Production of Innovative Eco-Friendly Efficient Clay Bricks Based on Construction Demolition Waste and Egg Shell Waste

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Abstract. This study investigates the reuse of Construction Demolition Waste (CDW), Eggshell Powder (ESP), and Manufactured Sand (M-Sand) in clay brick manufacturing. The aim is to develop eco-friendly and cost-effective bricks by partially replacing clay with these materials. To study properties of brick making material, survey availability of waste material in the environment and selected materials to be partially replaced to making of clay brick. Before replacement of waste materials, analysed the properties of physical and chemical behaviour of clay as well as the waste materials. The novelty of this process, utilizing ESP, CDW and M-Sand for the partial replacement to clay. Replacement of waste materials to clay by ESP, CDW and M-Sand materials various combination. The modified composites of bricks made in standard procedure with reference to IS 1077: 1992. After casted bricks are dried and to analysed various tests such as compression test, efflorescence test, water absorption test and soundness test are done with reference to IS 3495: 1994 Part I to IV. Examine these test results data are compared with conventional clay bricks to find out optimum replacement of particular waste material that produce the maximum strength.

Keywords: Egg shell Powder, Demolition Waste, M- Sand, Compression Test, Efflorescence Test, Water Absorption Test and Soundness Test

1 Introduction

The global demand for construction materials has significantly increased with infrastructure development, creating a need for sustainable and low-cost building alternatives. This highlights the importance of exploring alternative, cost-effective materials to reduce environmental impact. Most important traditional building materials like clay bricks are stonework unitscollected of non-metallic inorganic material and are mostly used as building work in worldwide [1,2]. The manufactured bricks dried by direct sunlight or burnt. The compare to the burnt bricks is stronger than others. There are different types of bricks, based on the admixture of raw material utilized for bricks manufacture. It is similarly adding of admixtures of raw materials of burnt brick to produce different properties in the end product. Still the construction field emerging to find the new advanced technique used with an importance gives on eco-friendly brick manufacturing technology that use of variety of

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industrial and agricultural waste materials [3].

Further find the new eco-friendly admixtures includes organic wastage, such as saw dust, coal, rice husks and dry dusty pulp etc., which burn out when the bricks undergo firing. This type of mixture of raw materials serves as they burn out; they leave pores in the bricks. As a result, it permits to control the bulk density, light weight and more porous inside the bricks [4].

The main advantage of this purpose to manufacturing of more burnt brick uniformly, specifically when the firing is being done outside of factory conditions, in which case inability to reach the minimum desired temperature of 1000°c results in un-burnt cores especially in solid bricks.

The pores formed as the raw material admixtures are allow the heat to reach into the inside the core, in that way avoiding un-burnt cores, while the admixtures on their part serve as extra fuel which runs extra hotness for the flammability. [5,6].

2 Materials and Methods

2.1 Egg Shell powder (ESP)

ESP is one of the novel Supplementary Cementitious Materials (SCMs) and a basis source of calcium carbonate in the pure form of calcite. Eggshell Powder (ESP) is rich in calcium carbonate and reacts readily with other compounds, as confirmed by activity tests. The prepared ESP powder is shown in Fig 1. Most of research have been studied on the usage of ESP power in various applications of construction field like pavement sub-base, hot mix asphalt, cement based concrete product. Embankments and flow-able fills. Also, the construction field research shows that ESP makes well in confident application without negotiation on the essential quality [7]. But there is lagging of implementation of usage of ESP in brick manufacturing work. However, more research shows that ESP can be utilized the clay brick manufacturing. The percentage of mixing of ESP with making of clay bricks were prepared with 25%, and 50%. In such properties of ESP covering either mounding sand mix was assessed, and it was found that there was enhanced mechanical strength, physical properties and chemical reactions [8].

The valorization of ESP in clay bricks at industrial scale was performed in a research study. Accordingly, it was concluded that ESP can be used in clay bricks. In another study, feasibility or recycling spent ESP in clay brick showed that spent foundry sand can be introduced in clay bodies in variable amounts depending on the clay and the plasticity of spent ESP the percentage of recyclable sand is reported to be influenced by the characteristics of the raw material and the brick making process.

Fig. 1. Egg Shell powder (ESP).

2.2 Construction Demolition Waste (CDW)

Recent research has improved a new technique to produce energy-efficient fencing materials using recycled building and demolition waste (C&D). This technique will also give the solution for solid waste management problems associated with C&D waste reduction. Construction demolition waste as shown in Fig 2.

Most buildings use materials such as concrete blocks, burnt bricks, hollow blocks, and fly ash bricks, which consume high amounts of energy during production and emit substantial carbon dioxide. This type of materials consume energy during making process, leading to emission of high embodied carbon and consume extracted raw material which leads to unsustainable constructions. In India approximately 900 million tons demands on blocks and bricks every year. Consequently, construction sites generate large amount of construction and demolition waste of approximately 100 million tons per year. In this situation give the importance to encourage sustainable building construction, to overcome the major issues such as conserving essential raw material usage and reduction of emissions. The clay is one of the heterogeneous nature raw material resources for manufacturing of traditional clay brick, in which adding various types waste materials are added and maintaining its technical standards aspects. In this study, we overcome the problem to encourage industrial waste to include as additive in traditional clay brick manufacturing. Thus, the CDW was combined to the clay bricks with CDW mixed ratio of 25% and 50% at used in non-structural building structure of masonry. The CDW consists of moreover moulding sand mix and it was found to improve the mechanical and physical strength [10,11].

Fig. 2. Construction Demolition Waste (CDW).

2.3 Manufactured Sand (M-Sand)

In recent years increased demand of traditional construction material resulted in need to search for alternate remedial material. Manufactured sand (M-Sand) is also known as crushed sand or manufactured fine aggregate. It is a substitute for river sand for construction field. It is produced by crushing rocks, mine stones, or big size aggregate portions into small sizes like less than 4.75 mm by using crushing machinery. This type of sand has a shape of angular and cubical shape. Fast growing infrastructure and construction field, the demand for river sand has vastly increased, causing insufficiency of the traditional river sand in most of the country [12]. In this reason reduce the quantity of river sand for construction and increase the usage of M-sand. At the same time the usage of M- Sand is its easily availability in nearby places, with minimum transport cost and low-cost material. Due to this reason, the construction cost can be reduced by the usage of M-Sand as an alternative for river sand. [13,14]. The additional benefit of usage of M-Sand is it can be dust free, M-sand size can be easily controlled so that it meets the essential grading for the construction. M-Sand sample as shown in Fig 3.

Fig. 3. M – Sand.

3 Lab Tests on Materials

The following analysis is done to study the physical properties and chemical properties of clay and waste materials are Liquid limit test, Plastic limit test and Specific gravity test.

3.1 Liquid Limit Test

Liquid limit Test is estimated the amount of water in soil at which changing behavior of a clay changes into plastic to liquid state and this test analyzes the sticky and flexibility of the soil. Fig 4 shows liquid limit test of the material.

Index Flow (If) = 32.258

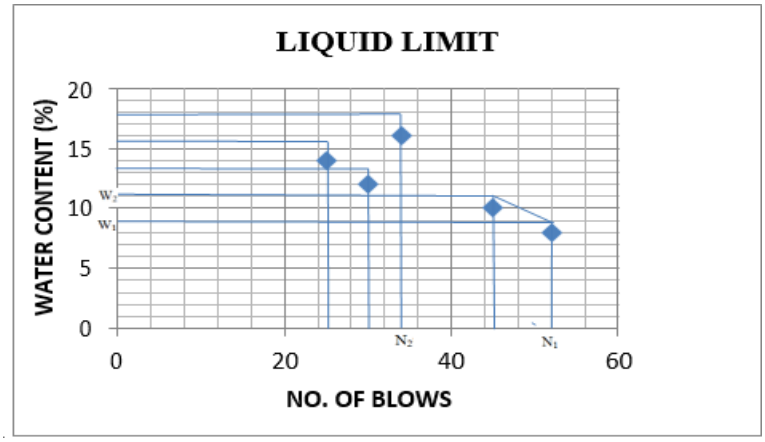

Fig. 4. Liquid limit Graph.

3.2 Plastic Limit Test

It is explaining the water content at which a soil wills justbeing to smash when rolled into a thread approximately 1/8" in dia.

Plastic limit (Wp) = 36.3

3.3 Specific Gravity Test

Specific gravity means that the ratio between weight of the taken volume of soil and weight of anequal volume of water

- Specific Gravity of Clay soil = 2.6
- Specific Gravity of Egg Shell Powder (ESP) = 1.06
- Specific Gravity of Construction DemolitionWaste (CDW) = 2.65
- Specific Gravity of M-Sand=2.6

4 Casting of Brick

The first and foremost work in casting of brick is identifying the shape and size of the brick and mould with respect to IS 1077:1992. The various steps of casting procedure of the brick

as follows:

The first step in the casting of brick is to take the dry soil and the waste materials which are to be added. If the soil is wet, then we should dry the soil by oven of more than 800 degree Celsius.

The dry soil and ESP, CDW, M-Sand are taken respectively according to the ratio of (2.5:7.5) or by 25% of volume of brick mould and also in the ratio of (5:5) or by 50% of volume of brick mould.

In this casting, we took 2 bricks volume of clay as 100% or 10 parts. From this 100% weight, firstly we took 25% of ESP, CDW, M-Sand respectively and 75% of clay to casting and then we took 50% of ESP, CDW, M-Sand respectively and 50% of clay to casting

First, we did the dry mix.

Further, we have done the wet mix by adding 25% of water into the dry mix. Mix the mixture thoroughly.

Using the standard size of mould (9 cm x 9 cm x 9 cm), the mixed soil is damped into the mould, remember that the air particles should not present.

Take the mould carefully so that it should not affect the shape of brick.

The brick is dried under the sun for 3 days.

After 3 days brick is carefully taken with help of knife which is to cut the ground sands which sticks on the brick.

The bricks are kept in oven for 6 days so that they will attain the strength and durability.

Finally, the bricks have been tested according to the code book IS3495:1994 PART I to IV. The cast brick as shown in Fig 5.

Fig. 5. Casted Bricks.

5 Result and Discussion

5.1 Compressive Strength Test

The compressive strength test for ESP, CDW & M-sand are shown in Table 1, 2 & 3. This test is estimating the strength of brick with reference to the IS: 3495 – Part (I)-1992 and to determine the compression strength of both conventional clay brick and casted bricks and as shown in Fig 6.

Fig. 6. Compressive Test.

Table 1. Compressive test for ESP

%OF WASTE MATERIAL ADDED IN BRICK	LENGTH (mm)	BREADTH (mm)	FAILURE LOAD (kN)	CRUSHING STRENGTH N/ mm2
25	190	90	30	2.75
50	190	90	18	1.93

Table 2. Compressive test for CDW.

%OF WASTE MATERIAL ADDED IN BRICK	LENGTH (mm)	BREADTH (mm)	FAILURE LOAD (kN)	CRUSHING STRENGTH N/ mm2
25	190	90	30	1.58
50	190	90	18	2.87

Table 3. Compressive test for M-sand.

%OF WASTE MATERIAL ADDED IN BRICK	LENGTH (mm)	BREADTH (mm)	FAILURE LOAD (kN)	CRUSHING STRENGTH N/ mm2
25	190	90	30	1.65
50	190	90	18	2.33

5.2 Efflorescence Test

Efflorescence is the usual term for deposit of soluble salts, formed in or near the surface of a porous material, as a result of evaporation of water in which they have been dissolved and as shown in Fig 7.

- Nil - No perceptible deposit of efflorescence
- Slight - Not more than 10% of the exposed area of brick is covered with a thin deposit of salts

The results are analyzed with a table and arrived.

- Our ESP partially added brick showed nileffloresce nce value.
- Our CDW partially added bricks showed nileffloresce nce value.
- Our M-Sand partially added bricks showed aslight efflorescence value.

Fig. 7. Efflorescence Test.

5.3 Water Absorption Test

Water absorption test values are tabulated in Table 4. The aim of the water absorption test on bricks is determining the quality, estimate the durability such as degree of burning, and

behavior of weathering, degree of compactness and as water is absorbed by pores in bricks. The water absorption properties of bricks increase with increase in pores of the bricks. So, the bricks which have water absorption properties less than 3% can be called as vitrified and as shown in Fig 8.

Fig. 8. Water Absorption Test.

Table 4. Water Absorption Test.

S. No.	Replacement of Waste Material in %	Initial Weight W1 (Kg)	Final Weight W2 (Kg)	Water absorption Value in %
		ESP		
1	25	3.02	3.43	13.57
2	50	3.13	3.50	11.82
		CDW		
1	25	3.17	3.61	13.88
2	50	2.96	3.49	17.91
		M-SAND		
1	25	3.06	3.54	15.68
2	50	3.03	3.49	15.18

5.4 Hardness Test

In this testing method, we analyze the hardness of bricks very easily. Using this method, to scratch on the surface of the bricks to make use of a fingernail. The bricks did not show any mark

while scratching the brick with fingernails. The results shown in Fig 9.

Fig. 9. Hardness Test.

5.5 Soundness Test

Brick type and soundness test are shown in Table 5. In this test, the two bricks struck each other. The bricks should not break and make the clear ringing sound formed.

Table 5. Various types of Brick and Their soundness Test.

S. No	BRICK TYPE	SOUND
1	ESP	Metallic ringsound
2	CDW	10% alone gave metallic ring sound remaininggave wooden sound
3	M-Sand	Metallic ringsound

6 Conclusion

In our effort to utilize waste materials in clay brick, we have identified the optimal ratio of replacement of waste material to attain higher strength. The optimum replacement percentage of waste material is identified from the compression test, water absorption test and so on. We used three types of waste materials such as ESP, CDW and M-Sand as replacement materials in clay. We cast bricks by replacing the waste materials by 25% to 50%. From compressive strength test, CDW produced maximum strength of 2.8 N/mm^2 at 50% of replacement and the strength is increased with increase of waste replacement. For ESP and M-Sand, the strength increases till 25% and 10% then it decreases. In water absorption test, produced result which is less than 20% of its weight. But CDW failed the soundness test. So, selecting 30% of M-Sand will produce maximum strengthand reuse of waste production to save the environment.

References

[1] P. Muthukumar, S. Divya, S. Sethuraman, A. Parthipan, “Experimental Investigation on Fully Replacement of Fly Ash By M-Sand Slurry in Light Weight Brick” International Journal of Scientific Development and Research (IJSDR), Volume 4, Issue 5 May 2019,

ISSN:2455-2631.

[2] Faisal Sheikh Khalid, Herman Shah Herman, Nurul Bazilah Azmi, and Mohd Irwan Juki," Sand Cement Brick Containing Recycled Concrete Aggregate as Fine-Aggregate Replacement", MATEC Web of Conferences,ISCEE 2016 .

[3] Singh, D., Kumar, R., Nighot, N.S., Rajput, A., Prajapati, A., Singh, B.K., Kirgiz, M.S., Srinivasaraonaik, B., Mishra, R.K., Khan, S. and Lakhani, R., 2023. A comprehensive review on valorisation of octal by-product as supplementary admixtures in the production of fired and unfired bricks. *Construction and Building Materials*, *408*, p.133641.

[4] Anayat Ali, Shamshad Alam," Partial Replacement Of Fine Aggregate With Brick Dust",International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED) Impact Factor:5.22 (SJIF-2017),e-ISSN:2455-2585.

[5] Blasius Henry Ngayakamoa,Abdulhakeem Belloa, Azikiwe Peter Onwualu," Development Of Eco- Friendly Fired Clay Bricks Incorporated With Granite And Eggshell Wastes" Environmental Challenges Volume 1, December 2020, 100006.

[6] E. Cilli, M. A. Bruneaux, L. Chateau,J. M. Lucatelli, C.Peyratout, A. Smith," Cleanliness of Mixed Fired Clay Bricks Coming from Construction and Demolition Waste',Waste Biomass Valor (2017) 8:2177–2185.

[7] M.Clement, Dr.P.Krishnakumar, M.Athipathy, M. Vijayakumar," An Experimental Study On Bricks Manufactured Using M-Sand, Saw Dust And Recycled Plastic", International Journal of Advanced Research inEngineering and Technology (IJARET) Volume 10,Issue 4, July-August 2019, pp. 171-178.

[8] Ambika, Ashwini, Seema,Vijaylaxmi,Rajani, Saranadgoudar," Experimental Investigation on theEffect of Eggshell Powder as a Partial Replacement ofClay in Bricks", International Journal for ScientificResearch & Development| Vol. 7, Issue 04, 2019 | ISSN: 2321-0613.

[9] Arpit Shukla, Abhishek Yadav," Brick Making Using Industrial Waste", INFOKARA RESEARCH, Volume 8 Issue 12 2019 272 ISSN NO: 1021-9056.

[10] Francis Adogla, Peter Paa Kofi Yalle, Moses Arkoh," Improving Compressed Laterite Bricks using Powdered Eggshells", The International Journal of Engineering and Science (IJES), Volume:5, Issue 4, Pages 65- 70,2016.

[11] Blasius Ngayakamo, Assia Mahamat Aboubakar, Charles Gbetoglo Komadja," Eco-Friendly Use Of Eggshell Powder As A Bio-Filler And Flux Material To Enhance Technological Properties Of Fired Clay Bricks",Metallurgical and Materials Engineering Association of Metallurgical Engineers of Serbia AMES, Research paper.

[12] Kavinraj A S Mr. G.Anand , Mr. K. Yuvaraj , Jothipriya K , Karthick R , Mouleeswaran S, Experimental Study on Partial Replacement of Cement by Pulverized Pond Ash in Concrete, International Advanced Research Journal in Science, Engineering and Technology, 07(04), 72-74.

[13] Yuvaraj, K., and S. Ramesh. "Experimental investigation on strength properties of concrete incorporating ground pond ash." Cement Wapno Beton 26.3 (2021): 253-262.

[14] Rabiatul Adawiyah Binti Abdul Wahab, Maryam Mohammad,Mazlini Mazlan "Eco-Friendly Bricks: Eggshells and Rice Husk as Clay Substitution and Silica Replacement", Virtual Innovation Competition 2020,University Teknologi MARA Kelantan Branch, page:301.