Use Of Industrial Wastes In Brick Manufacturing

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Abstract- Industrial waste disposal is undertaken for the well being of the environment. Soil blocks that are being tested consist of 60% of clay, 35% of sand and remaining consist of waste materials. The clay that is being incorporated is further tested so that it lies within the limit of IS specifications. The constituents are mixed, proportioned and placed in a standard brick mould. Then the soil block is sun dried and burned at kiln. Compression test, Flexural test, Water absorption test and Efflorescence are carried out on the obtained soil blocks. The results thus obtained are compared with that of the standard ones.

Index Terms- Compression test, Flexural test, Water absorption and Efflorescence.

I. INTRODUCTION

In recent decades, industrialization and urbanization are the two phenomena that are going unabated all over the world. Most important ill effect of these global processes has been the generation of large quantities of industrial wastes. Therefore, the problems related with their safe management and disposal has become a major challenge to environmentalists and scientists. Second related problem is the pressure on land, materials and resources to support the developmental activities, including infrastructure.

Brick is one of the most important masonry unit as a building material. Many attempts have been made to incorporate wastes into the production of bricks, for examples, limestone dust, wood, sawdust, processed tea waste, fly ash, polystyrene and sludge. Using such wastes by incorporating them into building materials is a practical solution for pollution problem. This paper reviews the use of different wastes like fly ash and copper slag into bricks. Most manufactured bricks with different types of waste have shown positive effects on the properties of fired clay bricks. The firing temperature for burning bricks incorporated with waste like fly ash, copper slag is less than the temperature required for ordinary bricks. Copper slag is one of the waste materials that are being used extensively in the construction industry. Copper producing units in India leave thousands of tons of copper slag as waste every day. Large quantities of the accumulated slag is dumped and left on costly land, causing wastage of good cultivable land. Based on U.S. environmental protection agency regulations, governing solid waste characteristics, copper slag can be classified as a non-hazardous material. Granulated copper slag is more porous and, therefore, has particle size equal to that of coarse sand. Here utilization of copper slag in burnt bricks is discussed.

Fly ash is another industrial waste produced by coal fired power plants during the combustion of coal. Fly ash mainly consists of inorganic glassy particles formed from the minor matter in the coal. During combustion, these minerals are heated to a molten state and chemically combined and solidified while suspended in the exhaust gas. They are then collected by electrostatic precipitators or bag houses. Fly ash is classified based on the chemical and physical composition of the ash. Self-cementing fly ash is normally produced from lignite or sub-bituminous coal. Fly ash is disposed of either in the dry form or mixed with water and discharged in slurry into locations called ash ponds. The quantity of fly ash produced worldwide is huge and keeps increasing every day.

Fly ash is used for soil stabilization. Soils can be treated with fly ash to modify engineering properties as well as produce rapid strength gain in unstable soils.

II. LITERATURE REVIEW

Jayant L. Patil et al. conducted tests such as water absorption, compressive strength, dry density on clay-fly ash burnt bricks were carried out. The mixtures of soil available with the fly ash of varying percentage by weight are prepared. Appropriate amount of water are added. These bricks are dried in an open atmosphere for 4-5 days and thereafter fired in separate open kiln (14 days). The kiln is allowed to cool for 4 days. The bricks are taken out from kiln and stacked in an open sky for 6 days and then brought to the testing laboratory of the institute and concluded that the variation is from 15.463 percentage at 0 percentage fly ash to 25.545 percentage at 75 percentage fly ash. The compressive strengths of the bricks increases with addition in fly ash percentage up to 40 percentage to 50 percentage and there after starts decreases. The dry densities of the brick samples are decreasing with every increase in percentage of fly ash.

Salmalizasalleh et al. studied the use of blasted copper slag from shipyard repair and maintenance as replacement of fine aggregates in the sand-cement brick. 20 bricks were produced with different blasted copper slag ratios from 0 to 60 %. Sand – cement brick mixtures were tested for their compressive strength, density and water absorption at 28 days of air curing and 16.28% improvement in compressive strength of brick with 20 % replacement of copper slag as fine aggregates however the addition of copper slag decreased the compressive strength and increased the density, also the result for water absorption decreased as the copper slag ratio in brick increases.Marimuthu Lakshmanan et al. studied the use of fly ash and copper slag in pavement which resulted in significant savings in cost of road aggregates. The use of waste materials in the road stabilization industry is gradually gaining significance, considering disposal and environmental problems and the gradual depletion of natural resources. Fly ash and Copper slag has been added to the weak soil in various proportions, in order to increase its bearing capacity.

C. K. Madheswaran et al. studied the use of copper slag as a replacement material for river sand in building construction. The use of copper slag as fine aggregate in cement mortar jointing material in brick masonry construction and cement concrete. Cement mortar mixtures prepared with fine aggregate made up of different proportions of copper slag and sand were tested for use as masonry mortars and plastering. Three masonry wall panels of dimensions 1 x 1 m were plastered. The studies showed that although copper slag based mortar is suitable for plastering, with the increase in copper slag content, the wastage due to material rebounding from the plastered surfaces increases. The Concrete mixes were evaluated for workability, density, and compressive strength. From the studies they concluded that the behaviour of copper slag seems to be similar to river sand for its use as fine aggregate in mortar. Copper slag can be used as a sand replacement material for plastering of floorings and horizontal surfaces up to 50 % by mass of the total fine aggregate, and this can be reduced up to 25 % by mass of the fine aggregate for vertical surfaces, such as, brick/block walls.

Dr.A.S. Kanagalakshmi et al. made an experimental investigation to evaluate the technical possibilities of incorporating fly ash, copper slag, marble dust and gypsum in the construction bricks. Various mixtures were prepared by incorporating these industrial waste with different weight proportion. The suitable mix proportion has been identified and the physical and mechanical properties of that specimen such as unit weight, compressive strength, water absorption and efflorescence values has been compared with conventional building material types shows utilization of these waste additives is not only for conservation of clay resources but also an alternative solution to difficult and expensive waste disposal problems. From the study the results collected was the industrial waste materials can be successfully used in a brick for the replacement of conventional brick.

Jinka Chandrshekhar et al. conducted a study on the utilization of copper slag in geotechnical applications. Copper slag is one of the waste materials that are being used extensively in the civil engineering construction industry. Copper producing units in India leave thousands of tonnes of copper slag as waste every day. Large quantities of the accumulated slag is dumped and left on costly land, causing wastage of good cultivable land. Various tests conducted such as specific gravity, grain size distribution, effect in CBR, effect on unconfined compressive strength were conducted for determining the results. After the determination of results they found that Copper slag has the potential to use as admixture to improve the properties of problematic soils. The grain size distribution and properties of copper slag are similar to that of medium sand and it can be used as a construction material in place of sand used in backfill for retaining walls and shallow foundations. By utilizing and reusing the industrial waste product, namely, copper slag, wastage of good cultivable land can be avoided when large quantities of the accumulated slag is dumped and left on costly land.

B. N. Patowary et al conducted a study on compressed stabilized earth blocks (CSEB). CSEBs are eco-friendly and as these blocks are unburnt products, during production no coal or burning material is needed. So, it does not produce any harmful gases during production. Here in this study, the soil was identified by various tests and thereby the further steps are to be worked out. Compressed Stabilized Earth Blocks (CSEB) represents a considerable improvement over traditional earth building techniques. The strength of the blocks will increase eventually, but un-burnt bricks are more economic than the standard fired one as the production of CSEBs require less labour and does not require coal.

C K Subramania Prasad et al conducted a study about plastic fibre reinforced soil blocks as a sustainable building material. Stabilization of the soil was done by adding cement, lime and their combination. Plastic fibre in chopped form from carry bags and mineral water bottles were added (0.1% & 0.2% by weight of soil) as reinforcement. The blocks were tested for density, and compressive strength, and observed failure patterns were analyzed. Blocks with 0.1% of plastic fibres showed an increase in strength of about 3 to 10%. For the soil collected for block making, standard soil classification tests were carried out. The final results shows that compared to raw blocks, there was an increase of 8.2% and 29.1% in strength when the soil was stabilized by 8% and 10% of cement respectively.

III. MATERIALS

Soil used for the present study was collected from English Indian Clay Limited, Thonnakkal. Latitude and Longitude at this region are 8°37'32"N and 76°51'11"E respectively. Various tests were conducted for determining the geotechnical properties of soil and are presented in Table 1

Table 1 Properties of soil

Properties	Values
Specific gravity (IS 2720 PART 3)	2.57
Liquid limit (%) (IS 2720 PART 5)	47%
Plastic limit (%) (IS 2720 PART 5)	28%
Shrinkage limit (%) (IS 2720 PART 5)	25%
IS Classification	MH
Optimum moisture content (%)	45.13%
Maximum dry density (g/cc) (IS 2720 PART 7)	1.194
Percentage of clay (IS 2720 PART 4)	4%
Percentage of silt (IS 2720 PART 4)	80%
Percentage of sand (IS 2720 PART 4)	16%

- Fly ash:

Fly ash for the present study was collected from Hindustan newsprint limited, Piravom road, Kottayam. Class F fly ash was obtained from there. Various tests were conducted for determining the properties of fly ash. Specific gravity of fly ash obtained is 2.88.

- Copper Slag

The copper slag for the present study was collected from BlastLine Private Limited, Angamaly. It is obtained from the process called 'Smelting'. Specific gravity of copper slag obtained is 3.49

Table 2 Plasticity index for various % of additives

Serial no.	Varying % of additives in soil	Plasticity index
1	10 % Fly ash + soil	9.8 %
2	20 % Fly ash + soil	11.1 %
3	30 % Fly ash + soil	15.23 %
4	40 % Fly ash + soil	15 %
5	10 % Copper slag + soil	12.5 %
6	20 % Copper slag + soil	13 %
7	30 % Copper slag + soil	19.46 %
8	40 % Copper slag + soil	6 %

V. METHODOLOGY

Manufacturing of bricksBricks were manufactured using locally available soil, soil mixed with varying percentage of fly ash (10%, 20%, 30% and 40%) and soil mixed with varying percentage of copper slag such as (10%, 20%, 30% and 40%) as per IS 2117:1991.

- Preparation of soil

The soil used for making building bricks should be processed so as to free it from gravel, vegetable matter etc. A requisite predetermined proportion of additives such as varying percentages of copper slag and fly ash (0%, 10%, 20%, 30% and 40%) should be mixed with locally available soil. The soil mass is then manually excavated, puddle, watered and left over for weathering and subsequent processing.

- Weathering

The soil should be left in heaps and exposed to weather as long as possible and for at least one month in case where such weathering is considered necessary for the soil. This is done to develop homogeneity in the mass of soils, particularly if they are from different sources and also to eliminate the impurities that get oxidized. Soluble salts in the soil would also be washed off by rain to some extent by this which otherwise may cause scrumming at the time of burning the bricks in the kiln. The soil should be turned over at least twice and it should be ensured that the entire soil is wet throughout the period of weathering.

- Tampering

Addition of water to the soil at the dump is necessary for the easy mixing and workability but addition of water should be controlled in such a way that it may not create problem in moulding and drying. Excessive moisture content may affect the size and shape of the finished brick. This will produce homogeneity in the mass of clay for subsequent processing. After weathering the required quantity of water was mixed with soils so as to obtain the right consistency for moulding. The quantity of water may range from 1/4 to 1/3 by mass of the soils, sandy soils require less water and clayey soils more water. Nature and degree of wetness of the soil at the stage of water addition was considered.

- Design and construction of the brick mould

As per IS 1077:1992 (reaffirmed 2002, 2007) a standard modular size is taken into account for the construction of the brick mould.

Table 3 Specification of standard modular size as per IS 1077:1992

Standard modular size	Length (mm)	Breadth (mm)	Height (mm)
1	190	90	90
2	190	90	40

Mould size adopted for the present study was 190 x 90x40mm as in figure 1.

Fig 1. Brick mould of size 190 x 90 x 40mm

- Moulding procedure

Hand made bricks may be either ground moulded or table moulded. A level firm surface of ground will be used in former case. Before moulding the inside of the mould will be cleaned, oiled and then sprinkled with sand or ash.

A quantity of soil slightly more than the volume of the mould should be taken, rolled in sand if found necessary then shaped suitably into a single lump and dashed firmly into the mould with a force so that the clay completely occupies the mould without air pockets and with the minimum surplus for removal.

The whole assembly of mould should then be lifted given a slight jerk and inverted to release the moulded brick on a pallet board in the case of table moulding or on a dry level surface of the ground in the case of ground moulding. The ground may be sprinkled with sand before releasing the brick over it so that the brick does not stick to the ground.

Specimen name	Particulars	No. of bricks
S	Soil alone	3
S+10 FA	Soil + 10 % Fly ash	3
S+ 20 FA	Soil + 20 % Fly ash	3
S+ 30 FA	Soil + 30 % Fly ash	3
S+ 40 FA	Soil + 40 % Fly ash	3
S+ 10 CS	Soil + 10 % Copper slag	3
S+ 20 CS	Soil + 20 % Copper slag	3
S+ 30 CS	Soil + 30 % Copper slag	3
S+ 40 CS	Soil + 40 % Copper slag	3

Table 4 Particulars of Bricks made

OPERATION OF BRICK MOULDING TABLE

Hand-moulding table was used for shaping building bricks may be used. For moulding bricks, clay is mixed with water and kneaded in the same manner as said earlier. The consistency of the clay should be plastic and preferably be kept marginally stiff. At the moulding table a quantity of clay is rolled into clots slightly larger in volume than the mould. The clot is then rolled over fine sand and thrown with little force into the mould so that the clay completely occupies the mould without air pockets and with minimum surplus for removal.

The surplus clay is removed off with a straight edge or a stretched wire and top surface is levelled. Pressing down the pedal then ejects the shaped brick when the loose bottom steel plate along with the shaped brick is lifted out of the mould. A wood plank of similar size as that of a brick is placed over the shaped brick and is manually lifted along with the loose base plate. The pedal is then released and the base plate drops to its original position.

The moulded brick is then turned on the side, over the wooden pallet. Both the plates loosely adhering to the brick surface are gently removed. The base plate is returned to the mould box for subsequent shaping of other bricks from the brick-moulding table. Another wooden pallet is then placed on -the top face of the brick, which is then carried away to the drying ground where it is placed on edge to dry.

Fig. 5 Bricks obtained after moulding

- Drying

The moulded brick should be allowed to dry to an approximate moisture content of 5 to 7 percent. As far as possible the moulded bricks should be protected effectively against rain and dampness till they are stacked inside the kiln.

- Handling and transportation of the moulded bricks

During conveyance to the kiln the moulded bricks should be loaded or unloaded one by one.

- Setting bricks in the kiln

Pattern of setting of bricks in bull's trench kilns is shown in Fig.6. The moulded bricks should be set in a uniform pattern in the kiln with trace holes, fuel shafts, flues, etc. in accordance with the design of kiln. While arranging the bricks a minimum space of 10 mm shall be given between adjacent bricks in the header and stretcher courses.

In the fuel shaft, bricks should be suitably arranged to project in such a manner so as to form a series of ledges on which the fuel could rest and burn, with only a small portion falling direct to the floor of the kiln. The top two courses of bricks in the kiln, should be set as close as possible with little or no spacing between them so as to form a complete roof covering for the kiln-setting. Holes of size not less than 100 x 100 mm shall be left in the roof for feed of fuel into the fuel shafts.

The top of the setting excluding portions occupied by feedholes should be covered with a fine ash about 200 mm thick. The feedholes should be tightly closed with cast iron pot and caps. After every second in the chamber a gap of about 120 mm should be left for inserting the sheet iron cross dampers. The wicket opening to chambers should be sealed by temporary cavity walls.

The cavity trace holes may be filled with fine kiln ash and the outside of the walls may be plastered over with a thick layer of mud.

Fig. 6 Setting bricks in kiln

- Initiation of fire

Firing may be started after nearly three-fourth of the trench has been loaded. The chimneys may be positioned about 5.5m – 6.0m away from the first row of feed holes. When starting the fire a temporary cross wall one brick thick is constructed at a distance of 250mm from the first row of brick columns. A number of air holes are left at the foot of this wall. Projecting bricks from either side closes up the top opening between this wall and the main setting and the usual cover of ash is laid on. A number of feedholes are provided on this space where the actual number depends on the width of the trench.Initially log of wood soaked in kerosene oil is fed through the top feed holes over the temporary wall and are ignited by introducing lighted rags through the air holes at the bottom. Feeding of firewood is continued at 20 – 30 min intervals, the holes being kept closed by metallic caps between the feeds. The red-hot charcoal that collects on the floor must be pushed forward through the trace holes in the setting by long iron pokers. The chimney should be observed for the formation of dense black smoke, which should not persist for more than 3-4 min after each feed. Observations should also be made of the condition of fire and the movement of flames and hot gases through the brick setting to get an idea of the draught. If draught appears, slack chimneys may be heated up by lightening small fires at the chimney basins.

After about 10 – 12 hrs of firing the kiln floor and the bricks in the first row of columns should be heated to red heat (750 -800 degree Celsius) and feeding of black coal in the first row of feed holes in the main setting is started. Within 5 – 6 hrs after this a good bottom heat in the furnace beyond the first row of feedholes should be obtained. Feeding in all the feedholes in the temporary wall as well as the first row of columns should be continued till sufficient bottom heat is built up. When a suffocating strong draught has been built up the chimney may be advanced by 5 – 6m and the position of the cross dampers are readjusted. Thus within 24 – 30hrs the kiln should be brought upto full firing order. Firing in the feedholes of temporary wall should be continued till fire has advanced by at least 10 – 12m and the bricks in the first row have been fully burnt. The wall can be pulled down only after the fire has gone round the curved part of the trench and the bricks in the first row have cooled down sufficiently to permit unloading to start.

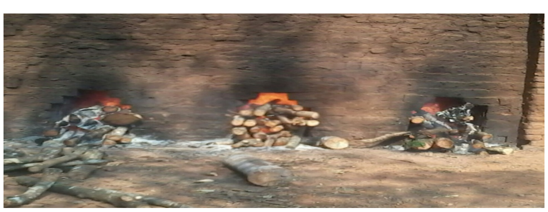

Fig. 7 Initiation of fire by feeding firewood through air holes at the bottom

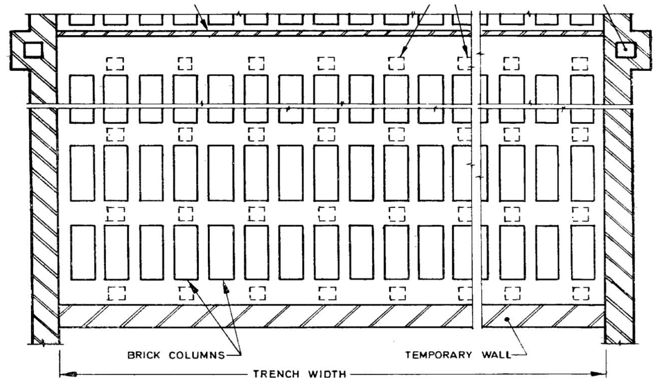

Fig. 8 Plan showing details of feedholes and temporary wall for initiating fire

Table 5 Number of chambers required in a kiln

Loading	1 chamber
Unloading	1 chamber
Firing	1 chamber
Preheat	3 chamber
Cooling	20 chamber
Empty	4 chamber
TOTAL	30 chamber

Fig. 9 Formation of dense black smoke after each feed

- Control of burning

As per IS 4805:1978, in a large capacity kiln there are normally 30 chambers. When the kiln has been brought up to regular firing order, the schedule of firing that generally should be maintained.

The schedule of firing may however vary according to the requirements of a kiln firing particular clay using a particular type of coal.

Bituminous slack coal Grade 1 should preferably be used for firing bricks. When advancing the fire, a fresh row should be opened only when the temperature at the base of the setting or on the kiln floor has reached at least 750°C. This is indicated by the appearance of a dull red glow. Initially small quantities of coal, say, 260 to 500 g should be fed at a time in each feedhole; the amount of feed should be raised gradually to 1 to 2 kg/feedhole as the temperature rises. After each feed the feedhole caps should be tightly replaced to pre- vent in-leakage of cold air. While feeding fuel, loose ash from the top covering should not be allowed to drop into the feedhole.

The temperature at which bricks are to be fired may range from 900 to 1000°. The temperature may be observed by means of suitable temperature measuring devices, and the fuel feed and draught adjusted for control. The rate of fire travel should generally be not less than 5 m/24 h. Operation of dampers, setting of bricks and emptying of bricks will keep pace with the advancing fire cycle.

There are five distinct stages in the firing cycle, such as (a) smoking, (b) pre-heating, (c) firing, (d) soaking, and (e) cooling, to which the bricks in the kiln should be subjected. The proper and efficient control of these stages greatly depends upon the technique and experience of the burner. Under normal conditions, the pair of chimneys is maintained at a distance of 10 to 15 m from the first row under fire, and is shifted once every 12 hours. However, if any combustible matter has been mixed with the clay then the chimneys should be maintained at a, distance of 20 m or so. The draught of the kiln should be observed by suitable draught gauges at the base of chimney and should be adjusted by operating the temperature as specified by the designer of the kiln. Cooling of the brick in the kiln should be gradual. Normally about 15 to 20 chambers are maintained in the cooling zone.

- Unloading of bricks from the kiln, sorting and stacking

The bricks should be unloaded from the kiln and conveyed to the sorting area with minimum breakage. In the case of bricks made from clays containing lime kanker, the bricks in stack should be thoroughly soaked in water (docked) to prevent lime bursting. The bricks should be sorted out into various classes.

V. EXPERIMENTAL INVESTIGATION

Compressive strength test (as per IS 3495 (part1) : 1992)

A compression testing machine, the compression plate of which shall have a ball seating in the form of a portion of a sphere shall be used.

- Preconditioning

Remove the unevenness observed on the bed faces to provide two smooth and parallel faces by grinding. Immerse in water at room temperature for 24 hours. Remove the specimen and drain out any surplus moisture. Now store under damp jute bags for 24 hours followed by immersion in clean water for 3 days. Remove and wipe out any traces of moisture.

- Procedure

Place the specimen with flat faces horizontal and between 2 plywood sheets each of 3mm thickness and carefully centered between the plates of the testing machine. Apply load axially at a uniform rate of 14N/mm^2 per minute till failure occurs and note the maximum load and failure. The load at failure shall be the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine. The report shall be given as below:

Compressive strength in N/mm^2 = (maximum load at failure in N)/(area of bed faces in mm^2)

The average results shall be reported by testing 3 bricks for each percentage of fly ash and copper slag (10 %, 20 %, 30 %, 40%)

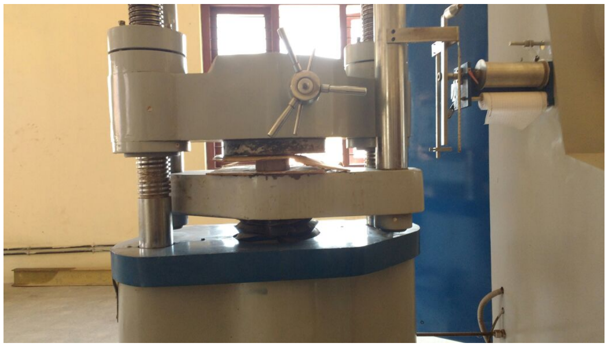

Fig. 10 Compressive strength test

Determination of water absorption (as per IS3495 (part 2): 1992)

- Apparatus

A sensitive balance capable of weighing within 0.1 percent of the mass of the specimen; and a ventilated oven.

- Preconditioning

Dry the specimen in ventilated oven at a temperature of 105 to 115 degree Celsius till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M1).

- Procedure

Immerse completely dried specimen in clean water at a temperature of 27 plus or minus 2 degree Celsius for 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from water (M2).

Water absorption, percent by mass, after 24 hour immersion in water is given by:

$$((M2-M1)/M1) \times 100$$

Determination of efflorescence (as per IS 3495 (PART3):1992)

- Apparatus

A shallow bottom dish containing sufficient distilled water to completely saturate the specimens. The dish shall be made of glass, porcelain or glazed stoneware and size of 180 x 180x40 mm depth for square shaped and 200mm diameter and 40 mm depth for cylindrical shaped.

- Procedure

Place the bricks in the dish. The depth of immersion in water being 25mm. Place the whole arrangement in a warm ventilated room until all the water in the dish is absorbed by the specimen and the surplus water evaporates. Cover the dish containing the brick with suitable glass cylinder so that excessive evaporation from the dish may not occur. When the water has been absorbed and the bricks appear to be dry, place the similar quantity of water in the dish and allow it to evaporate it as before. Examine the bricks for efflorescence after second evaporation and report the results.

When there is no perceptible deposits of efflorescence it is categorized as a null efflorescence. When more than 10 percent of the exposed area of the brick is covered with thin deposit of salts it is categorized as slight efflorescence. When 50 percent of the exposed area of the brick is covered with heavier deposits but unaccompanied by powdering or flaking of the surface it is categorized as moderate efflorescence. When there is a heavy deposit of salts covering 50 percent or more of the exposed area of the brick surface unaccompanied by powdering or flaking of the surface it is categorized as heavy efflorescence. When there is a heavy deposit of salts accompanied by powdering or flaking of the exposed surface it could be serious efflorescence.

Determination of Unit weight

- Procedure

Carefully measure the dimensions of the bricks and calculate the volume. Take the weight of the bricks. Unit weight is given by the equation.

Unit weight = weight of the soil mass/volume of the brick

VI. RESULT AND DISCUSSION

- Compressive strength test

Table 6 Result of compressive strength test on bricks

Specimen Name	Test 1 (N/mm^2)	Test 2 (N/mm^2)	Average (N/mm^2)
S	1.29	1.34	1.36
S+10 FA	3.01	3.10	3.06
S+20 FA	3.21	3.15	3.18
S+30 FA	3.62	3.68	3.65
S+40 FA	3.56	3.45	3.50
S+10 CS	3.61	3.59	3.60
S+20 CS	3.81	3.42	3.86
S+30 CS	4.48	4.57	4.52
S+40 CS	4.35	4.47	4.41

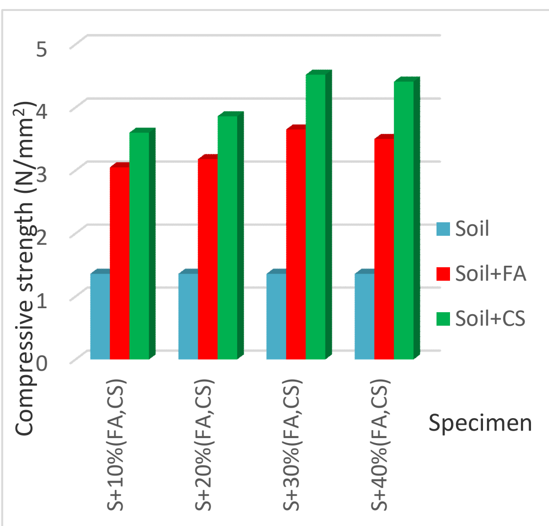

Fig. 11 Variation of compressive strength for bricks

The compressive strength was found to be optimum at 30 percentage inclusion for both fly ash and copper slag with the soil.This may be due to the pozzalonic reaction of fly ash and copper slag with the soil. The compressive strength at 30 percentage fly ash is obtained as 3.65 and for copper slag at 30 percentage is 4.52.The plasticity index range for 30 percentage is found to be within the range of 15 to 25 which is standard for brick manufacturing. This may also be a reason for the obtained optimum value.

- Water absorption

Table 7 Result of water absorption on bricks

Specimen	Water Absorption (%)
S	22.34
S+10 FA	21.82
S+20 FA	20.94
S+30 FA	19.75
S+40 FA	21.72
S+10 CS	21.67
S+20 CS	21.80
S+30 CS	20.53
S+40 CS	20.94

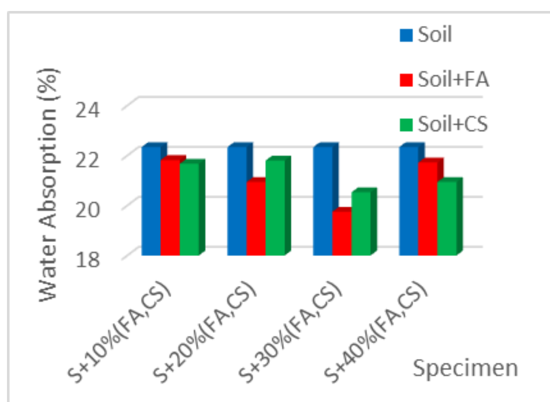

Fig 12 Variation of water absorption on bricks

The value obtained for water absorption is found to be less than 20 percentage for varying percentage of fly ash and copper slag

- Determination of unit weight

Table 8 Unit weight obtained for bricks

Specimen	Unit Weight
S	1.20
S+10 FA	1.54
S+20 FA	1.72
S+30 FA	1.86
S+40 FA	1.94
S+10 CS	2.21
S+20 CS	2.38
S+30 CS	2.54
S+40 CS	2.68

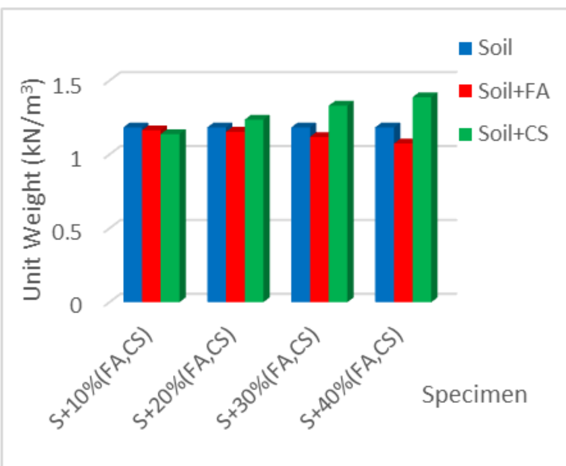

Fig. 13 Variation of unit weight for bricks

The unit weight increases linearly with the increase in addition of varying percentages (0%, 10%, 20%, 30% 40%) of fly ash and copper slag. The specific gravity of Fly ash and Copper slag are 2.88 and 3.49 respectively, which is more than that of soil. Hence the unit weight is found to be increasing.

VI. CONCLUSION

The optimum percentage of both Fly ash and copper slag was obtained as 30%. The compressive strength at 30 percentage Fly ash is obtained as 3.65 and for copper slag at 30% is 4.52. Water Absorption is found to be less than 20 percentage and efflorescence is reported to be NIL. Both the bricks confirm to class 3.5 (as per IS 1077 1992). Percentage improvement in compressive strength at optimum Fly ash content is 52 percentage and at optimum copper slag content is 70 percentage, from the study it is concluded that Fly ash and Copper slag can be utilized for the manufacturing of bricks.

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