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Strength and Durability Characteristics of Fly Ash, Waste Paper, Gypsum and Cement Bricks.

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Abstract:

A widely used type of brick for various constructions in the country is burnt clay brick. They are usually manufactured in the brick kilns which typically collects the clayey soil from the rural part of the country mainly from agricultural land. They are the backbone of construction in urban as well as rural India. A country which is typically dependent on agricultural production, the usage of soil from agricultural land has lead to its loss of fertility. The production of these burnt bricks has some serious environmental concerns such as burning of clay in brick kilns leads to production of many greenhouse gases such as carbon dioxide which leads to global warming. Smoke from brick kilns causes many serious health issues among the workers of brick kiln as well as people residing near them. Therefore a substitute for burnt clay i.e., cement, fly ash, phosphogypsum and waste paper is used in different proportions and their various properties are analyzed in this research paper.

Key Words

Waste Paper, Fly Ash, Cement, Durability, Sulphate resistance, non-conventional bricks.

1. Introduction

Generally ordinary burnt clay bricks are used in India for the construction of civil engineering structures.[1] There are numerous disadvantages of these such as environmental pollution like land and air pollution. Burning of bricks using coal cause air pollution.[2] Greenhouse gases are produced by burning of coal that results to pollution in the environment. Huge amount of clay is invested for manufacturing the clay bricks and those clay are obtained from agricultural land which also a reason for land pollution by removal of topmost fertile layer of the soil. Approximately 60 billion clay bricks are manufactured in the country annually causing a strong impact on unprocessed emissions and soil erosion.[3] About 150 million tonnes of top soil is required for clay brick production that converts approximately 8000 acres of fertile land to gets barren.[4] Several social issues related to labour and the wages are associated with the production of conventional bricks.[5] So nowadays researches are being carried out to study various properties of bricks prepared using various by products like fly ash, phosphogypsum and waste paper, etc. are used in appropriate proportion with cement to obtain bricks of the desired specifications, and it has been found that these bricks formed out of by products or some different virgin products can be used as a replacement of conventional bricks.[6] Moreover, such bricks can be easily manufactured at comparatively low cost with good compressive strength.[7] This paper focuses over the compressive strength of bricks and their durability formed out of these by products.

2. Material Used

In this study fly ash used is obtained from thermal power plant located at Kolkata. Phosphogypsum ($CaSO_4$. 2 H_2O) is achieved from agricultural products manufacturing company, cement from local market and waste papers are 80 GSM used bond paper.

3. Mix Proportions

The first part of this investigation is dedicated to various mix proportions of fly ash, cement, Phosphogypsum and waste paper, were investigated for their compressive strength and it was found that bricks prepared with fly ash, cement, Phosphogypsum or waste paper give satisfactory compressive strength. Water absorption parameter of these non-conventional bricks was found to be on higher side as compared to the traditional burnt clay bricks. The purpose of this investigation is to discuss the durability and strength of the non-conventional bricks, both the durability and strength parameter is discussed in this article. Table No.1 represents the various mix proportions used for the present investigations.

Table 1: Mix proportions

Sl. No.	Mix Proportion	Percentage of constituents

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		Fly ash	Cement	Phospho-gypsum	Waste Paper
1	P1	20	60	20	0
2	P2	22.5	55	22.5	0
3	P3	25	50	25	0
4	P4	27.5	45	27.5	0
5	P5	30	40	30	0
6	P6	32.5	35	32.5	0
7	P7	35	30	35	0
8	P8	37.5	25	37.5	0
9	P9	40	20	40	0
10	P10	42.5	15	42.5	0
11	P11	45	10	45	0
12	P12	0	50	0	50
13	P13	0	40	0	60
14	P14	0	30	0	70
15	P15	0	20	0	80

4. Methodology

Mixing of Raw Material: A pan was taken with weighed quantity of cement, fly ash & Phosphogypsum or paper and was mixed. Water was weighed and added according to the consistency test to the mixture. The mixture is kept on stirring constantly such that it attains a uniform colour, which states that the composition is uniform. A uniform standard cement mortar cube moulds of dimension 70.7mm x 70.7mm x 70.7mm are being used for the preparation of bricks. These moulds are then kept undisturbed for 24 hours, after that bricks are taken out from the moulds and are kept under the atmospheric condition for 48 hours for air drying. Once the bricks has attained sufficient strength, they are then transferred to a water filled curing tank. The durability of these bricks were deduced through curing them in the environment of sulphate solution. The sulphate solution is having a concentration of 10,000 ppm was used, prepared by mixing 14.79 g of Na2 SO4 in a litre of water.

5. Experimental Work and Test Results.

Brick cubes were prepared as per the proportions in table 1 and tested for compressive strength and was found that even the proportion P15 had the needful strength required for the brick to be used in construction works which is the most economical mix proportion among all. The results of the tests conducted are mentioned in the table 3 below.

Table 2: Compressive strength & water absorption of cubes

Mix Designation	Compressive Strength in MPa			Water Absorption (%)
	7 days	14 days	28 days	
P1	15.11	19.61	27.91	26.99
P2	13.66	18.91	26.14	27.36
P3	12.85	17.12	24.11	28.97
P4	11.56	16.56	22.00	29.36
P5	10.88	16.26	20.57	30.35
P6	10.54	15.99	18.98	30.97
P7	10.11	14.53	18.33	25.13
P8	6.87	13.55	17.87	22.82
P9	5.77	10.11	17.65	20.32
P10	4.55	9.96	13.43	25.00
P11	3.22	7.69	11.97	28.53
P12	3.43	6.98	11.69	28.63
P13	2.00	3.98	7.93	32.11
P14	1.87	2.98	4.46	33.83
P15	0.98	1.99	2.82	34.26

Figure 1 Shows the variation of compressive strength with the increment in the percentage of cement in the mixture of cement, flyash and Phosphogypsum at 7th day, 14th day and 28th day.

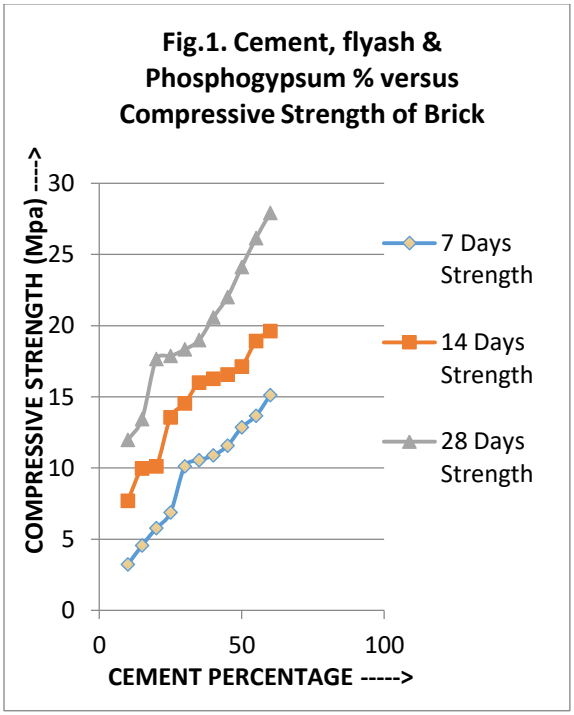

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Figure 2 Shows the variation of compressive strength with the increment in the percentage of cement in the mixture of cement and wastepaper at 7th day, 14th day and 28th day.

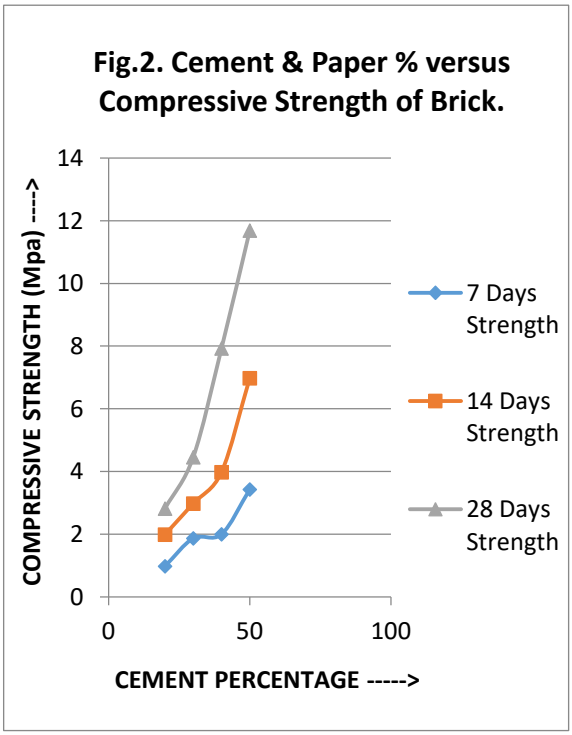

Table 3: Compressive strength and water absorption of bricks for P15 mix proportion

Mix Designation	Compressive Strength in MPa			Water Absorption (%) after 28 days
	7 days	14 days	28 days	
P15	0.98	1.99	2.82	34.26

After execution the compressive strength test and water absorption test on bricks prepared using P15 mix proportion, it was established that even the mix P15 is suitable enough to be used as brick material instead of clay.

Subsequently analysing the cubes for sulphate attack it was observed that the compressive strength decreases due to exposure to sulphate solution. Table 5 represent the data of all tests i.e. compressive strength of non-convention bricks with curing in water, compressive strength after curing in sulphate solution and water absorption test.

Table 4: Compressive strength of cubes after curing in Sulphate solution

MIX	P1	P2	P3	P4	P5
CS-28 days MPa.	21.11	20.67	19.16	18.38	17.65
MIX	P6	P7	P8	P9	P10
CS-28 days MPa.	17.16	16.97	16.55	16.33	12.69
MIX	P11	P12	P13	P14	P15
CS-28 days MPa	11.38	8.183	5.53	2.81	1.69

Table 5: Summary of results

Mix Designation	Compressive Strength in MPa		% loss of compressive strength due to sulphate attack.	Water Absorption (%)
	28 days curing in water	28 days curing in sulphate solution		
P1	27.91	21.11	24.36	27.87
P2	26.14	20.67	20.92	28.66
P3	24.11	19.16	20.53	29.97
P4	22.00	18.38	16.45	30.55
P5	20.57	17.65	14.19	31.34
P6	18.98	17.16	9.58	31.65
P7	18.33	16.97	7.41	25.11
P8	17.87	16.55	7.38	23.74
P9	17.65	16.33	7.47	20.68
P10	13.43	12 .69	5.51	26.13
P11	11.97	11.38	4.92	28.99
P12	11.69	8.183	30.00	29.43
P13	7.93	5.53	30.26	33.24
P14	4.46	2.81	36.99	35.88
P15	2.82	1.692	40.00	37.44

7. Conclusions.

On the basis of experimental investigation, these results could be concluded.

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1. There is a huge possibility exists for the bulk production of nonconventional bricks.
2. The test cubes are having sufficient compressive strength to be used as replacement of clay bricks.
3. Cement mixed with fly ash and phosphogypsum content equal to 90% provides much better compressive strength and 28.99 % water absorption, 11.97 Mpa compressive strength and fit for use in construction projects.
4. The non-conventional bricks being lighter in weight will reduce the dead load of the structure as a whole.
5. When the samples are subjected to Sulphate concentration, the cementitious binders which gave low water absorption exhibited a very low strength loss.
6. The water absorption percentage of non-conventional bricks with fly ash, waste paper, cement and phosphogypsum brick is found more than 20, but such bricks can only be used as non-structural elements where water absorption is not a problem. i.e. for internal separation walls.

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