SUITABILITY OF USING TEXTILE WASTE FOR MAKING MUD CEMENT PAVING BLOCKS, USED IN INDUSTRIAL FLOOR

Pathirana Mudiyanselage Wimukthi Priya Sampath

199629P

M. Sc. in Materials Science
Department of Materials Science and Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka
January 2025

SUITABILITY OF USING TEXTILE WASTE FOR MAKING MUD CEMENT PAVING BLOCKS, USED IN INDUSTRIAL FLOOR

Pathirana Mudiyanselage Wimukthi Priya Sampath

199629P

Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree
Master of Science in Materials Science

Department of Materials Science and Engineering
Faculty of Engineering

University of Moratuwa
Sri Lanka
January 2025

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to the University of Moratuwa the non-exclusive right to reproduce and distribute my thesis in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or in part in the future work (such as articles or books).

Signature: Date: 09/09/25

The above candidate has carried out research for the Master's thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Eng. (Mr.). S.P. Guluwita

Signature of the Supervisor: Date: 09/09/25

ABSTRACT

The construction industry is under increasing pressure to adopt sustainable alternatives to conventional building materials. This research investigates the feasibility of using mud cement composite blocks as an environmentally friendly and cost-effective solution for industrial floor paving applications. Locally sourced lateritic soil was stabilized with varying proportions of Ordinary Portland Cement (OPC) and textile waste fibers to develop blocks with improved mechanical and durability properties. A comprehensive experimental program was conducted to evaluate compressive strength, water absorption, and impact strength. Microstructural characterization was also performed to analyze the material behavior at the microscopic level. Results indicate that the incorporation of textile waste not only enhances the toughness and crack resistance of the blocks but also contributes to effective waste valorization. The optimum textile waste content was found to be 15%**,** as it provided a balance between impact resistance and mechanical strength. The optimal mix design parameters within acceptable limits for light- to medium-duty industrial flooring, while significantly reducing the carbon footprint and raw material cost. This study underscores the potential of mud cement blocks as a sustainable paving solution and contributes valuable insights into the development of green construction materials for industrial infrastructure.

ACKNOWLEDGEMENT

I wish to express my special thanks and sincere gratitude to my supervisor, Eng. (Mr.). S.P. Guluwita, Senior Lecturer at the Department of Materials Science and Engineering, Faculty of Engineering, University of Moratuwa, for his invaluable guidance, encouragement, patience, and the precious time he offered me. I would also like to thank the panel of examiners for reviewing the research as well as for their support during the study.

I would also like to extend my sincere gratitude and appreciation to the academic and nonacademic staff of Department of Materials Science and Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka, for providing the facilities to carry out the testing.

I greatly appreciate and express my sincere gratitude to Eng. (Mr.) D.D.D. Dewinda for technical support and providing the facilities to carry out the testing.

Lastly, I would like to thank my family and loved ones for their unwavering support throughout the entire process.

P.M.W.P. Sampath.

TABLES OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	**Description**
ACI	American Concrete Institute
OPC	Ordinary Portland Cement
BS	British Standard
BS EN	British Standard European Norm
ASTM	American Society for Testing and Materials
FRC	Fiber-Reinforced Concrete
ESD	Electrostatic Discharge
PET	polyethylene terephthalate
RPET	Recycled Polyester
UTM	Universal Testing Machine
FCB	First Crack Blow
UCB	Ultimate Crack Blow
INPB	Increase in Number per Blow

CHAPTER 1

With growing global emphasis on sustainability, the construction sector is increasingly exploring alternative materials that reduce environmental impact and promote resource efficiency. Incorporating waste products, such as textile fibers, into soil-cement composites presents a promising solution. This chapter outlines the background, research problem, objectives, scope, and knowledge gaps addressed in this study on the use of textile-reinforced mud cement paving blocks for industrial flooring applications.

1 INTRODUCTION

1.1 Background

Mud cement, also known as soil-cement, is a composite construction material formed by mixing natural soil, cement, and water. It has gained attention as an affordable and sustainable alternative to conventional concrete, particularly in developing countries and rural construction contexts. By utilizing locally available soils such as lateritic, sandy, or clayey soils, mud cement minimizes dependency on resource-intensive materials and reduces the overall environmental impact of construction (Millogo et al., 2008).

The stabilization of soil with ordinary Portland cement (OPC) improves the mechanical strength, water resistance, and durability of the resulting blocks or pavements. When properly compacted and cured, mud cement can achieve compressive strengths in the range of 5–40 MPa depending on mix proportions and soil type, making it suitable for non-load bearing walls, pedestrian walkways, and even industrial paving blocks (Walker & Stace, 1997; Ngowi, 1997).

In recent years, researchers have explored enhancements to traditional mud cement by incorporating natural or synthetic fibers, such as coconut coir, polypropylene, and textile waste. These fibers improve crack resistance, tensile strength, and thermal insulation, while also contributing to the circular economy by repurposing post-consumer textile materials (Oti et al., 2009; Amin et al., 2021).

This report investigates the feasibility of using textile waste-reinforced mud cement in paving block applications, focusing on mechanical performance such as compressive strength and impact resistance. The study aims to provide insights into the material's suitability for industrial flooring and its potential role in promoting sustainable and low-cost construction practices.

1.2 Research Problem

- Industrial floors require durable and high-performance materials capable of withstanding heavy loads, abrasion, and harsh environmental conditions. The suitability of textile waste for mud cement paving blocks remains underexplored, necessitating detailed research to determine its viability for industrial applications.

1.3 Objectives

- To optimize the mix design of textile and mud cement for achieving industrial-grade performance.
- To assess the environmental and economic impacts of utilizing textile waste in construction.

1.4 Gaps in Research

Long-Term Durability Studies: Limited data on the long-term performance of textile-waste-based materials.

Standardized Testing Protocols: A lack of universal standards for quality assurance.

CHAPTER 2

This chapter presents a comprehensive review of existing research relevant to the development of mud cement composites reinforced with textile waste. It examines the properties and applications of textile waste in construction, types of textiles commonly used in Sri Lanka, soil and cement characteristics, and the functional requirements of industrial flooring. The aim is to establish a theoretical foundation for evaluating the performance of textile-reinforced mud cement paving blocks and to identify existing knowledge gaps that this study seeks to address.

2 LITERATURE REVIEW

Mud cement, also known as soil-cement, has gained attention as a sustainable and affordable construction material, particularly for low-cost housing and infrastructure in developing countries. It involves stabilizing natural soil with a binder, typically Portland cement, to improve strength, durability, and resistance to moisture. The performance of mud cement depends significantly on the soil type, cement content, water-to-cement ratio, and curing conditions (Walker & Stace, 1997).

Various researchers have highlighted the importance of soil selection in mud cement applications. Lateritic soils, which are rich in iron and aluminum oxides, have shown favorable results when mixed with cement due to their good binding properties (Millogo et al., 2008). These soils, when compacted and stabilized, form strong and durable blocks suitable for structural and paving applications. In particular, the compressive strength of stabilized soil blocks has been reported to reach 30–40 MPa with appropriate mix design and curing (Ngowi, 1997).

Recent studies have explored the incorporation of natural and synthetic fibers to further enhance the properties of mud cement. The addition of fibers such as coconut coir, sisal, and textile waste improve the tensile strength and reduces the occurrence of shrinkage cracks, thereby enhancing the overall durability of the material (Oti et al., 2009). Textile waste, in particular, offers a promising solution for both construction and waste management sectors by reducing landfill loads and introducing sustainable reinforcement into concrete-like materials (Amin et al., 2021).

In addition to mechanical performance, environmental benefits play a significant role in the growing interest in mud cement. Unlike conventional concrete, which relies heavily on nonrenewable aggregates and produces high CO_2 emissions during cement production, mud cement can be manufactured using local materials with minimal environmental impact (Asteris et al., 2022). Its thermal mass and insulating properties also contribute to improved energy efficiency in buildings, making it ideal for eco-friendly construction projects.

Despite its advantages, mud cement does face some challenges. Variability in soil composition can affect consistency, and excessive clay content may lead to high shrinkage. These issues can be addressed by blending sand or modifying the mix proportions. Additionally, long-term durability and standardization are still under active research to promote broader adoption of this material in mainstream construction practices (Zami & Lee, 2010).

Overall, the literature supports the use of mud cement as a viable alternative to conventional concrete, particularly when supplemented with reinforcing fibers and optimized soil compositions. It offers a practical and environmentally sound solution for sustainable building practices in both rural and urban contexts.

2.1 Textile Waste in Construction

Now a day's construction industry has increasingly turned to alternative materials to address sustainability concerns, reduce environmental impact, and mitigate the over-reliance on traditional raw materials. This study explores the utilization of textile waste in construction, focusing on its properties, processing methods, applications, and challenges.

Textiles can be classified into several types based on the material used, the method of construction, and their use. Overview of textile types. (Pico Cleaners, 2023)

Based on fiber type - Natural fibers such as plant-based such as cotton, linen, hemp, jute, coir and sisal. Animal-based such as wool, Silk, Alpaca and Camel hair. Synthetic fibers such as polyester, nylon, acrylic, spandex and polypropylene. Semi-synthetic fibers such as rayon, modal and lyocell.

Based on construction method -Woven textiles. Such as plain weave, twill Weave, satin Weave and basket Weave. Knitted textiles - Such as warp knitting, weft knitting. Non-Woven textiles - Such as felt, geotextiles, disposable fabrics and lace textiles

Based on function - Apparel textiles are used for making garments such as denim, chiffon, jersey, and flannel. Household textiles are used in home items like curtains, upholstery, towels, and bed linens. Industrial textiles are utilized in manufacturing applications, for example, in making belts. Technical textiles include specialized fabrics such as smart textiles, geotextiles, medical textiles, and fire-resistant materials.

Based on fabric type - Lightweight fabrics include materials such as chiffon, voile, muslin, and lawn, commonly used for airy and delicate garments. Medium-weight fabrics such as poplin, broadcloth, and chambray are versatile and suitable for everyday clothing. Heavyweight fabrics like denim, canvas, gabardine, and corduroy are durable and ideal for structured or heavy-duty garments.

Specialty textiles - Eco-friendly textiles include materials like organic cotton, recycled polyester, and bamboo fabrics that are sustainable and environmentally conscious. Smart textiles such as conductive fabrics, temperature-regulating textiles, and moisture-wicking materials are designed with integrated technology for enhanced functionality. Luxury textiles include high-end materials like silk, pashmina, and velvet known for their softness, elegance, and exclusivity. Functional textiles such as waterproof fabrics, flame-retardant cloths, and UV-resistant textiles are engineered to perform specific protective or performance-enhancing roles.

2.2 Types of Textiles Used in Sri Lanka.

Here is an overview of the types of textiles used in Sri Lanka. (Textile Today Sri Lanka, 2023). Traditional textiles - Handloom textiles, widely produced in Kalutara, Batticaloa, and Jaffna, use materials like cotton and silk to create sarees, sarongs, shawls, curtains, and upholstery. Kandyan sarees (osariya) are traditional Sri Lankan garments made from silk or cotton and worn for cultural and ceremonial occasions. Beeralu lace (pillow lace) is a handmade decorative lace used in tablecloths, curtains, and garments, showcasing Sri Lanka’s artisanal heritage.

Apparel industry textiles - Knit and woven fabrics made from cotton, polyester, viscose, and blends are widely used in Sri Lanka’s export-oriented apparel sector for products like T-shirts, dresses, active wear, lingerie, and children’s wear. Synthetic textiles such as nylon, polyester, and spandex are used in performance and active wear and are exported by leading Sri Lankan manufacturers like MAS Holdings and Brandix.

Casual and every day wear - Cotton fabrics are widely used in sarongs, shirts, and dresses in Sri Lanka due to their breathability and comfort. Printed fabrics, especially colorful batik textiles, are popular for both casual and formal wear, with Kandy and Galle known for their production. Sarongs are traditional garments typically made from lightweight cotton or silk and feature distinctive cultural patterns.

Functional textiles - Uniform fabrics made from cotton, polyester, and woven materials are commonly used for office, school, and institutional uniforms. Technical and industrial textiles such as geotextiles, fishing nets, and tarpaulin materials are widely used in the construction, agriculture, and fishing industries

Luxury textiles - Silk fabrics are commonly used for wedding and ceremonial clothing and are often embellished with hand embroidery and sequins. Brocade and jacquard fabrics are traditionally used in sarees and jackets due to their rich textures and intricate patterns.

Eco-friendly and sustainable textiles - Organic cotton and recycled fabrics are widely used in Sri Lanka’s export market as sustainable textile options. Coconut fiber textiles (coir) are used in making mats, carpets, and various industrial products due to their durability. Bamboo fabrics serve as an eco-friendly alternative for clothing, valued for their softness and biodegradability.

Cultural and religious textiles - White cotton fabrics are traditionally used in religious ceremonies in Sri Lanka for their symbolism of purity. Yellow robes (sivuru) worn by Buddhist monks are typically made from cotton or silk, reflecting simplicity and spiritual discipline.

Export-oriented specialty textiles - Sportswear and active wear textiles are a major export product of Sri Lanka, catering to international performance apparel markets. Lingerie and intimates are produced using lace and microfiber fabrics, manufactured in Sri Lanka for leading global brands. Smart textiles are advanced fabrics with features like temperature regulation, developed for international high-tech apparel markets.

According to above details cotton and polyester remains the most commonly used textile in Sri Lanka. Properties of textile waste for construction. Fibrous structure enhances the tensile strength of concrete and mud by reinforcing the material with fibers. Thermal and acoustic insulation is improved when textile waste is added, helping to regulate temperature and reduce noise. Durability increases as fibers like polyester resist moisture, extending the life of the concrete. Lightweight concrete can be achieved by incorporating textile waste, reducing the overall density of construction materials.

2.2.1 Cotton

The chemical formula of cotton textile is essentially the same as the formula of cellulose, which is the primary component of cotton fibers. Cotton is made up of cellulose, a natural polymer. The chemical formula of cellulose is (C6H10O5)n . "n" represents the number of glucose units in the cellulose polymer chain. (Science Direct, Cotton fabric, *2025*)

Here’s a breakdown of this formula C6H10O5.This is the molecular formula of the glucose unit, the building block of cellulose. It consists of 6 carbon (C) atoms, 10 hydrogen (H) atoms, and 5 oxygen (O) atoms. In cotton, n can range from several hundred to over 10,000, depending on the fiber length.

Cellulose consists of long chains of glucose units linked by β-1, 4-glycosidic bonds. These chains are held together by strong hydrogen bonds, giving cotton its strength and durability. Due to the presence of hydroxyl (-OH) groups, cotton is highly absorbent and interacts well with water and dyes. Although cellulose is the main component, raw cotton fibers also contain small amounts of pectin, waxes, protein, inorganic salts (e.g., calcium, magnesium). These impurities are usually removed during the ginning and scouring processes.

2.2.1.1 Key Characteristics of Cotton Textiles

Cotton is a soft, breathable material that feels gentle on the skin, making it ideal for everyday wear. It is hypoallergenic and does not irritate sensitive skin. Cotton fibers are strong and can withstand frequent washing and wear. It has good tensile strength, making it resistant to tearing under normal use. Cotton is highly absorbent and can hold up to 25 times its weight in water. It is ideal for absorbing sweat and moisture, making it suitable for warm climates and athletic wear. Cotton is naturally breathable, allowing air to pass through and keeping the body cool. It reduces the buildup of heat and sweat, enhancing comfort. Cotton can be woven or knitted into a variety of fabrics (e.g., denim, muslin, jersey). It is suitable for a wide range of applications, from clothing to home textiles (bed sheets, towels, etc.). Cotton is a natural, renewable fiber and is biodegradable, making it environmentally friendly. Cotton fibers accept dyes easily, resulting in vibrant colors and prints that are long-lasting. Cotton tends to wrinkle easily, which may require ironing unless treated with wrinkle-resistant finishes. Cotton can shrink when washed or exposed to heat, especially if not pre-treated or pre-shrunk during manufacturing. Cotton fabrics can withstand high temperatures during washing and ironing without damage.

Cotton lacks elasticity, meaning it does not stretch much and can lose shape over time if not cared for properly.

These properties make cotton one of the most popular and widely used textiles globally.

2.2.2 Polyester

The chemical formula for polyester is generally the same as that of polyethylene terephthalate (PET), which is widely used in textile manufacturing. Its repeating unit represent as (-CO-C6H4-CO-O-CH2-CH2-O-) n. Polyester textiles make from PET, a synthetic polymer derived from the reaction of terephthalic acid (C8H6O4) and ethylene glycol (C2H6O2). The polymer consists of long chains of repeating units of the above formula, giving the fabric its durability and resistance to wrinkles and shrinking. These textiles are synthetic fabrics made from petroleum-based polymers. (Sew port, 2025)

2.2.2.1 Key Characteristics of Polyester Textiles

This textile highly durable and resistant to stretching, shrinking, and tearing. It retains its shape well, even after prolonged use and frequent washing. This textile is naturally resistant to wrinkling, making it ideal for low-maintenance clothing and home textiles. It does not require ironing as often as natural fibers like cotton. This textile is lightweight and comfortable to wear, making them suitable for active wear and sportswear. This textile is hydrophobic, meaning it resists water absorption. It dries quickly, making it excellent for outdoor and athletic clothing. This textile is less breathable compared to natural fibers like cotton, which can trap heat and moisture. Modern advancements like moisture-wicking finishes improve breathability in performance fabrics. This textile has moderate elasticity, which helps it maintain its structure and resist wrinkles. Blended polyester fabrics are more stretchable. This textile is resistant to UV rays, mildew, and most chemicals, making it suitable for outdoor applications. Polyester is less likely to fade when exposed to sunlight compared to natural fibers. This textile fibers accept dyes well, producing vibrant and long-lasting colors. Polyester is often used for prints and patterns that require bold colors. This textile resists shrinking and maintains its original size and fit after washing. This textile tends to build static electricity, which can attract dust and lint. This textile is recyclable, and recycled polyester (RPET) is becoming more popular as an eco-friendly alternative. This textile textiles are cost-effective compared to natural fibers, making them accessible for mass production.

2.3 Applications of Textile Waste in Construction

2.3.1 Several Innovative Uses of Textile Waste in Construction Materials

Fiber-Reinforced Concrete (FRC) uses textile fibers to improve tensile strength and crack resistance, with synthetic fibers helping to reduce shrinkage cracking and enhance durability (S. Hossain, I. A. Dipta, 2022). Mud cement and paving blocks benefit from textile fiber additions that increase compressive strength and reduce shrinkage cracks, making them suitable for industrial flooring. Insulation materials made with textile waste, especially natural fibers, provide excellent thermal and acoustic insulation for buildings. Lightweight bricks and panels incorporate textile waste to improve thermal efficiency while reducing overall material weight.

2.3.2 Benefits of Using Textile Waste in Construction

Waste management is improved by incorporating textile waste into concrete, reducing landfill burden and encouraging recycling. Sustainability is enhanced by minimizing the use of virgin materials and lowering carbon emissions during construction. Cost-effectiveness is achieved as textile waste is often more affordable than conventional construction materials. Improved properties such as enhanced durability and better thermal and acoustic insulation make textile-reinforced materials advantageous in building applications.

2.3.3 Challenges and Limitations

Textile waste in construction poses has several challenges. Heterogeneity of textile waste can lead to inconsistent material properties due to variations in fiber type, length, and composition. Processing requirements such as cleaning, shredding, and treating textile waste add to energy consumption and cost. Environmental concerns arise as synthetic fibers may release micro plastics into the environment during degradation. Standardization issues persist because industry standards for integrating textile waste into construction materials are limited or underdeveloped.

2.4 Soil in Construction

Sieve analysis is a method for determining the particle size distribution of soils. It is essential for understanding soil properties and suitability for various applications, including construction. Below is an overview of sieve analysis results for Sri Lankan soils. (Unknown Author, Soils of Sri Lanka)

Lateritic Sandy Soil - Composition of lateritic sandy soil is Gravel 1.9%, Sand 94%, Silt/Clay 4.1%. This indicates a well-graded soil with a predominant sand fraction, suitable for construction purposes.

Soils in the Wet Zone - In Sri Lanka's Wet Zone, including Red Yellow Podzolic soils, Reddish Brown Latasolic soils, Immature Brown Loams, and Alluvial soils, has provided their aggregate stability and particle size distribution. Sieve analysis percentages are not detailed in the available summary, these soils exhibit varying degrees of aggregate stability, influencing their behavior in construction.

Intermediate Zone Soils - In Sri Lanka's Intermediate Zone, such as the Ragala and Andigama series, have assessed wet aggregate stability, ranging from 55% to 98.5%. Although exact particle size distributions are not specified in the summary, the aggregate stability data suggest differences in composition and soil texture, which are critical for construction.

The soil in the Kubalgama area of Sri Lanka**,** as in most parts of the country, may typically exhibit properties of lateritic soil or red-yellow podzolic soil**,** which are common in Sri Lanka's lowland areas and upland regions. Here's an analysis tailored to the possible soil profile in that region: (Unknown Author, Soils of Sri Lanka)

2.5 Characteristics of Soil in Kubalgama

The soil is likely lateritic if sourced from high elevations, or sandy-clay if from lowlands or riverbanks. It is reddish to reddish-brown in color due to high iron and aluminum content. The texture typically ranges from sandy loam to clayey loam. It has moderate to high permeability in sandy areas but retains water in regions with clayey layers. The soil is slightly acidic, with a pH range of 5.0 to 6.5. While generally low in nutrients, the soil has good strength and binding properties suitable for construction (See Table *2-1*).

Well-graded soil indicates a mix of sand and finer particles, making it ideal for compaction and construction applications. Plasticity in lateritic soils is typically moderate, but if clay content exceeds 30%, sand blending may be necessary to improve suitability for uses like paving blocks. Add fine or coarse sand if the clay content exceeds 20%.

As subgrade material, the soil offers good strength when properly compacted. For soil-cement blocks, it performs well due to its strong binding properties with cement. For mud-cement paving blocks, it is optimal when combined with added sand or textile waste to minimize shrinkage cracks. (Unknown Author, Soils of Sri Lanka)

Table 2-1 Physical and mechanical properties of soil, (Unknown Author, Soils of Sri Lanka)

No table of figures entries found.	Value
Natural water content	26.00%
Liquid limit	36.77%
Plastic limit	22.95%
Plasticity index	13.82%
Linear shrinkage	6.71%
Specific gravity	2.37
Gravel	46.00%
Sand	44.00%
Silt & Clay	10.00%
Silica (SiO_2)	71.16%
Alumina (Al_2O_3)	16.15%
Iron oxide (Fe_2O_3)	4.98%
Potash (K_2O)	1.46%
Magnesia (MgO)	0.25%
Loss on ignition	5.61%

2.6 Cement

Ordinary Portland Cement (OPC) is the most widely used type of hydraulic binder in modern construction. It is primarily composed of calcium silicates, produced by the high-temperature calcination of limestone and clay materials in a rotary kiln. Upon hydration, OPC forms calcium silicate hydrate (C–S–H) gel, which imparts strength and durability to cement-based composites. Due to its well-established mechanical performance, availability, and compatibility with various aggregates, OPC serves as a reliable stabilizing agent in soil-based construction materials. However, its high carbon footprint has encouraged research into partial replacement and enhancement using sustainable alternatives.

2.6.1 Properties of the Cement

Fineness - Fineness describes how fine the cement particles are. Higher fineness increases the surface area available for hydration, leading to faster strength gain and better uniformity in concrete *(Neville, A. M. (2011)).*

Setting Time **-** OPC provides adequate working time before setting begins. The typical initial setting time is around 30 to 45 minutes, and the final setting time is under 10 hours. These values ensure workable concrete without premature stiffening. (*ASTM International. (2020)).*

Compressive Strength - OPC develops significant compressive strength, often exceeding 40 MPa at 28 days, depending on its grade. Strength development continues over time as hydration progresses. (*Mehta, P. K., & Monteiro, P. J. M. (2014)).*

Soundness - Soundness indicates the volume stability of cement after setting. OPC must not exhibit significant expansion after hydration. The Le Chatelier test is commonly used to assess this property. (*Bureau of Indian Standards. (2015)).*

Heat of Hydration - The chemical reaction of cement with water releases heat. While beneficial in cold climates for early strength gain, excessive heat generation in large pours may cause thermal cracking. *(Neville, A. M. (2011)).*

Specific Gravity - OPC has a specific gravity of approximately 3.15, which is used in concrete mix calculations for accurate volume-to-weight conversions. (*Mehta, P. K., & Monteiro, P. J. M. (2014); see* Table *2-2).*

Standard Consistency - The standard consistency refers to the water required to achieve a cement paste of normal workability. For OPC, it typically ranges between 25% and 30% of the cement weight. (*Bureau of Indian Standards. (2015)).*

Table 2-2 Properties of the cement, (ASTM International. (2020))

Compressive strength (MPa)	CEM 42.5N
Specific gravity (g/cm3)	3.15
Final setting time (min)	280
Volume expansion (mm)	1
Blaine fineness (cm2/g)	3.54

2.7 Industrial Flooring Requirements

Industrial floors are very important of industrial facilities, warehouses, workshops and factories. Industrial floors are subjected to heavy loads, high foot and vehicular traffic, abrasion and chemicals. It is very important proper material selection for Industrial floors. Key requirements for industrial flooring. (Unknown Author, Industrial flooring)

High load-bearing capacity is essential for industrial floors to support the weight of heavy machinery, vehicles, and equipment such as forklifts and trucks. Abrasion resistance ensures that industrial floors can withstand wear and tear from the continuous movement of heavy loads. Impact resistance allows industrial floors to absorb and resist damage caused by accidental drops of tools or materials. Industrial floors must be resistant to chemicals such as oils, acids, solvents, and cleaning agents commonly used in industrial environments. A protective chemical-resistant materials like epoxy or polyurethane coatings are often necessary. The flooring should have anti-slip properties, especially in areas prone to spills or water exposure. Textured slip-resistant coatings can be applied to improve traction. Industrial floors must endure temperature extremes, such as in food processing plants or areas with high heat exposure. Industrial flooring materials like concrete and epoxy must be able to handle thermal expansion and contraction without cracking. Industrial floors should allow easy cleaning and maintenance to meet hygiene and safety standards. Industrial floors must resist staining from spills and leaks. Industrial flooring should offer long-term value by minimizing repair and replacement costs. Industrial floors must resist cracking under heavy stress or due to environmental factors like moisture or temperature fluctuations. Reinforcement with fibers can improve crack resistance. Industries such as food processing, pharmaceuticals, and healthcare, floors must meet strict hygienic standards. Industries handling flammable substances or electronics, anti-static or electrically conductive flooring is required to prevent electrostatic discharge. Automotive manufacturing or assembly lines, require floors that can absorb and resist vibrations to reduce structural damage. Industrial flooring in customer-facing industrial facilities may also need to look clean and professional. Industrial floors made from eco-friendly materials, such as recycled content or renewable resources, may be preferred in modern industrial setups. Industrial floors lifespan of 10–20 years or more is typically expected, depending on usage and maintenance practices.

2.8 Common Flooring Materials for Industrial Use

Concrete is a durable and cost-effective flooring material that can be enhanced with fiber reinforcement for added strength. Epoxy coatings provide excellent chemical resistance, making them ideal for industrial and laboratory environments. Polyurethane floors are more flexible and resistant to scratches and impacts compared to epoxy floors. Vinyl flooring is used where anti-static or hygienic properties are required, such as in healthcare and cleanroom settings. Mud cement blocks (experimental) offer a sustainable and low-cost alternative for industrial flooring applications. High compressive strength (>30 MPa) and abrasion resistance are critical. Durability under dynamic loads and environmental stress is essential.

2.9 Mix Design Recommendations for Industrial Paving Blocks

Based on literature review and preliminary trials, the recommended composition for mud cement paving blocks was identified as follows:

- Amount of soil used: 60% to 70%
- Amount of cement used: 25% to 35%
- Amount of textile waste (fibers) used: 5% to 20%

Five distinct mix designs (M1–M5) were prepared by varying the textile content incrementally (0%, 5%, 10%, 15%, and 20%) while maintaining a consistent cement percentage of 30%. The purpose was to determine the optimal textile inclusion for maximum strength and durability.

CHAPTER 3

This chapter outlines the materials used and the experimental procedures adopted to investigate the suitability of textile waste-reinforced mud cement blocks for industrial flooring. It details the sourcing and preparation of soil, cement, and textile fibers, followed by the testing methodologies employed to evaluate mechanical and durability properties. The experimental framework was designed to ensure reproducibility, consistency, and relevance to real-world construction applications.

3 MATERIALS AND METHODOLOGY

3.1 Materials

3.1.1 Soil

The soil used in this study was sourced from homogeneous layers located approximately 600 mm below the surface as in Figure *3-1* to avoid contamination with organic matter or loose topsoil. Oversized particles were removed by sieving through a 20 mm mesh to ensure uniformity. Sieve analysis was conducted in accordance with BS EN 933-1 to determine particle size distribution, which confirmed its suitability for use in compressed earth blocks. The soil predominantly consisted of fine aggregates and silty clay fractions, which contribute to adequate workability and binding capacity when combined with cement.

Figure 3-1 Collecting soil samples

3.1.2 Cement

Ordinary Portland Cement (OPC) conforming to ASTM C150 Type I was used as the primary binding agent. OPC was chosen due to its high early strength, availability, and compatibility with earthen materials. The cement content was varied between 25% and 35% across different mixes to assess its impact on compressive strength and bonding with textile fibers.

3.1.3 Textile Waste Fibers

Textile waste was collected from local garment factories across Sri Lanka. The waste consisted primarily of synthetic polyester fabric, which was selected based on its durability, hydrophobic properties, and tensile strength. Polyester fibers are known to improve moisture resistance and crack resistance in cementitious composites. The scraps were cut into uniform 2 cm × 2 cm pieces to promote even distribution throughout the mix and reduce clumping. The textile preparation process involved several steps:

Measuring and Cutting: Fabric pieces were marked using chalk and a ruler, then cut into squares using scissors and later refined using a table knife for efficiency (see Figure *3-2*).

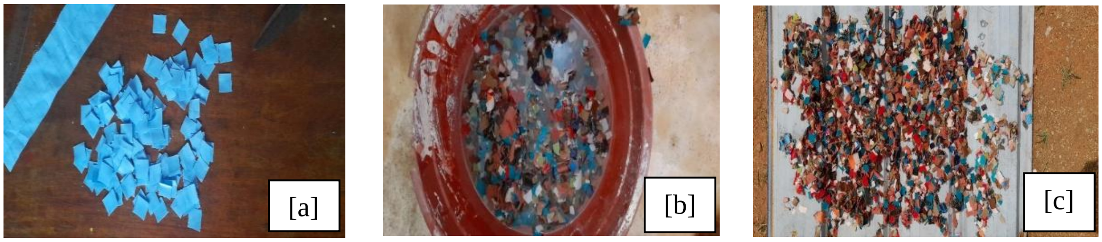

Figure 3-2 Cutting[a], soaking[b] and drying of textile samples[c]

Pre-treatment: To remove dirt and improve bonding with the cement matrix, the fibers were soaked in water. Cleaned fibers were air-dried at ambient conditions before being incorporated into the mix.

The primary components of the textile mixture were polyester-based weft and warp yarns, with occasional blended fabrics including viscose or cotton. However, polyester was the dominant component, offering high dimensional stability and resilience against moisture and chemical attack.

3.2 Experimental Procedure

- Sieve Analysis

Sieve analysis was carried out in accordance with BS EN 933-1 to determine the particle size distribution of the soil. The results confirmed that the majority of soil particles fell within the range of 0.075 mm to 2 mm, classifying it as well-graded fine soil suitable for block manufacturing. A proper grading ensures adequate compaction, minimizes voids, and enhances the bonding capability of the mix.

- Sample Preparation

All materials were weighed accurately to ensure consistency. Dry mixing of soil, cement, and textile fibers was carried out for uniform fiber dispersion. Water was added gradually to reach the desired workability. The fresh mix was compacted into 100 mm cubic molds using hand compaction and vibration. The samples were de-molded after 24 hours and cured under moist conditions for 28 days.

Figure 3-3 Cement cubes[a] and testing the cement cube using testing machine[b]

- Compressive Strength Test

Compressive strength tests were performed on 100 mm cubes according to BS EN 12390-3 using Universal Testing Machine (UTM) as in Figure *3-3*. A uniform load was applied at a constant rate until failure. Three samples were tested for each mix to ensure repeatability, and the average strength was recorded.

Compressive strength = load at failure / cross-sectional area

- Drop Weight Impact Test

The impact resistance of the blocks was evaluated using the drop weight impact test, following ACI 544 guidelines. A cylindrical steel hammer weighing 4.5 kg was repeatedly dropped from a height of 450 mm onto the center of each block (Figure *3-4*). The number of blows to initiate visible cracking and final failure were recorded. Energy absorption was calculated based on the number of impacts multiplied by the potential energy of each drop.

The drop weight impact test was conducted using standardized parameters to ensure consistency and reliability. The specimens used in the experiment were disc-shaped, with a diameter of 150 mm and a height of 65 mm. A steel hammer weighing 4.45 kg was employed as the drop weight, and it was released from a fixed height of 457 mm to apply repeated impacts to the center of each sample.

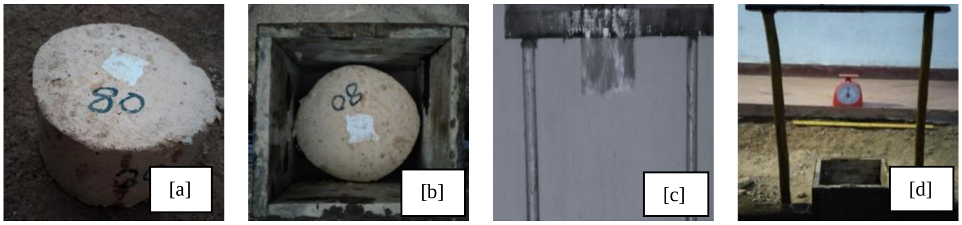

Figure 3-4 Disk shape samples[a], keeping the sample inside the safety frame[b], steel hammer[c] and drop weight testing apparatus[d]

- Standard Paving Block Testing

To assess real-world applicability, standard-sized paving blocks (200 mm × 100 mm × 60 mm) were fabricated using the optimized mix (M4: 15% textile content). The compressive strength was determined after 28 days of curing using a calibrated UTM. The performance was compared with that of conventional concrete blocks and analyzed for suitability in medium-duty industrial flooring.

This methodology ensures reproducibility of results while simulating practical conditions for industrial flooring. By incorporating textile waste into the mix and examining its physical, mechanical, and durability aspects, the research presents a comprehensive framework for sustainable material development.

CHAPTER 4

This chapter presents and interprets the experimental findings obtained from the evaluation of textile-reinforced mud cement paving blocks. It includes the results of sieve analysis, compressive strength testing, and impact resistance measurements, followed by a critical discussion of mechanical performance, crack behavior, durability, and environmental implications. The analysis aims to assess the material's suitability for industrial flooring and to validate the effectiveness of textile waste as a reinforcing component.

4 RESULTS & DISCUSSION

4.1 Sieve Analysis of Soil

The aggregate particle size distribution was determined in accordance with BS EN 933-1 standards, which provide standardized guidelines for conducting sieve analysis of aggregates.

Table 4-1 Sieve analysis results

Sieve Size (mm)	Weight Retained(g)	Cumulative Retained Weight	Percentage Passing
4.75	30	6	94
2.36	50	16	84
1.18	80	32	68
0.6	100	52	48
0.3	110	74	26
0.15	80	90	10
0.075	40	98	2
Pan	10	100	0

The graph is constructed using the aggregate data provided in Table 4-1.

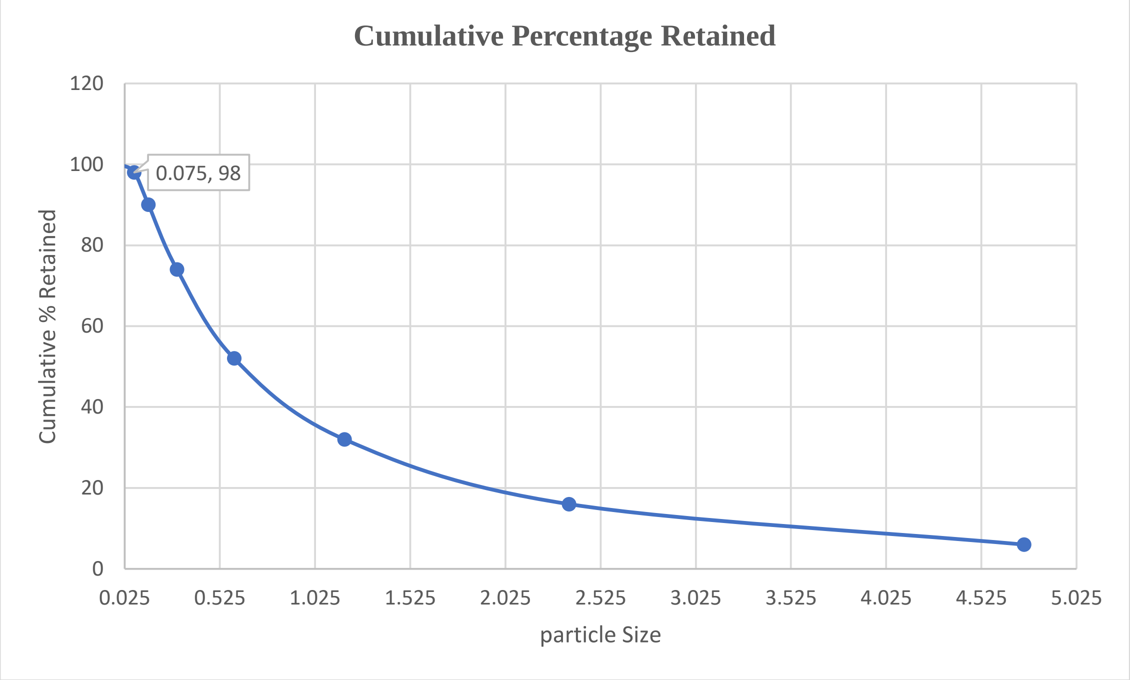

Figure 4-1 Cumulative percentage retained vs particle size

The results from The aggregate particle size distribution was determined in accordance with BS EN 933-1 standards, which provide standardized guidelines for conducting sieve analysis of aggregates.

Table 4-1 and Figure 4-1 indicate that the soil used is well-graded, with most particles ranging between 0.075 mm and 2 mm. This gradation helps ensure good compaction, reduced voids, and better bonding with cement. A smooth curve without sharp jumps also suggests consistent texture, which improves workability during block preparation and contributes to the strength and stability of the final product.

Figure *4-2* further supports this by showing a gradual percentage passing curve, confirming a uniform distribution of finer particles within the mix. The graph is constructed using the aggregate data provided in Table 4-1.

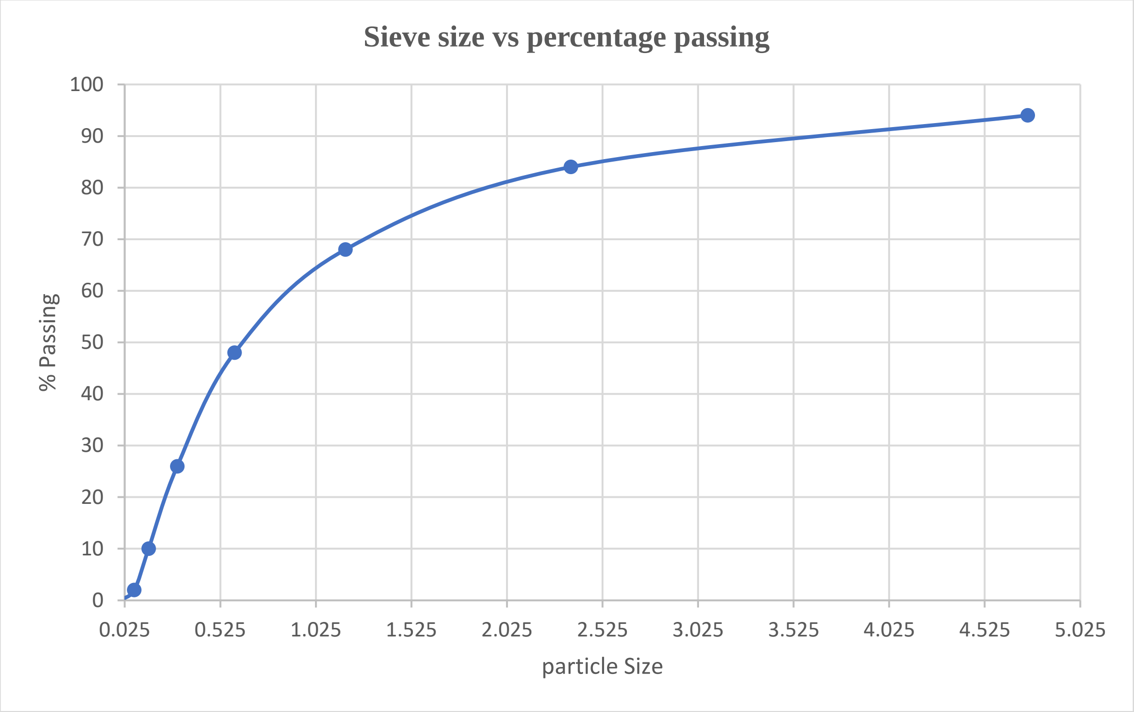

Figure 4-2 Percentage passing vs particle size

4.2 Compressive Strength of Soil Cement Cube

Table 4-2 Compressive strength of soil - cement cubes with varying mix proportions

Mix ID	**Soil Percentage**	**Cement Percentage**	**Textile Waste Percentage**	**Compressive Strength (MPa) at 28 Days**
M1	70	30	0	37
M2	65	30	5	38
M3	60	30	10	36
M4	55	30	15	33
M5	50	30	20	31

The graph is constructed using the aggregate data provided in Table 4-2.

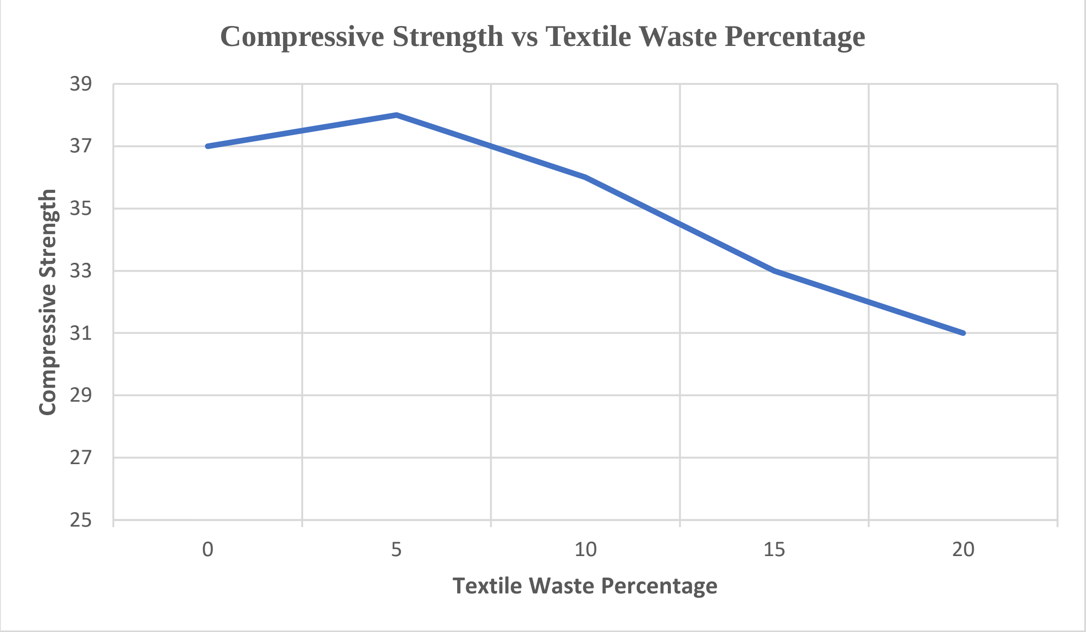

Figure 4-3 Compressive strength vs textile waste percentage

Figure 4-3 and results from Table 4-2 highlights how compressive strength changes with different amounts of textile waste in the mix. Interestingly, strength increases slightly at 5% textile content, showing that a small amount of fiber can enhance bonding and crack resistance. However, as textile waste increases beyond 10%, the compressive strength begins to drop. This suggests that too much fiber may disrupt the cement matrix and reduce compaction efficiency. The results clearly point to an optimal range around 5% to 10% where textile waste adds value without compromising strength.

4.3 Mix Proportions and Performance

Table 4-3 Drop weight test results of cylindrical specimen

Mix ID	**Soil Percentage**	**Cement Percentage**	**Textile Waste Percentage**	**Cracking Number for five samples**	**Failure number for five samples**	**Energy Absorbed for five sample(J)**	**Energy Absorbed for one sample(J)**
M1	70	30	0	59	81	1616	323.2
M2	65	30	5	62	85	1696	339.2
M3	60	30	10	64	90	1795	359.0
M4	55	30	15	63	92	1835	367.0
M5	50	30	20	61	88	1755	351.0

Table *4-3* highlights that impact resistance improved with textile addition, reaching peak performance at 15% content. This mix absorbed the highest energy and showed greater resistance to cracking and failure. Slight performance drop at 20% suggests that too much fiber may reduce internal cohesion.

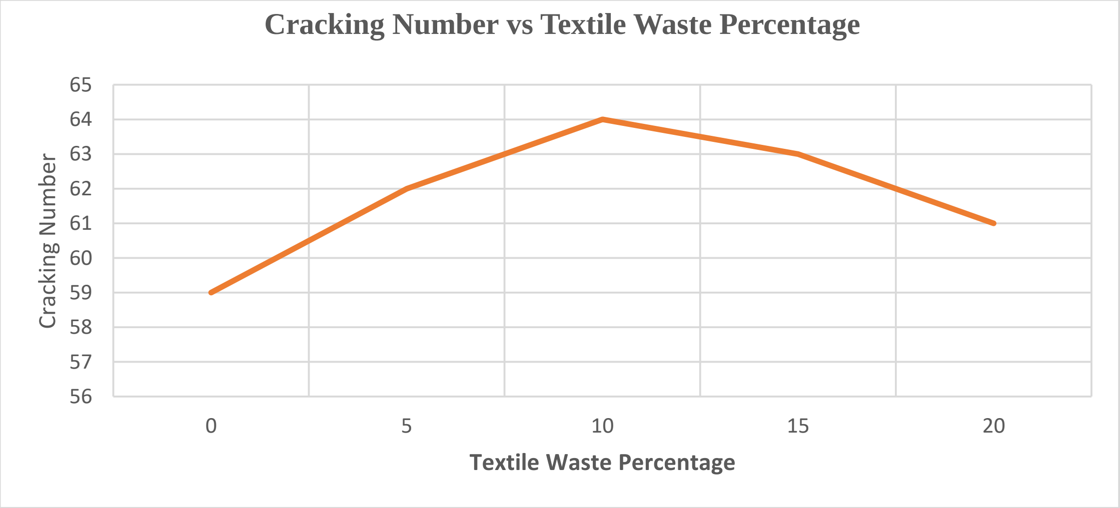

Figure 4-4 Cracking number vs textile waste percentage

Figure 4-4 shows that the number of blows needed to cause the first visible crack increases slightly with more textile waste in the mix. This means that adding textile fibers helps delay the onset of cracking, likely because the fibers absorb stress and hold the mix together more effectively. The improvement is most noticeable up to around 10–15% textile content. Beyond that, the benefit levels off, suggesting that while fibers help resist cracking, too much can make the mix harder to compact evenly.

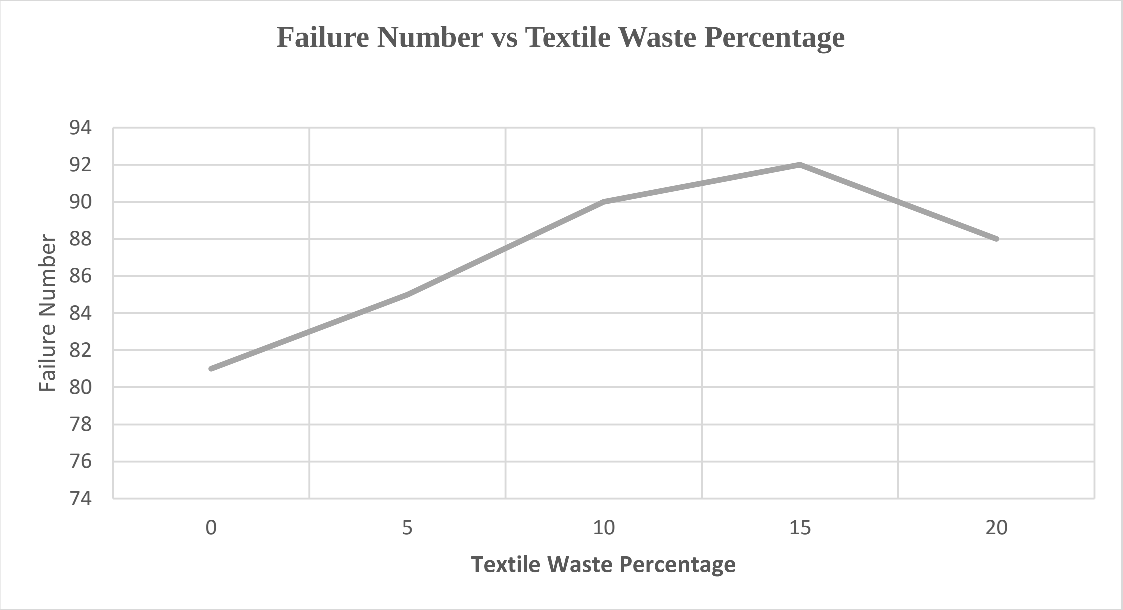

Figure 4-5 Failure number vs textile waste percentage

As shown in Figure *4-5*, the number of impacts the blocks could withstand before complete failure increased with textile content up to 15%. This suggests that textile fibers helped the blocks absorb more energy and resist breaking apart quickly. After 15%, the performance slightly drops, likely due to uneven fiber distribution. Overall, moderate fiber addition clearly improves toughness and makes the blocks more resilient under repeated impact.

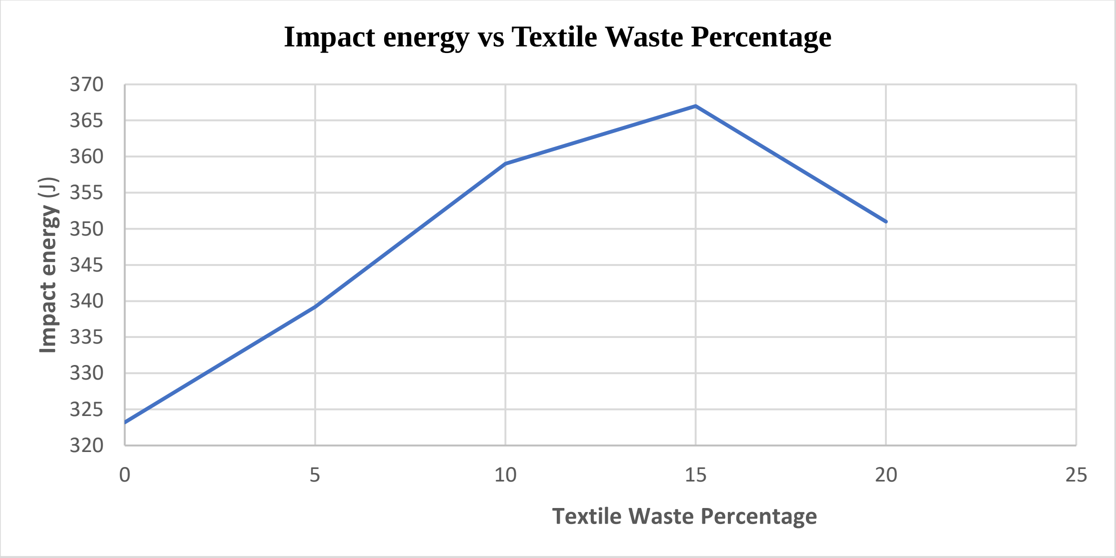

Figure 4-6 Impact energy vs textile waste percentage

Figure 4-6 illustrates that the impact energy absorbed by the blocks increases with textile waste content, reaching its highest value at 15%. This indicates that an appropriate amount of textile reinforcement improves the block's ability to withstand sudden impact by enhancing energy dissipation. A slight decrease beyond 15% suggests that excessive fiber content may hinder uniform compaction, leading to reduced performance. The results highlight the effectiveness of moderate fiber inclusion in improving impact resistance.

4.4 Compressive strength of a standard-sized paving block

Table 4-4 Compressive strength of a standard-sized paving block

Soil Percentage	Cement Percentage	Textile Waste Percentage	Compressive Strength (MPa) at 28 Days
55	30	15	31
55	30	15	32
55	30	15	31

Table *4-4* shows that the standard-sized paving blocks with 15% textile waste consistently achieved compressive strengths around 31–32 MPa. This confirms that the optimized mix maintains reliable structural performance at scale, aligning well with strength requirements for light to medium-duty industrial flooring.

4.5 Mechanical Performance and Compressive Strength

The experimental data showed compressive strengths ranging from 31 MPa to 38 MPa. The highest strength (38 MPa) was achieved at 5% textile fiber addition. However, higher percentages of textile waste led to a reduction in compressive strength, reaching 31 MPa at 20% inclusion. This pattern reflects the reinforcing effect of fibers up to an optimum threshold, beyond which their benefits diminish due to fiber clumping and void formation.

Fiber addition tends to enhance the internal structure by arresting microcracks and improving toughness. However, excess fiber content disrupts the matrix continuity and hinders effective compaction, thereby lowering the load-bearing capacity. The findings underscore the importance of optimizing the fiber percentage to strike a balance between strength and workability. At low dosages, fibers enhance mechanical performance by bridging microcracks and resisting tensile forces. This fiber-bridging mechanism allows stress to be transferred more effectively across the matrix, delaying crack propagation and increasing the composite's ductility (Bentur & Mindess, 2006). However, when the fiber content exceeds an optimal limit, issues such as fiber balling, poor dispersion, and increased porosity emerge. These factors weaken the interfacial transition zone (ITZ) and disrupt the homogeneity of the cement matrix, ultimately reducing compressive strength (Li et al., 2015).

The 15% textile content (M4) provided a balanced composition, yielding sufficient compressive strength (31.3 MPa) while maximizing energy absorption. This confirms the presence of an optimal range for textile addition, beyond which the mechanical benefits diminish.

4.6 Crack Formation and Structural Failure Patterns

Crack types observed included corner, horizontal, vertical, diagonal, hairline, and map cracks. Each type can be attributed to distinct causes.

Inclusion of textile fibers appeared to reduce the extent and severity of cracking by reinforcing the matrix and bridging stress concentrations. This performance reflects the capability of fibers to act as micro-reinforcement in cementitious systems, slowing crack propagation and distributing internal stresses more evenly.

Various crack patterns - corner, diagonal, horizontal, vertical, hairline, and map cracks were identified during load testing. Understanding these crack types is essential for diagnosing failure mechanisms and improving future block design.

Corner cracks emerged due to edge weakness or inadequate compaction, resulting in stress concentrations. Horizontal cracks indicated poor bonding between layers or lateral load imbalances (As shown in Figure 4-7).

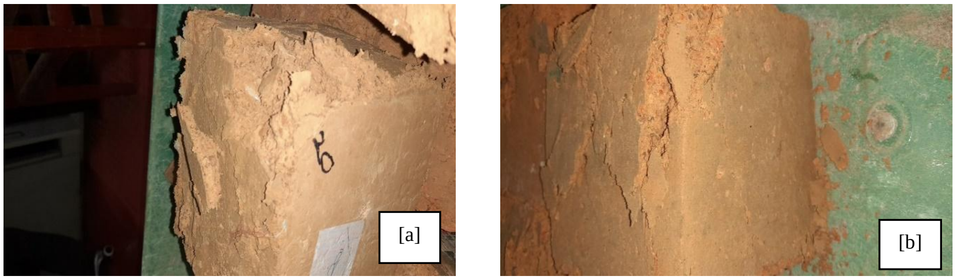

Figure 4-7 Corner cracks, horizontal[a], vertical cracks and diagonal cracks[b].

Diagonal cracks suggested shear failure under complex load paths. Vertical cracks were typically caused by tensile splitting and drying shrinkage.

Hairline and map cracks were associated with plastic shrinkage and differential drying rates, often exacerbated by poor curing (Neville, 2011).

Fracture mechanics theory supports these observations. When internal stress exceeds the material’s tensile strength, crack propagation becomes inevitable, particularly in brittle materials like cement-based composites. Fiber reinforcement mitigates this by acting as a bridge that slows down or redirects crack growth (Mindess et al., 2003).

4.7 Impact Resistance and Energy Absorption Characteristics

The drop weight impact test is a widely adopted method to assess the energy absorption capacity and impact resistance of cementitious composites, such as mud cement blocks. This test simulates sudden loading conditions and provides insight into the material’s behavior under dynamic stresses, which is particularly relevant for industrial flooring subjected to mechanical impacts.

Two key measurements are considered during the test: the First Crack Blow (FCB) and the Ultimate Crack Blow (UCB). The FCB corresponds to the number of impacts required to initiate the first visible crack on the specimen surface, indicating the onset of structural distress.

In contrast, the UCB represents the total number of impacts sustained before the specimen undergoes complete structural failure. These values collectively help assess the material's toughness and its ability to resist progressive damage. The energy absorption is calculated using the equation:

$$E=N\cdot m\cdot g\cdot h$$

Where, N is the number of impacts, m is the mass of the falling weight, g is the gravitational acceleration (9.81 m/s^2), and h is the drop height. This equation estimates the total energy transferred to the specimen before failure. A higher energy absorption value reflects better resistance to sudden impact loads and a more ductile failure mode.

Overall, the drop weight impact test provides a simple yet effective way to evaluate the durability and resilience of mud cement paving blocks, especially when reinforced with additives such as textile fibers. It enables the identification of optimal mix designs that offer a balance between strength and energy dissipation, both critical for long-term industrial use.

The drop weight test demonstrated a notable improvement in impact resistance when textile waste was included. The blocks with 15% textile content (M4) withstood the highest number of impacts, absorbing up to 367 J of energy compared to 323.2 J in the control sample (M1).

This increase is attributed to the energy dissipation mechanisms introduced by the fibers. During impact, fibers stretch, slide, or rupture, absorbing energy that would otherwise cause brittle failure. (Banthia & Sappakittipakorn, 2007). However, at 20% textile waste, the performance dropped slightly, likely due to the inconsistent distribution of fibers and the introduction of defects. Excess fiber volume can introduce discontinuities, increase entrapped air, and impair load transfer pathways, thereby limiting toughness (Zollo, 1997).

4.8 Standard Block Performance and Applicability

Standard paving blocks (200 mm × 100 mm × 60 mm) produced using the optimal mix (M4) achieved a compressive strength of 31.3 MPa. This strength falls within the acceptable range for industrial flooring, which often demands materials with compressive strengths between 25 MPa and 40 MPa (ACI Committee 330, 2008).

Although slightly lower than conventional concrete pavers, the textile-reinforced blocks offer superior impact tolerance and crack resistance critical qualities in environments subjected to mechanical loads, vibrations, and equipment traffic.

4.9 Durability and Service Life Considerations

Polyester textile waste improved the blocks’ resistance to moisture ingress, abrasion, and shrinkage. Polyester fibers are hydrophobic, reducing capillary suction and thus limiting internal moisture variation a primary cause of freeze–thaw degradation (Pacheco-Torgal & Jalali, 2011).

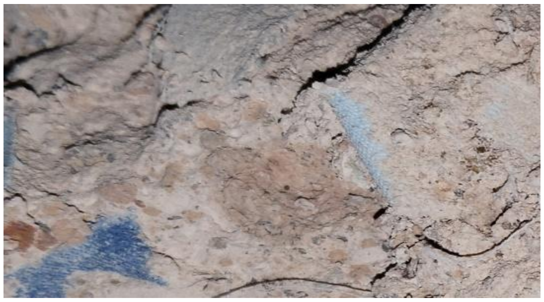

Figure 4-8 Distribution of textiles in the blocks

Moreover, the fibers act as internal micro-reinforcement, reducing plastic and drying shrinkage. This internal restraint effect is crucial for minimizing long-term cracking and deformation. The presence of randomly distributed fibers interrupts micro crack coalescence, delaying macro crack formation (Li & Stang, 1997).

Although long-term durability tests (e.g., accelerated aging or chloride penetration) were beyond this study's scope, the preliminary results indicate improved resistance to wear and environmental deterioration.

4.10 Environmental and Economic Evaluation

The inclusion of textile waste addresses two pressing issues: sustainable waste management and carbon footprint reduction. The cement industry contributes significantly to global CO2 emissions, accounting for approximately 7% of total anthropogenic emissions (Scrivener et al., 2018). Replacing a portion of cement with inert textile fibers offers direct environmental benefits by lowering embodied energy and reducing raw material consumption.

Economically, using readily available local soil and discarded textiles reduces procurement and transportation costs. The simplified production process without high temperature processing further enhances affordability and accessibility, particularly in low-resource regions.

This approach aligns with sustainable development goals (SDGs) related to responsible consumption, climate action, and innovation in infrastructure (UN, 2015).

4.11 Comparative Assessment with Conventional Paving Blocks

While concrete paving blocks typically possess higher compressive strengths, the textile-reinforced mud cement blocks demonstrated competitive mechanical properties with enhanced impact resistance and flexibility. These qualities are particularly advantageous in industrial settings involving dynamic loads, such as storage areas, manufacturing floors, and loading docks.

The enhanced ductility and toughness of textile-reinforced blocks also translate into longer service life and reduced maintenance. As such, they present a feasible alternative to concrete in medium-duty applications, especially when sustainability and cost-effectiveness are priorities.

4.12 Key Limitations and Practical Challenges

Despite promising outcomes, several limitations were noted.

Material heterogeneity**:** Textile waste varies in type, fiber length, and treatment history, introducing inconsistency in performance.

Labor-intensive processing**:** Manual fiber cleaning, drying, and cutting increase production time and cost.

Mixing complexity**:** Ensuring uniform fiber distribution in the matrix (as visible in Figure *4-8*) remains a technical challenge, affecting both strength and workability.

Standardization gap**:** The lack of codified guidelines for textile-reinforced earthen materials hampers widespread adoption and certification.

Addressing these issues requires targeted research into automated processing methods, standardized mix designs, and field validation under real-world load and weather conditions.

The incorporation of textile waste into mud cement paving blocks significantly enhances their mechanical and durability characteristics. The optimal mix design 55% soil, 30% cement, and

15% textile waste achieved a compressive strength of 31.3 MPa and an impact energy absorption of 367 J, proving its suitability for light to medium industrial flooring.

These results validate the theoretical benefits of fiber-reinforced composites and demonstrate practical improvements in crack resistance, ductility, and resilience. The environmental and economic advantages further underscore the potential of this innovation as a sustainable construction solution.

Looking ahead, expanding the research to include long-term aging, environmental simulations, and field-scale deployment will be crucial. In parallel, collaborative efforts with regulatory bodies and industry stakeholders will help bridge the gap between experimental success and mainstream construction application.

CHAPTER 5

This chapter presents the key conclusions drawn from the study, based on the research objectives outlined earlier. It reflects on the performance of textile-reinforced mud cement blocks in meeting structural, environmental, and economic goals. The findings are synthesized to highlight the most effective mix design and its broader implications for sustainable construction.

5 CONCLUSION

The study successfully optimized a mud cement mix reinforced with textile waste that meets the requirements for industrial-grade performance. Through systematic testing of various mix proportions, the blend containing 55% soil, 30% cement, and 15% textile waste demonstrated the best overall performance. It achieved compressive strengths above 31 MPa and exhibited excellent impact resistance and crack control. These results confirm that textile fibers, when used in the right proportion, can significantly improve the toughness and durability of mud cement blocks, making them suitable for light to medium-duty industrial flooring applications.

Beyond technical performance, the study also highlights the environmental and economic value of integrating textile waste into construction materials. Using discarded textile fibers helps reduce landfill pressure and supports circular economy practices by giving waste materials a second life. Additionally, the approach reduces dependency on high-emission materials like cement, contributing to a lower overall carbon footprint. From a cost perspective, sourcing local soil and waste textiles makes the production process more affordable and accessible especially in resource-constrained settings. Together, these findings demonstrate that this solution is not only structurally sound but also aligned with sustainable construction goals.

CHAPTER 6

This chapter summarizes the key findings of the study and reflects on the effectiveness of using textile waste in mud cement paving blocks for industrial applications. It highlights the optimal mix proportions, performance outcomes, and sustainability benefits observed. The chapter also outlines recommendations for future research to further develop and validate the proposed material system under practical conditions.

6 RECOMMENDATIONS

6.1 Recommendations for Future Research

To build upon the findings of this study, the following areas are recommended for future exploration:

- Long-term performance studies: Investigate the effects of aging, weathering, fatigue loading, and cyclic thermal expansion to assess real-world durability over time.
- Fiber processing optimization: Develop scalable, low-energy pre-treatment and mixing techniques to improve fiber distribution and reduce labor intensity.
- Field trials and pilot-scale validation: Implement the optimized mix design in actual industrial environments to evaluate practical performance, installation behavior, and maintenance requirements.
- Standard development: Contribute to the establishment of regulatory standards and testing protocols specific to textile-reinforced earthen composites to ensure consistent quality and support industry acceptance.
- Life cycle assessment (LCA): Conduct environmental and economic impact studies to quantify sustainability benefits compared to traditional concrete-based flooring systems.

REFERENCES

Amin, M. N., Khan, M. S., & Mahmud, H. M. I. (2021). Application of textile waste in concrete: A sustainable approach. *Materials Today: Proceedings*, 47, 5010–5015. https://doi.org/10.1016/j.matpr.2021.06.071

Millogo, Y., Hajjaji, M., & Ouedraogo, R. (2008). Microstructure and physical properties of lime-clay bricks from Burkina Faso. *Construction and Building Materials*, 22(3), 2386–2392. https://doi.org/10.1016/j.conbuildmat.2007.09.002

Ngowi, A. B. (1997). Improving the traditional earth construction: A case study of Botswana. *Construction and Building Materials*, 11(1), 1–7. https://doi.org/10.1016/S0950-0618(96)00027-5

Oti, J. E., Kinuthia, J. M., & Bai, J. (2009). Engineering properties of unfired clay masonry bricks. *Engineering Geology*, 107(3–4), 130–139. https://doi.org/10.1016/j.enggeo.2009.05.002

Walker, P., & Stace, T. (1997). Properties of some cement stabilised compressed earth blocks and mortars. *Materials and Structures*, 30(1), 545–551. https://doi.org/10.1007/BF02486383

Amin, M. N., Khan, M. S., & Mahmud, H. M. I. (2021). Application of textile waste in concrete: A sustainable approach. *Materials Today: Proceedings*, *47*, 5010–5015. https://doi.org/10.1016/j.matpr.2021.06.071

Asteris, P. G., Kolovos, K. G., & Douvika, M. G. (2022). Sustainable low-carbon cementitious materials: A review. *Buildings, 12*(5), 642. https://doi.org/10.3390/buildings12050642

Millogo, Y., Hajjaji, M., & Ouedraogo, R. (2008). Microstructure and physical properties of lime-clay bricks from Burkina Faso. *Construction and Building Materials, 22*(3), 2386–2392. https://doi.org/10.1016/j.conbuildmat.2007.09.002

Ngowi, A. B. (1997). Improving the traditional earth construction: A case study of Botswana. *Construction and Building Materials, 11*(1), 1–7. https://doi.org/10.1016/S0950-0618(96)00027-5

Oti, J. E., Kinuthia, J. M., & Bai, J. (2009). Engineering properties of unfired clay masonry bricks. *Engineering Geology, 107*(3–4), 130–139. https://doi.org/10.1016/j.enggeo.2009.05.002

Walker, P., & Stace, T. (1997). Properties of some cement stabilised compressed earth blocks and mortars. *Materials and Structures, 30*(1), 545–551. https://doi.org/10.1007/BF02486383

Zami, M. S., & Lee, A. (2010). Economic benefits of contemporary earth construction in low-cost urban housing – State of the art review. *Journal of Building Appraisal, 6*, 259–271. https://doi.org/10.1057/jba.2010.21

Udawattha, C., Galabada, H., & Halwatura, R. (2017). Case studies in construction materials, 7, 249–262. https://doi.org/10.1016/j.cscm.2017.06.005

Selvaraj, R., & Priyanka, R. (2015). Experimental study on strength of concrete by partial replacement of cement with sugarcane bagasse ash. *International Journal of Engineering Research, 4*, 891–895.

Juradin, S., Mihanović, F., Ostojić-Škomrlj, N., & Rogošić, E. (2022). Pervious concrete reinforced with waste cloth strips. *Sustainability, 14*(5), 2723. https://doi.org/10.3390/su14052723

Zhou, Z., Zhao, B., Lone, U. A., & Fan, Y. (2024). Experimental study on mechanical properties of shredded prepreg carbon cloth waste fiber reinforced concrete. *Journal of Cleaner Production, 436*, 140456. https://doi.org/10.1016/j.jclepro.2024.140456

Mallik, P., & Panda, S. K. (n.d.). Research on concrete use of recycled waste cloth. *[Unpublished manuscript or conference proceeding]*

Baskar, R., Begum, K., & Sundaram, S. (2006). Characterization and reuse of textile effluent treatment plant waste sludge in clay bricks. *Journal of the University of Chemical Technology and Metallurgy, 41*(4), 473–478.

Hossain, S., Dipta, I. A., Alam, M. A., & Habib, A. (2022). Recycled waste textiles as reinforcement in cement block. In *6th International Conference on Advances in Civil Engineering (ICACE-2022)* (pp. 524–531).

Palanisamy, V. (2011). Utilization of textile effluent waste sludge in brick production. *International Journal of Science and Basic Applied Research, 4*(1), 1–10.

Anglade, J., Benavente, E., Rodríguez, J., & Hinostroza, A. (2021). Use of textile waste as an addition in the elaboration of an ecological concrete block. *IOP Conference Series: Materials Science and Engineering, 1054*(1), 012005. https://doi.org/10.1088/1757-899X/1054/1/012005

Beg, T., Siddiqui, M. O. R., Butto, M. A., Iqbal, K., & Sun, D. (2022). Utilization of textile denim sludge waste in high load-bearing structural applications. *Polimery, 67*(7–8), 298–307. https://doi.org/10.14314/polimery.2022.7.2

Ispal, N. A., & Matlan, S. J. (2020). Development of paver block containing recycled plastic. *[Conference or Journal – please specify source if known]*

Pham, T. A., Kyokawa, H., Koseki, J., & Dias, D. (2022). A new index for the strength analysis and prediction of cement-mixed soils. *[Journal or conference name if known]*

DaSilva, F. M., Gachet Barbosa, L. A., Lintz, R. C. C., & Jacintho, A. E. P. G. A. (2015). Investigation on the properties of concrete tactile paving blocks made with recycled tire rubber. *Construction and Building Materials, 91*, 71–79. https://doi.org/10.1016/j.conbuildmat.2015.04.015

Muthukumar, M., & Mohan, D. (2004). Optimization of mechanical properties of polymer concrete and mix design recommendation based on design of experiments. *Journal of Applied Polymer Science, 94*, 1107–1116. https://doi.org/10.1002/app.21000

Unknown Author. (n.d.). *Soils of Sri Lanka* [PowerPoint slides]. SlideShare. https://www.slideshare.net/slideshow/soils-of-sri-lanka/219070496

Pico Cleaners. (2023, November 1). *The 12 different types of fabric*. https://picocleaners.com/the-12-different-types-of-fabric/

Sewport Support Team. (2025, March 9). *What is polyester fabric: Properties, how it's made and where*. Sewport. https://sewport.com/fabrics-directory/polyester-fabric

ScienceDirect. (n.d.). *Cotton fabric*. In *Materials science*. Retrieved March 9, 2025, from https://www.sciencedirect.com/topics/materials-science/cotton-fabric

Textile Today Sri Lanka. (2023, July 15). *Overview of textile types used in Sri Lanka*. Textile Today. https://www.textiletoday.lk/overview-of-textile-types-in-sri-lanka

Unknown Author. (n.d.). *Industrial flooring* [PowerPoint slides]. SlideShare. https://www.slideshare.net/slideshow/industrial-flooring-23870062/23870062

ACI Committee 330. (2008). *Guide for the Design and Construction of Concrete Parking Lots*. American Concrete Institute.

Amin, M. N., Khan, K., & Javed, M. F. (2021). Utilization of textile waste fibers in cement-based composites: A sustainable approach. *Journal of Cleaner Production*, 295, 126380.

Banthia, N., & Sappakittipakorn, M. (2007). Toughness enhancement in steel fiber reinforced concrete through fiber hybridization. *Cement and Concrete Research*, 37(9), 1366–1372.

Bentur, A., & Mindess, S. (2006). *Fibre Reinforced Cementitious Composites* (2nd ed.). CRC Press.

Li, V. C., & Stang, H. (1997). Interface property characterization and strengthening mechanisms in fiber reinforced cement-based composites. *Advanced Cement Based Materials*, 6(1), 1–20.

Li, Y., Chen, B., & Wu, K. (2015). Bond behavior of textile-reinforced cementitious composites with different types of textile. *Cement and Concrete Composites*, 56, 1–11.

Mindess, S., Young, J. F., & Darwin, D. (2003). *Concrete* (2nd ed.). Pearson Education.

Neville, A. M. (2011). *Properties of Concrete* (5th ed.). Pearson Education Limited.

Pacheco-Torgal, F., & Jalali, S. (2011). Cementitious building materials reinforced with natural fibers: A review. *Construction and Building Materials*, 25(2), 575–581.

Scrivener, K. L., John, V. M., & Gartner, E. M. (2018). Eco-efficient cements: Potential, economically viable solutions for a low-CO_2 cement-based materials industry. *Cement and Concrete Research*, 114, 2–26.

UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. United Nations.

Zollo, R. F. (1997). Fiber-reinforced concrete: An overview after 30 years of development. *Cement and Concrete Composites*, 19(2), 107–122.

Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw-Hill Education.

Neville, A. M. (2011). *Properties of concrete* (5th ed.). Pearson Education Limited.

ASTM International. (2020). *Standard specification for Portland cement* (ASTM C150/C150M-20). https://www.astm.org/c150

Bureau of Indian Standards. (2015). *Ordinary Portland Cement – Specification* (IS 269:2015). New Delhi: BIS.