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AN EXPERIMENTAL INVESTIGATION OF THERMAL INSULATION PROPERTIES OF BRICK WALL

1K.Pandeeswari, Assistant professor, Department of Civil Engineering,
Sethu Institute of Technology, Kariapatti, Viruthunagar.
2K.Vijay Anand, P.G.Scholar, Department of Civil Engineering
Sethu Institute of Technology, Kariapatti, Viruthunagar.

Abstract: Although the use of fly ash has many advantages, its low hydration at early stage causes the strength to be low. In this study, the experimental investigation was carried out to find the optimum mix percentage of fly ash brick. However the brick specimen of size 230mm x 110mm x 75mm were cast for different mix percentage of Fly ash (55 to 60%), Gypsum (5%), Lime (15 to 22%) and Quarry dust (20 to 25%), Cork powder-(1%,3%,5%,7%)compressive strength were studied for different mix proportions. The results shows the variation of compressive strength and thermal insulation for different mix proportions of materials mentioned earlier at different curing ages. From the results it was inferred that, the maximum optimized compressive strength and thermal insulation is obtained for optimal mix percentage of Flyash-60% Lime-20% Gypsum-5% Quarry dust-15%,Cork powder-(1%,3%,5%,7%).

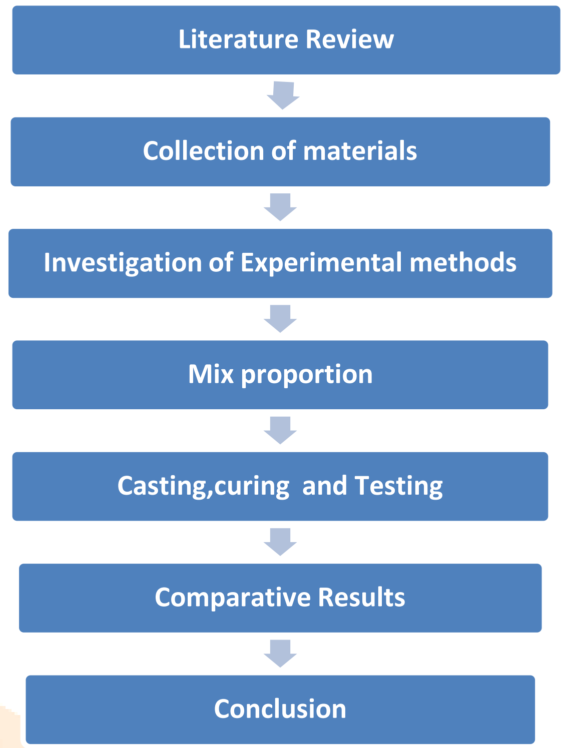
Key words: Fly ash, Lime, Gypsum, Quarry dust, Cork powder, Thermal insulation, Compressive strength and Water absorption.

Introduction

In the present scenario in the construction industry, use of economic and environmental friendly material is of a great concern. One of the main ingredients used is cement. It is observed from various studies that the heat emitted from cement accounts to a greater percentage in global warming. Cement industries account to a greater emission of CO_2 and they also use high levels of energy resources in the production of cement. In order to minimize these effects, replacement of cement with some pozzolanic materials such as fly ash, can have an improving effect against these harmful factors. In this work, identified the optimum mix of fly ash (major ingredients) generated at Barapukuria Thermal Power Plant, sand, hydrated lime and gypsum and also optimized the brick forming pressure. Fly ash- 55%, sand- 30% and hydrated lime – 15% with gypsum-14% was found to be the optimum mix. For the optimum mix studied the compressive strength, microstructure, shrinkage property, unit volume weight, Initial rate of absorption,

absorption capacity, apparent porosity, open pore and impervious pore of the fly ash–sand–lime-gypsum bricks produced with optimized composition under various brick forming pressures, Efflorescence and radio activity of the bricks formed under optimized conditions were also investigated1. In this paper, experimentally investigated the fly ash brick mix proportions by Taguchi method. Least quantity of cement and fly ash has been used as binding materials and considered the control factor as water binder ratio. Both. So the effects of water/binder ratio, fly ash, coarse sand, and stone dust on the performance characteristics are analyzed using signal-to-noise ratios and mean response data. Furthermore, the estimated optimum values of the process parameters are corresponding to water/binder ratio of 0.4, fly ash of 39%, coarse sand of 24%, and stone dust of 30%. 2. The addition of fly ash up to 60% at a fixing temperature as 950ºc has no significant harmful effects on the brick quality.It seems that the fly ash added building bricks show reasonably good properties and may become competitive with the conventional building bricks. Use of fly ash as a raw material for the production of building bricks is not only viable alternative to clay but also a solution to difficult and expensive waste disposal problem. 3. In the present work the attempt has made to find the optimum mix percentage of to obtain maximum compressive strength of flyash brick admixed with lime, gypsum and quarry dust at various proportions.

Objective: To find out the optimum mix design for making brick so as to achieve the maximum compressive strength and thermal insulation by using thermal sensor.



Methodology:

Materials used

Fly Ash

Quarry dust

Lime

Gypsum

Cork powder

Properties of Materials

Fly ash:

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. ASTM broadly classify fly ash into two classes Class F: Fly ash normally produced by burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only. Class C: Fly ash normally produced by burning lignite or sub-bituminous coal. Some class C fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties, class C fly ash also possesses cementious properties. Fly ash used is of type class C with a specific gravity of 2.19.

Quarry dust:

It is residue taken from granite quarry. Due to excessive cost of transportation from natural sources locally available river sand is expensive. Also creates environmental problems of large-scale depletion of these sources. Use of river sand in construction becomes less attractive, a substitute or replacement product for concrete industry needs to be found. Whose continued use has started posing serious problems with respect to its availability, cost and environmental impact. In such a case the Quarry rock dust can be an economic alternative to the river sand. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. After processing fine particles of size less than 4.75 mm is used in this work.

Lime:

Lime is an important binding material in building construction. It is basically Calcium oxide (CaO) in natural association with magnesium oxide (MgO).Lime reacts with fly ash at ordinary temperature and forms a compound possessing cementitious properties. After reactions between lime and fly ash, calcium silicate hydrates are produced which are responsible for the high strength of the compound.

Gypsum:

Gypsum is a non- hydraulic binder occurring naturally as a soft crystalline rock or sand. Gypsum have a valuable properties like small bulk density, incombustibility, good sound absorbing capacity, good fire resistance, rapid drying and hardening with negligible shrinkage, superior surface finish, etc. In addition it can strengthen material or increase viscosity. It has a specific gravity of 2.31 grams per cubic centimeter. The density of gypsum powder is 2.8 to 3 grams per cubic centimeter.

First Arriving mix percentage of flyash bricks for Flyash (55 to 60%), Lime (15 to 22%), Gypsum (5%) and Quarry dust (20 to 25%).Standard flyash brick size of 230 mm x 110mm x 75 mm are used to cast the bricks. For each proportion 50 number of bricks are casting in that nine bricks are used to determine the compressive strength of brick in N/mm² at 7days,14days,21days curing time and three bricks are used to determine the water absorption. Compressive Stress is determined using Compression Testing Machine (CTM) of 3000 kN capacity.Thermal insulation is determined by using thermal sensor.

Cork powder:

Cork is an impermeable, buoyant material, a prime-subset of bark tissue that is harvested for commercial use primarily from Quercus suber (the Cork Oak), which is endemic to southwest Europe and northwest Africa. Cork is composed of suberin,a hydrophobic substance, and because of its impermeability, buoyancy, elasticity, and fire resistance, it is used in a variety of products. The Montado landscape of Portugal produces approximately 50% of cork harvested annually worldwide. Cork was examined microscopically by Robert Hooke, which led to his discovery and naming of the cell. The cork used in the present work is coming from Maamora's forest located in the vicinity of Salé city, Morocco. The exploitation of cork oak trees in Morocco aims to manufacture cork panels, champagne bottles cap etc.; the granular cork waste resulting (of this manufacturing) is then used in the present work to improve
thermal properties of gypsum. Collected cork was ground in a hammer-mill at 3000 cycles per minute, sieved at sizes <12.5 mm. The density of the used cork is 70–85 (kg m3) corresponding to thermal conductivity of 0.049–0.05 (W m_1 -K_1); the density and thermal conductivity of cork does not depend on the grains size.

Mix Proportion:

To make the fly ash brick following mix proportions are arrived by trial and error method. The Table.1shows the various mix proportions

Table 1 Various Mix Proportions

Proportion of Binder	FLY ASH %	STONE DUST %	CORK POWDER%	LIME%	GYPSUM%
FAB1	60	14	1	20	5
FAB2	60	12	3	20	5
FAB3	60	10	5	20	5
FAB4	60	8	7	20	5

The quantity of materials required to cast a single brick is arrived by taking a brick weight of 3.1kg is given in the Table.2.

Table 2 Quantity of Materials used

Proportion of Binder	FLY ASH kg/brick	STONE DUST kg/brick	CORK POWDER kg/brick	LIME kg/brick	GYPSUM kg/brick
FAB1	1.86	0.434	0.031	0.62	0.155
FAB2	1.86	0.372	0.093	0.62	0.155
FAB3	1.86	0.31	0.155	0.62	0.155
FAB4	1.86	0.248	0.217	0.62	0.155

Preparation and Testing of Specimens

Casting of bricks

The normal hand mould is used to cast the bricks with the standard size of 230mm x 110mm x75mm.They were cast according to the standard procedure with various mix proportions arrived. The required quantity of Fly ash, Lime, Gypsum, Quarry dust,Cork powder is calculated previously, according to that the materials mixed properly. Then required quantity of water was added. Then they mixed thoroughly. Then the prepared mix was poured in to the machine and it is compacted. After compacting gets over then the mould is removed. Then the wet brick was kept under air curing for 2 days and then bricks were water cured for a period of 7,14,21 days.

Tests are applied to bricks:

Compressive Strength test

Water Absorption test

Temperature test

Compressive strength test

The compressive strength of flyash brick is three times greater than the normal clay brick. The minimum compressive strength of clay brick is 3.5 N/mm².So as the flyash brick has compressive strength of 10-12 N/mm². Bricks to be used for different works should not have compressive strength less than as mentioned above. The universal testing machine is used for testing the compressive strength of bricks.

After the curing period gets over bricks are kept for testing. To test the specimens the bricks are placed in the Compression testing machine of capacity 3000 kN applied a load uniform at the rate of 2.9 kN/min. The load at failure is the maximum load at which specimen fails to produce any further increase in the indicator reading on the testing machine. In that three numbers of bricks were tested for each mix proportion. Each brick may give different strength. Hence, average of three bricks was taken.

Water absorption

Fly ash Bricks should not absorb water more than 12%. Immerse completely dried and weighed W1 brick in clean water for 24 hrs at a temperature of 27±20 Degree Celsius. Remove the bricks and wipe out any traces of water and weigh immediately (W2).

Water absorption in % by weight = (W2 – W1/W1) x 100

The average of three bricks should be taken. Our bricks absorb 11.99 % of water only; it has less water absorption property.

Table 4 Mean values of Compressive Strength (N/mm²)

Proportion	7 days N/mm2	14 days N/mm2	21 days N/mm2
FAB1	2.35	4.23	8.1
FAB2	1.97	3.86	6.45
FAB3	1.89	3.82	6.38
FAB4	1.76	3.27	5.40

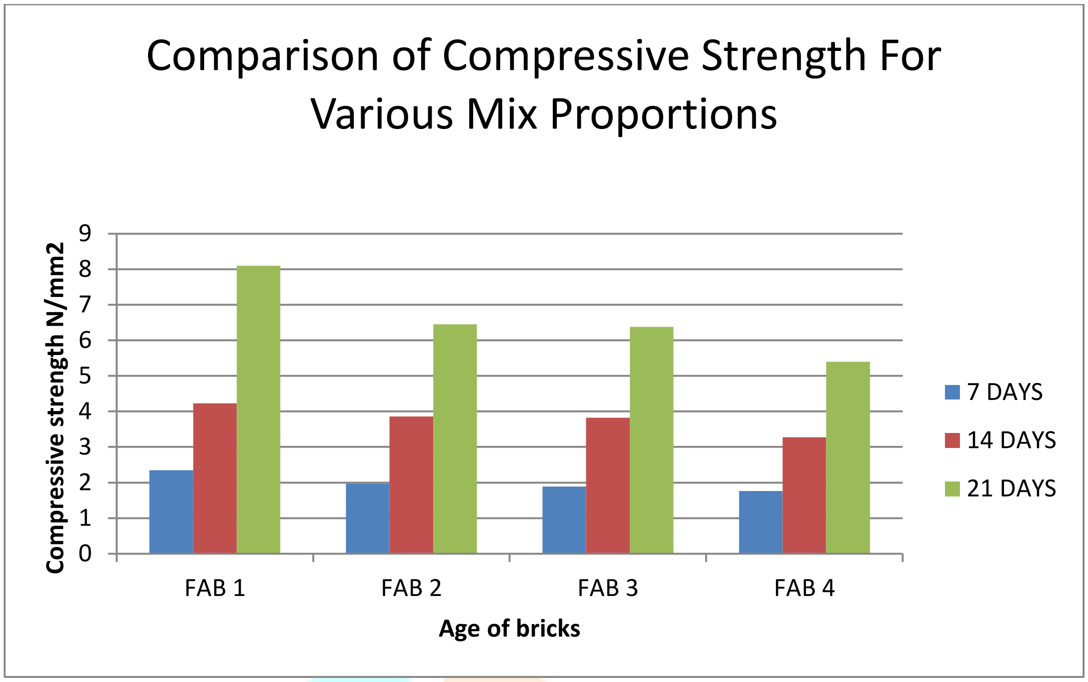
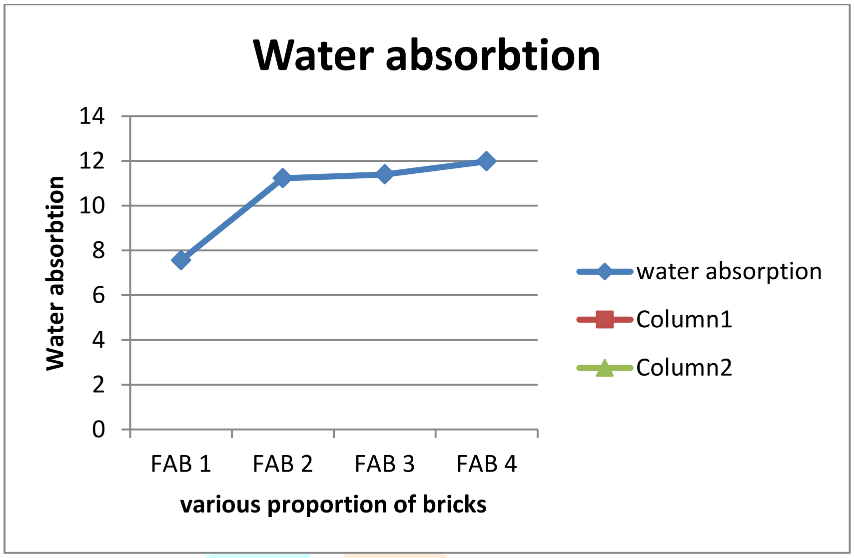


Table 5 Calculation of Water Absorption value (%)

Proportion	Dry weight of brick kg	Wet weight of brick kg	Percentage of increase in weight %	Average Percentage increase in weight %
FAB1	**3.43** **3.35** **3.25**	**3.75** **3.52** **3.51**	**9.32** **5.07** **8.3**	**7.56**
FAB2	**3.37** **3.25** **3.34**	**3.74** **3.61** **3.73**	**10.97** **11.07** **11.67**	**11.23**
FAB3	**3.26** **3.29** **3.27**	**3.65** **3.67** **3.62**	**11.96** **11.55** **10.7**	**11.40**
FAB4	**3.23** **3.22** **3.30**	**3.68** **3.61** **3.63**	**13.93** **12.11** **10**	**11.99**

Water absorption= (W2-W1)/W1x100 = [(3.68-3.23)/3.23]x100 = 0.1393x100 = 13.93

From the results obtained water absorption for avg optimal mix percentage is 11.99%.It is lesser then the standard value of 12%.And also observed that for maximum strength only good water absorption obtained. The following figure shows the variation of water absorption with compressive strength of brick.



Temperature test:

Proportion	OUTSIDE TEMPERATURE 1 C	INSIDE TEMPERATURE1 C	OUTSIDE TEMPERATURE2 C	INSIDE TEMERATUREP2 C	OUTSIDE TEMPERATURE 3 C	INSIDE TEMPERATURE3 C
FAB1	35.1	35.8	36.3	35.6	36.8	36.1
FAB2	35.1	35.2	36.3	35.3	36.8	35.1
FAB3	35.1	34.7	36.3	34.6	36.8	34.7
FAB4	35.1	34.3	36.3	34.2	36.8	34.2

Conclusion:

The study was conducted to find the thermal insulation to optimum mix percentage of fly ash brick. However the brick specimen of size 230mm x 110mm x 75mm were cast for different mix percentage of Flyash (55 to 60%), Gypsum (5%), Lime (15 to 22%),Quarry dust (20 to 25%) and Cork powder (1%,3%,5%and7%). However the specimens have been tested for four mix proportions. 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 four proportions the maximum optimized compressive strength is obtained in 1% of mix Flyash-60% Lime-20% Gypsum-5% Quarry dust-15% , Cork powder (1%,3%,5%and7%) as 8.1 N/mm² and 7% of cork powder replacement is given good temperature reduced compare to 1%,3% and 5%.