International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 04 | Apr 2024 www.irjet.net p-ISSN: 2395-0072

MANUFACTURING OF BRICKS USING SEWAGE SLUDGE AND IRON TAILINGS

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Abstract – *Finding alternative sources of raw materials is essential for sustainability of construction. Engineers are increasingly striving to use wastes as a sustainable supplement for conventional building materials. Many researchers have been advocating various processes to utilize the waste materials in as a supplement to the scarce traditional sources. Nowadays decomposition of waste materials is one of the most difficult problems, which affects the environment. Sewage sludge is the residual left from sewage treatment processes. Sludge production raises proportionately to the wastewater collection at treatment facility and also increase in the amount of effluent in water. Sewage sludge contains pathogens and potentially harmful chemicals that cause risk to human health. Hence by making use of this material, it will become a remedy for this problem. Iron tailings, is a waste material from blacksmith's workshop. The inclusion of iron tailings and sewage sludge offers ideas and a vision for recycling waste to enhance the qualities of construction materials and prevent the loss of natural resources like clay. Through this study, different proportions of sludge and iron tailings are used to cast clay and cement bricks. While also increasing the usage of industrial wastes and improving sustainability of bricks as a construction material*.

Key Words: Bricks, Sewage sludge, Iron tailings, Waste management, Recycling waste, Sustainable construction materials.

1.INTRODUCTION

Clay bricks are made from clay that is usually mixed with sand and other additives to enhance its properties. The mixture is then formed into rectangular blocks using moulds, which are then left to dry in the sun or in a controlled environment. After drying, the bricks are fired in a kiln at high temperatures to make them strong and durable.

One of the advantages of clay bricks is that they are environmentally friendly, as they are made from natural materials and are recyclable. They also provide excellent thermal insulation, helping to keep buildings cool in the summer and warm in the winter. So many attempts have been made to incorporate the wastes into the production of bricks to reduce the clay content in bricks and thereby protecting the environment. Conventional cement brick is a mixture of cement and aggregate. Properties of aggregate affect the durability and performance of bricks. The mostly used fine aggregate is natural river or pit sand. Aggregates constitute about 75% of total volume.

Sewage sludge, also known as biosolids, is the semi-solid material left over after wastewater treatment processes. Treated sludge, also known as biosolids, is sewage sludge that has undergone a treatment process to reduce the levels of pathogens and contaminants and make it safe for beneficial use. Sludge from waste water is biodegradable but it requires large area and time to dispose completely. Use of sludge from waste water treatment plants in the production of bricks not only reduce the environmental harm but also reduce cost of production of bricks as sludge is waste material. The sewage sludge has plastic properties similar to that of clay and hence the clay is replaced by sludge.

Iron tailings is also a waste material obtained from blacksmith's workshop waste. Iron tailings can be added to clay bricks as a fluxing agent to impart heat to the clay during firing and also improve the compressive strength. The addition of iron tailings in clay brick production can have several benefits, including improved strength and enhanced aesthetics.

To introduce a satisfactory means of disposal, these two wastes were combined to produce a building material. It gives an innovative approach to convert largely unacceptable wastes to a beneficial and useful material. The reuse of sludge as brick material is a long- term approach to sludge disposal for economic and environmental sustainability. Here, bricks have to be cast for various proportions of sludge, iron filings and soil mixture. The structural and environmental suitability of the brick have to be evaluated and they have been tested for various engineering properties.

2. THE METHODOLOGY

- Collection of raw materials.
- Identification of properties of materials.

- Preparation of raw materials.
- Manufacturing of bricks.
- Testing of bricks.
- Analysis of results.

3. MATERIAL PROPERTIES

3.1 Sewage Sludge

Dry sludge should have a low moisture content to prevent excessive shrinkage and cracking during the drying and firing process. Dry sludge can contain organic matter that can affect the firing process and the properties of the final product. The organic content should be low to prevent excessive smoke, odors, and cracking during firing. The particle size of dry sludge can affect the workability and homogeneity of the clay mixture. It should be finely ground to ensure proper mixing and distribution within the clay mixture. The chemical composition of dry sludge can affect the firing process and the properties of the final product. It should be free from contaminants such as heavy metals, pathogens and other harmful substances.

3.2 Iron Tailings

Iron tailings can improve the strength of the bricks by acting as a reinforcing material. When the bricks are fired, the iron tailings fuse together with the clay particles, forming a stronger bond. This can help to reduce energy consumption and improve the energy efficiency of buildings constructed with these bricks.

Iron tailings can help to reduce cracking in the final product by reducing shrinkage during the firing process. This is because iron tailings do not shrink or expand as much as clay during the firing process, helping to reduce the overall shrinkage of the brick, improved color. Depending on the type of iron tailings used, the bricks can have a unique reddish-brown color that can be appealing in certain applications.

Figure-1: Dried sewage sludge

Figure-2: Iron tailings

4. MANUFACTURING OF BRICK

The clay brick is manufactured by mixing the soil with various percentages of sewage sludge and iron tailings. The silty clay type of soil is used for the manufacturing of brick. The silty clay soil contains silica, alumina, iron oxide, magnesia, lime and organic matter.

Sewage sludge possess a similar nature to that of clay. For the manufacturing of bricks, the sewage sludge is dried and sieved. The dried sludge of size below 600 microns is used. The sludge is added in various percentages like 10%, 15%, and 25%. Similarly iron tailings are also powdered and sieved. The tailings of size below 600 microns is used to manufacture bricks. The iron tailings is added in varying percentages of 1, 2 and 3% in clay bricks. The cement bricks were made by adding iron tailings in various percentages. The cement bricks are made in the proportions of M15 and M20 with partial replacement of fine aggregate (sand) by 25 and 50 %.the proportions of clay bricks are given in the table below.

Table-1: Proportion of clay bricks

Sl. No.	Mix Proportion		
	Soil (%)	Sewage sludge (%)	Iron tailings (%)
1	89	10	1
	88	10	2
	87	10	3
2	84	15	1
	83	15	2
	82	15	3
3	74	25	1
	73	25	2
	72	25	3

The figure below shows the manufactured clay bricks.

Figure-3: Manufactured clay bricks with sludge and iron tailings

5. TESTS ON CLAY BRICKS

Various tests are done on bricks to find the suitable proportion of bricks made with sewage sludge and iron tailings.

5.1 Compression test

The compressive strength of conventional clay bricks is 11.25 N/mm^2. The surface area of brick is 20000mm².

Table shows the compressive strength test results of various proportions of bricks.

Mix proportion			Breaking load (KN)	Compressive strength (N/mm^2)
Soil (%)	Sludge (%)	Iron tailings (%)		
89	10	1	275.00	13.75
88	10	2	231.25	11.56
87	10	3	220.00	11.00
84	15	1	256.25	12.81
83	15	2	227.00	11.37
82	15	3	212.50	10.62
74	25	1	222.00	11.12
73	25	2	210.00	10.50
72	25	3	206.25	10.32

The graphical representation of compressive strength results is shown below;

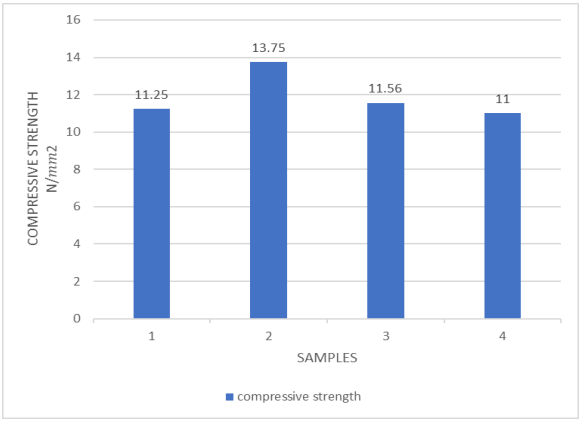

Chart-1: Compressive strength of brick with 10 % sludge

The figure shows the compressive strength results of natural clay bricks and bricks with 10 % sewage sludge with varying percentages of iron tailings as 1, 2 and 3%. From the graph we can analyze that the bricks with 10 % sludge and 1% iron tailings gave higher compressive strength with a value of 13.75 N/mm^2. The bricks with proportion 10% sludge and 2% iron tailings also give higher compressive strength than conventional brick. But the brick with 10% sludge and 3 % possess a lower compressive strength than conventional brick. As the iron tailings increases the brick may be gaining brittle nature and hence lower strength.

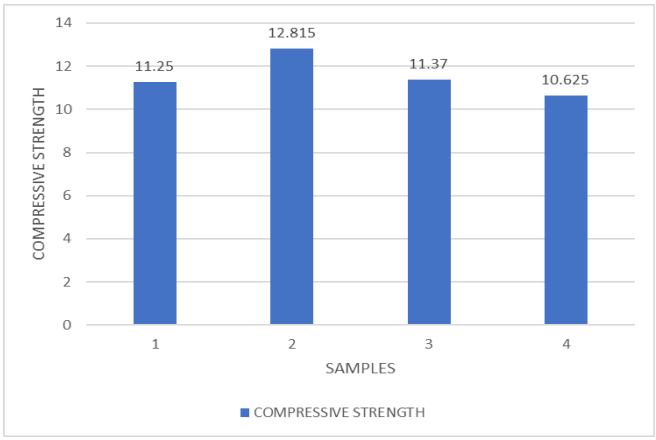

Chart-2: Compressive strength of brick with 15 % sludge

The graph above shows the compressive strength of natural clay bricks and bricks with 15% sludge with varying percentages of iron tailings like 1, 2 and 3 %. By the comparison of the compression test results, the bricks with 15 % sewage sludge and 1% iron tailings gives the higher compressive strength than conventional brick. It gives a value of 12.81 N/mm^2. The other proportion with 2 % iron

tailings also gives more compressive strength than conventional bricks with a value of 11.37 N/mm^2. But the proportion of bricks with 3 % iron tailings gives lower compressive strength than conventional clay bricks.

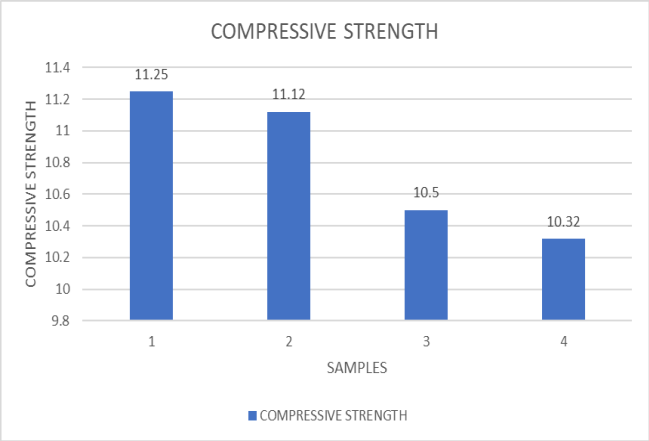

Chart-3: Compressive strength of brick with 25 % sludge

The above graph shows the compressive strength of bricks with 25 % sewage sludge with varying percentages of iron tailings. The results of the test give that, they possess a lower compressive strength than conventional bricks. By comparison, the compressive strength of the bricks reduces when the percentage of adding iron tailings is increased.

5.2 Water Absorption test

The water absorption test of conventional brick is done for comparison. The dry weight of the conventional brick is 2039g and the wet weight is 2538g. The water absorption of conventional brick is 19.66%. For mix with 10% sewage sludge, the minimum water absorption is shown by brick with 1% iron tailings. For the mix with 15% sludge, the minimum is shown by the brick with 1% iron tailings. For the mix with 25% sludge, the minimum water absorption is shown by brick with 1% iron tailings. When the sludge content increases the water absorption also increases. The Mix with 25% shows the maximum water absorption. Also, increase in the amount of iron tailings increase the water absorption of bricks. Thus, water absorption is less for bricks with 1% iron filings. The graphical representation of water absorption is given below.

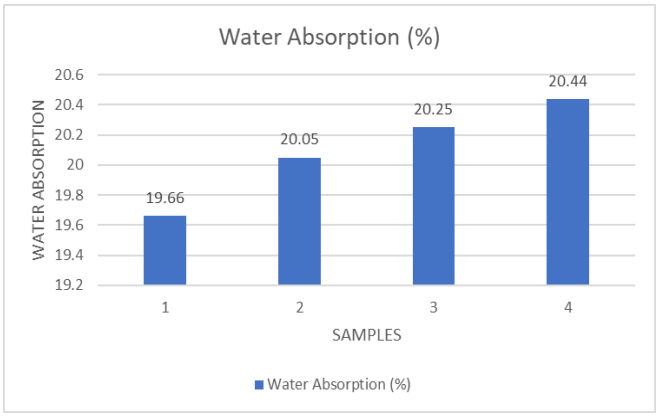

Chart-4: Water absorption of bricks with 10% sludge

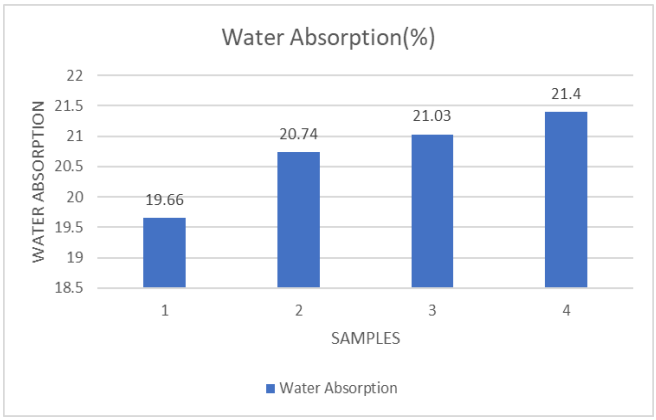

Chart-5: Water absorption of bricks with 15% sludge

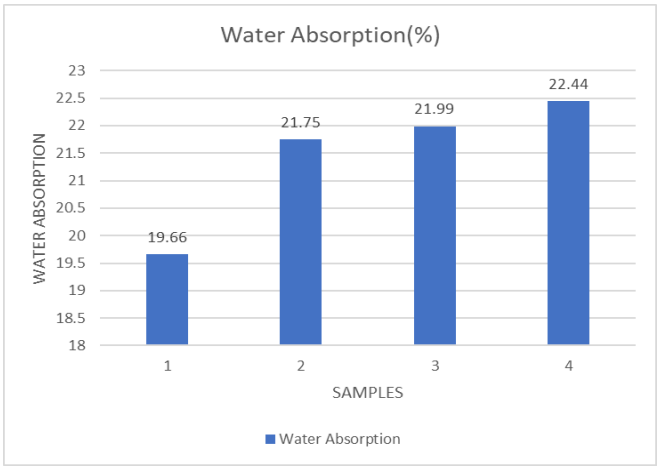

Chart-6: Water absorption of bricks with 25% sludge

5.3 Efflorescence test

Efflorescence is an important issue in the development of alkali-activated or geopolymer binders. All bricks were examined for efflorescence. Efflorescence is not occurred in any bricks under observation. From the test results, white patches didn't appear on the surface of bricks. So, bricks are free from salt content.

5.4 Hardness test

Hardness of brick is the resistance to scratching or cutting. In this test, a scratch is made on the brick surface with the help of a finger nail. No impressions are left on the bricks after scratching by finger nails. Therefore, bricks are sufficiently hard.

5.5 Soundness test

Two bricks are taken, one in each hand, and they are struck with each other lightly. The manufactured brick with sewage sludge and iron tailings did not break and a clear ringing sound is produced.

5.6 Color test

The manufactured brick possesses a uniform color of reddish brown. The uniformity in color of bricks represents uniformity in chemical composition and homogenous burning of brick.

5.7 Shape and size test

Bricks are compared according to their length, width and height. All bricks are seemed of similar size.

6. TEST ON CEMENT BRICKS

6.1Compressive strength of cement bricks

Cement bricks made with iron tailings also gives more compressive strength than conventional cement bricks. The replacement of fine aggregate by 25% gave more compressive strength than conventional cement bricks. The replacement of sand by 50 % iron tailings gave lower compressive strength than conventional cement bricks. The curing is done for 7 days and 14 days and their compressive strengths are determined. The comparison of compressive strength of normal bricks, bricks with 25% replacement of fine aggregates and 50% replacement respectively are given below.

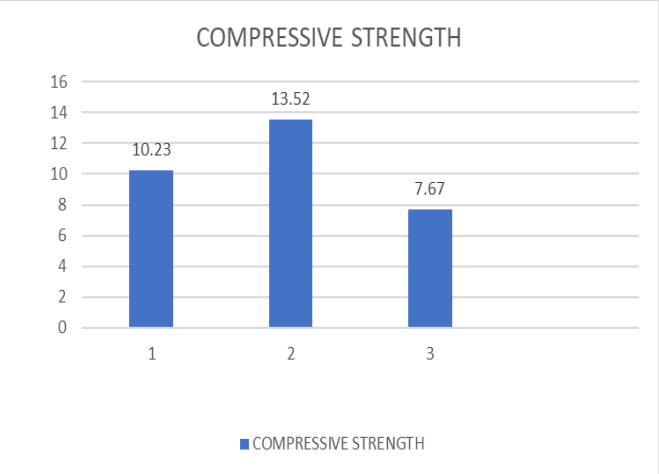

Chart-7:compressive strength of mix ratio M15 of 7 days curing.

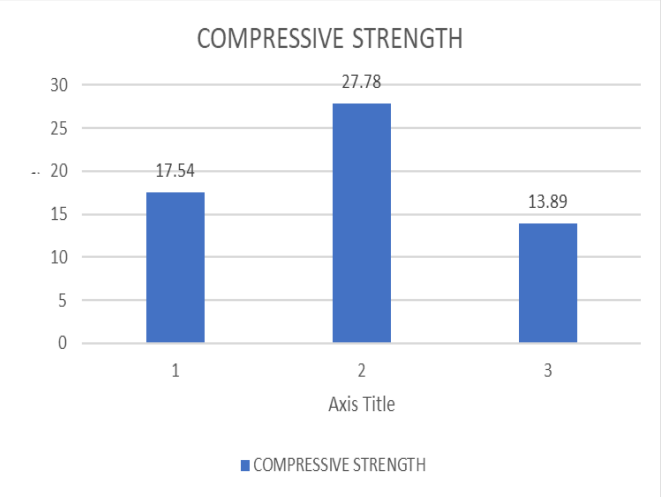

Chart-8:compressive strength of mix ratio M15 of 14 days curing.

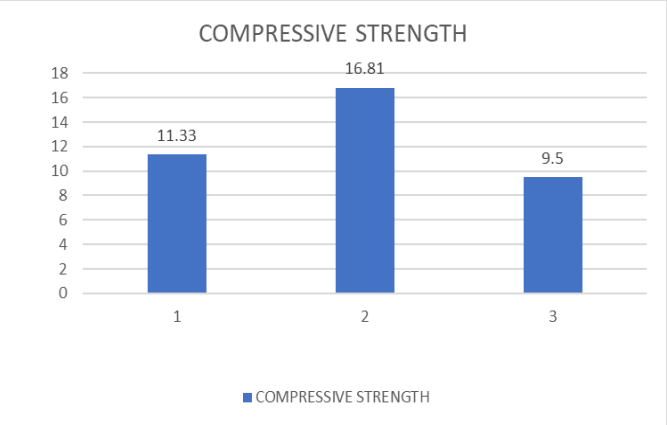

Chart-9: compressive strength of mix ratio M20 of 7 days curing

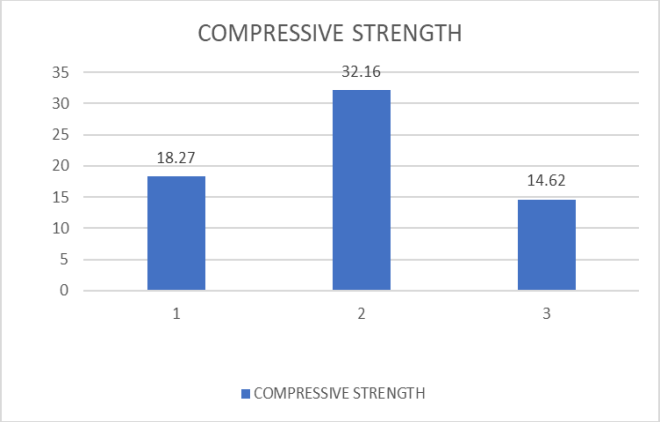

Chart-10: compressive strength of mix ratio M20 of 14 days curing

The comparison of results finalizes that the compressive strength of cement bricks also increases with the replacement of fine aggregate by iron tailings. But more replacement of sand by iron tailings decreases the compressive strength of brick.

7. CONCLUSIONS

- By utilizing these waste materials, it provides an alternative way to make brick in most cost effective way. Use of tailings with clay for producing bricks can lead to consumption of large quantities of waste materials and manage it in an environment friendly way.
- As per the tests, the clay bricks with 10% and 20% sludge with 1 and 2% iron tailings gives more compressive strength than conventional bricks. The other proportions give a lower compressive strength than conventional brick.
- The water absorption test of 10% sludge and 1% iron tailings gave minimum water absorption of 20.05%.
- From the result analysis, it can be concluded that the bricks with 10% sludge and 1% iron tailings is a suitable proportion to manufacture the bricks with good qualities.
- The replacement of sand by iron tailings by 25% in cement bricks also gives higher compressive strength than normal brick. But 50 % replacement of iron tailings gives lower compressive strength.
- The bricks made with sewage sludge and iron tailings will introduce a good quality, ecofriendly, and feasible bricks in to the construction field where no additional techniques are needed for the production of bricks.

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