Comparative Study of Properties of Fly Ash -Cement Bricks Made with Addition of Sand and Rice Husk Ash using PYTHON

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Abstract - *Bricks are important building material and it consumes larger amount, approximately 350 million tonns of fertile, top soil which leads to soil removal and land degradation. An imperative step in brick manufacturing is use of brick kilns, which causes serious environmental pollution and health harms. Burning of bricks mainly influence the concentrations of greenhouse gases in the atmosphere causing severe air pollution. So, there is a essential need for affordable, locally made, low tech eco bricks with a good strength as compared to the ordinary clay bricks for the masses, to avoid all these environmental threats. Fly Ash is a fused residue of clay minerals present in coal. This resource has been gainfully utilized for manufacture of Fly Ash- cement bricks as a substitute to common burnt clay bricks, leading to the conservation of natural resources and improvement in environment quality as well. The texture of Fly Ash Bricks is very similar to that of clay bricks and are comparatively lighter in weight and stronger than the ordinary Clay bricks.*

The present research aims at manufacturing two types of bricks using Fly Ash – Cement, first with sand and in second, sand is replaced with Rice Husk Ash. The parameters considered in the study are compressive strength, water absorption, dimension of bricks and structural test. The study outcome indicates an increase in compressive strength in Fly Ash – Cement-Sand bricks till the percentage of sand increases from 10% to 15% and decrease in compressive strength till the percentage of sand increases from 15% to 25%. The same trend is observed in the Rice Husk Ash-Fly Ash bricks, but higher compressive strength was found to be achieved in Fly Ash – Cement-Sand bricks. From the results it is also observed that, less amount of water is absorbed by Fly Ash – Cement-Sand bricks (9.13% for 15% of Sand), as compared to, the Fly Ash – Cement -Rice Husk Ash bricks (10.33% for 15% of Rice Husk Ash).

Key Words: Bricks, Fly Ash, Cement, Compressive Strength, Rice Husk Ash.

1. INTRODUCTION

In the present scenario in the construction industry, use of economic and environmental friendly material is of a great concern. Among various types of building materials-bricks, form the backbone of the construction sector. The Clay brick sector consumes nearly 35 million tonnes of coal annually, and its total carbon dioxide (CO_2) emissions are estimated at 41.6 million tonnes, accounting for 4.5 percent of total greenhouse gas emissions from India. In addition to coal, the red brick sector also consumes approximately 350 million tonnes of fertile top soil. Though alternative technologies such as fly ash bricks, are also being used which are manufactured using Major percentage of Fly ash generated from Thermal Power station. There are about 40 major thermal power plants in India which produces about 15 million tones of fly ash every year. Such enormous quantities need huge dumping grounds, and create pollution problems. Thus, Fly ash utilization reduces the top soil requirement for land filling / brick manufacturing and saves agricultural land. Also these bricks are subjected to less amount of damage than conventional bricks when exposed to salt crystallization cycles. Hence for the present study Fly Ash bricks are used instead of conventional bricks and other raw materials used are Cement, Rice Husk Ash, and Sand.

2. LITERATURE REVIEW

At the global level, extensive researches are going on to manufacture bricks, by using industrial wastes. Study of few pioneers have been discussed below:

Kayali (2005) investigated the high performance of bricks from Fly Ash. He concluded that the Fly Ash brick had 24 % better compressive strength and 44% higher bond strength than the good quality clay brick. Also, he reported that the tensile strength of the Fly Ash brick was three times greater than the value for standard clay bricks.

Taner (2006) determined the usability of clay and fine waste of boron from the concentrator plant in Kirkar as a fluxing agent in the production of red mud brick. Scale tests for production of bricks were carried out. Clay and fine wastes have similar chemical composition but include different types and amounts of oxides. They were added in amounts of 5%, 10% and 15% of weight to red mud bricks. Those consist of high amounts of Fe203, Al203, SiO2, and alkalies. Six different sets of samples have been produced and fixed at 700°C, 800°C and 900°C dry shrinkage of green body, bending and compressive strength, drying shrinkage, water absorption, frost resistance and harmful magnesia and line tests on heat –treated bodies.

Mistry (2011) reported that the Fly Ash bricks with conventional masonry work save 28% in cost compared with common red brick and conventional masonry work. The masonry work with new technology Rat-Trap bond in Fly Ash brick saves 33% cost as compared to common bricks.

Pitroda (2013) The resulting large quantities of agricultural wastes, unfortunately, are not always well managed or utilized. These wastes can be recycled, such as by retrieving fibres from disposed leaves and fruits bunches, and then incorporate in brick making. Class F Fly Ash is utilized in the brick manufacturing work as judicious decision taken by Engineers. As the percentage of the Rice Husk in brick increases, the compressive strength of the brick increases. In this experimental work 1% fibre addition in the brick gives the maximum strength 7.861 N/mm^2 after 21 days.

Varshney et al. (2014) researched on making bricks with Fly Ash, Stone dust, and cement, which are better alternative to conventional burnt clay bricks in structural, functional and economical aspects and can fulfill the objectives of affordable housing. The proportion of the raw materials is taken in the ratio at 64% of stone dust, 30% of Fly Ash, 6% of cement and water. The results show that the Stone dust Fly Ash cement bricks have more compressive strength & less water absorption in comparison to conventional clay bricks. Hence, it concludes that the use of stone dust and Fly Ash in the brick manufacturing industry is techno-economically viable.

Rai and Kumar (2014) Study about Bricks with the varying combinations of fly Ash and other ingredients materials like Fly Ash, Lime, Gypsum, Cement, Stone Dust Bricks. These bricks are better in cost and strength comparison to conventional Clay Bricks. The strength and cost are affected by varying the quantity of fly ash and other ingredient of these bricks.

Sumathi (2015) The study was conducted to find the optimum mix percentage of Fly Ash brick. However, the brick specimen of size 230mm x 110mm x 90mm were cast for different mix percentage of Fly Ash (15 to 50%), Gypsum (2%), Lime (5 to 30%) and Quarry dust (45 to 55%). The mechanical properties such as compressive strength were studied for different mix proportions, at different curing ages. From the results it was inferred that, among the seven proportions the maximum optimized compressive strength is obtained for optimal mix percentage of Flyash-15% Lime-30% Gypsum-2% Quarry dust-53% as 7.91 N/mm^2.

Naganathan et al. (2015) an investigation carried out on manufacturing of bricks using Fly Ash and bottom ash through a non-conventional method. Bricks were cast using self-compacting mixtures of bottom ash, Fly Ash and cement eliminating both pressing and firing. Bricks are then tested for compressive strength, modulus of rupture, ultrasonic pulse velocity (UPV), and water absorption, initial rate of suction, fire resistance, and durability. The author concludes that the results showed better performance when compared to conventional clay bricks and these bricks can be used as an alternative to conventional bricks and hence it contributes to sustainable development.

Gurlhosur et al. (2015) based on the test results concluded that addition of optimum or minimum quantity of Super plasticizer was identified. It was observed that by adding 2.5ml of Super plasticizer, Compressive Strength decreased as compared to the addition of 3ml Super plasticizer. As per standard norms the required Compressive Strength for Fly Ash based bricks are generally of the order 7.5-10 N/mm2 after 21 days of curing. By adding 2.5ml of Super plasticizer the Compressive Strength was less than or nearly equal to 7.5 N/mm^2. Therefore, it was decided to add another 0.5 ml and Compressive Strength was studied. It was seen that by adding 3ml the Compressive Strength raised to 12 N/mm^2 after 21 days of curing.

Kumar and Hooda (2016) researched on the effect of Fly Ash bricks on the performance and the properties with the comparison between clay brick and Fly Ash brick. The different tests are conducted like crushing strength, water absorption, shape and size, soundness, hardness and efflorescence. Based on the test results, Fly Ash bricks are stronger, more durable and economical when compared to conventional clay bricks.

Venkatesh et al. (2017) discussed on the implementation of Fly Ash and quarry dust as an effective replacement for cement in the manufacturing of bricks. The author examined three trial mix proportions such as Cement (50%, 60%, 70%), Fly Ash (40%, 30%, 20%) and 10% of Quarry dust. Based on the test results, the author concluded that the percentage of cement content can be replaced with quarry dust up to 25% without much loss in compressive strength and other properties.

Kumar & Tendulkar (2017) Based on limited experimental investigations concern that Bagasse ash Compressive strength decreases on growth in percent of Bagasse ash as evaluate to Fly Ash. Use of bagasse ash in brick can clear up the disposal hassle; reduce price and produce a 'greener' Eco- friendly brick for construction. Environmental results of wastes and disposal issues of waste may be reduced thru this research. A higher degree through an innovative Construction Material is fashioned through this study. It presents modern use of magnificence class "F" Fly Ash which incorporates much less than 20% lime. In this study, maximum compressive energy is received at 10% replacement of Fly Ash as bagasse ash. Bagasse ash bricks lessen the seismic weight of building.

Shariq and Parihar (2018) Study about Fly ash Cement Bricks which are manufactured by composition of Fly ash, cement and sand with requisite quantity of water mixed in proper proportions. Fly ash cement bricks are comparatively lighter in weight and stronger than the ordinary clay bricks. The strength and cost is affected by varying the quantity of fly ash and other ingredient of these bricks. The edges of Fly ash Bricks are good compared to lime bricks and clay bricks. Fly Ash Bricks were found to be sufficiently hard as scratching by the finger nail on the surface left no impression on it as compared to normal bricks.

3. MATERIALS AND TOOLS USED IN MANUFACTURING OF BRICKS

The following section describes about the materials used in the experimental investigation and the relevant engineering properties for conducting of experiments.

3.1Fly Ash

According to the American Concrete Institute (ACI) Committee 116R, fly ash is defined as 'the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system' (ACI Committee 232 2004). Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging in diameter from less than 1 µm to no more than 150 µm. The types and relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. The chemical composition is mainly composed of the oxides of silicon (SiO2), aluminums (Al2O3), iron (Fe2O3), and calcium (CaO), whereas magnesium, potassium, sodium, titanium, and Sulphur are also present in a lesser amount. The major influence on the fly ash chemical composition comes from the type of coal. The combustion of sub-bituminous coal contains more calcium and less iron than fly ash from bituminous coal. The physical and chemical characteristics depend on the combustion methods, coal source and particle shape. The chemical compositions of various fly ashes show a wide range, indicating that there is a wide variation in the coal used in power plants all over the world (Malhotra and Ramezanianpour 1994).Fly ash chemical composition determined using X-Ray Fluorescence (XRF) equipment in the CSIR – CIMFR, Bilaspur (C.G.) Laboratory.

Table -1: The Chemical Composition of fly ash from NTPC SIPAT

Constituents of Flay Ash	Percentage (%)
SiO_2	59.65
Al2O3	31.17
CaO	1.416
Fe_2O_3	5.040
Mgo	0.464
TiO_2	2.385
K_2O	1.414
N_2O	0.078

According to ASTM C 618-03, the amount of SiO2+ Al2O3+ Fe2O3 in fly ash should be less than 70%, while Sulphur trioxide (SO3) should be not more than 4%, and calcium (CaO) content not exceeding 10%. As per as data provided from X-Ray Fluorescence (XRF), fly ash used in this experiment was a class F fly ash. It was found that fly ash particles are generally spherical having different sizes with broken surfaces.

3.2 Rice Husk Ash (RHA)

Rice Husk Ash is derived from rice husks, which are usually regarded as agricultural waste and an environmental hazard. Rice husk, when burnt in open air outside the rice mill, yields two types of ash that can serve as fillers in plastics materials.The upper layer of the RHA mound is subjected to open burning in air and yields black carbonized ash. The inner layer of the mound being subjected to a higher temperature profile results in the oxidation of the carbonized ash to yield white ash that consists predominantly of silica.

3.3 Screw Jack Machine

Screw Jack Machine comprises of vertical threaded shaft reciprocating into the rectangular mould thus rendering the compressive force to fill material. The mould is used of dimension to cast a brick of standard dimension of 19 cm × 9 cm × 9 cm.

Fig. 1: Screw Jack Machine

3.4 Compression Testing Machine

Compression Testing is very common testing method that is used to established the compressive force or crush resistance of a material. Compression tests are used to determine the material behavior under a load. The maximum stress a material can sustain under a gradual load (constant or progressive) is determined. Compressive Strength Test is performed on a CT machine using 19cm × 9cm× 9cm samples. Three samples for each proportion are tested, with the average strength values stated in this report.

Fig. 2: Compression Testing Machine

4. PREPARATION OF BRICKS

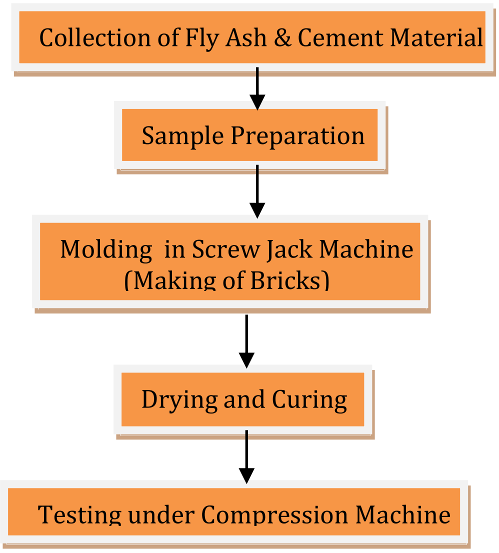

Fig. 3: Preparation of Bricks

The flow chart shows the preparation of bricks. The Fly Ash used from in present study is collected from NTPC sipat, and OPC collected from nearer 'RMC' plant. The collected fly ash and cement is sieved through 90-micron sieve size. The obtained fly ash and cement is taken, as well as the materials including rice husk ash, sand. These materials are sieved through 600 microns. Sample of 2 kg is taken (including 10%, 15%, 20%, 25% of materials- rice husk ash, sand) and then mixed with 500ml of water. Prepared sample is then used to make brick using Screw Jack Machine. Prepared brick is kept in an open space under sunlight for 2 days. These bricks are then cured under water at 7, 14, and 28 days. After curing, bricks were remove from water and soaked on cotton cloth; then after this various tests including Compressive Strength Test, drop down Test, Nail Scratch Test and Water Absorption Test are performed on the bricks.

Fig. 4: Prepared Bricks

5. RESULT AND DISSCUSSION

Tests on bricks were performed as recommended in IS-1077:2007. The observations were recorded for Sand, Rice Husk Ash. The obtained results in each test is compared with recommendations for 1st class brick is IS1077: 2007. The main focus is on compressive strength and water absorption of bricks. Compressive strength test on the brick are carried out to determine the load carrying capacity of bricks under compression. Water absorptions test shows the degree of compactness of the brick. The compression test is done to evaluate the strength of brick in compression. It is necessary for brick to have sufficient strength, to bear the loads. The present research illustration the estimation of 7, 14 and 28 days compressive strength of fly ash bricks made of cement, Sand, Rice Husk Ash.

Table -2: Compressive Strength of Fly Ash-Cement- Sand Bricks

S. No.	Fly Ash	Cement	Sand	Bricks	Compressive Strength (MPa)		
					7 Days	14 Days	28 Days
1	70	20	10	FCS1B1	3.16	4.97	8.31
				FCS1B2	3.11	5.1	8.15
				FCS1B3	3.12	4.92	8.27
2	65	20	15	FCS2B1	3.74	5.74	9.73
				FCS2B2	3.59	5.85	9.59
				FCS2B3	3.66	5.69	9.56
3	60	20	20	FCS3B1	3.31	5.24	8.71
				FCS3B2	3.52	5.31	8.69
				FCS3B3	3.39	5.29	8.61
4	55	20	25	FCS4B1	3.13	4.64	7.94
				FCS4B2	2.98	4.41	7.72
				FCS4B3	3.05	4.53	7.81

Table -3: Avg. Compressive Strength Fly Ash-Cement-Sand Bricks

S. No.	Fly Ash	Cement	Sand	Avg. Compressive Strength (MPa)		
				7 Days	14 Days	28 Days
1	70	20	10	3.14	5.02	8.25
2	65	20	15	3.67	5.76	9.64
3	60	20	20	3.40	5.28	8.67
4	55	20	25	3.06	4.52	7.83

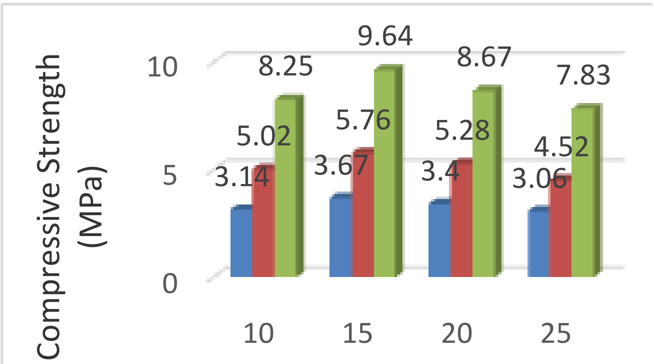

Chart -1: Avg. Compressive Strength Fly Ash-Cement- Sand Bricks

Table-4: Compressive Strength of Fly Ash-Cement- Rice Husk Ash Bricks

S. No.	Fly Ash	Cement	RHA	Bricks	Compressive Strength (MPa)		
					7 Days	14 Days	28 Days
1	70	20	10	FCR1B1	2.88	3.98	7.21
				FCR1B2	2.82	4.10	7.04
				FCR1B3	2.79	4.07	7.12
2	65	20	15	FCR2B1	3.41	4.54	8.62
				FCR2B2	3.26	4.72	8.48
				FCR2B3	3.30	4.64	8.53
3	60	20	20	FCR3B1	2.98	4.44	7.49
				FCR3B2	3.12	4.32	7.43
				FCR3B3	3.04	4.36	7.42
4	55	20	25	FCR4B1	2.71	3.78	6.95
				FCR4B2	2.83	3.75	6.79
				FCR4B3	2.69	3.63	6.81

S. No.	Fly Ash	Cement	RHA	Avg. Compressive Strength (MPa)		
				7 Days	14 Days	28 Days
1	70	20	10	2.83	4.06	7.13
2	65	20	15	3.34	4.63	8.54
3	60	20	20	3.05	4.39	7.45
4	55	20	25	2.74	3.71	6.84

Table -5: Avg. Compressive Strength Fly Ash-Cement- Rice Husk Ash Bricks

Chart -2: Avg. Compressive Strength Fly Ash-Cement- Rice Husk Ash Bricks

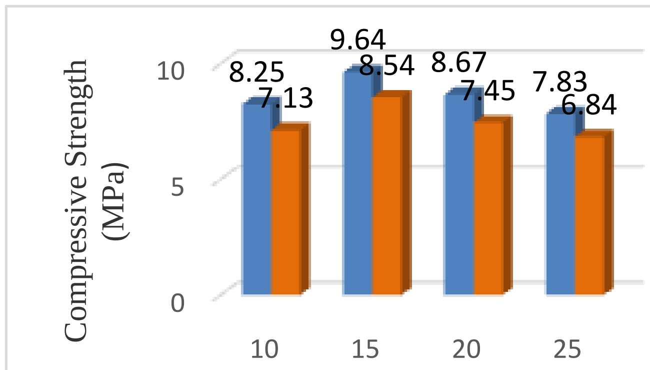

Chart -3: Compressive Strength of Fly Ash Cement - Sand Bricks and Fly Ash- Cement - Rice Husk Ash Bricks

Table 2 and Table 4 indicate the magnitude of compressive strength of Fly Ash- Cement- Sand bricks, Fly Ash- Cement - Rice Husk Ash bricks respectively after Curing Period of 7, 14, 28 days. The Chart 1 and Chart 2 graphically represent the average compressive strength of Fly Ash- Cement- Sand bricks and Fly Ash- Cement -Rice Husk Ash bricks respectively. The Sand and Rice Husk Ash were added in Fly Ash- Cement in the proportion of 10%, 15%, 20% & 25% by weight of Brick. From the Chart 3 it is clear that Compressive strength for Fly Ash- Cement- Sand bricks found to be 9.64 N/mm^2 for when 15% sand is added. On the other hand the Sand is replaced by Rice Husk Ash in same percentage with Fly Ash- Cement, the compressive strength found to be 8.54 N/mm^2.

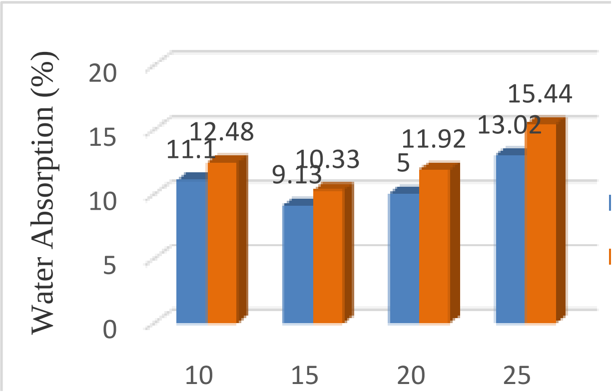

Chart -4: Water Absorption of Fly Ash Cement - Sand Bricks and Fly Ash Cement - Rice Husk Ash Bricks

Other impertinent parameter is water absorption. The water absorption for the two bricks when observed, i.e. Fly ash – Cement - Sand bricks and Fly ash –Cement- Rice Husk bricks decreases with percentage increases from 10% to 15 %, material. As a result, 9.13% of water is absorbed by Fly Ash – Cement- Sand bricks for 15% of Sand. For Fly Ash –Cement- Rice Husk bricks, it absorbed 10.33% of water when 15% of Rice Husk Ash is added. Therefore, the water absorption criteria is also fulfilled for a 1st class brick according to IS 1077-2007. Other test like drop down, nail scratch, dimension (IS 2691:1988) and structural homogeneity it satisfy all the norms of first class brick.

6. DATA VISUALIZATION USING PYTHON

Data visualization is the discipline of trying to understand data by placing it in a visual context so that patterns, trends and correlations that might not otherwise be detected can be exposed. This can be said as a graphic representation of data by the practice of translating information into a visual context, such as a map or graph, to make data easier for the human brain to understand and pull insights from. The main goal of data visualization is to make it easier to identify patterns, trends and outliers in large data sets. In this project, plots were made using Matplotlib, Pandas visualization and Seaborn. Using python the following contours were prepared which indicate the compressive strength of the Fly Ash Cement - Sand Bricks

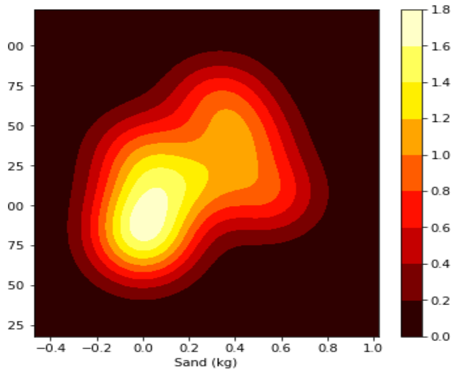

Fig.5: Contour Plot of Compressive Strength for Fly Ash Cement - Sand Bricks for 7 days

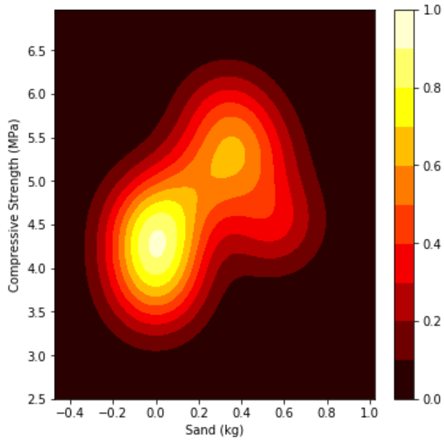

Fig.6: Contour Plot of Compressive Strength for Fly Ash Cement - Sand Bricks for 14 days

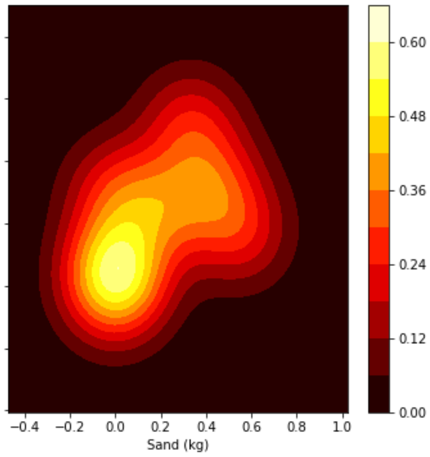

Fig.7: Contour Plot of Compressive Strength for Fly Ash Cement - Sand Bricks for 28 days

7. CONCLUSIONS

Various tests were performed on Fly Ash Bricks made of Materials (Cement, Sand, Rice Husk Ash) as per IS Recommendation IS 12894–2002. On the basis of present study various conclusions were drawn. From the result it is concluded that compressive strength for Fly Ash-Cement – Sand bricks increase till the percentage of Sand increases from 10% to 15% and found to be 9.64 N/mm^2 when the percentage of sand is 15%. The Compressive Strength decreases till the percentage of Sand increases from 15% to25%. In Fly Ash – Cement -Rice Husk Ash bricks the compressive strength increases with increases in percentage of Rice Husk Ash up to 15% and found to be 8.54 N/mm^2. Further increase of percentage of Rice Husk Ash as 20% to 25% the compressive strength is seen to be decreasing. In water absorption test, Fly Ash – Cement -Sand bricks absorbed less amount of water i.e. 9.13% for 15% of Sand. Similarly, Fly Ash- Cement - Rice Husk Ash brick absorbed 10.33% of water for 15% of Rice Husk Ash. In Drop-down Test, brick was found in a good condition when dropped from 1 meter of height. These Bricks were uniform in shape and size hence no finishing was required. In structural test, the broken surface of brick was homogeneous, compact and free from any defects such as holes, lumps etc. when observed. Thus in the present research, utilization of the waste material was done for making bricks. Other important fact is that, by using the rice husk or fly ash for making bricks, the top layer of fertile soil is being conserved. Therefore, soil as the natural resource is being saved from getting depleted and the bricks made out of the waste materials coming out from industries and agriculture like Fly Ash and Rice Husk Ash are preventing environmental pollution as well.

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