - Determination of Water Absorption. For each mix combination, a set of 3 brick specimens was tested after 28 days of curing.

The dry brick specimen was kept in oven at a temperature of 105°C to 115°C till it attained substantially constant mass. The bricks were taken out from oven and kept to cool at room temperature and the weight of the brick was noted (M1). The dried bricks were immersed in clear water at room temperature of 27± 2°C. After 24 hours, all the bricks were taken out from water and wiped out with a damp cloth to remove any traces of water. The weight of saturated brick was noted (M2). Water absorption value of brick is the percentage ratio of the change in mass to original mass.

Water absorption = $\frac{M2-M1}{M1}$ X 100

2) Initial rate of Absorption Test

As per the code ASTM Code 67 – Standard Methods of Sampling and Testing Brick and Structural Clay Tile is used for initial rate of absorption (IRA) test.

The IRA test setup is shown in Figure 4.4. A transparent tray was used for this test under room temperature. The paint was applied all fives side and except bottom side of the earth block. The bottom bed surface of the earth block was kept in contact with water. The other faces of the brick were sealed with paint. The bottom bed surface of the brick was placed inside the tray. The initial rate of absorption test shows that water flows in only one direction. Initial Rate of Absorption of earth block was measured for a period of 1- minute and 2-minutes. Following figure 6.7 shows the painted specimen and figure 6.8 shows the test setup of initial rate of absorption test.

3) Efflorescence Test

The efflorescence test is performed to know the presence of any alkaline matter in the bricks. It was performed as per IS: 3495 (Part 3):1992 - Methods of Tests of Burnt Clay Building Bricks - Determination of Efflorescence.

A set of 6 bricks was tested after 28 days of curing. The brick was placed in the plastic cage, the depth of immersion in water being 25 mm. The whole arrangement was placed in warm and ventilated room. The brick specimen absorbed almost all water in the dish. When the water was absorbed and bricks appeared to be dry, equal quantity of water added to maintain 25-mm depth of water in the Dish and the same water added to maintain 25 mm depth of water in the dish and the same procedure was repeated. The brick was examined for white/grey patches after second evaporation. The development and appearance of white/grey patches could be described as nil, slight, moderate, heavy or serious.

VII. RESULTS AND DISCUSSION

A. Compressive Strength Test Result

Compressive strength for different combination for Di-Ammonium Phosphate & Ammonium Phosphate ratio of fly ash, clay and river sand are tested using Compressive Testing Machine at 28th day. Before testing, the specimen should be prepared scratching the surface to make the surface even to distribute the load properly. Compressive strength result for the brick specimens of 40 combinations are shown in Table 3 and Table 4.

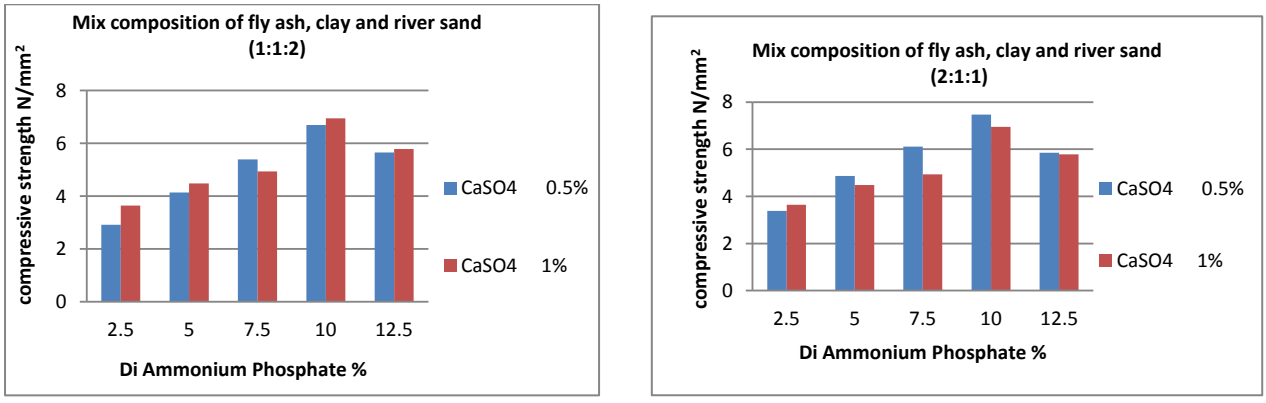
TABLE 3 COMPRESSIVE STRENGTH OF BRICK SPECIMEN FOR DI-AMMONIUM PHOSPHATE

Sample No	Mix composition of fly ash, clay and river sand (1:1:2)			
	$CaSO_4$ %	Di Ammonium Phosphate %	Load (kN)	Comp Strength (N/mm^2)
1	0.5	2.5	45	2.92
2		5	63.67	4.14
3		7.5	83	5.39
4		10	103	6.69
5		12.5	87	5.65
6	1	2.5	56	3.64
7		5	69	4.48
8		7.5	76	4.94
9		10	107	6.95
10		12.5	89	5.78
	Mix composition of fly ash, clay and river sand (2:1:1)			
11	0.5	2.5	52	3.38
12		5	75	4.87
13		7.5	94	6.11
14		10	115	7.47
15		12.5	90	5.85
16	1	2.5	65	4.22
17		5	78	5.07
18		7.5	89	5.78
19		10	128	8.32
20		12.5	98	6.37

TABLE 4 COMPRESSIVE STRENGTH OF BRICK SPECIMEN FOR AMMONIUM PHOSPHATE

Sample No	Mix composition of fly ash, clay and river sand (1:1:2)			
	$CaSO_4$ %	Di Ammonium Phosphate %	Load (kN)	Comp Strength (N/mm^2)
21	0.5	2.5	49	3.18
22		5	70	4.55
23		7.5	88	5.72
24		10	120	7.8
25		12.5	95	6.17
26	1	2.5	62	4.03
27		5	77	5
28		7.5	89	5.78
29		10	127	8.25
30		12.5	96	6.24
	Mix composition of fly ash, clay and river sand (2:1:1)			
31	0.5	2.5	64	4.16
32		5	83	5.39
33		7.5	105	6.82
34		10	120	7.8
35		12.5	97	6.3
36	1	2.5	74	4.81
37		5	86	5.59
38		7.5	95	6.17
39		10	134	8.71
40		12.5	103	6.69

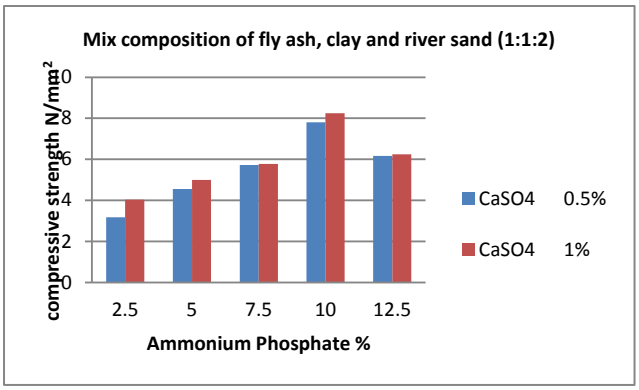
Bar chart is drawn between compressive strength at 28th day on y axis and chemical stabilizer (DAP& AP) on x axis for mix composition of fly ash, clay and river sand 1:1:2 & 2:1:1 ratio of binder to filler as shown in Figure 5 & Figure 6.



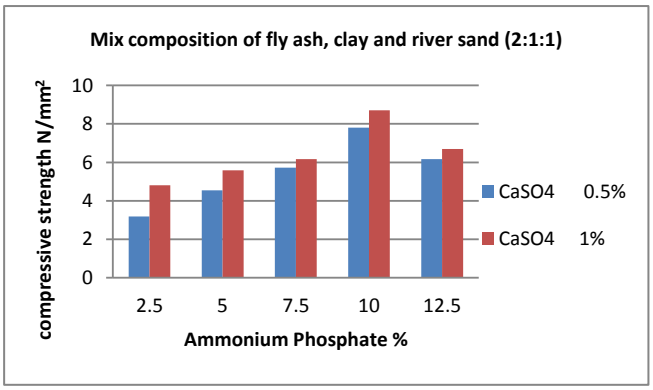
(a) *(b)*

Fig.5 Compressive strength vs. Di-Ammonium phosphate added

a.) Mix 1:1:2(fly ash : clay: river sand) *b.) Mix 2:1:1(fly ash : clay: river sand)*



(a)



(b)

Fig.6 Compressive strength vs. Ammonium phosphate added

a.) Mix 1:1:2(fly ash: clay: river sand) *b.) Mix 2:1:1(fly ash: clay: river sand)*

B. Durability Test Result

Durability test result for optimum compressive strength result bricks

TABLE.5 DURABILITY TEST RESULT MIX COMPOSITION OF BINDER : FILLER RATIO OF 1:2 & 1:1

Sl. No	Name of the durability test	Mix composition of fly ash, clay and river sand (1:1:2)	Mix composition of fly ash, clay and river sand (2:1:1)
1	Water absorption test value	13.67%	17.34%
2	Initial rate of absorption test value	For 1 minute - 0.424kg/m^2	For 1 minute - 0.524kg/m^2
		For 2 minute - 0.784kg/m^2	For 2 minute - 1.014kg/m^2
3	Efflorescence test value	Slight	Slight

C. Discussions

The residuals of waste collected from the thermal power plants such as fly ash and black cotton soil are used to reduce the use cement binder by adding chemical stabilizer to improve strength and durability properties. To do so, sand and fly ash has good properties of reducing shrinkage and cracking. The addition of sand has highly improved the grading properties of the fly ash. In this phase I project following discussions were made. Finally the compressive strength test for the standard brick specimen at different level of stabilizing agent(2.5%, 5%, 7.5%, 10% and 12.5%) at 28 days curing ages for the specimens were undertaken.

- The maximum and the minimum compressive strength obtained were 8.71 N/mm^2 (for 2:1:1 mix composition of fly ash, clay and river sand respectively for 1% of gypsum added with 10% chemical stabilizer Ammonium Phosphate) and 2.92 N/mm^2 (for 1:1:2 mix composition of fly ash, clay and river sand respectively for 0.5% of gypsum added with 10% chemical stabilizer Di-Ammonium Phosphate)
- Durability test were done on the optimum compressive strength attained cube on a brick size of 190mm x 90mm x 90mm, the test result shows are ready to use it as second class bricks.

VIII. CONCLUSION

In this project, an experimental investigation is carried out to manufacture a Sustainable Stabilized Fly ash Building Blocks (SSFBB) and tested. The following conclusions were drawn from the results of this experimental study.

Different research workers have contribution on the Sustainable Stabilized Building Blocks (SSBB) without using cement as a stabilizing agent in terms of different parameters. SSBBs were eco-friendly and these blocks were un-burnt products, during manufacture of these kind of bricks no coal or burning materials are used. So it does not produce any harmful gases like CO_2, CO and SO_4. The average compressive strength value calculated from sample with mix composition of fly ash , clay and river sand in a ratio of 2:1:1 with % of gypsum added with 10% chemical stabilizer Ammonium Phosphate gives a higher compressive strength when compared to country bricks for building construction. Durability test were done on the optimum compressive strength attained cube on a brick size of 190mm x 90mm x 90mm, the test result shows are ready to use it as second class bricks.

REFERENCES

[1] Sivakumar Naganathan, Kamal Nasharuddin Bin Mustapha , Alaa.A.Shakir “Development Of Bricks From Waste Material” , *Australian Journal of Basic and Applied Sciences*. ISSN 1991-8178. Vol. 7(8). 2013.

[2] M, Bennet Jose Mathew, Sudhakar M., “Development of Coal Ash – GGBS based geopolymer bricks”. *European International Journal of Science and Technology*. ISSN: 2304-9693.Vol. 2 No, 5 June 2013.

[3] P.M.Vijaysankar, R. Anuradha, V.Sreevidya, Dr. R. Venkatasubramani "Durability Studies of Geopolymer Concrete Solid Blocks" *International Journal of Advanced Scientific and Technical Research*, Vol.3(2), 2013.
[4] Radhakrishna, G. S. Manjunath. Tirupati Venu Madhava., K. Venugopal "Phenomenological Model to Re-proportion the Ambient Cure Geopolymer Compressed Blocks" *International Journal of Concrete Structures and Materials*. ISSN 19760485/eISSN 2234-1315. Vol.7, No.3, pp.193–202, September 2013.
[5] Cheah Chee Ban,C. A. Jeyasehar, S. Kandasamy "The high volume reuse of hybrid biomass ash as a primary binder in cementless mortar block"., *Journal of Engineering Science and Technology* Review 6 (1) (2013) 25-32. 2013
[6] B. Vijaya Rangan, Djwantoro Hardjito, SteenieE.Wallah, and Dody M.J. Sumajouw. Geopolymer: Green chemistry and sustainable development solutions, pp.133-137.
[7] Lingling, Xu, et al. "Study on fired bricks with replacing clay by fly ash in high volume ratio". *Construction and Building Materials* 19.3 (2005): 243-247.
[8] Turgut, Paki, and Halil Murat Algin. "Limestone dust and wood sawdust as brick material". *Building and Environment* 42.9 (2007): 3399-3403.
[9] Caroline EV, Dylmar PD, Jose N, Ronaldon P. "The use of submerged-arc welding flux slag as raw material for the fabrication of multiple-use mortars and bricks." Soldagem Insp 2009;14(3):257–62.
[10] Raut, S. P., R. V. Ralegaonkar, and S. A. Mandavgane. "Development of sustainable construction material using industrial and agricultural solid waste: A 51 review of waste create bricks." *Construction and Building Materials* 25.10 (2011): 4037-4042.