International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 10, October-2018

PARTIAL REPLACEMENT OF FLYASH WITH GGBFS AND GNSA IN FLY ASH BASED GEOPOLYMER CONCRETE

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ABSTRACT:* Concrete is the second biggest expending material after water on the earth. The generation procedure of cement produces a colossal measure of CO_2 into the air. The construction industry enhancing alternate binders too fully or partially to downgrade environmental pollution with supplements like fly ash, rice husk ash, GNSA, silica fumes, GGBFS, and meta kaoline etc., Fly ash is produced in huge volume from the combustion of coal in thermal power plants. The GGBFS is the remnant after manufacturing of steel in the steel manufacturing industries. The groundnut shell ash was obtained from ground nut shells which are the by-product of groundnut processing and as wastage which is used in small-scale boiler units in the manufacturing process of products the ground nutshell is used as fuel in large quantity to produce thermal energy. The expenditure of landfills amounts can be diminished by utilizing the plush siliceous material as a supplement in manufacturing concrete. The GGBFS, Fly ash, and GNSA are rich in silica content which will react with the alkali solutions chemically. Experiments were demeanour on fly ash based geo polymer concrete specimens of standard sizes with surrogate of various percentages of GNSA i.e., 2.5%, 5%, 7.5%, 10% and constant percentage of GGBFS i.e., 10% by weight of fly ash in fly ash based geo polymer concrete. The alkaline liquids sodium silicate and sodium hydroxide (NaOH) of 10M concentration utilized, and results were compared with those of plain fly ash based geo polymer concrete. For each percentage of GNSA and GGBFS added in geo polymer concrete, 9 specimens were tested for their respective mechanical properties at ambient curing periods of 7 days, 28 days and 60 days. The change in mechanical strength of geo polymer concrete i.e., Split tensile strength, Compressive strength, and Flexural strength is determined and analysed. The results obtained show us that the optimum content of GNSA and GGBFS to be added in combination to fly ash based geo polymer concrete is 5% and 10% to the weight of fly ash, and consequently there has been a significant increase in Split tensile strength, compressive strength, and Flexural strength of geo polymer concrete.

Keywords: Geo polymer Concrete, GGBFS, GNSA, Compressive strength, split tensile strength, Flexural strength.

1. INTRODUCTION

1.1 GEOPOLYMER CONCRETE

The term "Geo polymer" was first initiated to the world by Davidovits, anticipated that an alkaline liquid could be used to react with the silicon and the aluminum in a supply material of geological origin or in byproduct material such as low calcium groundnut shell ash to turn out binders. Because the chemical response that takes place is a polymerization procedure, he invented the term "geopolymer" to represent these binders. Geo polymers are the member of the family unit of inorganic polymers. Geo polymer concrete (GPC) is an impending material for structural application as an alternative of ordinary Portland cement (OPC) concrete. It can play a major role in green concrete technology by eliminating cement and utilizing various by-product materials such as groundnut shell ash and blast furnace slag. Studies demeanour over the preceding decades indicated potential repayment of fly ash based geo polymer over OPC concrete. It has been evidenced that based geopolymer concrete achieved outstanding durability and mechanical properties when cured in high temperature. Recent works on the geo polymerization of fly ash based geopolymer concrete reported that the production of geo polymeric materials with less water absorption, high mechanical strength, low density, significant fire and chemical resistance and negligible shrinkage. Due to these properties, geo polymeric materials are going over as an substitute to Portland cement for certain industrial applications in the areas of construction, transportation, mining, road building, aerospace, and metallurgy. The progress of compressive strength of geopolymers is attributed to specific structural transformations occurred in fly ash, GGBFS and GNA during geo polymerization and especially, due to the formation of a new amorphous alumina silicate gel phase in the geo polymeric matrices.

The main response item for consumption of alkali-activated silica is an alkaline silico-aluminate gel. The OH ion is active as a reaction catalyst all through the activation procedure and the alkaline metal (Na) take action as a structure-forming element. The arrangement of the gel contains Si and Al tetrahedral randomly disseminated along the polymeric chains that are cross-related so as to offer cavities of sufficient size to accommodate charge balancing hydrated sodium ions. Generally, the polymerization is accelerated at elevated temperature than ambient. Since groundnut shell ash based geopolymer paste reacts slowly at a low ambient temperature as compared to heat cured samples, these mixtures are usually subjected to mild curing temperatures ranging in between 30ºC to 85ºC and high essential humidity of about 95%. Curing times also different from quite a few hours to quite a few days and requires supplementary conditioning at ambient temperature.

Why Groundnut shell ash is used in geo polymer concrete?

Biomass is the third major chief energy resource in the world, after coal and oil. In all its forms, biomass currently provides more than 1250 million tonnes oil equivalent (MTOE) of primary energy. India is one of the major groundnut growing countries with 8.0 x 10^6 ha area under this crop with the average productivity of 938 kg/ha. It is as well known as peanut, monkey nut and goober nut. In the groundnut, kernel percent is 60-70% and groundnut shell is about 30-40% depending on the assortment and agro-climatic conditions. Presently loose groundnut shell is used for domestic heating and in industrial boilers. Burning of groundnut shell in loose form creates smoke polluting the environment. The GNSA is disposed in open lands which is diminishing the environment. The outcome of burning process is GNSA i.e., is very rich in silica and potassium oxide and Sodium oxides which may act as binders in Geo polymer concrete. The groundnut shell ash is taken from local Nandyal, Kurnool district, Andhra Pradesh.

2. MATERIALS AND METHODOLOGY

2.1 Fly ash:

Fly ash is characterized as the finely defined residue that outcome of the ignition of ground or powdered coal and that is transported by gases from the ignition zone to the particle removal system. Fly ash is removed from the ignition of gases by the dust compilation system also mechanically or by with electrostatic precipitators, before they are set free to the atmosphere. Fly ash particles are typically spherical, finer than lime and Portland cement, ranging in diameter less than 1micrometer not more than 150 micrometres. The fly ash for this study is collected from the RTPP, Produttur, Andra Pradesh.

2.2 GNSA (Groundnut shell ash):

The ground nut shell ash is collected from the small scale kilns which uses the ground nut shell as the main source for the heat generation. The collected ground nut shell ash is graded so that the debris particles if present they can be separated. The ground nut shell ash is sieved. The ground nut shell ash collected that should be free from water. The ground nut shell is collected from the boiler from the Nandyala, Kurnool district.

2.3 GGBFS (GroundGranulated Blast Furnace Slag):

GGBFS normally comes out of steel refining factories with higher lime content generally more than 30 % often as high as 50 %. Elevated percentage levels of Calcium Oxide (CaO) may give GGBFS unique self-hardening characteristics. It is also stated that the presence of Calcium in GGBFS in noteworthy quantities could interfere with polymerization setting pace and rework the microstructure. Therefore, it appears that the utilization of GGBFS is more preferable as a source material to make geo polymers. GGBFS used in this study was from the JSW cement, Nandyal, Andhra Pradesh.

2.4 Coarse Aggregates (CA):

The aggregate dimension superior than 4.75 mm is well thought-out as coarse aggregate. It can be establish from original bed rocks. Coarse aggregate are available in unlike shape as Irregular, Flaky, or rounded, Angular, partly rounded etc. It should be free from any organic impurities and the dirt content should be negligible. Either primary or secondary are sources from which the coarse aggregate is collected. In this cram the coarse aggregate used were of nominal size of 20mm and 12mm.

2.5 Fine Aggregates

Fine aggregate are basically sand come first from the marine environment or the land. Fine aggregates commonly consist of crushed stone or natural sand with most percentage of particles passing through a 4.75mm sieve. Natural sands are universally used as fine aggregates. Sand may be obtained from pits, river, and lake or sea shore and may contain chlorides which may cause corrosion of reinforcement, and may cause efflorescence. Hence it should be meticulously washed before use. Similarly, if river sand contains impurities likewise mud etc. it should be sponge down before utilize.

2.6 Alkaline Solutions:

The Alkaline solutions are sodium hydroxide, potassium hydroxide; sodium silicate and potassium silicate are the different solutions available in the market. Sodium-based solutions were preferred as they were economical than Potassium-based solutions.

2.6.1 Sodium hydroxide:

The sodium hydroxide with 97-98% purity, in pellet or flake form, is available in enormously. The sodium hydroxide(NaOH) solution was prepared by dissolving the pellets or flakes in water to formulate a solution with the required concentration.The mass of NaOH solids in a solution diverge depending upon the concentration of the solution expressed in terms of molar, M**.** The solution has been prepared before 24 hours of the mix so that the dissolution process should be completed and large amount of heat is liberated due to the process of dissolution should get dissipated for easy handling and mixing of geo polymer concrete. The concentration used in this study is 10M.

2.6.2 Sodium silicate:

The sodium silicate solution (Na_2Sio_3) is commercially available in diverse grades. The sodium silicate solution A53 with Sio_2:Na_2O proportion by mass approximately 2 is recommended. The sodium silicate solution should not allow to the environment for not more than 30min otherwise the thick layer will be formed on the solution.

2.7 Super plasticizers:

Super plasticizers represent a comparatively new category and superior version of plasticizer. They are chemically different from normal plasticizers. Utilization of super plasticizers consent the reduction of water to the extent up to 30% without diminishing workability and whereas the possible lessening up to 15% in case of plasticizers. The utilization of super plasticizer is being practiced for creation of flowing, self compacting, and self levelling and for the manufacture of high strength and high performance concrete. In this study, CONPLAST SP430 has been used in concrete mix to have high workability.

Curing Methodology:

The polymerization process is a chemical reaction between the silica and alumino liquids will occur as covalent bond. The formation of covalent bond occurs at high heat hence oven or stream curing is adopted for 24 hours at 70^{o} or higher. The ambient curing may possible by adding small percentage of calcium materials such as lime, GGBFS etc., so that there would be internal heat developed for the formation of covalent bond. In this study the GGBFS is added to accelerate the heat for the chemical reaction.

3. EXPERIMENTAL TEST RESULTS

3.1 Results of Workability Tests:

The test results were carried out for the Mixes for the combination of constant percentage GGBFS i.e., 10% and altering percentage of GNSA i.e., 2.5%, 5%, 7.5%, and 10% in the fly ash based geo polymer concrete. The of the Slump cone test were shown in below.

S.NO	Materials used in percentages	Notation of the mix	Slump cone test values (mm)
1	100% fly ash	M0	51
2	90% fly ash + 10% GGBFS + 0% GNSA	M1	57
3	87.5% Fly ash + 10% GGBFS + 2.5% GNSA	M2	52
4	85% Fly ash + 10% GGBFS + 5% GNSA	M3	44
5	82.5% Fly ash + 10% GGBFS + 7.5% GNSA	M4	38
6	80% Fly ash + 10% GGBFS + 10% GNSA	M5	26

Table 3.1: Slump cone values

The graph has been plotted for the above slump values which are represented below:

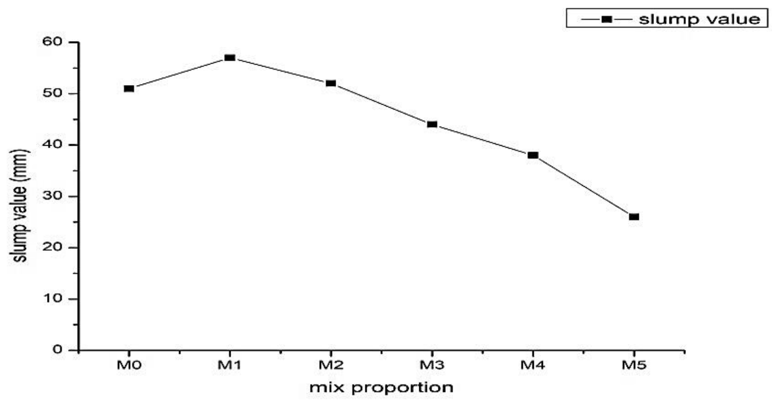

Fig 3.1: Slump Cone test

3.2 Results of Compressive Strength:

To test the compressive strength of the partial substitute of the GGBFS and GNSA in fly ash based geo polymer concrete the enormous standard sizes of cubes are tested for the ambient curing period of 7days, 28 days, and 60 days. The results of those specimens are demonstrated below.

S.No	Mix Notation	Materials used in percentages	7 days compressive strength	28 days compressive strength	60 days compressive strength
1	M0	100% fly ash	19.1	27.14	33.98
2	M1	90% fly ash + 10% GGBFS + 0% GNSA	28.79	43.62	48.09
3	M2	85% Fly ash + 10% GGBFS + 5% GNSA	29.43	45.93	49.87
4	M3	80% Fly ash + 10% GGBFS + 10% GNSA	25.98	42.36	45.64
5	M4	75% Fly ash + 10% GGBFS + 15% GNSA	22.06	37.46	40.24
6	M5	70% Fly ash + 10% GGBFS + 20% GNSA	19.27	30.58	32.86

Table 3.2: Compression test values

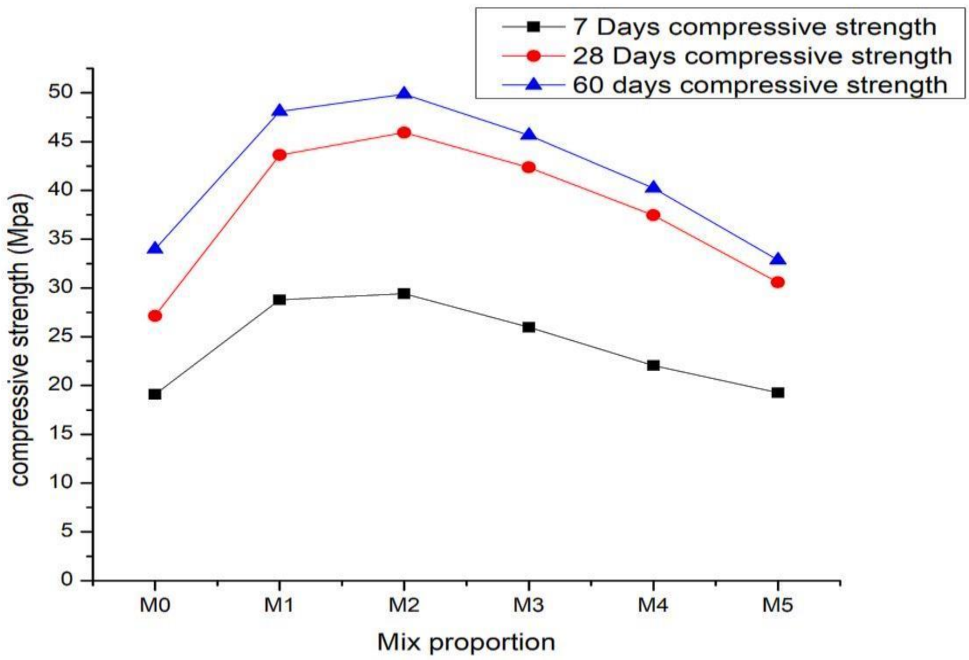

Fig 3.2: Compressive strength of the cubes for 7, 28 and 60 days of ambient curing

Different mixes with altering proportions exhibited different values which are observed. By observing the results it is noted that there is a significant increment in compression strength of cubes when replaced with a combination of GNSA and GGBFS. The values vary from 33.98 N/mm^2 to 49.87 N/mm^2 at a percentage replacement for the combination of 10% GGBFS and 5% GNSA. The greater compressive strength may be achieved with the addition of GGBFS and GNSA at optimum percentage.

3.3 Results of split tensile strength:

To test the split tensile strength of the partial substitute of the GGBFS and GNSA in fly ash based geo polymer concrete the enormous standard sizes of cylinders are tested for the ambient curing period of 7days, 28 days, and 60 days. The results of those specimens are demonstrated below.

S.No	Mix Notation	Materials used in percentages	7 days Split tensile strength	28 days split tensile strength	60 days split tensile strength
1	M0	100% fly ash	1.86	2.9	3.1
2	M1	90% fly ash + 10% GGBFS + 0% GNSA	2.3	4.07	4.589
3	M2	85% Fly ash + 10% GGBFS + 5% GNSA	2.36	4.12	4.599
4	M3	80% Fly ash + 10% GGBFS + 10% GNSA	1.98	3.53	3.69
5	M4	75% Fly ash + 10% GGBFS + 15% GNSA	1.73	2.84	3.07
6	M5	70% Fly ash + 10% GGBFS + 20% GNSA	1.59	2.53	2.67

Table 3.3: Split tensile test values

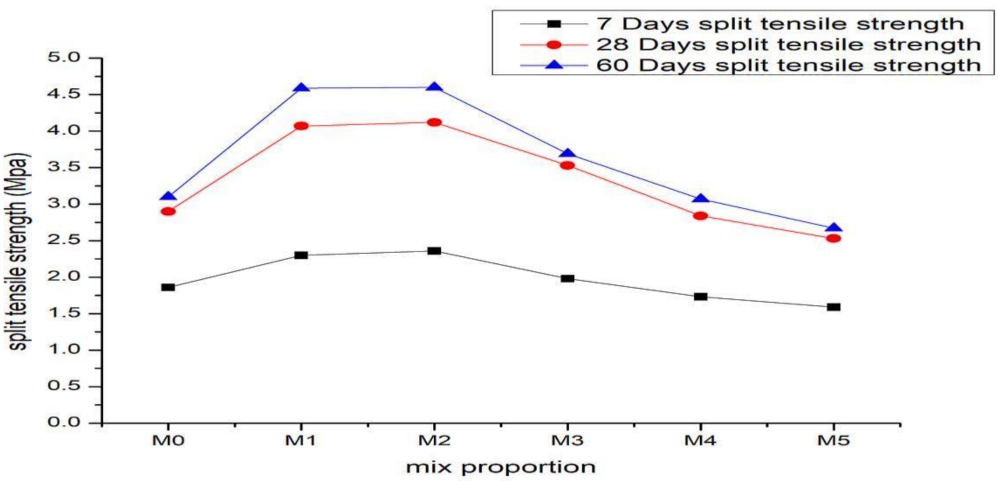

Fig 3.3: split tensile strength of the cylinders for 7, 28 and 60 days of ambient curing

Different mixes with altering proportions exhibited different values which are observed. By observing the results it is noted that there is a significant increment in split tensile strength of cylinders when replaced with a combination of GNSA and GGBFS. The values vary from 3.1 N/mm^2 to 4.599 N/mm^2 at a percentage replacement for the combination of 10% GGBFS and 5% GNSA. The greater split tensile strength may be achieved with the addition of GGBFS and GNSA at optimum percentage.

3.4 Results of flexural strength:

To test the flexural strength of the partial substitute of the GGBFS and GNSA in fly ash based geo polymer concrete the enormous standard sizes of beams are tested for the ambient curing period of 7days, 28 days, and 60 days. The results of those specimens are demonstrated below.

S.No	Mix Notation	Materials used in percentages	7 days flexural strength	28 days flexural strength	60 days flexural strength
1	M0	100% fly ash	3.05	3.66	4.15
2	M1	90% fly ash + 10% GGBFS + 0% GNSA	3.83	4.72	4.98
3	M2	85% Fly ash + 10% GGBFS + 5% GNSA	3.92	4.95	5.19
4	M3	80% Fly ash + 10% GGBFS + 10% GNSA	3.42	4.56	4.94
5	M4	75% Fly ash + 10% GGBFS + 15% GNSA	3.18	4.12	4.54
6	M5	70% Fly ash + 10% GGBFS + 20% GNSA	2.92	3.68	4.09

Table 3.4: flexure test values

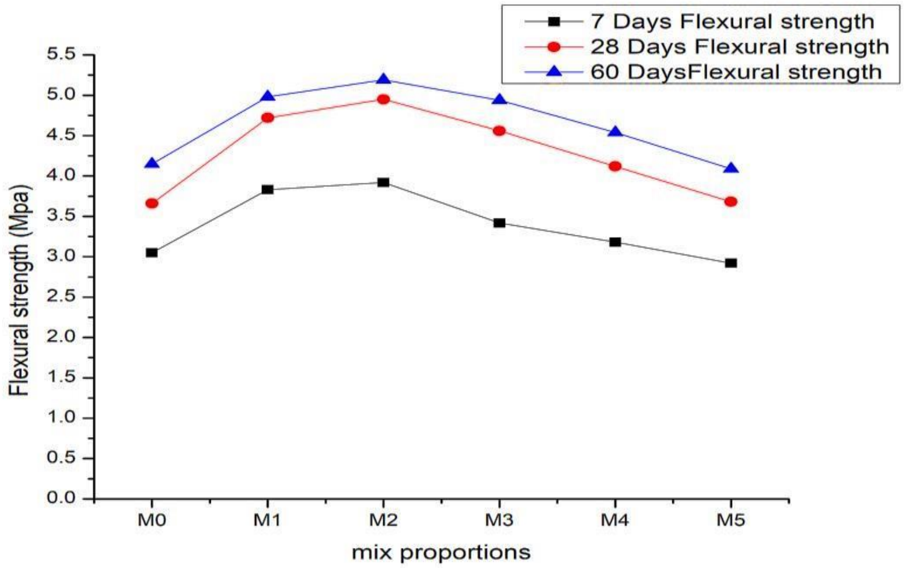

Fig 3.4: flexural strength of the beams for 7, 28 and 60 days of ambient curing

Different mixes with altering proportions exhibited different values which are observed. By observing the results it is noted that there is a significant increment in flexural strength of beams when replaced with a combination of GNSA and GGBFS. The values vary from 4.15 N/mm^2 to 5.19 N/mm^2 at a percentage replacement for the combination of 10% GGBFS and 5% GNSA. The greater flexural strength may be achieved with the addition of GGBFS and GNSA at optimum percentage.

4. CONCLUSIONS

From the above investigations, the effect of GGBFS and GNA as replacement of Fly ash in fly ash based geo polymer concrete but GGBFS is constant for all proportions adding for fly ash replacement, the following tentative conclusions are observed:

- By observing above results, we conclude that the workability of concrete is decreased by increasing the GNA content from 0% to 20% and constant GGBFS of 10% fly ash by weight
- The results show that the constant GGBFS and with regular increase in GNA content gives higher Compressive Strength, Split Tensile Strength and Flexure Strength compare to the fly ash based geo polymer concrete.
- As the GNA content increases, Compressive Strength, Split Tensile Strength and Flexure Strength increases up to 5% GNA by weight of fly ash and then decreases. Hence the GNA optimum replacement is 5%.
- The maximum increase in Compressive Strength, Split Tensile Strength, Flexure Strength are 46.76 %, 48.35%, 25.06% respectively compare to fly ash based geo polymer concrete.
- In all 3, 7 and 28days the maximum Compressive Strength, Split Tensile Strength and Flexure Strength obtained at the 5% of GNA with 10% of GGBFS with fly ash replacement in fly ash based geo polymer concrete.

REFERENCES

1. Gaurav Nagalia, Yeonho Park, Ali abolmia and Pranesh Aswath (2016), "Compressive strength and micro structural properties of fly ash based geo polymer concrete", journal of materials in civil engineering, ISSN 0899-1561.
2. B. Vijayarangan (2014), "Geopolymer Concrete for environmental protection", The Indian Concrete Journal, Volume 88, Issue 4, PP 41-48, 50-59.
3. P.Vignesh, K. Vivek (2015), "An experimental investigation on strength parameters of fly ash based geo polymer concrete with GGBFS" International Research journal of engineering and Technology Volume 02, Issue 02, PP 135-142.
4. Pattanapong Topark-Ngarm, Priya chindaprasirt and Vanchai sata (2015) "setting time, strength and bond of high calcium Fly ash geo polymer concrete", journal of materials in civil engineering ISSN 0899-1562.
5. Pradip Nath, Prabir kumar sarker (2014), "Effect of GGBFS on setting, workabilityand early strength properties of fly ash based geopolymer concrete cured in ambient condition" ELSEVIER PP163-171.
6. Kawade U.R , P.A Salunkhe and S.D. Kurhade (2014) "Fly ash based geo polymer concrete", IJIRSET, Volume 3, Special Issue 4, PP 135-138.
7. Madheswaram C.K, Gnanasundar G & Gopal Krishnan. N (2013), "Effect of molarity in geopolymer concrete", International jounal of civil and structural engineering, Volume 4, Issue 2, PP 106-114.
8. Buari T.A, Ademola S.A, Ayegbokiki S.T (july 2013), "Characteristics strength of GNSA and OPC blended Concrete in Nigeria", IOSRJEN, Volume 3, Issue 7, PP 01-07.
9. H. Mahmoud, Z.A. Belel, C.Nwakaire (2012), "Groundnut Shell Ash as Substitute of cement in Sandcrete blocks production", International journal of Development and Sustainability, Volume 1, Issue 3, PP 1026-1032.
10. Nadiminti Venkata Lakshmi, Polinati Satya Sagar (2017), "Study on substitute of Groundnut shell ash with cement", Challenge Journal of Concrete Research Letters, PP 84-90.
11. Fernado PR, Devika Madushai LA, Praththana M and Nanayakkara HM (2018), "Synthesis and Characterization of Clay Brick Utilized Waste GNSA", Journal of Waste resources and recycling, Volume1 Issue1.