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A review on the utilization of textile waste to manufacturing bricks

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ABSTRACT

The textile industry is one of the oldest and largest sectors in India. As the industrial growths increasing day by day, waste generation also increases day by day. There is a need to figure out a different way to use textile waste. Waste resulting from textile industries creates the problem of disposal. Moreover, dewatered waste is usually disposed of by spreading it on the ground or filling it in the land. Landfilling, on the other hand, might not be an effective waste disposal method in highly urbanized cities due to land scarcity. This paper demonstrates that textile waste can be used to make bricks with a proportionate mix and design.

Keywords: *Textile Waste, Bricks, Compressive Strength, Water Absorption.*

1. INTRODUCTION

Currently, India generates approximately 960 million tonnes of solid waste per year as a by-product of manufacturing, mining, municipal, agricultural, and other processes. There are 350 million tonnes of organic waste from agricultural sources, 290 million tonnes of inorganic waste from manufacturing and mining, and 4.5 million tonnes of radioactive waste. [1]Rapid industrialization and urbanisation are wreaking havoc on the environment. One of the most pressing issues is the safe and proper handling of solid waste. Moreover, Sugar, paper pulp, and textiles are three major agro-based industries in India that generate large amounts of solid and liquid waste after consuming large amounts of fresh water, and the textile industry, which is India's second-largest sector after sugar, has sludge disposal issues. For wet operations like desizing, bleaching, and dyeing, textile mills use a lot of fresh water. The wastewater formed by these processes is treated in the ETP with chemicals including alum, ferric chloride, lime, and polyelectrolyte to extract traces of cotton and dyes. During treatment, sludge accumulates in the primary and secondary clarifiers and is then dried in sludge drying beds. ETP sludge is not only troublesome for the industry, but it is also harmful to the environment. Many textile mills use final disposal methods such as landfilling. As a result, there is a growing need to explore various waste material reuse options for long-term growth. [2]. To address the problem, the textile industry has taken several steps to reduce its negative impact on the environment.Textile recycling, which includes the reuse and replication of fibres from textile waste, is one of these steps. Textile recycling benefits the environment and the economy by decreasing demand for textile chemicals, reducing landfill space requirements, consuming less electricity, and reducing water waste. [3]. Furthermore, Due to the use of coagulating chemicals (magnesium salts and lime) in the ETP process, the calcium and magnesium content of the textile ETP sludge is high. Because of the high calcium and magnesium content, this sludge can be used as a partial replacement. The demand for building materials in India is projected to be on the order of US$ 1333 million per year. Other industrial wastes have been used in construction materials as a partial substitute for cement, as a replacement for clay in bricks, or use in flooring tiles and walling materials. The use of beneficiated phospho-gypsum (a byproduct of gypsum) in the manufacture of semi-hydrated plasters and plaster goods, fibrous gypsum plasterboards, gypsum blocks, slotted paving, and gypsum tiles has been examined. [4,5,6]. The primary aim of this study is to develop and produce a sludge brick that can be used in place of traditional bricks. By preparing a cost-effective sludge brick with various ingredients and deciding the proportions of certain ingredients that will be feasible to use. This paper will propose an optimal proportion for sludge bricks that is both economically and structurally stable. The bricks are found to be sufficiently strong, and the majority of heavy metals are trapped within them.[7]. The findings of using dried sludge and sludge ash as brick-making materials as an alternative to sludge disposal are also presented in this review article. [8].

2. MATERIAL AND METHOD

Normal methods and IS codes protocols are used to analyse textile mill sludge for important parameters such as pH, basic gravity, dry density, and EC. XRF (X-Ray Fluorescence Spectrometer, Phillips - PW 2404 model) analysis is used to determine the chemical composition of textile mill sludge. Furthermore, the chemical content of soil samples is calculated using Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP- AES) (Model- Jobin Yuon Ultima II). The effect of temperature on textile mill sludge is investigated using thermo-gravimetric analysis of red, white, and black soils. In contrast, three types of soils (red, white, and black) are proportioned according to the local brick manufacturer's procedure. Initially, 40 percent red soil, 40 percent white soil, and 20 percent black soil are used to make bricks. The base material is a mixture of these soils. Later, textile mill sludge is used to cover the base material, beginning with (95 percent base material and 5% textile mill sludge) and progressing up to (95 percent base material and 5% textile mill sludge) (65 percent base material and 35 percent textile mill sludge). Moulds measuring 70 mm x 70 mm x 70 mm are used to cast bricks. After casting, bricks are air-dried for two days in the shade (in a laboratory) before being dried in the sun for four days. The weight of sundried bricks has been documented. Sun-dried bricks are stored in a muffle furnace at various temperatures (6000 C, 7000 C, and 8000 C) for different firing/baking times (8 hrs. 16 hrs. and 24 hrs.).The bricks are allowed to cool completely before being weighed after firing. After that, the compressive strength of bricks is calculated using IS 3495 (Part-I) – 1992-[20]. The bricks' toughness can be determined using the water absorption test [IS 3495 (Part-II) - 1992]. [20.] For 24 hours, weighted baked and cooled bricks are submerged in water. The bricks are weighed again after 24 hours to determine the percent water absorption. Brick efflorescence is measured according to the IS code process outlined in IS 3495 (Part-III) – 1992- [20]. [2].

Textile waste, ordinary Portland cement, and river sand were used to make the bricks. The textile sludge had a moisture content of around 30% at the start. The sludge was dried for 24 hours at 100 degrees Celsius in a hot air oven. After drying, the sludge was ground manually in a dry clean steel tray with the use of a trowel. Ground sludge that passed a 212-micron sieve and was preserved on a 90-micron sieve was used in the study. In this study, the fine sludge that passed the 90-micron sieve was discarded. The cement used was ordinary Portland cement (43-grade) that complied with BIS, IS: 12269. To determine the compressive strength of cement, different percentages of Textile ETP sludge were applied to the cement at different curing days, and building materials were made from River sand passed through an IS: 1.18 mm sieve. Also determined were the consistency limit, basic gravity, and chemical properties of cement, as well as cement with different percentages of textile sludge. The water to cement ratio was kept at 0.45–0.75 for cement and various percentages of sludge, and the cement to sand ratio was kept at 1:3. Sludge up to 30% and other materials such as cement, dolomite powder, stone quarry dust, 6 mm stone chips, sand, and composite clay soil were used to make common burnt clay building bricks (IS: 1077–1976) with dimensions of 190 x 90 x 90 mm (for bricks). The water absorption capacity of three samples from each of the construction materials was chosen and immersed in water for 24 hours, then removed and wiped dry; each unit was weighed immediately after saturation and wiped; the samples were oven-dried for 24 hours, cooled to room temperature, and re-weighed. By immersing brick samples in water for 24 hours and then removing them and allowing them to dry in the shade, the efflorescence of bricks was detected. The presence of white or grey deposits on the surface of bricks was considered a sign of soluble salts in the bricks (BIS, IS: 3495 (part3): 1976). [4]

Textile sludge, clay, and lime were used in the production of bricks. The moist sludge from the CETP was collected and dried. The dust was then sieved out of the dried sludge. It is then pulverised into a powdered form and mixed with the soil sample using a soil pulverizer. A total of 125 unburnt compressed bricks of size 22.5 x 10.5 x 7 cm are manufactured in this study, with the mix proportions of clay soil, sludge, and lime, and the physical and mechanical properties of GREEN bricks are investigated. In this study, ETP Sludge was used at a rate of 0 percent with a 5 percent increment, and it was discovered that the maximum percentage of sludge addition to the soil was less than 25% for the mix proportion. While 10% lime was used in the mix proportions. Visual, compressive strength, water absorption, and efflorescence tests were performed on the GREEN bricks. The table show mix proportion of green brick. [5].

Table 1: Mix proportion of Green Brick

Specimen	Soil(%)	ETP Waste(%)	Lime (%)
M1	90	0	10
M2	85	5	10
M3	80	10	10
M4	75	15	10
M5	70	20	10
M6	65	25	10

Textile CETP sludge is combined with clay up to 30% by weight in 3 percent increments and thoroughly mixed to form a homogeneous mixture. A standard of pure clay was used for comparison. The sample is made pasty by adding the appropriate amount of water to achieve the desired moisture content. The mixture is degassed to eliminate any trapped air to avoid cracking during the firing process. The mixtures were then moulded into 70x70x70 mm cubes in batches. The specimen was shaped and then dried in the open air for 24 hours before being baked at 110°C for 6 hours. The dried samples were then fired in a muffle furnace at 200, 400, 600, and 800°C for various firing times (2, 4, 6, 8 hrs). Compressive strength, water absorption, percentage shrinkage, and percentage weight loss were all measured on the brick specimens. IS 3495 (Part 1 to 2): 1992 standards were used to assess compressive strength and water absorption. The compressive strength of the brick samples is tested using a compression testing machine with a 110 cm ram diameter. [6].

A crushing machine was used to grind and crush sludge mixed with clay into fine pieces. For comparison, two types of brick samples were prepared. Clay was mixed with different percentages of dried sludge in one sample. To remove the organic matter from the other sample, the sludge was first fired at 600° C or higher in a furnace. After the burning process, the sludge ash was collected and mixed with clay at different percentages to create a second set of brick samples. The percentages of dried sludge used in the first sample were 10%, 20%, 30%, and 40% by weight. The percentages of sludge ash used in the other sample were 10%, 20%, 30%, 40%, and 50%, respectively. As a reference, a sample with no sludge or sludge ash was prepared. Each mixture was fed into an extrusion machine, which produced brick samples measuring 40 mm long, 20 mm wide, and 10 mm thick. After that, the brick samples were dried in a 100° C oven for 24 hours. The dried bricks were fired in a kiln for about 24 hours at a temperature of over 1,000° C. The finished products were put to the test to see how they performed. [8]

3. RESULT

As the percentage of sludge in bricks increases, the compressive strength decreases. This is because sludge has a lower silica content than the base material. As the firing temperature and time are increased, the compressive strength increases. A firing temperature of 8000 C and a firing time of 24 hours yield strong compressive strength with the same percentage of sludge in the bricks. According to the IS code classification-[23], the compressive strength of bricks must be 3.5 N/mm2. The maximum amount of sludge that can be applied without compromising the 3.5 N/mm2 compressive strength is 15% by weight. However, as the percentage of sludge rises, the percentage of water absorption by bricks increases. Increases in firing temperatures and time often increase the amount of water consumed by bricks. The explanation for this is that the organic matter in the sludge burns at higher temperatures and the volatile matter escapes during the baking process, creating voids in the bricks' body. As a result of the voids created, the bricks' water absorption rate increases. The amount of water consumed should be less than 20%. The maximum sludge content is 15%, which satisfies this requirement. At all temperatures and firing time combinations, maximum water absorption of 42 percent is observed with a sludge content of 35 percent. Meanwhile, efflorescence is rising, going from zero for 0% sludge to mild to moderate efflorescence for sludge percentages up to 35%. In bricks containing 15% sludge, efflorescence is greatly reduced. The ringing sound gets quieter as the sludge content increases. Initial base material bricks with 0% sludge have a great ringing tone. In the case of bricks containing 35 percent sludge, the ringing sound is the least noticeable. This may be attributed to the bricks' increased porosity of a certain percentage. A good ringing sound can be heard from bricks with a 15% sludge addition. [2]

Brick is found to be less than the water absorption property of standard good quality burnt clay bricks, which is a maximum of 20%. When the sludge ash percentage rises, the efflorescence rises with it, and M3 falls into the ‘Slight' category, while M4, M5, and M6 fall into the ‘Moderate' category. Efflorescence increases with increasing sludge percentage, from no efflorescence for 0 percent sludge to mild to moderate efflorescence for sludge percentages up to 25%. There is very little efflorescence in bricks with 0 percent, 5 percent, or 10% sludge addition. [5]

It can be seen that the strength of the brick is influenced not only by the amount of waste in it but also by the temperature at which it is fired. The compressive strength of bricks decreases As the waste mix in the bricks increases, but increases as the firing temperature and time increase. As the temperature is increased above 400°C, the compressive intensity increases by around 70% to 80%. With time, the compressive intensity increases almost linearly. Increased firing temperature reduces water absorption and thus improves weathering resistance. The presence of comparatively more organic and inorganic matter burnt off during firing causes the weight loss to increase as the sludge content increases. Weight loss due to ignition increasing firing temperature. The weight loss during firing is initially important, but after about two hours, it is negligible. The maximum amount of sludge that can be applied is in the range of 6 to 9%, which corresponds to compressive strength values of 4.25 to 3.54 N/mm2, which follows the IS requirements. Quality Bricks are made from a sludge mix that contains less than 9% sludge and is fired at 800°C for more than 8 hours. be applied is in the range of 6 to 9%, which corresponds to compressive strength values of 4.25 to 3.54 N/mm2, which follows the IS requirements. Quality bricks are made from a sludge mix that contains less than 9% sludge and is fired at 800°C for more than 8 hours. [6]

The bricks have a compressive strength of 87.2 N/mm2 for 0 percent sludge, 37.9 N/mm2 for 40 percent dried sludge, and eventually drops to 69.4 N/mm2 for 50 percent sludge ash. The compressive strength of bricks containing 10% dried sludge is around 30% lower than control samples. The compressive strength of 10 percent sludge ash bricks is comparable to that of clay bricks. Water absorption in bricks is 0.03 percent for 0 percent sludge and rises to 3.63 percent for 40 percent dried sludge when using dried sludge. Water absorption improves for brick samples made with sludge ash, but only to 1.70 percent for bricks made with 50 percent sludge ash. This means that bricks made from sludge ash are more likely to last than bricks made from dried sludge. [8]

4. CONCLUSION

The sludge produced by textile effluent treatment plants can be reused in the manufacture of building materials, which will increase the bulk use of sludge in building bricks and eliminate the issue of ultimate disposal, i.e. landfilling, according to this study. Furthermore, this is the most effective way to improve performance in terms of mitigating pollution problems and providing an affordable brick that provides better bonding, higher compressive strength, and lower water absorption.

According to IS: 1077– 1979, the compressive strength of 10% bricks exceeds the standard 3.5 N/mm2 compressive strength for load-bearing units. The compressive strength of the 20% and 30% sludge bricks is lower than the IS: 1077– 1979 specification. The brick samples tested did not meet the ASTM (C62–80) minimum compressive strength criteria for Grade NW bricks. It should be noted that the ASTM standard for commercial bricks requires 2.9 times the minimum compressive strength of the Indian standard (BIS, 1979), and the ASTM standard is considered too rigid in India. The water absorption of all bricks containing 10%, 20%, and 30% sludge is lower than the IS's requirement of 20%. The efflorescence of all bricks containing 10%, 20%, and 30% sludge was zero. For bricks used in building, efflorescence should be minimal, according to BIS requirements. The addition of more than 20% sludge to the clay influenced the shrinkage of the bricks during drying. As compared to bricks without sludge, those with more than 20% clay had small cracks, which resulted in more water absorption. [4]

The compressive intensity steadily increased and then decreased after hitting the optimum amount of ETP sludge waste, which was found to be 10% at the end of 28 days. When comparing all of the mix proportions to traditional bricks, it was discovered that the M3 mix proportion provides greater strength in both cases, with unburnt bricks reaching 80.33 percent of strength when compared to burnt bricks. The adhesivity of the mixture decreases as the percentage of ETP sludge waste rises, but the internal core of the brick increases. As a consequence, the amount of water consumed increases. The water absorption property of all proportions of GREEN.

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