

# Plastic Fibre Reinforced Soil Blocks as a Sustainable Building Material

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## ABSTRACT

Solid waste management, especially the huge quantity of waste plastics, is one of the major environmental concerns nowadays. Their employability in block making in the form of fibres, as one of the methods of waste management, can be investigated through a fundamental research. This paper highlights the salient observations from a systematic investigation on the effect of embedded fibre from plastic waste on the performance of stabilised mud blocks. Stabilisation of the soil was done by adding cement, lime and their combination. Plastic fibre in chopped form from carry bags and mineral water bottles were added (0.1% & 0.2% by weight of soil) as reinforcement. The blocks were tested for density, and compressive strength, and observed failure patterns were analysed. Blocks with 0.1% of plastic fibres showed an increase in strength of about 3 to 10%. From the observations of failure pattern it can be concluded that benefits of fibre reinforcement includes both improved ductility in comparison with raw blocks and inhibition of crack propagation after its initial formation.

**Keywords :** Sustainable building materials, plastic fibres, stabilized blocks, density, compressive strength

## 1 INTRODUCTION

Earth as mud bricks has been used in the construction of shelters for thousands of years. Approximately 30% of the world's population still lives in earthen structures [1]. Compressed soil masonry blocks formed using moist soil compacted mechanically to improve physical characteristics have aimed popularity recently. Benefits of earth in this manner include improved strength and durability as compared to adobe while maintaining significantly low embodied energy levels than alternative materials. However problems arise from the materials low tensile strength, brittle behaviour and deterioration in the presence of water [2]. Stabilisation by a hydraulic binder such as cement or lime or a combination of the two can significantly improve water resistance and strength to some extent [3], [4], [5], [6]. Also natural fibres have been used in adobe and other traditional forms of earthen construction for many thousands of years to reduce shrinkage cracking, to improve tensile strength, durability and ductility in tension [1], [2], [7], [8], [9], [10], [11], [12], [13]. Apart from that baking of composite bricks with natural fibres and grain leaves a porous structure which consequently enhances thermal and acoustical insulation of the finished products [10], [12]. Theoretical models were also developed on composite soil blocks reinforced with fibres subjected to shear [8]. In almost all of the above studies the fibres used are sisal fibres, coconut fibres, vegetable fibres, straw, palm fibre.

Solid waste management, especially the huge quantity of waste plastics, is one of the major environmental concerns nowadays. Their employability in block making in the form of fibres (plastic fibre- mud blocks), as one of the methods of waste management, can be investigated through a fundamental research. Also, as mentioned above, the review of the existing literature shows that most studies on natural fibres are focussed on cellulose based/ vegetable fibres obtained from renewable plant resources except in one case - animal fibre [13], and in another case - plastic fibre and polystyrene fabric

[9].

In this context, for the plastic fibre-mud blocks to be more widely applicable a systematic quantification of the relevant physical and mechanical properties is crucial; to enable an objective evaluation of the composite material's response to actual field condition. This paper highlights the salient observations from the preliminary investigation of a systematic study on the effect of embedded fibre made of plastic waste on the performance of stabilised mud blocks.

## 2 MATERIALS AND METHODS

For the soil collected for block making, standard soil classification tests were carried out and a summary of the test results are as follows: (i) Sand = 52.0%; (ii) Silt = 43.5%; (iii) Clay = 4.5%; (iv) Specific gravity = 2.68; (v) OMC = 18%; (vi) Dry density = 1.84 g/cc. The grain size distribution of the soil sample is shown in Fig. 1. Stabilisation of the soil was done by adding cement, lime and their combination. The quantity of cement and lime added was 8% & 10%, and 2% & 4% by weight of soil respectively after many trials. Similar observations regarding the quantity of stabilisers (7.5% of cement and 2% lime) were made by Jagadeesh, 2007 [6]. It actually depends on the type of soil [14]. Combinations of these stabilisers were also tried. Plastic fibre of length 20 mm, chopped form carry bags (aspect ratio = 125) and mineral water bottles (aspect ratio = 84) were also added (0.1% & 0.2% by weight of soil) during block making (Fig. 2). The mixture composition is shown in Table 1. Blocks of size 305mm x 143mm x 100mm were made by pressing the prepared soil at OMC using ASTRA block making machine developed in IISc, Bangalore (Fig. 3). The blocks were cured by gently sprinkling water on straw and gunny bag which are used to cover the stack of blocks for curing. The blocks were tested for compressive strength after 3, 7, and 28

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## **Plastic Fibre Reinforced Soil Blocks As A Sustainable:**

**Eco-Architecture VIII** S. Hernández,P. Chias,2020-11-18 New opportunities for solving the challenges of contemporary architecture occur as a result of advances in the design and new building technologies as well as the development of new materials Many of the changes are motivated by a drive towards eco architecture trying to harmonise architectural products with nature Another important issue is the adaptation of the architectural design to the natural environment learning from nature and traditional construction techniques Contemporary architecture is at the threshold of a new stage of evolution deeply influenced by the advances in information and computer systems and the development of new materials and products as well as construction processes that will drastically change the industry Never before in history have architects and engineers had such a range of new processes and products open to them In spite of that the construction industry lags behind all others in taking advantage of a wide variety of new technologies This is understandable due to the inherent complexity and uniqueness of each architectural project Advances in computer and information systems including robotics offers the possibility of developing new architectural forms construction products and building technologies which are just now starting to emerge Changes have also taken place in the way modern society works and lives due to the impact of modern technologies Patterns of work have been disrupted and changed affecting transportation and the home environment The demand is for a new type of habitat that can respond to the changes and the consequent requirements in terms of the urban environment This volume originates from the 8th International Conference on Harmonisation between Architecture and Nature and deals with topics such as building technologies design by passive systems design with nature cultural sensitivity life cycle assessment resources and rehabilitation and many others including case studies from around the world

**Marine Plastics: Innovative Solutions to Tackling Waste** Siv Marina Flø Grimstad,Lisbeth Mølgaard Ottosen,Neil A. James,2023-07-31 This open access book reflects aims of the Blue Circular Economy BCE project which focused on small and medium sized enterprises SMEs aiming to create value using circular economy concepts related to products and services within fishing gear recycling in the Northern Periphery and Arctic NPA area Cluster establishment and operation were carried out in collaboration with academia industry and government agencies following a triple helix approach Discarded fishing gear constitutes a large part of marine plastics Preventing future discharge of fishing gear into the ocean is a vital step in combating plastic pollution Circular economy is one of the tools in the European Green deal targeting waste minimisation Closing the loop for waste fishing nets by transferring them to a resource could be a solution for preventing discharge at sea exploring this opportunity is at the core of this book

**Smart Geotechnics for Smart Societies** Askar Zhussupbekov,Assel Sarsembayeva,Victor N. Kaliakin,2023-08-04 Smart Geotechnics for Smart Societies contains the contributions presented at the 17th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering 17th ARC Astana Kazakhstan 14 18 August 2023 The topics covered include Geomaterials for soil improvement Tunneling and rock

engineering Slope embankments and dams Shallow and deep foundations Soil dynamics and geotechnical earthquake engineering Geoenvironmental engineering and frost geotechnics Investigation of foundations of historical structures and monitoring Offshore harbor geotechnics and GeoEnergy Megaprojects and transportation geotechnics Smart Geotechnics for Smart Societies will be of interest to academics and engineers interested or involved in geotechnical engineering

*Proceedings of International Conference on Innovative Technologies for Clean and Sustainable Development (ICITCSD - 2021)* Varinder S. Kanwar, Sanjay K. Sharma, C. Prakasam, 2022-04-28 This volume presents select proceedings of the International Conference on Innovative Technologies for Clean and Sustainable Development ICITCSD 2021 held at the National Institute of Technical Teachers Training Research and Chitkara University Himachal Pradesh India It covers several important aspects of sustainable civil engineering practices dealing with effective waste and material management natural resources industrial products energy food transportation and shelter environmental impact mitigation waste minimization and management sustainable infrastructure and geospatial technology for sustainable and clean environment Emphasis is placed on conserving and protecting the environment and the natural resource base essential for future development The book includes case studies and ongoing research work from various fields related to civil engineering presented by academicians scientists and researchers The book also discusses engineering solutions to sustainable development and green design issues Special emphasis is given on qualitative guidelines for the generation treatment handling transport disposal and recycling of wastes The book is intended as a practice oriented reference guide for researchers and practitioners It will be useful for anyone working in sustainable civil engineering and related fields SDGs in Africa and the Middle East

Region Ismaila Rimi Abubakar, Izael da Silva, Rudi Pretorius, Khaled Tarabieh, 2024-09-01 Africa is one of the most vulnerable regions and one where the implementation of the SDGs is particularly urgent Underinvestments in natural conservation are increasing the vulnerability of people across many African countries whose well being is endangered by deteriorating socio economic and environmental conditions This volume provides a contribution towards showcasing how natural resources may be more efficiently used and investments may be mobilised to augment the limited public sector funds available to achieve the SDGs This book is part of the 100 papers to accelerate the implementation of the UN Sustainable Development Goals initiative *Handbook of Sustainable Materials: Modelling, Characterization, and Optimization* Ajay, Parveen, Sharif

Ahmad, Jyotsna Sharma, Victor Gambhir, 2023-03-31 Handbook of Sustainable Materials presents recent developments in sustainable materials and how these materials interact with the environment It highlights the recent advancements involved in proper utilization of sustainable materials including chemical and biological approaches With chapters written by global experts the book offers a guide and insights into sustainable materials from a variety of engineering disciplines Each chapter provides in depth technical information on the sustainable materials theory and explores synthesis strategies green materials and artificial intelligence The book considers applications in sectors such as aerospace automobile and biomedical for rapid

prototyping and customized production without negative environmental impacts It features research outcomes and case studies of optimization and modeling techniques in practice Features Presents recent developments in sustainable materials from various engineering fields and industry applications Emphasizes analytical strategies computational and simulation approaches develop innovative sustainable materials Discusses an artificial intelligence approach rapid prototyping and customized production This book is designed for researchers and professionals working with sustainable materials clean manufacturing and environmental impacts      **Recent Advances on Green Concrete for Structural Purposes** Joaquim A.O. Barros,Liberato Ferrara,Enzo Martinelli,2017-05-29 This book is mainly based on the results of the EU funded UE FP7 Project EnCoRe which aimed to characterize the key physical and mechanical properties of a novel class of advanced cement based materials incorporating recycled powders and aggregates and or natural ingredients in order to allow partial or even total replacement of conventional constituents More specifically the project objectives were to predict the physical and mechanical performance of concrete with recycled aggregates to understand the potential contribution of recycled fibers as a dispersed reinforcement in concrete matrices and to demonstrate the feasibility and possible applications of natural fibers as a reinforcement in cementitious composites All of these aspects are fully covered in the book The opening chapters explain the material concept and design and discuss the experimental characterization of the physical chemical and mechanical properties of the recycled raw constituents as well as of the cementitious composite incorporating them The numerical models with potentialities for describing the behavior at material and structural level of constructions systems made by these composites are presented Finally engineering applications and guidelines for production and design are proposed

**Bioenergy from Dendromass for the Sustainable Development of Rural Areas** David Butler Manning,Albrecht Bemann,Michael Bredemeier,Norbert Lamersdorf,Christian Ammer,2015-08-17 Based on the results of two bioenergy research initiatives in Germany this reference examines the sustainable management of wood biomass in rural areas The large number of participating organizations and research institutes ensures a balanced and unbiased view on the potentials and risks is presented taking into account economic ecological and social aspects Most of the results reported are available here for the first time in English and have been collated in central Europe but are equally applicable to other temperate regions They highlight best practices for enhancing dendromass potential and productivity while discussing the implications on rural economies and ecosystems      **Green Building Materials** Gonzalo Martínez-Barrera,Stanislav

Kolisnychenko,2022-09-09 Aggregated Book      *Natural Fiber Composites* Mohamed Zakriya G,Ramakrishnan Govindan,2020-09-28 This book covers the use of accessible natural fibers towards the requirement and compatibility of industrial sustainability Using natural characteristics of composites through technology and techniques the inherent qualities of natural fibers are discussed in relation to the design of experiments This book also elaborates on the durability of composites subjected to environmental conditions biodegradability environmental issues product life cycle assessment and

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**Biocomposites - Bio-based Fibers and Polymers from Renewable Resources** R. Arun Ramnath, Sanjay M. R, Sergey M. Gorbatyuk, Steffen Fischer, Suchart Siengchin, 2023-11-30 Biocomposites Bio based Fibres and Polymers from Renewable Resources Processing Performance Durability and Applications provides a systematic and comprehensive review of recent developments in this important area of research Chapters discuss novel techniques for processing and the characterization of biocomposites derived from renewable resources focusing on durability strength prediction aging methods and performance evaluation Future trends directions and opportunities are also addressed Readers will find an up to date summary of recent research findings that have been conducted on biocomposites making this an essential reference resource for academic and industrial researchers and anyone working in the development of innovative materials from renewable resources Provides wide coverage of processing methods mechanical performance and industrial applications Emphasizes durability assessment of natural fiber composites in different environments Natural Fiber-Reinforced Composites Senthilkumar

Krishnasamy, Senthil Muthu Kumar Thiagamani, Chandrasekar Muthukumar, Rajini Nagarajan, Suchart Siengchin, 2022-04-18 Natural Fiber Reinforced Composites In depth overview of thermal analysis of natural fiber reinforced composites In Natural Fiber Reinforced Composites Thermal Properties and Applications a team of distinguished researchers has delivered a comprehensive overview of the thermal properties of natural fiber reinforced polymer composites The book brings together information currently dispersed throughout the scientific literature and offers viable and environmentally friendly alternatives to conventional composites The book highlights the thermal analysis of natural fiber reinforced composites with techniques such as Thermogravimetric Analysis Dynamic Mechanical Analysis Thermomechanical Analysis Differential Scanning Calorimetry etc This book provides A thorough review of the thermal characterization of natural fiber based hybrid composites Detailed investigation of the thermal properties of polymer composites reinforced with various natural fibers such as flax fiber pineapple leaf fiber sisal sugar palm grass fiber and cane fiber Discussions on the thermal properties of hybrid natural fiber reinforced composites with various thermosetting and thermoplastic polymers Influence of nanofillers on the thermal stability and thermal decomposition characteristics of the natural fiber based hybrid composites Natural Fiber Reinforced Composites Thermal Properties and Applications is a must read for materials scientists polymer chemists and professionals working in the industry This book is ideal for readers seeking to make an informed decision regarding materials selection for applications involving thermal insulation and elevated temperature The suitability of natural fiber reinforced composites in the automotive mechanical and civil engineering sectors is highlighted *Testing and Characterisation of*

*Earth-based Building Materials and Elements* Antonin Fabbri, Jean-Claude Morel, Jean-Emmanuel Aubert, Quoc-Bao Bui, Domenico Gallipoli, B.V. Venkatarama Reddy, 2021-11-26 This book presents the work done by the RILEM Technical Committee 274 TCE. It focuses on the estimation of the parameters which are necessary to properly design earthen constructions. It provides a compilation of the value classically obtained for the key parameters of earthen materials, a pedagogical presentation of the main testing procedures for earthen materials, their advantage and their drawback, and an overview of most standards on earthen materials whatever their origin and their language. The book is divided into eight chapters. After a general introduction on earthen materials and constructions, the state of the art on the material characterisation techniques, the assessment of hygrothermal performance, the mechanical behaviour, seismic resistance, and the durability will be presented each in a dedicated chapter. On the basis of these last chapters, a critical review of the standards which are used for earthen material will be presented in the last chapter. The last chapter is dedicated to the analysis of the environmental potential of earth-based building materials.

*Integrated Waste Management* Akanksha Gupta, Ravinder Kumar, Vinod Kumar, 2024-04-14 This book explores a diverse spectrum of waste materials encompassing industrial, hazardous, and non-hazardous waste, agricultural waste, biomass waste, radioactive waste, municipal solid and liquid waste, as well as e-waste, and investigates their adverse impacts on the environment. It is an exciting exploration of various approaches to waste management, highlighting the importance of adopting sustainable practices such as the 7Rs principle, utilization of nanomaterials, and photocatalysis. It also covers zero waste management techniques, recycling, and upcycling techniques, and IoT-enabled strategies. It provides a critical assessment of the challenges and opportunities in transforming waste into value-added products for the industry. This book is designed to provide constructive insights for researchers, environmentalists, policy makers, and professionals engaged in enhancing waste management, fuelling the circular economy, and paving the way for a sustainable future.

**Encyclopedia of Renewable and Sustainable Materials**, 2020-01-09 Encyclopedia of Renewable and Sustainable Materials Five Volume Set provides a comprehensive overview covering research and development on all aspects of renewable, recyclable, and sustainable materials. The use of renewable and sustainable materials in building construction, the automotive sector, energy, textiles, and others can create markets for agricultural products and additional revenue streams for farmers, as well as significantly reduce carbon dioxide (CO<sub>2</sub>) emissions, manufacturing energy requirements, manufacturing costs, and waste. This book provides researchers, students, and professionals in materials science and engineering with tactics and information as they face increasingly complex challenges around the development, selection, and use of construction and manufacturing materials. Covers a broad range of topics not available elsewhere in one resource. Arranged thematically for ease of navigation. Discusses key features on processing, use, application, and the environmental benefits of renewable and sustainable materials. Contains a special focus on sustainability that will lead to the reduction of carbon emissions and enhance protection of the natural environment with regard to sustainable materials.

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