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# Transforming Textile Waste into Sustainable Construction Materials: A Comprehensive Study

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*Abstract*—**The textile industry in India is of significant importance due to its extensive historical legacy that spans numerous centuries. However, the increase in industrialization has led to a proportional escalation in the production of waste. The effective management of textile waste is a matter of great importance, commonly addressed by practices such as ground dispersal or landfill disposal. Unfortunately, the effectiveness of landfilling in metropolitan areas may be impeded by the constrained availability of land. Scholars have undertaken investigations to explore the potential utilization of textile sludge for the production of eco-friendly construction materials as a means to address this issue. This involves the usage of it as a partial substitute for fine aggregate, cement, and clay in non-structural construction components, such as environmentally friendly building blocks, clay bricks, mortar, concrete, and paver blocks. The present study offers a thorough assessment of the manufacturing process of the aforementioned materials and suggests the most favourable parameters for their use.**

***Keywords—Cement, Concrete, Construction, Compressive Strength (CS), Sludge, Textile Industry Waste***

## I. Introduction

India generates around 960 million tonnes of solid garbage on a yearly basis, stemming from diverse industries such as manufacturing, mining, agriculture, and municipal operations. According to the cited source, the total garbage generated consists of 350 million tonnes of organic waste derived from agricultural activities, 290 million tonnes of inorganic waste originating from manufacturing and mining processes, and 4.5 million tonnes of waste classified as radioactive [1].

The environment is experiencing adverse consequences as a result of the fast processes of industrialization and urbanization. One of the most pressing concerns pertains to the appropriate management of solid waste. The sugar, paper pulp, and textile industries in India are prominent agro-based sectors that produce substantial quantities of solid and liquid waste, while concurrently utilizing substantial volumes of freshwater resources. The disposal of sludge generated by wet operations such as desizing, bleaching, and dyeing poses issues for the textile industry in India, which is the country's second-largest sector following the sugar industry. In the effluent treatment plant (ETP), the wastewater is subjected to chemical treatment using substances such as alum, ferric chloride, lime, and polyelectrolyte in order to separate and remove residual cotton fibres and colours present in the industrial effluent. Throughout the treatment procedure, the main and secondary clarifiers experience the accumulation of sludge, which then undergoes the drying process in sludge drying beds. The sludge generated by the Effluent Treatment Plant (ETP) presents significant issues for the industry, while also causing detrimental impacts on the environment. Numerous textile mills engage in the practice of discarding waste materials in landfills, hence underscoring the imperative to investigate diverse alternatives for repurposing such waste in order to foster sustainable development over an extended period of time [2].

In response to the issue at hand, the textile industry has implemented various measures aimed at mitigating its adverse environmental effects. Textile recycling, encompassing the repurposing and reproduction of fibres derived from discarded textiles, constitutes one of these measures. Textile recycling confers environmental and economic advantages through its capacity to diminish the need for textile chemicals, mitigate landfill space demands, curtail electricity consumption, and alleviate water wastage [3].

Furthermore, the ETP (Effluent Treatment Plant) technique utilized in the textile industry entails the application of coagulating agents, like magnesium salts and lime, to facilitate the coagulation of contaminants. Consequently, the sludge generated from the effluent treatment plant (ETP) in the textile industry has elevated concentrations of calcium and magnesium. The aforementioned sludge possesses the potential to serve as a viable substitute for various materials, hence offering an alternative to conventional disposal methods. Nevertheless, the addition of sludge to cement has the potential to impede the setting process of construction elements [4].

India experiences a substantial annual demand for building materials. In order to decrease dependence on cement and clay, alternative industrial byproducts have been employed as partial replacements in construction materials, as well as in the production of flooring tiles and walling materials [5].

The primary objective of this study is to develop a sludge brick as a potential substitute for conventional bricks. In order to accomplish this objective, a variety of components will be utilized in the production of an economical sludge brick, with the aim of ascertaining the optimal ratios for each constituent. The objective of this study is to determine an ideal ratio that is both economically viable and structurally sound. The findings of our study indicate that the sludge bricks possess sufficient strength and exhibit the capacity to effectively sequester a majority of heavy metals [6].

According to the study, an alternative to traditional disposal methods for dried sludge and sludge ash is their use in brick production. The optimal mix for brick building is up to 40% dried sludge and 50% sludge ash, combined with clay. It should be noted, however, that including 10% dried sludge in bricks resulted in a 30% decrease in their compressive strength, unlike bricks with 10% sludge ash that showed similar strength levels to conventional clay bricks [7].

Sludge management is a significant concern for local wastewater and industrial effluent treatment plants, contributing to environmental issues globally. Various techniques are utilized to handle sludge, including using it as a fertilizer, incorporating it into cement, generating biogas, and producing construction materials like burnt clay bricks, concrete, and tiles. The recyclability of sludge is contingent on its composition and attributes. One solution to this issue is to use it for the production of burnt clay bricks. The textile sector produces sludge from coagulants and chemicals used in wastewater treatment, which are dried before disposal in landfills. Utilizing sludge or sludge ash in burnt clay bricks or tiles aids in managing heavy metals during firing, oxidizing organic matter, and eliminating pathogens. Textile effluents differ depending on the type of textiles produced and chemicals used, containing hazardous substances that can have an impact on the environment and human health. These substances include suspended and biological oxygen demand, chemical oxygen demand, dissolved solids, chemicals, colour, and aroma. Additionally, textile effluents contain heavy metals like chromium, cadmium, arsenic, lead, and zinc, which can be detrimental to the surrounding environment [8].

The disposal of textile materials is a great illustration of how the circular economy can be put into practice. It demonstrates the potential for more effective use and creation of goods that align with current trends and the only viable economic model in today's world: one that prioritizes the closing of the resource loop [9].

Managing hazardous waste is crucial to prevent harm to both human health and the environment. One approach to minimize the amount of garbage that ends up in landfills is the 3R strategy, which stands for Reduce, Reuse, and Recycle. This strategy conserves natural resources, landfill space, and energy. Recycling is a key component of this framework because it can transform waste into valuable commodities. In India, the garment industry generates a significant amount of fabric waste from both organized and unorganized sectors. Despite being of high quality and still usable, this waste is typically sent to landfills. Utilizing new technology that utilizes water-soluble films can transform textile waste into fabric patches, which can raise awareness among manufacturers and consumers about sustainable recycling methods. Implementing this approach is critical in establishing a structured textile waste management system, which is currently lacking in regulatory interventions. Manufacturers can also incorporate this technology into their corporate social responsibility initiatives, potentially creating employment opportunities for individuals with intermediate levels of competence [10].

By mixing textile cuttings with hydraulic cement as a binder, a new composite material can be created. This material is lightweight and cost-effective, making it a suitable replacement for certain concrete products and wooden boards. Additionally, using textile waste cuttings in construction can help to eliminate environmental pollutants and provide an alternative material for the construction industry [11].

In construction, textile waste can be repurposed for creating partitions and for building eco-friendly structures. However, to ensure that the materials used are environmentally sustainable, it is necessary to conduct extensive research and development. This includes studying technical, economic, and environmental aspects, as well as exploring standardization, government policies, and public education on waste recycling and sustainable development. Additionally, to achieve large-scale production of bricks from waste materials, further investigation is needed [4].

### *A. Applications of Textile Industry Waste in the Construction Industry*

The applications of textile industry waste in the construction industry are a sustainable approach to resource utilization and waste reduction. Textile industry waste, which includes various textile by-products and waste materials, can be repurposed and used in construction in several ways:

1. Insulation Materials:
   - Waste textile materials such as cotton, wool, and polyester fibers can be used to create insulation materials for buildings. These materials are often shredded or processed into batts, rolls, or loose-fill insulation.
   - Textile insulation can be used in walls, roofs, and floors to improve thermal insulation, reduce energy consumption, and enhance indoor comfort.
2. Soundproofing Products:
   - Waste textile fibers can also be employed in soundproofing products. When combined with other materials like recycled rubber or foam, they can create effective acoustic barriers.
   - These products can be used in walls, ceilings, and floors to minimize sound transmission and create quieter indoor environments.
3. Erosion Control and Geotextiles:
   - Textile industry waste can be converted into geotextiles, which are permeable fabrics used in civil engineering and construction for erosion control, soil stabilization, and drainage.

- Geotextiles made from waste textiles help prevent soil erosion, improve the stability of slopes, and enhance the performance of roadways and retaining walls.

4. Recycled Concrete Aggregates:
   - Waste textiles can be incorporated into the production of recycled concrete aggregates (RCAs). RCA is a sustainable alternative to natural aggregates in concrete.
   - By using waste textiles as part of the aggregate mix, the construction industry can reduce the demand for virgin aggregates and decrease the environmental impact of concrete production.
5. Eco-Friendly Building Blocks:
   - Some innovative building blocks are manufactured by mixing waste textile fibers with other sustainable materials like cement and fly ash.
   - These eco-friendly blocks are lightweight, offer good insulation properties, and can be used for constructing walls and partitions.
6. Roofing Materials:
   - Recycled textile waste can be integrated into the production of roofing materials like shingles and tiles. These materials can enhance the durability and energy efficiency of roofs.
   - Roofing products made from textile waste are often designed to reflect sunlight, reduce heat absorption, and lower cooling energy consumption.
7. Landscaping and Green Infrastructure:
   - Textile waste can be used in landscaping applications. For example, shredded textile waste can be mixed with soil to improve water retention and nutrient distribution in gardens and green spaces.
   - In some cases, textile waste can also be integrated into green roof systems, contributing to better stormwater management and urban sustainability.
8. Recycled Carpet Tiles:
   - Waste carpet materials from the textile industry can be recycled and repurposed into carpet tiles for commercial and residential flooring.
   - These recycled tiles are not only environmentally friendly but also offer ease of maintenance and replacement.
9. Temporary and Emergency Shelter Solutions:
   - In humanitarian and emergency response situations, waste textiles can be used to create temporary shelters and housing solutions, providing rapid relief in disaster-stricken areas.
10. Facade Cladding and Aesthetic Applications:
    - Some construction projects incorporate waste textiles into facade cladding systems to add unique aesthetic features and textures to buildings.

Incorporating textile industry waste into construction practices helps reduce landfill waste, conserves resources, and promotes sustainability in the construction sector. However, it's essential to ensure that these recycled materials meet relevant industry standards and performance criteria for safety and quality in construction applications.

*B. Advantages of Textile Industry Waste in Concrete*

Using textile industry waste in concrete can offer several advantages, making it a sustainable and eco-friendly practice. Here are some key advantages of incorporating textile waste into concrete:

1. Waste Reduction: Utilizing textile industry waste in concrete helps reduce the volume of textile waste sent to landfills, contributing to waste reduction and minimizing environmental impact.
2. Resource Conservation: It conserves valuable resources such as aggregates and energy by substituting them with recycled textile materials.
3. Improved Insulation: Textile-based additives can enhance the thermal and acoustic insulation properties of concrete, reducing heating and cooling energy consumption and improving indoor comfort.
4. Enhanced Flexural Strength: Certain textile fibers, when mixed with concrete, can increase its flexural strength and resistance to cracking, enhancing the durability of structures.
5. Crack Mitigation: Textile fibers can help mitigate cracking in concrete, especially in situations where shrinkage cracks may occur due to temperature changes and drying.
6. Reduced Weight: The lightweight nature of textile materials can lead to lighter concrete mixtures, making it easier to transport and handle during construction.
7. Improved Workability: Textile fibers can enhance the workability and cohesion of concrete mixes, leading to easier placement and finishing.
8. Durability: Textile additives can improve the long-term durability of concrete structures, reducing maintenance and repair costs.
9. Reduced Carbon Footprint: Using recycled textile waste in concrete can result in a lower carbon footprint compared to traditional concrete production, as it often requires less energy and fewer raw materials.
10. Sustainable Building: Incorporating textile waste aligns with sustainable building practices and green building certifications, appealing to environmentally conscious clients and developers.
11. Versatility: Textile waste can be repurposed into various concrete products, including precast elements, blocks, and panels, providing versatility in applications.
12. Market Demand: There is a growing demand for sustainable construction materials, and the use of textile industry waste in concrete aligns with sustainability trends and eco-friendly building practices.
13. Resistance to Cracking: Certain textile fibers, like polypropylene or glass fibers, can enhance the concrete's resistance to cracking under various loading conditions.

14. Rapid Construction: Improved workability and reduced weight of textile-reinforced concrete can lead to faster construction, reducing labor costs and project timelines.
15. Innovative Aesthetics: Textile-reinforced concrete can offer unique textures and aesthetics, allowing for innovative design possibilities in architectural applications.
16. Circular Economy: Incorporating textile waste into concrete promotes a circular economy, where materials are reused, repurposed, and recycled, contributing to sustainability.

It's important to note that the selection of the appropriate textile waste type and its compatibility with the specific concrete application are crucial to achieving the desired performance benefits. Additionally, adherence to safety, quality, and regulatory standards is essential to ensure the long-term durability and safety of concrete structures.

*C. Disadvantages of Textile Industry Waste in Concrete*

While the use of textile industry waste in concrete offers several advantages, it is also important to consider potential disadvantages and challenges associated with this practice. Here are some of the disadvantages of using textile industry waste in concrete:

1. Lack of Standardization: The incorporation of textile waste in concrete is still a relatively new practice, and there is a lack of standardized guidelines and regulations for its use. This can lead to variability in product performance and quality.
2. Compatibility Issues: Textile waste materials may not be compatible with all types of concrete mixes. Compatibility issues can arise, affecting the workability, strength, and durability of the concrete.
3. Reduced Structural Strength: In some cases, the addition of textile waste may lead to a reduction in the structural strength of the concrete, especially if the waste materials are not properly processed or if their properties are not well understood.
4. Quality Control Challenges: Ensuring consistent quality and performance of concrete with textile waste can be challenging, as the properties of waste materials can vary widely depending on their source and processing.
5. Durability Concerns: The long-term durability of concrete with textile waste additives may be uncertain. Factors such as fiber degradation over time, exposure to environmental conditions, and chemical reactions can affect durability.
6. Limited Research: While research on the use of textile waste in concrete is ongoing, there is still a limited body of knowledge regarding its long-term performance and behaviour in various construction applications.
7. Environmental Impact: The environmental impact of textile waste treatment and processing, as well as its transportation to concrete production sites, should be considered. The sustainability benefits may be offset by the energy and resources required for processing.
8. Cost: Depending on the availability and processing of textile waste materials, there may be additional costs associated with their acquisition and incorporation into concrete mixes.
9. Uniform Distribution: Achieving a uniform distribution of textile waste within the concrete mix can be challenging, and uneven distribution may result in inconsistent performance.
10. Workability Issues: Some types of textile waste may affect the workability of concrete, making it more difficult to place and finish. Proper mix design and testing are essential to address workability concerns.
11. Testing and Certification: The lack of standardized testing methods and certification processes for concrete with textile waste can create challenges in ensuring compliance with industry standards.
12. Regulatory Compliance: Depending on the region and local regulations, there may be compliance challenges related to the use of recycled materials in construction.
13. Limited Availability: The availability of suitable textile waste materials may vary by location, making it difficult to consistently source materials for construction projects.
14. Aesthetics: The use of textile waste in concrete may not always achieve the desired aesthetics or appearance, which can be a concern in architectural applications.
15. Project-Specific Considerations: Each construction project is unique, and the suitability of using textile waste in concrete should be evaluated on a case-by-case basis, considering project requirements and constraints.

To mitigate these disadvantages, it is essential to conduct thorough research, testing, and quality control measures when incorporating textile waste into concrete. Additionally, collaboration between researchers, manufacturers, and construction professionals can help address these challenges and promote sustainable and effective use of textile waste in construction.

## II. Textile Sludge Utilization Research

*A. Concrete*

Dos Reis (2009) suggests that waste from textile cutting can be mixed with thermosetting epoxy resin and foundry sand to create a lightweight composite material for construction. This material has reduced compressive and flexural properties, but it also alleviates brittleness in unreinforced polymer concrete. While it doesn't increase strength, it can remove pollutants from the environment and provide alternative building materials [12].

Heniegal et al. (2015) found that using recycled fibres from industrial, agricultural, and post-consumer waste offers benefits such as resource conservation, waste reduction, low-cost resources, and decreased landfill demand. They combined different ratios of sisal, flax, glass, and carpet waste fibres with concrete pieces. Flax had the highest rate of absorption among the fibres, followed by sisal, waste carpet, and glass fibres. Increasing cement concentration to 350 and 400 kg/m$^3$ improved the compressive strength of all mixtures, including 0.5% fibers (glass fibre, carpet waste, sisal fibre, and flax fibre) [13].

According to Harpreet Kaur et al. (2017), resource consumption has surged due to population expansion and better living standards, producing dangerous Textile Mill Sludge (TMS) from Effluent Treatment Plants (ETPs). The environment is negatively impacted by this trash. The research investigates an environmentally acceptable method of managing sludge by using plasticizer at 1% by weight of cement and substituting TMS for fine particles in M20 grade concrete. On the other hand, if more TMS is added, the concrete's workability and strength may suffer. Both workability and compressive strength diminish when plasticizer is added and fine aggregates are substituted with TMS to a degree greater than 35%. The research intends to lessen the harmful effects of sludge waste and dispose of it properly to safeguard the environment by using TMS in concrete [14].

The utilization of wastewater from the textile industry in the production of concrete cubes was studied by Arulkesavan et al. (2017). They discovered that TETW (treated effluent water) and textile effluent both had similar strengths and were more resistant to acid assaults [15].

Kaur et al. (2019) investigated the use of leftover materials to make concrete, substituting Textile Mill Sludge (TMS) for up to 35% of the cement in M20 grade concrete. Unfortunately, because of the replacement's low specific gravity and density, the concrete mix's workability was impacted [16].

Bartulović et al. (2021) investigated the possible advantages of using cotton knit fabric waste (CKFW) in concrete with the objective of reducing waste and improving the qualities of the material. The quantity of textile waste used determines how workable CKFW concrete is, and when more cotton-knitted textiles are added in lieu of aggregate, the compressive strength of the mixture falls proportionately [17].

Kasaw et al. (2021) investigated ecologically friendly ways to manage textile sludge, such as incinerating it and utilizing it to replace some of the cement in concrete manufacturing. Because the sludge contains a lot of heavy metals, it has to be disposed of appropriately. The use of ash lengthens the time required for hydration and enhances the intended compressive strength by 20% [18].

Beg et al. (2022) discovered that adding sludge to concrete and mortar may shorten the time it takes for the cement to cure as well as lower the materials' flexural and compressive strengths. Nevertheless, as the manufacturing of Portland cement generates around 7% of greenhouse gas emissions, using textile ETP sludge is anticipated to have the least negative environmental effect. Additionally, the cost of concrete and mortar may be greatly decreased by using textile denim sludge for cement [19].

*B. Bricks*

In order to produce high-quality bricks, Baskar et al. (2006) investigated the use of sewage sludge from textile industry effluent treatment facilities as a clay alternative. They discovered that adding more waste mix causes bricks' compressive strength to diminish, with a maximum sludge addition of 6 to 9% [20].

The compressive strength of bricks decreases as the sludge content increases, according to Palanisamy (2011). Compared to pulverized and ground forms, bricks that have been sieved and ground have superior compressive strength. However, the minimally needed compressive strength and water absorption may be achieved with up to 20% of pulverised and sieved sludge combined with additional additives [21].

Priyadharshini et al. (2018) found a way to manage solid waste by using textile sludge waste to produce building bricks. As the sludge concentration rises, brick density, compressive strength, and ringing sound decrease while efflorescence and water absorption rise. When making bricks, textile sludge may successfully substitute some of the clay soil with another material [8].

According to Patel et al. (2021), sludge from textile effluent treatment facilities may be recycled into construction materials, boosting sludge's bulk usage and removing the need for landfilling. With this process, bricks with stronger bonding, greater compressive strength, and less water absorption may be produced at a cheaper cost while also improving performance and reducing pollution issues [22].

Teklehaimanot et al. (2021) looked at the possibility of using cotton micro waste to make innovative, lightweight bricks for the building sector. The findings demonstrated that, in contrast to contemporary concrete bricks, substituting clay soil and cement with cotton micro dust produced a smother surface, showed a high energy absorption capacity, and significantly decreased unit weight. Because the bricks made from soil and cotton waste burn to strengthen them, they work well as sound-absorbing panels, walls, hardwood planks, and less expensive alternatives to concrete blocks [23].

*C. Blocks*

Anglade et al. (2021) 53 million tonnes of fibre are generated worldwide in the textile sector, 12 percent of which is recycled. Recycled materials are being used more often in the building industry to save energy and $CO_2$ emissions. Comparing them to traditional concrete blocks, however, has resulted in lower void content, compressive strength, thermal conductivity, water absorption, acoustic insulation, and unit cost. The expense of staff and recycled materials contributes to the 16% increase in the price of polyester concrete blocks [24].

Research on composite materials in buildings was done by Hossain et al. (2022), with an emphasis on waste materials and lightweight constructions. They discovered that lightweight sand-cement blocks may be made from any kind of textile fibre. At every step of the curing test, cotton waste with varying amounts of cement addition showed significant strength; 1.5% added had the maximum compressive strength. Cotton fibre had a reduced ability to absorb water as well [25].

*D. Paver blocks*

Sudheesh et al. (2015) found that adding textile sludge and quarry dust to paver blocks improves concrete compressive strength. However, the compressive strength decreases with the amount of cement replacement. The addition of fiber up to 0.5% increases the strength by up to 30%. Paver blocks with sludge up to 20% and all fiber fractions up to 1% yielded 28 days of compressive strength of over 50 Mpa, making them suitable for heavy traffic applications like industrial complexes, service stations, and roads on expansive soils [26].

Patel et al. (2017) found that using textile effluent treatment sludge as a cement substitute in M30 grade Rubber Mould Paver Blocks (RMPB) can improve their compressive strength and abrasion resistance [27].

Arulpandian et al. (2020) developed paver blocks blended with textile effluent treatment plant (TETP) sludge to manage textile sludge effectively. The mix results showed that 30% of cement replacement could be achieved by effectively utilizing TS from the textile industry. The addition of textile sludge and M-sand reduced the density of samples, making the concrete lightweight [28].

Kanmani et al. (2022) investigated the use of textile sludge as a partial substitute for sand and cement in paving block construction. Chemicals like fly ash and lime were applied to the sludge, which was collected near the dyeing unit and stabilized to reduce its negative impact on paver blocks. Various trial mixes of M20 grade concrete were created for paver block casting. The sludge paver block replaced by sand showed good mechanical properties and durability, with better split and flexural strength. Overall, the use of textile sludge in paving block construction has shown potential for improving the quality and durability of paving blocks [29].

*E. Soil*

Cheng et al. (2020) devised a technique known as solidification/stabilization (S/S) with the aim of enhancing the strength of textile sludge and effectively stabilizing both metals and harmful organic compounds. The use of the skeleton building approach effectively decreases the ratio of liquid to solid, resulting in significant reductions in binder dose and associated expenses. The results of the leaching test demonstrated a reduction in the presence of metals and organic compounds in the leachate, suggesting that the technique has the capability to be used for subgrade disposal [30].

The following are outcomes based on textile sludge waste utilization in research:
1. Textile Mill Sludge is hydroscopic in nature, and requires more water, with the addition of sludge [16].
2. The use of denim-based textile ETP sludge has been explored for the production of non-structural building components in situations where reduced strength requirements are acceptable [19].
3. According to a study, it has been shown that textile waste, namely cotton knitted fabric waste (CKFW), may be used as a partial replacement for aggregate in concrete. This substitution has the potential to decrease the total weight of CKFW concrete [17].
4. The use of Textile Sludge as a viable alternative material for clay soil in the production of bricks has shown promising results [8].
5. The potential use of textile effluent treatment plant (TETP) sludge in the development of sustainable building materials has been indicated by its chemical composition [31].
6. According to a study [31], the ideal ranges of Total Effective Thermal Performance (TETP) for the production of mortar, concrete, clay bricks, and paver blocks are 5-30%, 5-40%, 5-50%, and 20-40%, respectively.
7. The fundamental characteristics of cement are satisfied by textile ETP sludge, therefore rendering it suitable for use as a binding agent in concrete [32].

## III. Conclusion

From the whole of this study, it was concluded that
1. The potential use of waste from textile effluent treatment plants as a substitute raw material in the manufacturing of clay-based goods may alleviate difficulties related to waste disposal.
2. The use of Textile Sludge may be further expanded to include its application in the production of paver blocks and walkway structures, among other uses.
3. Therefore, the use of Textile Sludge mitigates the adverse impacts on land and air pollution, making it an ecologically sound solution.
4. The inclusion of textile waste, including denim and cellulose fibres, as well as natural fibres such as coconut and jute fibres, in the composition of sand cement blocks leads to a decrease in compressive strength. This reduction in strength may be attributed to the loss of cohesiveness within the blocks.
5. A cement replacement may be derived from textile ETP waste, with a utilization potential of up to 20%.
6. Paver blocks composed of sludge mixtures are suitable for applications with little or moderate levels of traffic, excluding heavy traffic scenarios.
7. The commercial viability of the created product may be assessed by a cost-benefit analysis to evaluate its techno-economic feasibility.

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