Development of Sustainable Bricks by Utilizing Vermicompost as an Alternate Material – A Waste Created Brick

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Abstract. Many different types of wastes are being generated on a daily basis which includes household waste, industrial waste, hazardous waste, construction and demolition waste etc. This generation of waste has increased enormously, and it needs to be considered as a prominent problem, as the waste management and waste disposal is not being done properly. Thus, it will lead to environmental degradation and pollution. On the other hand, over utilization of materials for construction activities leads to its extinguishing. Both scenarios will pose a threat to the environment. So, this study is carried out by utilizing vermicompost as a replacement material for red soil in the manufacturing of clay bricks. Initially, the physical properties of the raw materials are studied and the brick specimens are casted by varying vermicompost at 5, 10, 15 & 20% for red soil and they are tested for compressive strength, water absorption, loss on ignition. Among the replacements done, 10% of vermicompost for red soil gave higher strength to the bricks which is 6.23 N/mm^2 higher than the control specimen. The water absorption for all the trials is found to be less than 20% as per IS 3495 part 2. The loss in weight of the bricks due to ignition is less than 15% for all the specimens manufactured. Therefore, the utilization of vermicompost will reduce the waste disposal considerably and also the cost of the bricks can be minimally reduced as waste is being incorporated in it.

Introduction

Clay is the foremost raw material that is been used for ages in the manufacturing of bricks [1]. Various elements are present in the clay bricks. Even though the clay bricks contain silica in major proportion, the alumina present in it is responsible for imparting the plasticity to the bricks so that they can be moulded in to various shapes and sizes easily [2]. Compressive strength is one of the main properties that is required to be considered in the manufacturing of bricks as it will directly impact the mechanical property of the bricks [7]. On the other hand, waste generation and its disposal has become a major problem nowadays. There are various techniques such as incineration to reduce the waste to landfill. In our country, the waste generated contains a lot of organic matter. So composting is one of the best techniques that can be adopted to reduce the volume of waste that is sent to landfill [8].

In recent times, the motive towards attaining sustainability materials in increasing [9]. Also, the bricks have taken various forms such as fly ash bricks, cement bricks, hollow bricks etc., but still many people stick to the conventional clay bricks and the manufacturing of clay bricks is also not affected due to this change. To achieve sustainability a lot of waste material is being utilized in the construction materials and it is validated through proper researches [10,11]. In this study, an

approach towards waste reduction is chosen so that the waste can be effectively reproduced in to newer form to use it for an alternate purpose. So, the waste generated within the university is composted and the by product is used as a replacement material in brick manufacturing. This paper is an attempt to produce bricks by using vermicompost as a replacement material. So, the physical and microstructural properties of materials are analysed and studied first and then then brick specimens are casted and they are tested for its strength and quality.

Materials and methods

Generally, clay and red soil are the materials used in the making of the bricks [1]. The type of the soil used in the manufacturing of bricks will vary from region to region, as the locally available material is preferred in the making of bricks.

Materials

In this study, the locally available clay and red soil is used in the brick making process. In addition to it vermicompost is added as a replacement material for red soil. Vermicompost is a by product obtained from the decomposition of waste using earthworms. The vermicompost used in this study is obtained from the university's vermicompost plant. The waste generated within the campus and the hostel buildings is used to produce the vermicompost.

Methods

Initially, the characteristic properties of the raw materials used in the study are tested. Sieve analysis, plastic limit, liquid limit and specific gravity are the tests done to determine the characteristic properties. The percentage composition of the raw materials is determined by Energy Dispersive X Ray Analysis (EDAX). Also, the microstructure of the raw materials is identified by Scanning Electron Microscopy (SEM) with a Scanning Electron microscope EVO 18 (CARL ZEISS). Then the brick specimens are casted with varying proportions of vermicompost at the rate of 5, 10, 15, 20% for red soil and they are tested for compressive strength, water absorption, loss on ignition. The compressive strength is carried out in a compression testing machine.

Results and discussions

Physical properties

The colour of the clay, red soil and vermicompost as observed is dark brown, red and brown in colour respectively. The specific gravity of the vermicompost and red soil are found to be 1.90 and 2.67 respectively. The plastic limit and liquid limit of the clay is found to be 29.52 and 56% respectively.

Particle size distribution

The gradation of the raw materials namely red soil and vermicompost is performed by means of sieve analysis and the curve is plotted for the both. From the graph, the coefficient of uniformity (Cu) and the coefficient of curvature (Cc) is calculated. The Cc and Cu values of red soil as observed from the graph are 0.61 & 6.1 respectively whereas for compost the values of Cc and Cu are 0.9 and 3 respectively. From the Cu and cc values and as per IS 1498: 1970 [6] both the materials come under poorly graded soil. The particle size distribution graph for red soil vermicompost is shown in Fig. 1 and Fig. 2 respectively. From the graph it can be observed that the shape looks almost similar.

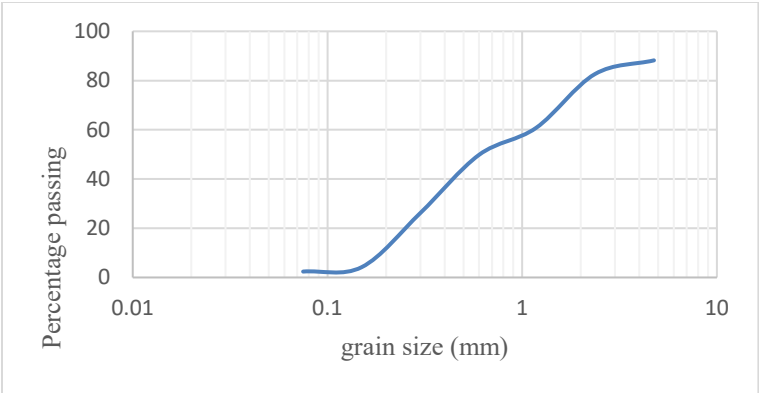

Figure 1. Particle size distribution for red soil

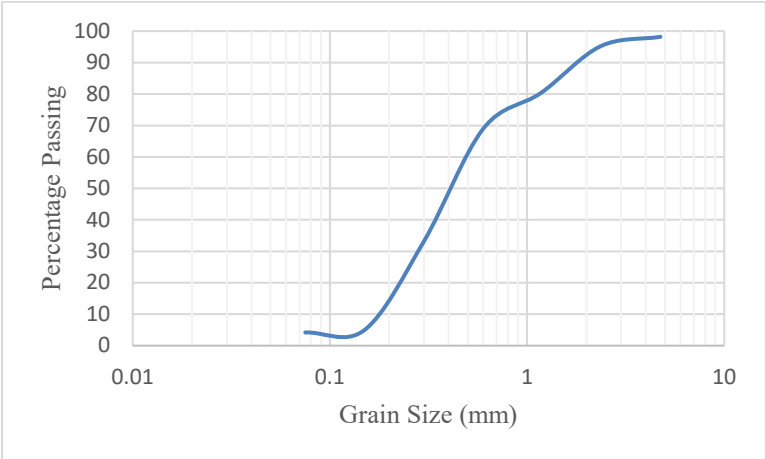

Figure 2. Particle size distribution for vermicompost

Composition

The elemental composition for red soil, vermicompost and clay are represented in Table 1.

Table 1. Composition of raw materials

Element	Weight %		
	Red soil	**Vermicompost**	**Clay**
C	6.7	19.9	38.4
O	49.3	49.4	43.5
Na	3.5	1.7	-
Mg	1.2	-	0.8
Al	10	4.8	3.7
Si	17.5	13.6	8.9
K	0.8	1	0.7
Ca	4.8	4.7	0.9
Ti	0.8	0.6	-
Fe	5.3	3.9	3.2
Cl	-	0.3	-
Mo	-	0.3	-

The main element essential for the making of bricks are silica and alumina and they are present in vermicompost also. The presence of alumina will impart plasticity to the bricks [2]. As alumina

is present in vermicompost, it will not affect the brick making process. Other elements such as Fe, Ca, K, O, Na, Ti are also present in both red soil and vermicompost.

Scanning Electron Microscopy

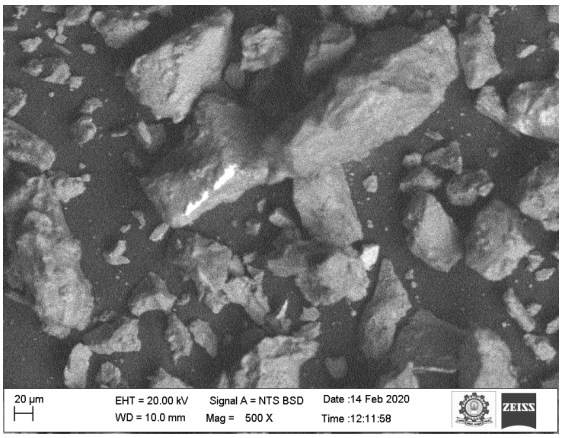

Figure 3. SEM image of red soil

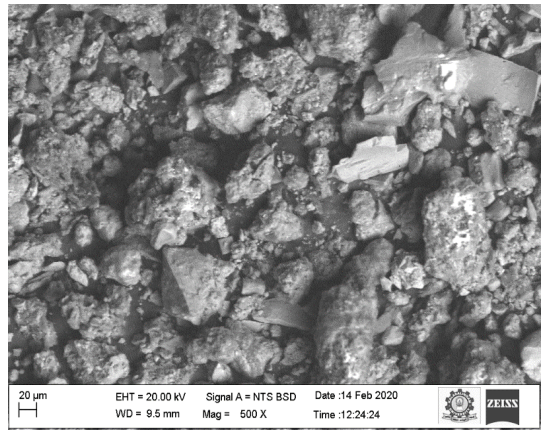

Figure 4. SEM image of vermicompost

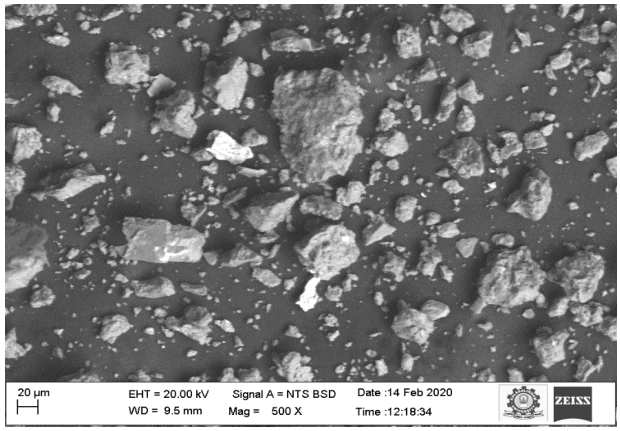

Figure 5. SEM image of clay

The Fig. 3, 4 & 5 shows the SEM image of red soil, vermicompost and clay respectively. From the Fig. 3 & 4 it can be noted that the shape of the particles of red soil is angular with sharp edge and that of the vermicompost is found to be angular with round edges. The black colour spot that is visible in between the particles are the pores present in the material. Also, it can be noticed that the structure of vermicompost is denser than the red soil [3,12]. The particles of vermicompost are packed more closer to each other than the red soil which indicates that the particles of various sizes are present in it. So, vermicompost will fill the pores present in the matrix thus making the entire matrix denser [4]. From Fig. 5, the shape of the particles of clay are found to be spherical and angular in shape. It is evident that the black spot present between the particles of the clay is more thus it increases the porosity. So, the water absorption required for the brick matrix will get higher.

Compressive strength

The load carrying capacity of the bricks are tested by means of compressive strength test and it is carried out in a compression testing machine. The compressive strength of the manufactured brick specimens with varying percentage of compost is shown in Table 2 and the Fig. 6. Shows the pictorial representation of compressive strength for various percentage of compost for red soil in brick making.

Table 2. Compressive strength of brick specimens with vermicompost

S. No	Vermicompost percentage in brick specimens (%)	Compressive strength (N / mm^2)
1.	0	5.49
2.	5	5.89
3.	10	6.23
4.	15	4.83
5.	20	4.51

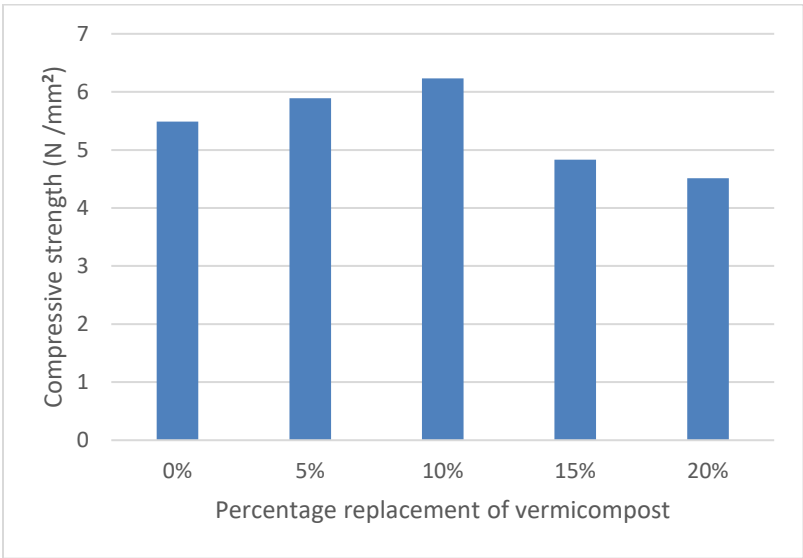

Figure 6. Compressive strength of brick specimens

From the Table 2 and Fig. 6 it can be noted that the compressive strength of the brick specimens with 5% and 10% of vermicompost replacement for red soil increases and it is also found greater than the control specimen. After 10% of replacement the compressive strength of the brick specimens tends to decrease gradually.

Water absorption

Water absorption is the test done to assess the quality of the bricks. The test is carried out in accordance to IS 3495 (II): 1992 [5].

Table 3. Water absorption of brick specimens

S. No	Vermicompost percentage in brick specimens (%)	Water Absorption (%)
1.	0	12
2.	5	10.15
3.	10	9.39
4.	15	9.06
5.	20	9.8

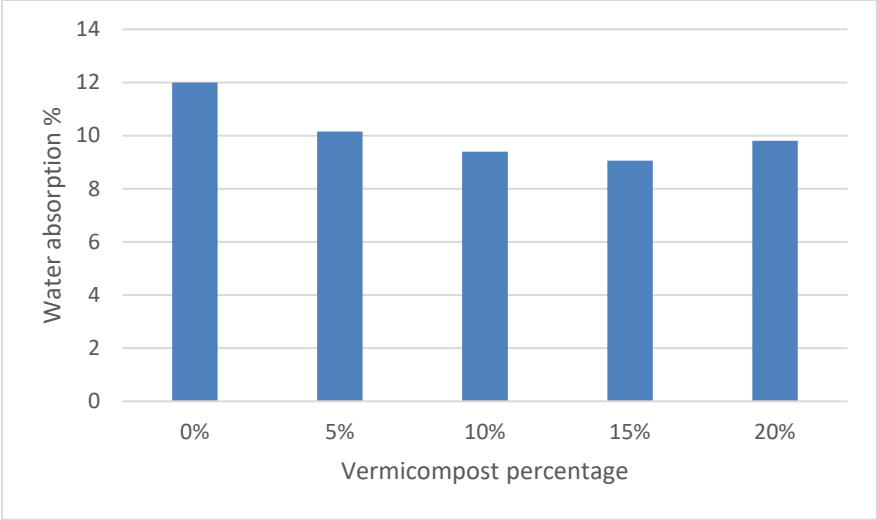

Figure 7. Graph showing water absorption of brick specimens

From the Table 3 and Fig. 4, it can be seen that the water absorption is less than 20% for all the brick specimens manufactured. As per the IS code provision the water absorption of the bricks should not exceed 20%. Hence the manufactured bricks with different percentage of vermicompost possess good quality.

Loss on Ignition

Table 4. Loss on ignition of brick specimens

S. No	Vermicompost percentage in brick specimens (%)	Loss on ignition (%)
1.	0	12.79
2.	5	13.64
3.	10	13.16
4.	15	13.38
5.	20	12.23

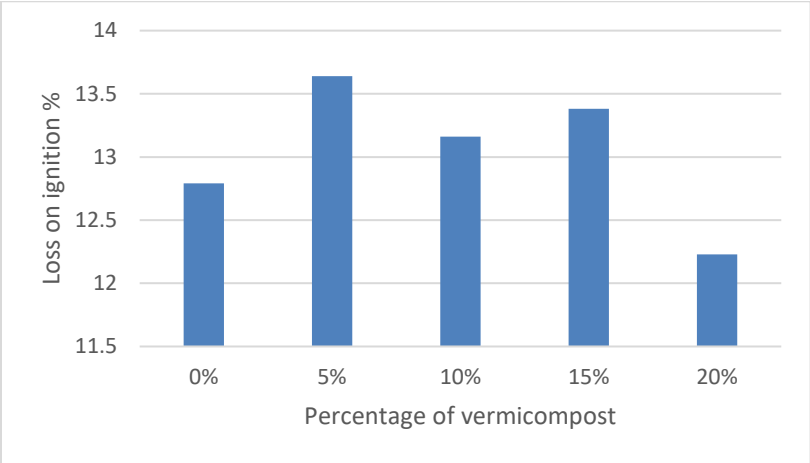

Figure 8. Graph showing loss on ignition

Table 4 shows the loss on ignition values of brick specimens with various percentage of vermicompost replacement. And the Fig. 8 shows the pictorial representation of the Table 4. This

test is carried out by keeping the brick specimens in muffle furnace at 600 degrees Celsius for a period of 6 hours. It can be noted that the loss on ignition decreases with increase in percentage of compost.

Conclusion

- Brick specimens were able to cast successfully with varying percentage of vermicompost.
- While speaking about the physical properties, the specific gravity of the vermicompost is found to be lesser than the red soil.
- In the microstructural study carried out for the raw materials, it is found that the vermicompost possess denser microstructure than all other materials.
- The particle size distribution of vermicompost and red soil comes under poorly graded soil and both the curves look alike.
- The compressive strength of the bricks with vermicompost increases up to 10% addition and beyond that the strength tends to decrease. In other words, the bricks with 10% vermicompost possess higher compressive strength than the control specimen.
- The water absorption of all the bricks is found less than 20% as specified in the IS code for water absorption.
- The loss on ignition of the bricks for all the trials is found to be less than 15%.
- Overall, it can be suggested that, bricks can be manufactured effectively by replacing vermicompost up to 10%.
- By this, the waste to landfill can be reduced and bricks can be manufactured sustainably and also the cost of the bricks can be lowered as waste material is added to it.

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