The Asian Review of Civil Engineering
ISSN: 2249-6203 (P) Vol.9 No.2, 2020, pp.1-7

DOI: https://doi.org/10.51983/tarce-2020.9.2.2556

Experimental Investigation on Bricks by Using Cow Dung, Rice Husk, Egg Shell Powder as a Partial Replacement for Fly Ash

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Abstract - **The usage of solid waste materials in the production of construction materials has received considerable attention across the world. Various types of bricks are used in construction. The most common are conventional bricks. Owing to the exploitation of large amount of natural resources in the manufacturing of conventional bricks, we provide an alternative solution for conventional bricks through this project. The present study investigates the feasibility of using rice husk powder, cow dung and egg shell powder in the manufacturing of fly ash bricks. Fly ash bricks of different compositions with rice husk, cow dung and egg shell powder were prepared in steel moulds. After casting, the brick samples were stored at 35 C and a relative humidity of 50% until the ages required for testing. The brick samples were checked for dimensions and visible defects. The effects of rice husk, cow dung and egg shell powder contents on the engineering properties of the solid bricks were also investigated. The test results showed that all brick samples exhibited good compressive strength. The compression strength ranged between. It is concluded that the manufactured bricks acquired sufficient strength and became more economical.**
Keywords: **Fly ash, Bricks, Compressive strength**

I. INTRODUCTION

It is always common explaining about 3R methodology which includes reduce, reuse and recycle. Here we have come out with 4R methodology which includes recovery too. Management of solid waste has become one of the biggest problems that we are facing today. The common approaches towards the solid waste management like dumping of waste, landfills and incineration are not much eco-friendly**.** Dumping of waste forces bio-degradable materials to rot and decompose under improper, unhygienic and uncontrolled condition which leads to infectious diseases and spoilage of aesthetic value of the area.

Nowadays using solid waste materials in the production of construction materials has received considerable attention across the world. One of the important and prevalent building materials used is bricks. India and the United States, for example, consume some 20 billion and 9 billion bricks each year, respectively. Due to exploitation of large number of natural resources in the manufacturing of conventional bricks, a demand for alternative materials for brick production has been created. In this project we investigates the use of wastes like rice husk, egg shell powder, cow dung as the partial replacement of fly ash in the manufacturing of eco-friendly construction bricks. The use or disposal of rice husks has frequently proved difficult because of the tough, woody, abrasive nature of the husks, their low nutritive properties, and resistance to weathering, great bulk and ash content. In fact in countries like India where rice acts as major food the accumulation of heaps of rice husks is a significant problem. Therefore, utilizing rice husk in construction could protect the environment from contamination. Eggshells are known to have good strength characteristics. Most of the eggshell waste is commonly disposed in landfills without any pre-treatment because it is traditionally useless. We also make an attempt of reducing the cow dung in manufacturing of bricks through our work. Thus rice husk, cow dung and egg shell powder can be applicable to reduced cost of construction material and produced a new raw material for development in the construction industry.

II. PROBLEM STATEMENT

In India, waste disposal is one of the factors contributing the environmental problem and increasing dramatically year by year. In India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors and 4.5 million tonnes are hazardous in nature. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling and recovering different wastes and utilise them in value added applications. The other factors which act as causative agents for the environmental destruction are the exploitation of natural resources and environmental pollution. The manufacturing process of conventional bricks contributes to the above mentioned problems by means of utilising natural resources like clay and by generation of gases like carbon-di-oxide in burning process of brick making. The fig. 1 represents the amount of different types of wastes generated in India.

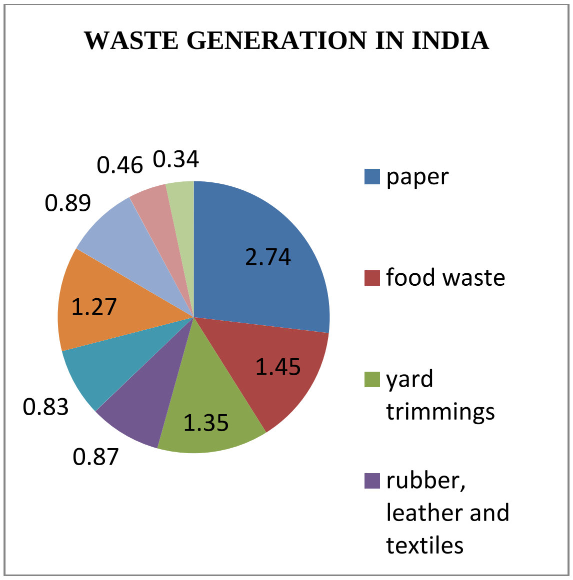

Fig.1Wastage Generation in India

Hereby, this work provides a solution for some of the problems mentioned above by using the waste materials in the production of eco-friendly bricks.

III. OBJECTIVES OF STUDY

1. To determine the Compressive strength of Fly ash Bricks replaced by rice husk using CTM (Compression Testing Machine).
2. To determine the Compressive strength of Fly ash Bricks replaced by cow dung using CTM (Compression Testing Machine).
3. To determine the Compressive strength of Fly ash Bricks replaced by egg shell powder using CTM (Compression Testing Machine).
4. To validate the obtained strengths from the different composition of various waste materials.
5. To recommend the most efficient waste material suitable for brick manufacturing.

IV. SIGNIFICANCE OF THE PURPOSE OF STUDY

This research is very important because India is the largest consumers for bricks and this method will help to contribute to reduce the construction cost. And also it resolves arising issues of waste disposal problem including environmental problems that mainly cause pollution to public health. Besides that, it will improve the strength properties and the durability of brick thus helps our economy industries of construction.

V. METHODOLOGY

The methodology of the project work is discussed in this part. The flow chart representing the processes involved in the project is given below:

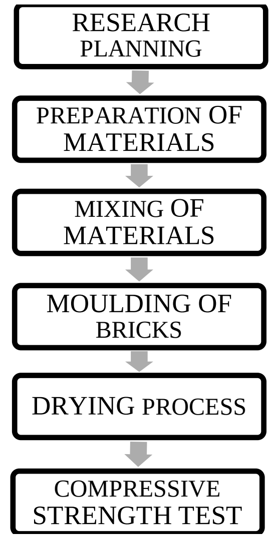

Fig.2 Flow Chart of the Methodology

A. Research planning

In the sustainable point of view, the manufacturing process of bricks contributes to the exploitation of natural resources. In order to reduce the resource extraction from the earth, engineers and constructors came out with bricks made of fly ash which is obtained as a waste product of coal burning. Presently, most of the people are getting switched on from normal conventional bricks to fly ash bricks due to its economic advantages and eco-friendly properties. We, through this project would like to investigate the fly ash bricks with enhanced strength, good thermal insulation and reduced cost respectively.

B.Preparation of Materials

After the research planning, the materials have been selected based on the requirements of the society. So, the materials are selected based on the existing severe problems which are solid waste management and economic factor. Three locally available materials are selected which are cow dung, rice husk and egg shell powder to replace fly ash in bricks. Accordingly, the materials involved in the manufacture of intended bricks are fly ash which is a major base material in the project, rice husk, cow dung and egg shell powder which are the replacing materials of fly ash in bricks and finally water for proper mixing and to maintain appropriate water content.

The resources chosen for the project are explained below:

1. Fly Ash

Pulverized fuel ash commonly known as fly ash is a useful by-product from thermal power stations using pulverized coal as fuel and has considerable pozzolonic activity. This national resource has been gainfully utilized for manufacture of pulverized fuel ash-lime bricks as a supplement to common burnt clay buildings bricks leading to conservation of natural resources and improvement in environment quality. Pulverized fuel ash-lime bricks are obtained from materials consisting of pulverized fuel ash in major quantity, lime and an accelerator acting as a catalyst. Pulverized fuel ash-lime bricks are generally manufactured by intergrading blending various raw materials are then moulded into bricks and subjected to curing cycles at different temperatures and pressures. On occasion as and when required, crushed bottom fuel ash or sand is also used in the composition of the raw material. Crushed bottom fuel ash or sand is also used in the composition as a coarser material to control water absorption in the final product. Pulverized fuel ash reacts with lime in presence of moisture from a calcium hydrate which is a binder material. Thus pulverized fuel ash –lime in presence of moisture form calcium–silicate hydrate which is binder material. Thus pulverized fuel ash –lime brick is a chemically ended bricks. These bricks are suitable for use in masonry construction just like common burnt clay bricks. Production of pulverized fuel ash-lime bricks has already started in the country and it is expected that this standard would encourage production and use on mass scale. This stand lays down the essential requirements of pulverized fuel ash bricks so as to achieve uniformity in the manufacture of such bricks.

The 80 billion tons of common burnt clay bricks are consumed annually approximately 340 billion tonnes of clay about 5000 acres of top layer of soil dug out for bricks manufacture, soil erosion, emission from coal burning or fire woods which causes deforestation are the serious problems posed by brick industry. The above problems can be reduced some extent by using fly ash bricks in dwelling units. Demand for dwelling units likely to rise to 80million units by year 2015 for lower middle and low income groups, involving an estimated investment of $670 billion, according to the associated chamber of commerce and industry. Demand for dwelling units will further grow to 90 million by 2020, which would require a minimum investment of $890billion. The Indian housing sector at present faces a shortage of 20million dwelling units for its lower middle and low income groups which will witness a spurt of about 22.5million dwelling units by the end of Tenth plan period. There is ample scope for fly ash brick and block units. In Chennai alone 1 crore bricks are required for constructional activities in every day. But good quality of bricks as well as required quantity is not available moreover during the rainy seasons supply of clay bricks are very difficult. Therefore, in order to fulfil the required demand there will be a great chance to start more units in the field of fly ash bricks. At present 20no's units are engaged and 40 lakhs no of bricks per month are manufactured in our state. And there will be scope to start near about 100 units, which will be produced more than 2 cores no of bricks per month in future. Thus marketing of these product are well shinning. Fly Ash s the inorganic mineral residue obtained after burning of coal/lignite in the boilers. Fly Ash is that portion of ash which is collected from the hoppers of ESP's and pond ash is collected from the ash ponds. Bottom ash is that portion of ash which can be collected from the bottom portion of the boilers. The characteristics of fly ash depend upon the quality of lignite/coal and the efficiency of boilers. India depends upon primarily on coal for the requirement of power and her power generation is likely to go up from 60,000MW in the year 2010, while generation of power from bituminous sources is on increase. The generation of fly ash is also likely to increase. The fly ash generation in India Thermal Stations is likely to shoot up to 170 million tons in 2010 from the present level of 100 million tonnes. The disposal of fly ash in the present method will be a big challenge to environment, especially

Properties of Fly Ash

The physical and chemical properties of Fly Ash are tabulated below:

a. Physical Properties
 Specific Gravity -2.54 to 2.65 gm/cc
 Bulk Density -1.12 gm/cc
 Fineness -350 to 450 m^2/Kg

b. Chemical Properties
 Silica - 35-59 %
 Alumina- 23-33%
 Calcium Oxide - 10-16%
 Loss on ignition - 1-2%
 Sulphur - 0.5-1.5%
 Iron -0.5-2.0 %

It may be seen that lignite fly ash is characterized primarily by the presence of silica, alumina, calcium etc. Presence of silica in fine form makes it excellent pozzolonic material. Its abundant availability at practically nil cost gives a very good opportunity for the construction agencies. About 50 to 80% fly ash may be used for the production. Fly ash conform to IS 3812/1981is one of the important aspects.

2. Rice Husk

It is a potential material, which is amenable for value addition. The usage of rice husk either in its raw form or in ash form is many. Most of the husk from the milling is either burnt or dumped as waste in open fields and a small amount is used as manure, etc. The exterior of rice husk are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica. The presence of amorphous silica is concentrated at the surfaces of the rice husk and not within the husk itself.

Properties of Rice Husk

The chemical composition of rice husk is similar to that of many common organic fibres and it contains of
 Cellulose - 40-50 percent,

Lignin - 25-30 percent
Ash - 15-20 percent
Moisture – 8-15 percent.

After burning, most evaporable components are slowly lost and the silicates are left. The typical properties of rice husk are indicated. No other plants except paddy husk is able to retain such a huge proportion of silica in there are two distinct stages in the decomposition of rice husk - carbonization and decarbonation. Carbonization is the decomposition of volatile matter in rice husk at temperature greater than 300°C and releases combustible gas and tar. Decarbonation is the combustion of fixed carbon in the rice husk char at higher temperature in the presence of oxygen.

3. Cow Dung

Cow dung, manure, or faeces is indigestible plant material released on to the ground from the intestine of a cow. It's a useful material and helps us in a variety of ways. It's also a plentiful and renewable resource. It's a shame when it's wasted.Cow manure has a soft texture and tends to be deposited in a circular shape, which gives dung patches their alternate names of cow pies and cow pats. The manure is used as a rich fertilizer, an efficient fuel and biogas producer, a useful building material, a raw material for paper making, an insect repellent, and a disinfectant. Cow dung "chips" are used in throwing contests and cow pie bingo is played as a game. The manure also plays an essential role in the lives f various animals, plants, and microbes, including dung beetles and the Pilobolus fungus.

Properties of Cow Dung

Specific Gravity - 2.62-2.65
Bulk Density (Kg/m3) - 1528-1410
pH - 9.5
Loss on Ignition (%) - 1.0-12.28
Fineness modulus - 2.62
Blains Fineness (m^2/Kg) - 370-338

4. Egg Shell Powder

It consists of several mutually growing layers of $CaCO_3$, the innermost layer-maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle. The eggshell primarily contains calcium, magnesium carbonate (lime) and protein.

In many other countries, it is the accepted practice for eggshell to be dried and use as a source of calcium in animal feeds. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine grained powder with suitable proportion which is sieved to the required size before use with concrete/mortar.

5. Water

Water is a chemical substance that is essential to all known forms of life. It appears colourless to the naked eye in small quantities, though it is actually slightly blue in colour. It covers 71% of Earth's surface. Current estimates suggest that there are 1.4 billion cubic kilometres (330 million m3) of it available on Earth, and it exists in many forms. It appears mostly in the oceans (saltwater) and polar ice caps, but it is also present as clouds, rain water, rivers, freshwater aquifers, lakes, and sea ice. Water in these bodies perpetually moves through a cycle of evaporation, precipitation, and runoff to the sea.

C.Mixing Process

First, each of the ingredients is conveyed to a separator that removes oversize materials. After the removal of oversized debris from the raw materials, a scalping screen is often used to separate the different size of material. Next materials like rice husk, egg shell powder and cow dung are mixed separately with the fly ash. Subsequently, water is added to the mixture. Then the materials are shifted for moulding process.

D. Moulding Process

Giving the required shape to the prepared brick-earth is known as moulding of bricks. There are two different ways of doing it. They are

1. Hand moulding, and
2. Machine moulding

In our project we preferred hand ground moulding, because hand mould was easily available for us.

1. Hand Moulding

Hand moulding of bricks is extensively used India. This could be done on ground or on table known respectively as *Ground moulding* and as *Table moulding*

2. Ground Moulding

This method is adopted when a large and level area of land is available for the purpose. The area of land on which moulding is to be done is levelled, plastered smooth and sprinkled over with sand.

1. To prevent the moulded bricks from sticking to the moulds either sand is sprinkled on the inner sides of the mould or the mould is dipped in water each time before moulding is done. When sand is used to prevent the sticking of earth to moulds the moulded bricks are known as sand moulded and if the mould is dipped in water each time before moulding a brick then the bricks are known

as slopmoulded bricks. Sand moulded bricks have better finish sharper edges.

2. After either sprinkling sand on the inside of the mould or dipping the mould in water take a lump of well-prepared earth, the volume of which is a little more than that of the brick. This lump is shaped in hands to the size and shape of the brick.
3. Now it is rolled in sand and with a jerk the lump is n gives blows with his fists and presses in the corners and edges with the thumbs.
4. The surplus soil is then scrapped off and the top surface levelled. A metal plate with a sharp edge, known as strike is used for removing the surplus soil. Generally a thin wire stretched on a frame is used for this purpose.
5. After the brick has been moulded the mould is given a gentle stroke with something hard and the mould lifted leaving the brick to dry on the ground. The mould is placed nearby to mould another brick and the process is repeated.

Bricks moulded directly on the ground have their lower faces objectionably rough and can have no frog*. To avoid it bricks ear (*Frog is an indentation provided in a face of the brick. It may carry the trade mark of the manufacturer. Bricks are laid in masonry with frog up. Frog provides a key for the mortar and holds the bricks on top firmly in place) moulded on a block of wood known as the moulding block, having a projection 0.

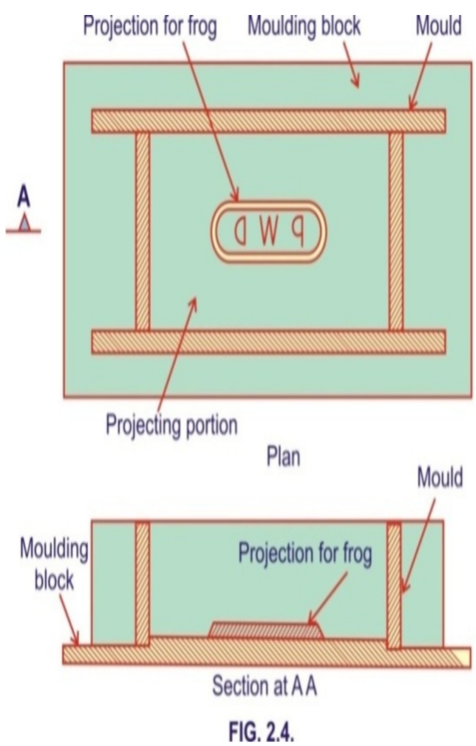

Fig. 3 Brick Mould

The figure given below is the brick moulded based on the processes mentioned above:

Fig.4 Actual Study Brick Mould

E. Drying process

After moulding process the bricks contain some amount of moisture in it. So, drying is to be done otherwise development of crack may occur while burning. The drying of raw bricks is done by natural process. The bricks are laid in stacks. A stack consist 8 to 10 stairs. The bricks in these stacks should be arranged in such a way that circulation of air in between the bricks is free. The period of drying may be 3 to 10 days. It also depends upon the weather conditions. The drying yards are also prepared on higher level than the normal ground for the prevention of bricks from rain water. In Some situations artificial drying is adopted under special dryers or hot gases. We preferred natural sun dried bricks in our project. So, the manufactured bricks are left under sun light for 15 days.

F.Compression Strength Test

Compressive strength of a brick is determined by testing the brick under standard conditions using a Compression testing machine which is given in fig.4. The procedure as mentioned in IS 3495 (Part-2) shall be used to determine the compressive strength of brick work.

Fig.5 Compression Testing Machine (CTM)

Five numbers of manufactured bricks of each composition are tested and the average compressive strength value has been reported.

IS-5454 has been referred for sampling of bricks for compressive strength test.

1. The manufactured brick specimen is carefully centred between plywood plates of compression testing machine given in fig.4. The plywood sheets will ensure that the load is transferred uniformly.
2. Then axial load is applied at a uniform rate until the brick fails.
3. The maximum load at failure is noted and the procedure is repeated for other specimens.

The minimum compressive strength required for a Burnt Clay Brick as per IS code is 3.5 N/mm2.Preconditioning.

The following steps are done on all the specimens before they are tested:

1. The dimensions of the brick are measured.
2. The unevenness observed on the bed faces (i.e., frog side and on the opposite side) are removed by grinding.

VI. RESULTS AND DISCUSSIONS

A. Compressive Strength of Manufactured Bricks

The specimens of the size 20x21x22cm for the various proportions of rice husk, cow dung, egg shell powder and fly ash are manufactured. The manufactured bricks are sundried for 7days and tested for compression strength.

Compressive strength = P/A

Where,

P = Maximum load in N applied to the specimen
A = Cross sectional area of the specimen in mm^2

B. Compressive Strength of Rice Husk Replaced Fly Ash Bricks

TABLE I COMPRESSIVE STRENGTH OF RICE HUSK REPLACED FLY ASH BRICKS.

Sl.No.	Percentage of fly ash	Percentage of rice husk	Compressive strength (Mpa)
1	60	40	4.0
2	70	30	4.1
3	80	20	4.3
4	90	10	4.5

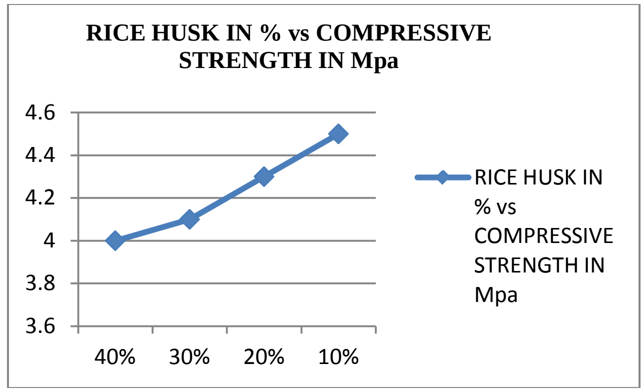

Fig.6 Relation between the percentages of rice husk added to the compressive strength of rice husk replaced bricks.

It is observed that the compression strength of the bricks decreases with increase in the rice husk content.

C. Compressive strength of cow dung replaced fly ash bricks

TABLE II COMPRESSIVE STRENGTH OF COW DUNG REPLACED FLY ASH BRICKS.

Sl.No.	Percentage of fly ash	Percentage of cow dung	Compressive strength (MPa)
1	60	40	3.9
2	70	30	4.0
3	80	20	4.2
4	90	10	4.1

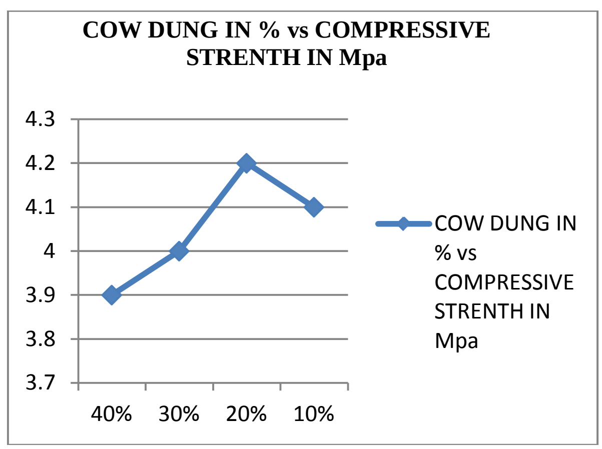

Fig.7 Relation between the percentages of cow dung added to the compressive strength of rice husk replaced bricks.

It is observed that the compression strength of the bricks decreases with increase in the cow dung content.

D. Compressive Strength of Egg Shell Powder Replaced Fly Ash Bricks

TABLE III COMPRESSIVE STRENGTH OF EGG SHELL POWDER REPLACED FLY ASH BRICKS.

Sl.No.	Percentage of fly ash	Percentage of egg shell powder	Compressive strength (Mpa)
1	60	40	3.8
2	70	30	3.9
3	80	20	4.0
4	90	10	4.05

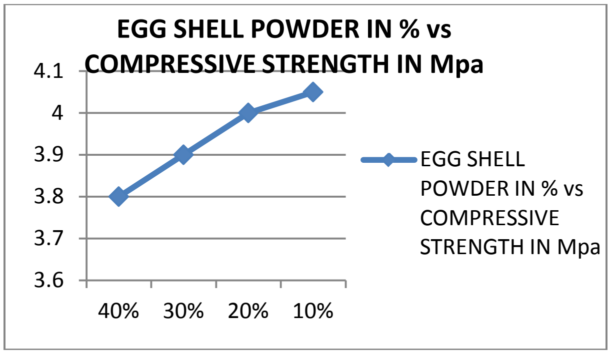

Fig.8 Relation between the Percentages of Egg Shell Powder Added to the Compressive Strength of Egg Shell Powder Replaced Bricks

It is observed that the compression strength of the bricks decreases with increase in the egg shell powder content.

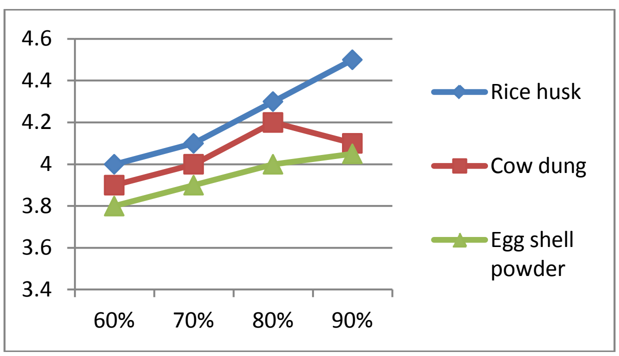

Fig. 9 Comparison of all the three Materials i.e. Rice Husk, Cow Dung and Egg Shell Powder.

Finally, it is concluded that the usage of rice husk in partial replacement of fly ash in bricks is much better and suitable when compared with other materials like cow dung and egg shell powder.

VII. CONCLUSION

The results showed significant potential and scope for utilizing the solid waste for manufacturing of building materials that are energy-efficient, lightweight and sustainable. The tests done on the fly ash bricks show that the use of waste materials like rice husk, cow dung and egg shell powder in the brick production led to a significant reduction in compressive strength of bricks. The compressive strength of bricks decreased with increase in the replaced materials content. However, if the amount of materials is limited (20% in the project), almost normal compressive strength of bricks can still be obtained. The use of waste materials in the brick production also helped in the management of wastes in the locality considered.

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