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USAGE OF POLY-STYROFOAM AND BAGASSE ASH IN LIGHT WEIGHT BRICK.

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Abstract
In India, bricks are usually made up of clay, and are generally produced in traditional, unorganized small-scale industries. Brick making consumes larger amount of clay which leads to top soil removal and land degradation. To avoid all this environmental threat an attempt was made to study the behaviour of bricks manufactured using, waste materials from sugarcane industrial waste. As we all know that the waste from the industries is very harmful for the environment as well as to our health, if not disposed in proper manner. The fibrous residue of sugarcane after crushing and extraction of its juice, known as "bagasse" is one of the largest agriculture residues in the world. The bagasse is however used as a biomass fuel for boilers, but after burning the by-product left is of no use and generally disposed into the rivers which affects the health of human being, environment, fertile land, sources of water bodies etc. bricks make from clay are also heavy in weight that why we use poly-Styrofoam to reduces their weight. In this research we mainly focused on bricks light weight and their good strength, by using sugarcane bagasse ash, press mud, molasses, poly-Styrofoam and prepare different proportion of these materials to manufacturing bricks. After the full manufacturing process the bricks are to be tested in the laboratory and results are analysed regarding the water absorption and compressive strength. The aim of this research was to make economical and light and green bricks to maintain environmental balance and avoid problem of ash disposal. It was also expected that bricks must be lighter in weight, energy efficient and meet required compressive strength requirements

Keywords – Sugarcane Bagasse Ash, Molasses, Press Mud, Styrofoam.

1-Introduction

Sugarcane bagasse, the fibrous residue left after the extraction of sugar juice from sugarcane, is a major source of energy in sugar mills. This abundant biomass material is widely used as a biofuel to generate steam and electricity in boilers, which is essential for various processes involved in concentrating, purifying, and crystallizing the sugar syrup. When sugarcane is processed in a factory, approximately 30-34 tons of bagasse is obtained from every 100 tons of sugarcane. Of this amount, around 22-24 tons are used within the sugar processing operations, while the remaining 8-10 tons are saved for other applications. This demonstrates the significant utilization of bagasse as a renewable energy source within the sugar industry. In addition to its use as a biofuel, sugarcane bagasse finds applications in various industries:

- Pulp and paper products: Bagasse fibers are used in the manufacture of pulp and paper products, providing an alternative to wood-based materials and contributing to sustainable paper production.
- Filler for building materials: Bagasse can be processed into particles or fibers and used as a filler or reinforcement in building materials such as boards, panels, and composites.

Substrate for growing mushrooms: Bagasse can serve as a substrate for growing mushrooms due to its organic content and moisture-retaining properties, While the combustion of bagasse in sugar mills does contribute to carbon emissions, it is important to note that the carbon released during combustion is part of the carbon cycle. The carbon dioxide emitted has already been absorbed by the sugarcane during its growth, making the overall carbon footprint of the sugar industry relatively neutral. This aspect, combined with the utilization of bagasse for energy generation, contributes to the environmentally-friendly nature of the sugar industry as a whole. Efforts continue to further optimize bagasse utilization, improve energy efficiency, and explore additional value-added applications for this valuable by-product of the sugarcane industry.

1.1 Availability of sugarcane bagasse in India:

Annually, India generates 90 million tonnes of bagasse, and approximately 8-10 % by weight of total bagasse is used to produce bagasse ash i.e. 44220 tonnes/day. Due to rapid increase in implementation of cogeneration processes in sugar mills, ash generation is also predominantly increasing.

Table-1: Data of Sugar cane Bagasse ash yearly in India (2015)

(Availability of sugarcane bagasse in different states)

S.No	State	Number of sugar mills	Bagasse ash tonnes/day
1	Andhra Pradesh	33	2196
2	Bihar	9	867
3	Gujarat	21	1628
4	Chhattisgarh	1	65
5	Haryana	15	1055
6	Karnataka	56	4222
7	Madhya Pradesh	9	455
8	Maharashtra	192	10689
9	Orissa	7	309
10	Punjab	22	1295
11	Tamil Nadu	40	3063
12	Uttar Pradesh	143	17163
13	Uttarakhand	10	999
14	Other states	8	245
	Total	566	44821

Fig-1: Sugarcane Bagasse

1.2 Materials

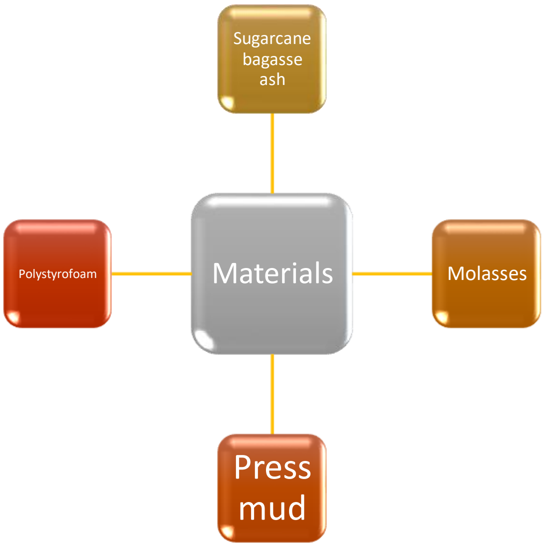

Fig. 2 Flowchart Represent materials

1. **Sugarcane Bagasse Ash**

   Bagasse is a residue that remains after the extraction of sugar juice from sugarcane in sugar factories. It is primarily composed of cellulose fibers . In many sugar factories, bagasse is burnt as a fuel to generate steam and run boilers for various processes within the factory. The burning of bagasse produces bagasse ash as a by-product. Bagasse ash contains various components, including amorphous silica. This silica content gives bagasse ash cementing properties, making it potentially useful in construction materials and other applications. India, being a major sugarcane-producing country, generates a significant amount of bagasse waste. With approximately 90 million tons of bagasse being produced annually in India alone, proper disposal and effective utilization of this waste material pose challenges for sugar factories. Researchers and scientists have been exploring ways to utilize bagasse and bagasse ash effectively, both economically and environmentally. Some of the current applications of bagasse and bagasse ash include:

- Biofuel: Bagasse is widely used as a biofuel to produce heat and electricity in sugar factories, reducing reliance on fossil fuels.

- Pulp and paper production: Bagasse fibers can be processed and used in the manufacture of pulp and paper products.

- Building materials: Bagasse ash's cementing properties make it suitable for use in the production of building materials such as bricks, blocks, and concrete.

- Agricultural applications: Bagasse can be utilized as a mulching material, composted for soil enrichment, or used as animal feed.

Efforts are being made to further explore and develop innovative uses for bagasse and bagasse ash, taking into account their potential economic and environmental benefits. These research initiatives aim to address the disposal challenges associated with bagasse waste while promoting sustainable practices in the sugarcane industry..

Table -2: properties of sugarcane bagasse ash

Minerals	Percentage(%)
Sio_2	73
Al_2O_3	6.7
Fe_2O_3	6.3
CaO	2.8
MgO	3.2
P_2O_5	4.0
Na_2O	1.1
K_2O	2.4
Loss of ignition	0.9

Fig -3: sugarcane bagasse ash

2. **Press Mud**

Press mud, also known as filter cake or sugarcane press mud, is a by-product obtained from sugar mills during the clarification and filtration process of sugarcane juice. It is a fibrous residue that contains organic matter, moisture, and various nutrients. Press mud is considered a valuable source of organic fertilizer due to its nutrient content, including nitrogen, phosphorus, potassium, and organic carbon. It can be used directly as a soil amendment to improve soil fertility, enhance water-holding capacity, and promote plant growth. In addition to its use as a fertilizer, press mud has found applications in bio composting and waste management. In bio composting, press mud can be combined with other organic materials such as spent wash from the distillery (a by-product of alcohol production) to create a composting mixture. The spent wash provides additional organic matter and moisture, facilitating the decomposition process and enhancing nutrient availability. The concept of anaerobic digestion, which involves the biological degradation of organic waste in the absence of oxygen to produce methane gas, has been utilized by waste management industries for many years. Press mud, being an organic waste, can also be subjected to anaerobic digestion to generate biogas, primarily methane. Biogas produced from press mud can be utilized as a source of renewable energy for various applications, including electricity generation and thermal heating. The utilization of press mud in these applications helps in the sustainable management of industrial waste and contributes to environmental sustainability. By converting waste materials into valuable resources such as organic fertilizers and biogas, the sugar industry can reduce waste generation, minimize environmental pollution, and promote circular economy principles.

Table-3: chemical composition of Press mud

Compound	Percentage(%)
Cellulose	11.4
Hemi cellulose	10.0
Lignin	9.3
Protein	15.5
Wax	8.4
Sugar	5.7
Na	0.22

Fig-4:Press mud

3. **Molasses**

Molasses, a by-product obtained during the sugar refining process, can have certain effects on concrete and brick production:

Concrete fluidity: Molasses can be used as a plasticizer or water-reducing agent in concrete mixes. It improves the fluidity of fresh concrete, making it easier to pour and work with during construction.

Delayed hardening time: The presence of molasses in cement paste can slow down the hydration process and extend the setting and hardening time of the concrete. This property can be advantageous in situations where longer workability or curing times are desired.

Regarding the use of Styrofoam in brick production, it is possible to reduce the density of bricks and improve their thermal insulation properties by incorporating Styrofoam beads or granules into the brick composition. Styrofoam, a type of expanded polystyrene foam, is known for its low density and excellent insulation properties. When added to the brick mixture, it creates air pockets, reducing the overall density of the bricks and enhancing their insulation capabilities. By incorporating Styrofoam in brick production, the resulting bricks can have improved thermal insulation properties, making them more energy-efficient and suitable for applications where temperature regulation is important. Additionally, the reduced density of the bricks can lead to benefits such as lower transportation costs, easier handling, and potentially reduced material usage. It's worth noting that the specific proportions and techniques for incorporating molasses or Styrofoam in concrete and brick production may vary depending on the desired properties and requirements of the final product. Proper testing and evaluation should be conducted to ensure the desired outcomes are achieved while maintaining the structural integrity and performance of the concrete or bricks.

Table-4: chemical composition of molasses

Composition	Range
Sucrose	29-40
Water	17-25
Glucose	4-14
Ash	7-15
Potassium	4-50.83
Calcium	0.8-15
Magnesium	1-14
Sodium	0.09-9
Protein	0.5-4.5
Sulphate	2.24-9.91
Amino acid	0.3-1.5
Non-nitrogenious acids	1.5-8
Wax, sterols, phosphatides	0.1-1
Biotin	0.1-2ppm,0.36mg/kg
Riboflavin	1-6ppm,1.8mg/kg

Fig-5: Molasses

4. **Poly-Styrofoam**

Polystyrene foam, often referred to as Styrofoam, is a commonly used material in the production of lightweight bricks and concrete. It is added to the raw materials of bricks as a pore-forming material, creating voids within the structure of the bricks. Polystyrene is a polymer made from the monomer styrene, which is derived from petroleum. At room temperature, polystyrene is a solid thermoplastic. However, it can be melted at higher temperatures for molding or extrusion and then resolidified into various shapes. Polystyrene foam is lightweight and has good insulating properties, making it suitable for reducing the weight of bricks and improving their thermal insulation capabilities. By incorporating polystyrene foam beads or granules into the brick composition, air pockets are created within the bricks, reducing their overall density. This reduction in density makes the bricks lighter, which can result in benefits such as easier handling, reduced transportation costs, and potentially lower material usage. In addition to its use in bricks, polystyrene foam is also utilized in the manufacturing of cutlery and other products. Its lightweight and insulating properties make it an ideal choice for disposable foodservice items. It's important to note that the use of polystyrene foam in construction materials should be done in compliance with relevant regulations and guidelines, as some regions have restrictions or guidelines for the use and disposal of polystyrene foam due to its environmental impact.

Table-5 properties of poly-Styrofoam

Properties	**Range**
Formula	(C_8H_8)
Density	0.96-1.05g/cc
Melting point	240 °C (464 °F; 513 K) for isotactic polystyrene
Boiling point	430 °C (806 °F; 703 K) and depolymerizes
Thermal conductivity	0.033 W/(m·K) (foam, ρ 0.05 g/cm3)
Solubility in water	Insoluble

Fig-6:polysyrofoam

2.Literature review

1. **G. C. Cordeiro etal. (2009):**
   Used Ultrafine grinding of sugar cane bagasse ash for application as pozzolanic admixture in concrete in 2009, and used sugarcane bagasse ash with different preposition of materials in this research size of D_{80} (80%passing size) through sieve for manufacturing of cement
2. **D. Tonnayopas etal. (2013):**
   Used sugarcane bagasse ash for manufacturing of green bricks in which the advantages of less firing, shrinkage, less weight, loss on ignition and greater compressive strength**.** In 2013 it used 30 percentage of sugarcane bagasse ash for the energy saving and maximum use of ash.
3. **M. V. Madurwar etal. (2014):**
   Used Bricks, quarry dust, lime, sugarcane bagasse ash in 2014 for manufacturing of bricks, they tested the seven bricks in which bricks 7 show 1.4% and 88.3% more than that of commercially available fly ash–cement bricks and burnt clay bricks.
4. **Rohan Rahjput (2016):**
   Used Quarry dust, Lime, Sugarcane bagasse ash, Scrap for manufacturing of bricks in 2016.

This study helps in converting the non-valuable bagasse ash into bricks and makes it valuable, In this research maximum compressive strength can be attained, Bagasse ash bricks can reduce the seismic weight of building, The expected cost of the bricks can be reduced.

5. **Manish Detroja (2018):**
   In 2018 the used Bagasse ash, Clay, Water, Sand, Admixture for manufacturing of the bricks in this study we get if addition of bagasse ash more than 20% causes more water absorption, reduction in compressive strength, less hardness, under burnt. So recommended percentage is 20-25
6. **Reena Gautam, Harsh U. Chordiya(2021):** In 2021 they used sugarcane bagasse ash, press mud, ordinary Portland cement, molasses, Styrofoam, water, fine aggregates, for manufacturing of light weight concrete. The crushing strength or compressive strength of bricks named as 4 is 9N/mm² and the brick named as 6 is 6N/mm² and the brick named as 8 is 5N/mm². Hence, they strongly recommend brick 4 has a good compressive strength and suitable for construction. Environmental effects of wastes and disposal problems of waste can be reduced through this brick manufacturing process

7. **Bhimashankar A. Vithalkar(2022):**

In 2022 they used Bagasse ash, Press mud, Lime, Clay, Water for manufacturing of bricks in this study the tested three bricks in which brick 3 have better properties in which recommended percentage of sugarcane bagasse ash in 15 percentages.

3. Methodology

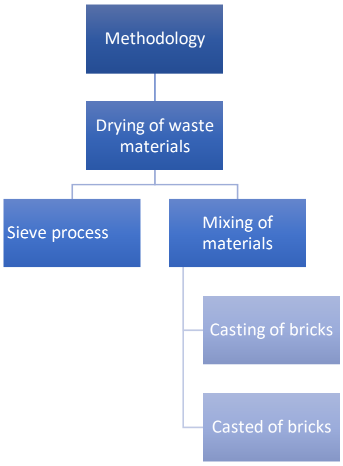

Fig:-7 Flow chart represent process

3.1.Process

i. Drying of waste materials

Drying waste materials is a common practice to reduce their moisture content and improve their handling and storage properties. Sun drying is one of the methods used to accomplish this. The process involves exposing the waste materials to direct sunlight for a specific period of time to allow evaporation of moisture.

ii. Sieve Process

It is essential to sieve the fine aggregate and bagasse ash in Is sieve size of 4.5mm for the proper binding of bricks. Sieving the fine aggregate and bagasse ash is indeed an important step in brick manufacturing to ensure proper binding and the desired quality of the bricks. The use of an appropriate sieve size, such as a 4.5mm sieve, helps in achieving the desired particle size distribution and removing any larger or smaller particles that may affect the brick's performance.

iii. Mixing of materials

The above materials are mixed based on the mixed design for proper binding.

iv. Casting of Bricks

The mixture is casted in the mould of size 250mm x 120mm x 65mm.

v. Casted Bricks

The casted bricks are named as 4, 6 & 8 based on the mix design, then the bricks are sun dried for a period of 5hrs and it is subjected to curing for 28 days. The cured bricks are undergone various test for identifying the strength.

3.2. Test on bricks and results

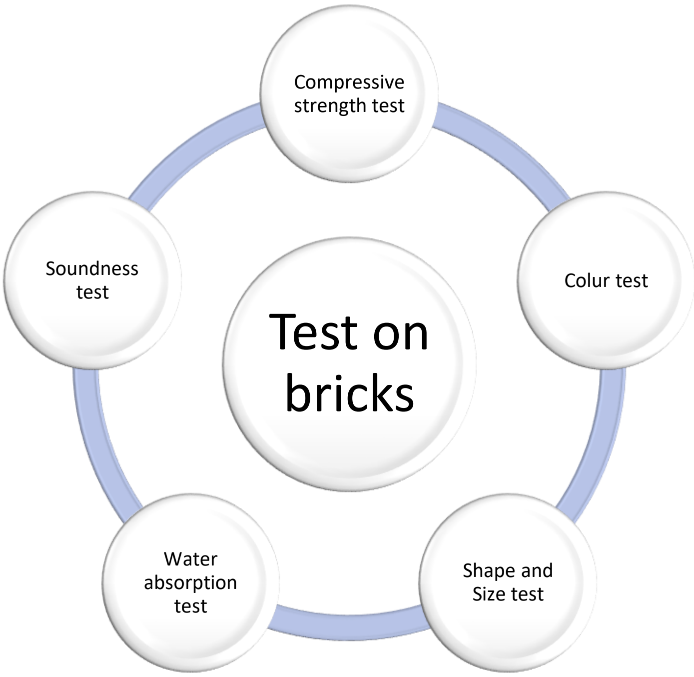

Fig:-8 flow chart represent test

1. **Compressive Strength Test / Crushing Strength (IS 3495-PART-1:1992)**

   The brick specimens are immersed in water for 24 hours. The specimen is placed in compression testing machine with 6 mm plywood on top and bottom of it to get uniform load on the specimen. Then load is applied axially at a uniform rate of 10 N/mm2. The crushing load is noted for the bricks named 4, 6, and 8.

Table -6: compressive test results

SR. No	Name of the brick (for identification)	Compressive Test(N/mm^2)	Is code (IS-1077:1992) Compressive strength(N/mm^2)
1	4	9	7
2	6	6	7
3	8	5	7

Fig :-8 compression test

2. **Water Absorption Test (IS 3495 – PART 2)**

to determine the water absorption of bricks. By weighing the brick before and after immersion in water, the difference in weight represents the amount of water absorbed by the brick.The water absorption of a brick is an important property that affects its durability, strength, and other characteristics. Excessive water absorption can lead to issues such as cracking, deterioration, and reduced thermal insulation properties. The guideline you mentioned, which states that the amount absorbed by the brick should not exceed 20 percent of the weight of the dry brick, is a general rule of thumb often used in the construction industry. This criterion helps ensure that the brick has a reasonable level of resistance to water penetration and can withstand environmental conditions without significant damage.

Fig :-9 water absorption test

Table -6: Water absorption test results

SR. No	Name of the brick (for identification)	Water absorption test (%water absorption in kg)	Is code (IS-1077:1992) Water absorption test (% water absorption in kg)
1	4	13.89	20
2	6	14.76	20
3	8	16.00	20

3. **Shape & Size Test**

In this test, a brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges. For this purpose, 3 bricks are selected at random and they are stacked length wise, along the width and along the height

Fig:-10 shape and size test

Table -6: Shape And Size test results

SR. No	Name of the brick (for identification)	Height (mm)	Length (mm)	Width (mm)	Is code (IS-1077:1992) Length(mm)	Is code (IS-1077:1992) Height(mm)	Is code (IS-1077:1992) Width(mm)
1	4	225	110.5	74.5	225	112.5	75
2	6	225	108.5	73.5	225	112.5	75
3	8	223	112	74.5	225	112.5	75

4. **Soundness test**

In this test two bricks are held by both hands and struck with one another. If the bricks give clear metallic ringing sound and don't break then those are good quality bricks.

Soundness test result

When two bricks are struck with one another, up to 20% proportion, they give metallic sound. But 30% and 50% proportion gives dull sound.

5. **Colour test**

Colour test result

Up to 20% proportion for bagasse ash, bricks has good red uniform colour. But after 20% proportion, bricks have yellowish colour. Under burnt bricks.

Table-7: average decrease in weight of bricks

Addition of Styrofoam in (%)	Average weight in kg
0	3.5
10	3.29

20	2.8
30	2.4

3.3.Mix design

Table-8: mix design of materials

SR .No	Name of the bricks (for identification)	Amount of Sugarcane bagasse ash(%)	Amount of Silica (%)	Amount of Styrofoam (%)	Amount of Molasses (%)	Amount of Lime (%)	Amount of Iron oxide (%)	Amount of Press mud (%)
1	4	25	30	20	14	4	2	5
2	6	15	30	30	15	4	1	5
3	8	30	30	10	15	6	2	7

4.Conclusion

- We used sugarcane bagasse as to provide the density to bricks and used press mud as a fine- aggregates.
- We also used molasses as a liquid material for binding and provide a good strength.
- Styrofoam used as a material to reduced weight of bricks.
- The use of waste materials will reduce the cost of manufacture and improve the value of industrial waste.
- Earthquake loads that work will be smaller because the weight of the structure is reduced, so that the structure will be safe and suitable for residential buildings in the earthquake area.
- It will reduce the transportation cost of bricks and also reduced manpower for bricks.
- It will maintain thermal conductivity of structure.
- Sample number 4 brick has better compressive strength of 9N/mm^2 and water absorption value of 13.6%of weight as compared to other which can compare with class 2nd bricks which is used in for internal walls and compound walls.
- Sample number brick 4 has composition of

Name of the bricks (for identification)	Amount of Sugarcane bagasse ash(%)	Amount of Silica (%)	Amount of Styrofoam (%)	Amount of Molasses (%)	Amount of Lime (%)	Amount of Iron oxide (%)	Amount of Press mud (%)
4	25	30	20	14	4	2	5

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