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# "Technical Properties of Pond Ash - Clay Fired Bricks – An Experimental Study"

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***Abstract:*** In the thermal power plants the coal is burnt to heat the water for making the steam, which in turn is used to run the turbines. The pond ash is a waste product from the boilers. It is mainly obtained from the wet disposal of the fly ash, which when get mixed with bottom ash is disposed off in large pond or dykes as slurry. The pond ash is being generated in an alarming rate. The generation of the pond ash is posing a lot of threat to environment and thus its sustainable management has become the thrust area in engineering research. As the pond ash is relatively coarse and the dissolvable alkalies present in it are washed with water, its pozzolanic reactivity becomes low and hence it is not preferred as part replacement of cement in concrete as in the case of fly ash.
In this research work an attempt is made to find out the possibility of using pond ash in burnt clay bricks. The part of the clay is replaced by pond ash in different composition and the bricks are made in conventional method at a brick manufacturing plant. The bricks are fired in a traditional way as per usual practice in the area and the final products with different composition of pond ash are tested in laboratory; for tolerance in dimension, water absorption, compressive strength, initial rate of absorption and weathering. The results of all the tests on brick samples with different % of pond ash are compared with clay bricks and the effect on different characteristics of bricks due to addition of pond ash are studied.

***Keywords:*** *– Burnt Clay Bricks, Compressive Strength, Fly Ash, Pond Ash, Pond Ash – Clay Fired Bricks, Silica*

## I. INTRODUCTION

The pond ash is a waste product from boilers, where the coal is burnt to heat the water for preparing the steam, which is a common process in most of coal based thermal power plants. It is mainly obtained from the wet disposal of fly ash. The fly ash gets mixed with bottom ash and disposed off in large pond or dykes as slurry. It is also termed as ponded fly ash and contains relatively coarse particles. The large areas of land are used to store such a mixture of pond ash resulting in land degradation near the thermal power plants. As the pond ash is being produced at an alarming rate, hence the efforts are required to safely dispose it and if possible find ways of utilizing it. In the pond ash the dissolvable alkalies present are washed with water. The metal oxides, sulphur, siliceous & aluminous materials with less pozzolonic properties than fly ash, are some main constituents of pond ash. These ash produced, if disposed off unscientifically, can cause environmental risks i.e. air pollution, surface water and groundwater pollution and thus its safe disposal is indispensable.
In fact, the pond ash is a mixture of fly ash and bottom ash. The main difference between pond ash and fly ash is in their particle size. The pond ash being coarser and less pozzolonic and hence is not being accepted as pozzolona. Some of the physical properties of pond ash are described in Table -1.

**Table – 1 : Physical Properties of Pond Ash**

| *Sr.No.* | *Properties* | **Pond Ash** |
|---|---|---|
| 1. | Lime Reactivity of Pond ash | 0.66 |
| 2. | Specific Gravity | 2.16 |
| 3. | Bulk density in Loose State | 824 kg/m$^3$ |
| 4. | Bulk density in Compacted State | 990 kg/m$^3$ |
| 5. | Atterberg's Limits<br>Liquid Limits percentage | <br>47.3 |
| 6. | Grain size distribution<br>Sand %<br>Silt %<br>Clay % | <br>72<br>28<br>NIL |
| 7. | IS Classification | SP-SM |

The chemical compositions of fly ash & pond ash generally lie in same range except in their particles size as shown in Table – 2.

Table - 2 : Chemical Compositions of Fly ash & Pond ash

| **Constituent** | **Fly ash (%)** | **Pond ash (%)** |
|---|---|---|
| Silica ($SiO_2$) | 49 – 67 | 67.40 |
| Alumina ($Al_2O_3$) | 16 – 29 | 19.44 |
| Iron Oxide ($Fe_2O_3$) | 4 – 10 | 8.5 |
| Calcium Oxide (CaO) | 1 – 4 | 2.7 |
| Magnesium Oxide (MgO) | 0.2 – 2 | 0.45 |
| Sulphur ($SO_3$) | 0.1 – 2 | 0.30 |
| Loss of Ignition | 0.5 – 3 | 3.46 |

## II. LITERATURE REVIEW

***Pandey and Agarwal (2002)*** manufactured the pond ash bricks and normal clay bricks. One part by weight of hydrated lime and sand was added to about eight parts by weight of pond ash. The compressive strength in bricks is mainly due to Mullite ($3Al_2O_3.2SiO_2$). The main aim of this work was to synchronize mullite ($3Al_2O_3.2SiO_2$) generation in the bricks. Four categories of bricks of differing proportion were made. The burning of these bricks was carried out at different temperatures viz. 200°, 800° and 1200°C and thereafter tested for apparent porosity, bulk density, weight, compressive strength and water absorption. It is concluded that, based on the superior quality, strength and aesthetic merits, mixed pond-ash clay bricks have a greater potential for wider acceptance of the consumers.

***Sarkar et al (2007)*** did experiments by using the pond ash in combination with local clay for making the bricks. The clay were mixed with the two different ashes in the range 10 to 90 weight %, hydraulically pressed and fired at 1000$^o$C. The fired products were characterized for various quality properties required for bricks. The properties of the optimal compositions were compared with conventional red clay bricks including the developed microstructures and the comparative study generally showed that the ash-clay bricks were of superior quality to the conventional products.

***Vaka et al (2007)*** reported an experimental work on fly ash utilization and development of low density red clay bricks. The bricks with different compositions of fly ash, red clay and organic matter, were made and tested for bulk density, water absorption, porosity, shrinkage and crushing strength. The fly ash and red clay content used in bricks was up to 50 and 70% respectively. The organic matter was varied from 0 to 10 %. The bricks made of 40 % fly ash have shown good physical properties. The crushing strength of the brick increased with increase in fly ash content and the brick strength decreased with increase in clay content. The properties of bricks that are fired at 700$^0$C, 800$^0$C and 900$^0$C were obtained. The higher firing temperatures offered greater shrinkage. The bricks developed in the study possess crushing strength up to 16.40 MPa.

***Vidya et al (2013)*** conducted an experimental investigation on pond ash burnt clay bricks. The raw materials used for making the bricks were pond ash, fly ash, lime, gypsum and sand. The modular brick samples of size 230 mm x 110 mm x 75 mm were casted as per IS 12894-2002 using various mix proportions. The four number of mix combinations were arrived by changing the pond ash and lime proportion. The properties of bricks such as compressive strength, water absorption, weight density, efflorescence test were conducted in laboratory. The compressive strength of the bricks observed varying from 9.2 to 7.6 N/mm$^2$.

## III. EXPERIMENTATION

The experimentation is done to study the effect of pond ash in clay-pond ash burnt bricks. The clay is replaced with pond ash. The pond ash for this purpose is collected from Eklahare Thermal Power Station at Nashik, Maharashtra. The pond ash is mixed with the local clay, which is being used for making the bricks in a local brick Kiln at outskirt of Dhule city. The mixtures of clay and the pond ash with different percentage by weight are prepared. The total number of nine mixtures with different proportions of pond ash is selected for experimentation, varying from 0% to 30%. These mixtures are mixed thoroughly by adding the appropriate amount of water, are used to make the clay-pond ash bricks. The special wooden mould of size 230 x 100 x 75 mm size are used for molding the bricks, with a marking 0 – 9, for differentiating the bricks of different proportions of pond ash. The bricks with different % of pond ash blends marked with specific numbers in their frog to identify them at the time of testing are prepared with the help of local laboures working in the Kiln who are trained for this job. The prepared bricks are then air dried in an open atmosphere for 4 - 5 days. About 1400 bricks in total are made. Thereafter, these bricks are fired in a central portion of the open Kiln of capacity 40000, which is then fired for around 15 days, in a traditional way as practiced around Dhule. All the bricks are taken out from the Kiln as per usual procedure, cooled and thereafter transported to the material testing laboratory. The average size of the brick after burning and cooling was measured as 220 x 95 x 70 mm. The flow chart of the process is given in the Figure - 1.

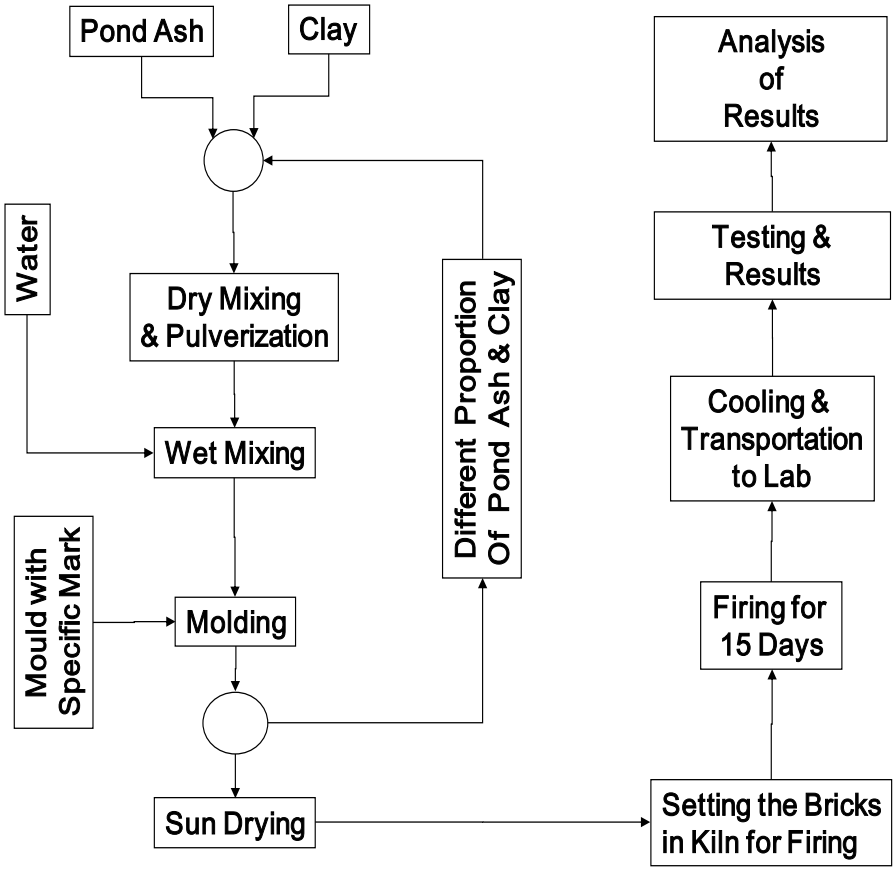


Figure - 1 : Flow Chart Showing Experimental Procedure

## IV. RESULTS

**Dimension and Tolerance**

The bricks are of non-modular type. The dimension and tolerance test is conducted on bricks of all types made with different % of pond ash. As per BIS 1077 : 1992, for non modular size bricks of size 230 x 110 x 70 mm, the permitted tolerance for 20 bricks in row, is 4600 ± 80 mm in length in 2200 ± 40 mm width and in 1400 ± 40 mm in height. The permitted tolerance in terms of % is 1.739 in length, 1.818 in width and 2.857 in height. It is observed that for pond ash more than 20%, the dimensions are beyond the tolerance limit. It can be seen that the bricks are swelling as the % of pond ash is increasing. The % of swelling is more in height as compared to length and width.

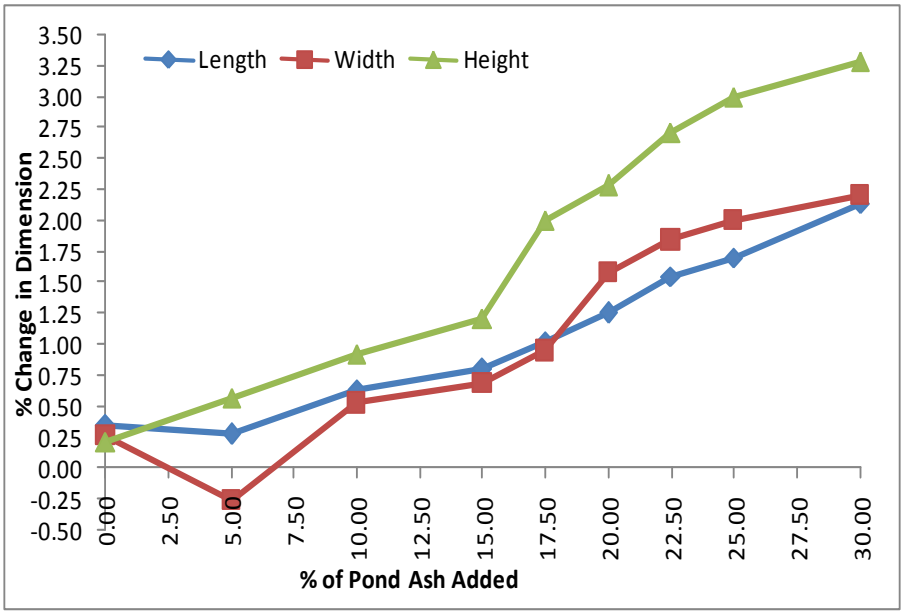


Figure - 2 : Variation in Dimension with % of Pond Ash Added

**DRY DENSITY -**

The plot of dry densities versus pond ash percentage as shown in Figure – 3, exhibit that the dry density decreases with increase in pond ash percentage.

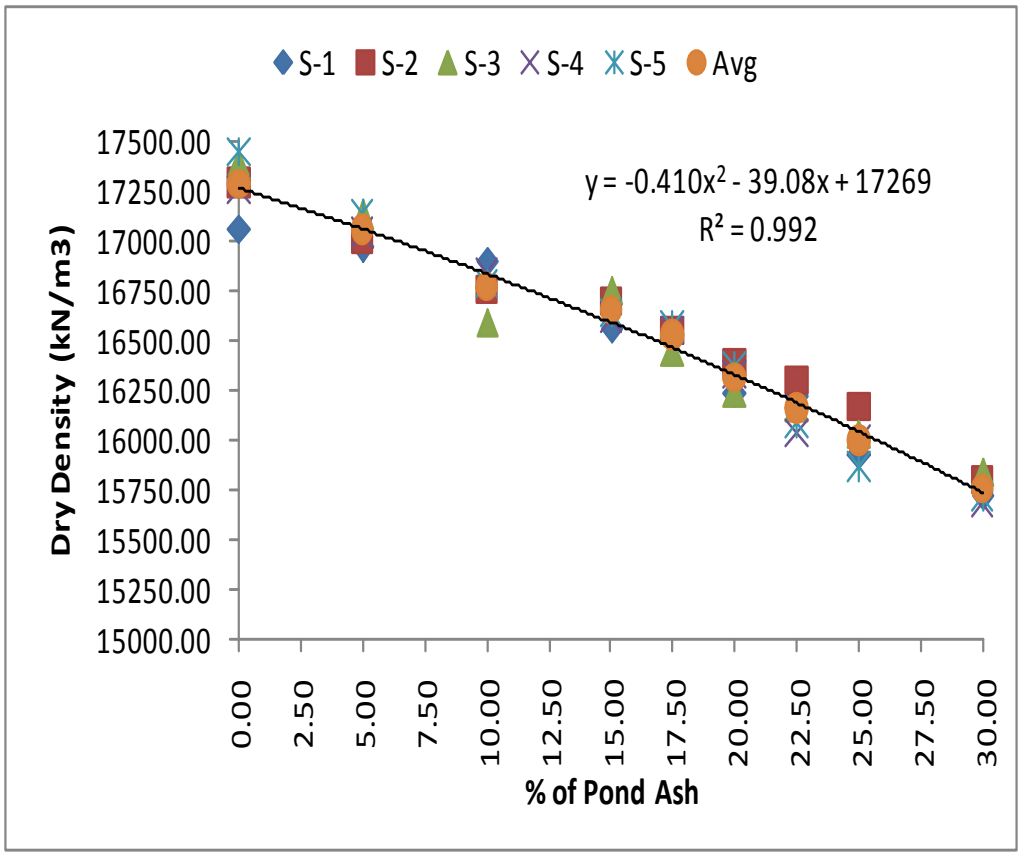


Figure - 3 : Variation in Dry Density with % of Pond Ash Added

**WATER ABSORPTION -**

A plot of water absorption in % versus the % of pond ash in bricks is shown in Figure - 4, which shows a positive relationship, i.e. the water absorption (%) increases with pond ash % in bricks.

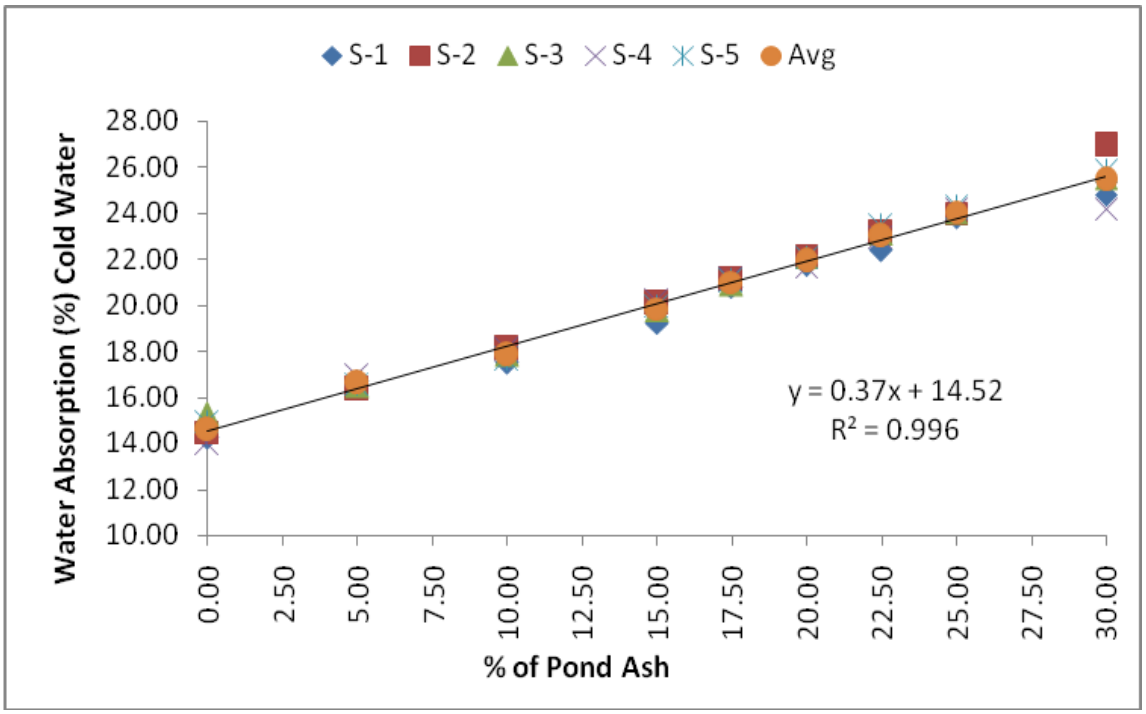


Figure – 4 : Water Absorption (Cold Water) versus Pond Ash % in Bricks

The water absorption % of brick samples after immersing for five hours in boiling water is calculated as per procedure. A plot of water absorption in % versus the % of pond ash in bricks exhibits a positive relationship as in previous case; however, in this case the water absorption % is observed more than that what is observed in cold water.

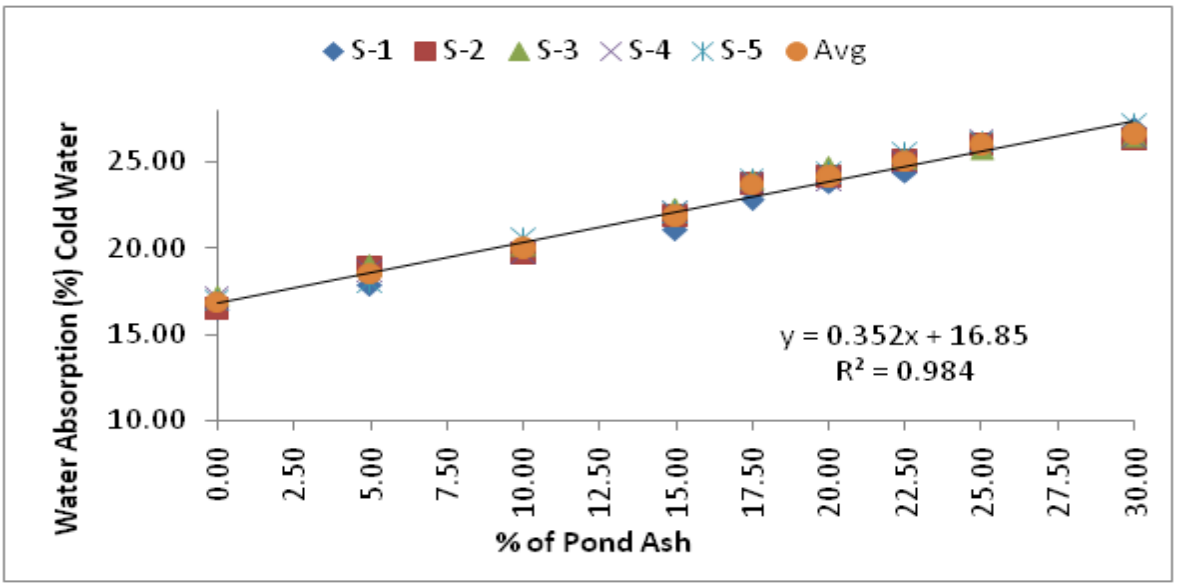


Figure - 5 : Water Absorption (Hot Water) vs Pond Ash % in Bricks

**INITIAL RATE OF ABSORPTION (IRA)**

The initial rate of absorption test is conducted by immersing 1 cm height of brick in water at room temperature for one minute. The test is conduct on three number of brick samples. The IRA is calculated in gm/cm$^2$/minute by finding the difference between the wet and dry weight of sample dividing by the plan area of the brick. The IRA value for different % of pond ash in bricks is shown in Figure – 6 which shows that the IRA value increases with increase in % of pond ash in brick.

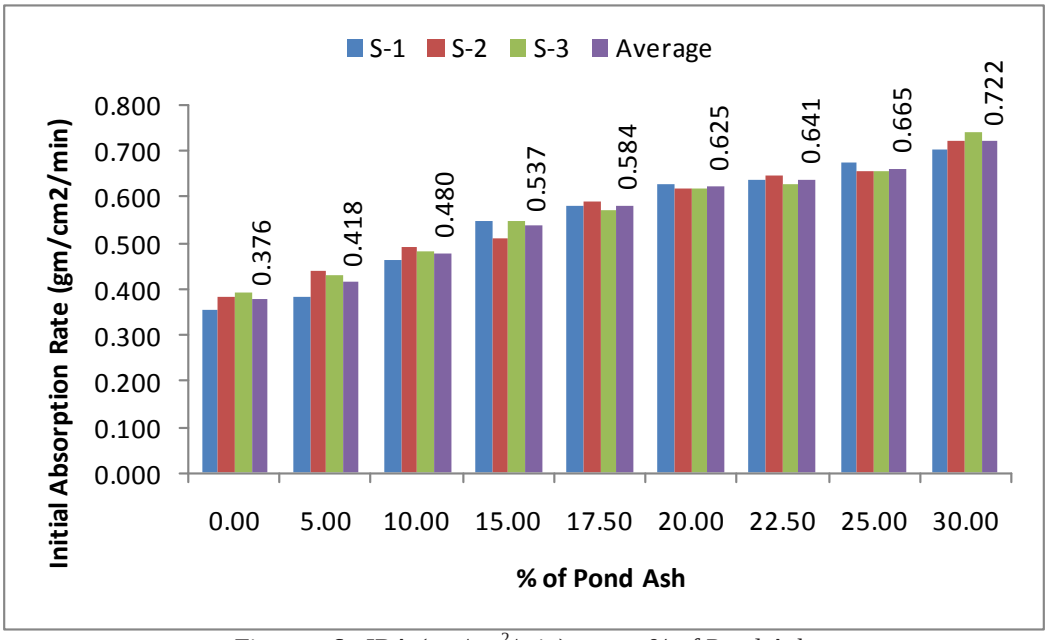


Figure – 6 : IRA (gm/cm$^2$/min) versus % of Pond Ash

**COMPRESSIVE STRENGTH**

The test for compressive strength is conducted on five brick samples of each set of bricks. The bricks are prepared and tested for compressive strength in compression testing machine (CTM). The average dimension of brick is taken to find out the area of the brick to calculate the stress at failure.

A plot of compressive strength versus the % of pond ash in bricks, shows that there is an increase in compressive strength with pond ash % in brick up to 15 ~ 17.5% and thereafter the compressive strength decreases.

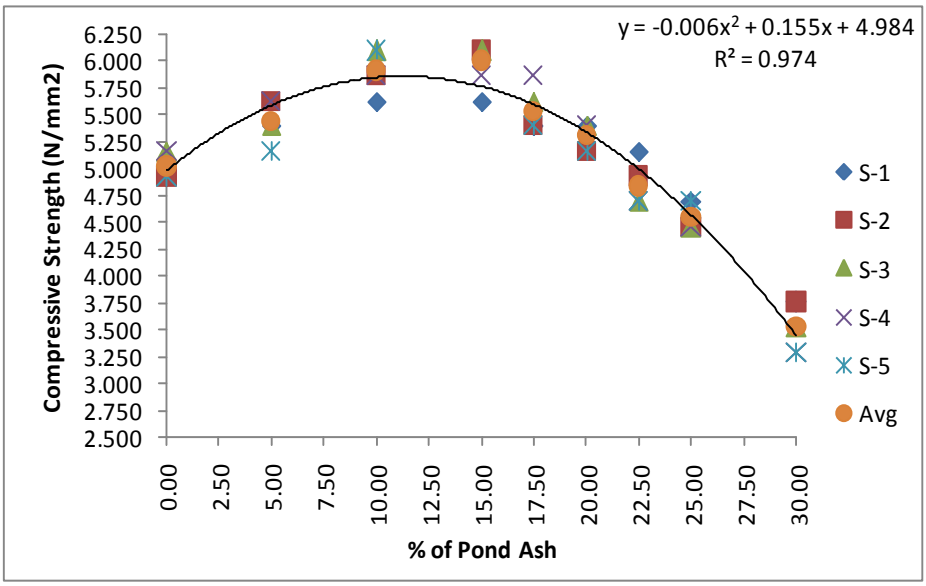


Figure - 7 : Compressive Strength versus Pond Ash % in Bricks

**WEATHERING TEST –**

The weathering test of the bricks is not conducted as per procedure due to some difficulties during experimentation. The experiment is performed only on one brick. The loss in weathering in each cycle is calculated in percentage with respect to the original dry weight of the sample for each composition of brick. The loss in weathering in percentage versus % of pond ash is shown in Figure 8, which shows that loss in weathering is minimum at 15%.

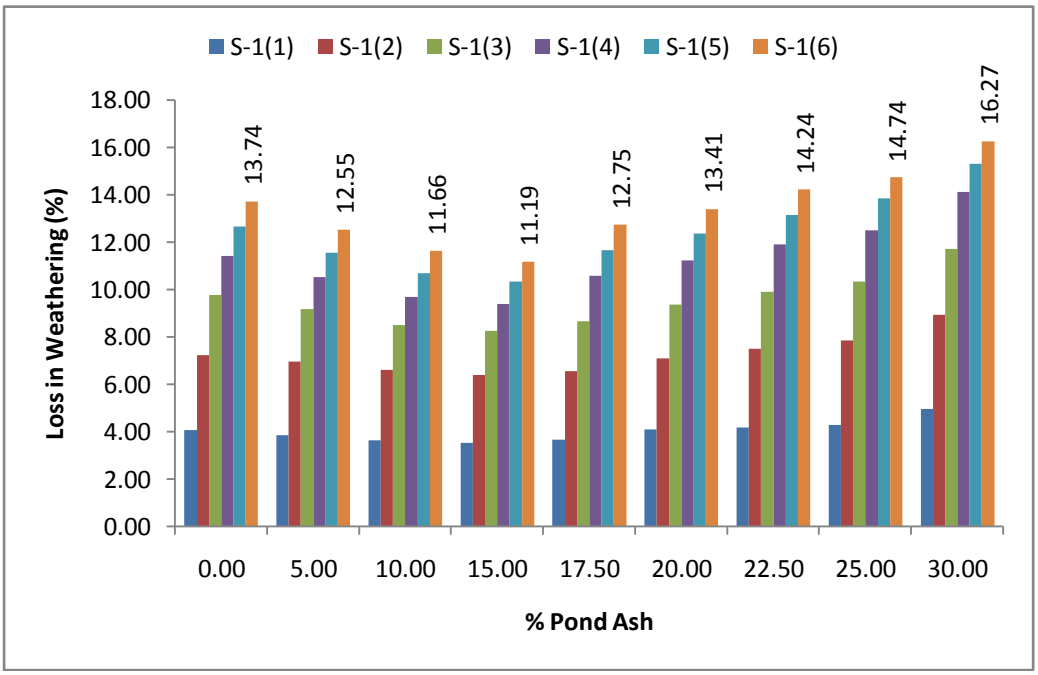


Figure – 9 : Loss in Weathering (%) versus % of Pond Ash

## V. CONCLUSIONS

The following conclusions are drawn from the various tests conducted on clay – pond ash brick samples prepared with various percentage of pond ash.

- The result of tolerance test on dimension shows that for clay – pond ash bricks in which the % of pond ash is beyond 20, the dimensions are exceeding the tolerance limit. It is observed that the bricks are swelling as the % of pond ash is increasing. The % of swelling is more in height as compared to length and width.
- The dry density of the bricks decreases with increase in % of pond ash. The decrease in dry density for bricks with pond ash 5.00, 10.00, 15.00, 17.50, 20.00, 22.50, 25.00 and 30.00% are 1.35%, 2.99%, 3.68%, 4.40%, 5.64%, 6.54%, 7.48% and 8.89% respectively.
- The % of water absorption increases with increase in pond ash in bricks, when immersed in cold water for 24 hours. The water absorption percentage varies from 14.59% for clay brick (with no pond ash) to 25.46% for clay – pond ash brick with 30% pond ash.
- In case of boiling water test the pattern of water absorption % is same as that of cold water test. However in this case, the % of water absorption is more as compared to cold water test. In this case the % of water absorption varies from 16.86% for clay brick (with no pond ash) to 26.66% for clay – pond ash brick with 30% pond ash.
- The results of the compressive strength test on brick shows that there is an increase in compressive strength with pond ash % in brick up to 15 ~ 17.5% and thereafter the compressive strength decreases. More precisely, it is evident that the average compressive strength of brick increases up to 19.626 % corresponding to % of pond 15 in pond ash-clay bricks and thereafter falls rapidly with increase in % of pond ash. A decrease of in compressive strength by 29.907% is observed corresponding to 30% pond ash.
- The result of IRA test shows that the IRA value increases with increase in % of pond ash in brick. The IRA value for clay bricks is 0.375 gram/cm$^2$/minute, whereas it varies from 0.415 gram/cm$^2$/minute for pond ash clay brick with 5% pond ash to 0.722 gram/cm$^2$/minute with 30% pond ash.
- The weathering test is done on one brick sample of each composition, which shows that that loss in weathering is minimum at 15%.

**LIMITATIONS & FUTURE SCOPE OF STUDY -**

There are many limitations while preparing the bricks for experimentation and testing the bricks in the laboratory. The properties of pond ash-clay bricks depends mainly upon the main ingredients i.e. clay and pond ash and in present case the firing temperature. In the present case, the firing of the brick samples prepared with different composition of pond ash is done in traditional way in uncontrolled manner.

The effect of firing temperature on different composition of bricks may be studied and the conclusion based on that may be more logical and useful. This will require the additional facility of high temperature furnaces of bigger sizes.

The BIS code does not provide the procedure for conducting the IRA test and weathering test. The procedure which is mentioned in ASTM is followed partially for getting the results.
The surface porosity and pore size may be determined by using the modern techniques such as scanning electron microscopy (SEM) and the results of water absorption test may be correlated.
The tests for determining the tensile strength, flexural strength and the stress strain characteristics should be conducted for finding out the structural characteristics of the bricks.

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