

Green Infrastructure

Materials and Applications

Editors: Rohana Hassan, Nor Hayati Abdul Hamid, Ahmad Kamil Arshad, Anizahyati Alisibramulisi, Muhd Norhasri Muhd Sidek, Norshariza Mohamad Bhkari, Ekarizan Shaffie

Rohana Hassan · Nor Hayati Abdul Hamid ·
Ahmad Kamil Arshad · Anizahyati Alisibramulisi ·
Muhd Norhasri Muhd Sidek ·
Norshariza Mohamad Bhkari · Ekarizan Shaffie
Editors

Green Infrastructure

Materials and Applications

Editors

Rohana Hassan
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Nor Hayati Abdul Hamid
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Ahmad Kamil Arshad
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Anizahyati Alisibramulisi
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Muhd Norhasri Muhd Sidek
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Norshariza Mohamad Bhkari
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

Ekarizan Shaffie
IIESM
Universiti Teknologi MARA
Shah Alam, Selangor, Malaysia

ISBN 978-981-16-6382-6

ISBN 978-981-16-6383-3 (eBook)

<https://doi.org/10.1007/978-981-16-6383-3>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

This book highlights green infrastructure materials and their applications along with their limitations in contributing towards green industries. It starts by discussing modifications in concrete design by adding recycled polyethylene terephthalate bottles as partial replacement of aggregates, mortar, ordinary Portland cement, alternative binder for paving blocks and others. This mixed concrete can be used as sustainable wall panels and concrete blocks. These types of sustainable wall panels can be used to construct green buildings and to save the environment through reduction of waste plastic bottles at landfills.

The initial chapters discuss the repair and retrofitting of concrete structure by using palm oil fly ash (POFA) which is the byproduct of palm oil industries as alkaline and physical activated POFA cement paste. A review of concrete performance on tin slag polymer concrete as green structural material for sustainable future and its study on the effect of waste paper sludge ash (WPSA) in addition to fresh and hardened ultra-high-performance concrete are explained and elaborated.

Chapters “[Flexural Performance of Strengthened Glued Laminated \(GLULAM\) Timber Beam Using Glass Fibre-Reinforced Polymer \(GFRP\)](#)”–“[Analysis of the Flexural Strength of Reinforced Beam with Bamboo by Empirical Modeling Using Statistical Model](#)” present the physical and mechanical properties of timber as one of the green material that contributes to green infrastructure construction and sustainability. The experimental results on flexural performance of strengthened glued laminated (glulam) timber beam using glass fibre reinforced polymer (GFRP); overview on bending and rolling shear properties of cross laminated timber (CLT), together with delamination test for Mengkulang timber species using method A and C are presented. Further analysis on flexural strength of reinforced beam with bamboo by empirical modelling using statistical model is also presented in the book.

The two following chapters in this book discuss road pavement materials and their testing and evaluation. It includes innovative new and waste materials which can be recycled to prolong the life span of road pavements. In order for the pavement to withstand the ever-increasing loadings from vehicles in terms of intensity and axle applications, pavement materials must have adequate strength to withstand these loads and must also be durable to withstand the effects of environment, namely

moisture and temperature. Chapter “[Application of Pavement Evaluation for Road Maintenance and Rehabilitation](#)” describes the process of pavement evaluation and the application of its results for use in the maintenance and rehabilitation of roads. Meanwhile, chapter “[Performance Evaluation of Stone Mastic Asphalt Containing Steel Fibre as Additive](#)” presents the findings of a study on addition of steel fibre in stone mastic asphalt (SMA) application. SMA is a gap-graded asphalt mixture that consists of a large proportion of coarse aggregate, a high percentage of asphalt binder and a substantial amount of filler which provides a durable surface course.

Chapters “[Post-construction Complexity Factors Impacting Infrastructure Project Performance in Malaysia](#)”–“[Governance Practices in Poverty Alleviation Projects: Case Study from Stewardship-Driven Perspective and Sustainability Context](#)” present the post-construction complexity factors that impact the infrastructure project performance in Malaysia, followed by the SWOT analysis of green technology application for the development of low carbon cities and a sharing of a case study from stewardship-driven perspective and sustainability context through governance practices in poverty alleviation projects.

Discussion on interception loss of tree canopy as green infrastructure and an evaluation of parameters for sustainability assessment of green infrastructure in the urban water system are presented in chapters “[Interception Loss of Tree Canopy as Green Infrastructure](#)” and “[Evaluation of Parameters for Sustainability Assessment of Green Infrastructure in the Urban Water System](#)”, respectively. This contemporary book also covers a green community-based social enterprise (CBSE) for B40 in Sabah, through a sharing of freshwater lobster production-green Aquaponics Perennial System (flp-gaps) in chapter “[Freshwater Lobster Production-Green Aquaponics Perennial System \(FLP-GAPS\): A Green Community-Based Social Enterprise \(CBSE\) for B40 in Sabah](#)”. Last but not least, chapter “[An Edible Cutleries Using Green Materials: Sorghum Flour](#)” presents the use of sorghum flour as one of the green materials in a form of edible cutleries performance.

This comprehensive book entitled “Green Infrastructure Materials and Applications” is suitable for engineering students to develop competency in theory, practical and communication skills. It presents a framework for engineers to add on different materials into practice. The chapters in the book also present the link between materials and the application processes. The various engineering materials presented in this book will inspire and stimulate discussions in academia and industry to develop and promote green infrastructure materials and their applications for the future.

Shah Alam, Malaysia

Rohana Hassan
Nor Hayati Abdul Hamid
Ahmad Kamil Arshad
Anizahyati Alisibramulisi
Muhd Norhasri Muhd Sidek
Norshariza Mohamad Bhkari
Ekarizan Shaffie

Contents

Recycled Plastic Bottles as Sustainable Materials	1
N. H. Hamid and M. M. H. Shamsudin	
Performance of Alkaline-Activated Cement Paste Toward Repairing and Rehabilitation on Concrete Structure	21
N. I. Halim, A. Newman, M. S. Muhd Norhasri, H. M. Saman, and N. H. Suliman	
Physical Properties of Activated Pofa Cement Paste for Repair and Retrofitting Purposes	33
A. Newman, N. I. Halim, M. S. Muhd Norhasri, H. M. Saman, and A. Alisibramulisi	
A Review on Tin Slag Polymer Concrete as Green Structural Material for Sustainable Future	43
M. S. Manda, M. R. M. Rejab, Shukur Abu Hassan, and Ma Quanjin	
The Effect of Waste Paper Sludge Ash Addition to the Fresh and Hardened Properties of Ultra-High-Performance Concrete	59
Muhamad N. A. Kamaruddin, Adiza Jamadin, Sakhiah Abdul Kudus, and Nur Kamaliah Mustaffa	
Flexural Performance of Strengthened Glued Laminated (GLULAM) Timber Beam Using Glass Fibre-Reinforced Polymer (GFRP)	75
A. O. A. Zamli, R. Hassan, M. N. M. Sidek, A. Awaludin, B. Anshari, N. H. A. Hamid, and S. M. Sapuan	
Overview on Bending and Rolling Shear Properties of Cross-Laminated Timber (CLT) as Engineered Sustainable Construction Materials	93
W. C. Lum, M. B. Norshariza, M. S. Nordin, and Z. Ahmad	

Delamination Test for Mengkulang Timber Species Using Methods A and C 113
 N. J. Abd Malek, R. Hassan, A. Alisibramulisi,
 S. M. Abdullah Alesaei, and S. M. Sapuan

Analysis of the Flexural Strength of Reinforced Beam with Bamboo by Empirical Modeling Using Statistical Model 131
 W. A. Y. Banafea and T. A. R. Hussin

Application of Pavement Evaluation for Road Maintenance and Rehabilitation 159
 Ahmad Kamil Arshad, Ekarizan Shaffie, Mohd Izzat A. Kamal,
 Mat Zin Hussain, and Nuryantizpura M. Rais

Performance Evaluation of Stone Mastic Asphalt Containing Steel Fibre as Additive 179
 Ekarizan Shaffie, Hanis Eizzati Ahmad, Ahmad Kamil Arshad,
 Wardati Hashim, Haryati Yaacob, and Fionna Shiong

Post-construction Complexity Factors Impacting Infrastructure Project Performance in Malaysia 197
 Akhtarul Norfaiza Che Nen, Che Maznah Mat Isa,
 and Che Khairil Izam Bin Che Ibrahim

SWOT Analysis of Green Technology Application for the Development of Low Carbon Cities 211
 Nur Kamaliah Mustaffa, Sakhiah Abdul Kudus,
 Muhamad Fuad Shukor, Ridza’uddin Mohd Radzi,
 and Verona Ramas Anak Joseph

Governance Practices in Poverty Alleviation Projects: Case Study from Stewardship-Driven Perspective and Sustainability Context 227
 Abdul Muhaimin Abdul Latiff, Che Maznah Mat Isa, and Aini Jaapar


Interception Loss of Tree Canopy as Green Infrastructure 245
 A. B. Azinoor Azida

Evaluation of Parameters for Sustainability Assessment of Green Infrastructure in the Urban Water System 263
 A. H. Jemat and N. A. Kamal

Freshwater Lobster Production-Green Aquaponics Perennial System (FLP-GAPS): A Green Community-Based Social Enterprise (CBSE) for B40 in Sabah 285
 Rozita [a] Uji Mohammed, Cyril Supain [a] Christopher,
 Hendry Joseph, and Surail Abdul Kahar [a] Eting

An Edible Cutleries Using Green Materials: Sorghum Flour 305
 Mohd Hafizalrisman Kabir, Nuramidah Hamidon, Mariah Awang,
 Mohammad Ashraf Abdul Rahman, and Suraya Hani Adnan

A Review on Tin Slag Polymer Concrete as Green Structural Material for Sustainable Future

M. S. Manda, M. R. M. Rejab , Shukur Abu Hassan & Ma Quanjin

Chapter | [First Online: 06 December 2021](#)

141 Accesses

Abstract

Ordinary Portland cement concrete (OPC) is widely utilized in construction industry as structural material, but it has environmental issue due to natural resources consumption and Carbon emission. Therefore, polymer concrete (PC) with tin slag (TS) waste are introduced to replace aggregate and cement in OPC. Previous research on potential to apply TSPC as structural material has provided compressive strength data which shows that it can compete with OPC. PC using polyester and 100% TS aggregate with resin-aggregate ratio 30:70 consist of fine (<1 mm) uniformly graded aggregate has achieved compressive strength 58.21 MPa. After that, in another study, gap graded performance of TSPC using raw (4 mm) and coarse (2 mm) TS aggregate introduced and result in compressive strength 37.71 MPa, highest compared to other variation. By applying external FRP strengthening with two layers of CFRP increase strength to 125.07 MPa and finally uniformly graded TSPC with three layers of CFRP wrapping increased strength to 156.88 MPa. This discovery has contributed to the beginning of active study in TSPC as green structural material for sustainable future.

Keywords

Green

Structural Material

Polymer Concrete

Tin Slag

Compressive Strength

FRP Confinement

TSPC

Sustainable

References

Asif A, Ansari A (2013) Polymer concrete as innovative material for development of sustainable architecture. In: 2nd international conference on emerging trends in engineering & technology

[Google Scholar](#)

Barrera GM, Santiago EV, Lahri A, Dixit D (2015) Alternatives to cement in concrete—a review. *Int J Sci Eng Res* 6(10):50. ISSN 2229-5518

[Google Scholar](#)

Bedi R, Chandra R, Singh SP (2014) Reviewing some properties of polymer concrete. *Indian Concrete J* 88(8):47–68

[Google Scholar](#)

Brito JD, Ferreira JDS, Pacheco J, Soares D, Guerreiro M (2016) Structural, material, mechanical and durability properties and behaviour of recycled aggregates concrete. *J Build Eng* 6:1–16

[CrossRef](#) [Google Scholar](#)

Chellapandian M, Prakash SS, Rajagopal A (2017) Analytical and finite element studies on hybrid FRP strengthened RC column elements under axial and eccentric compression. *Compos Struct* 184:234–248

[CrossRef](#) [Google Scholar](#)

Cheng JF, Peng SC, Deng J, Chen GM, Tao Y (2014) A technique for reducing strain concentrations in FRP wrapped concrete columns. In: *Proceedings of the 7th International conference on FRP composites in civil engineering (CICE 2014)*

[Google Scholar](#)

Dikeou JT, Kukacka LE, Backstrom JE, Steinberg M (1969) Polymerization makes tougher concrete. *ACI J Proc* 66(10):829–839

[CAS](#) [Google Scholar](#)

Faidzal MMY, Hassan SA, Omar B, Zakaria K, Zaharuddin MFA (2018) Particle size effect on optimal mixture ratio of tin slag polymer concrete under compression. *J Built Environ Technol Eng* 5. ISSN 0128-1003

[Google Scholar](#)

Acknowledgements

This review is to explore gap and research potential in TSPC study in the aspect of external strengthening to be applied as structural material. The funding of this research comes from a collaborative research grant from University Technology Malaysia (CRG UTM—Tin Slag) under Vot. CRG: RDU192311 and also from Postgrad Research Scheme 2021(PGRS), UMP under Vot. Project PGRS210339.

Author information

Affiliations

Politeknik Sultan Haji Ahmad Shah, Kuantan, Pahang, Malaysia

M. S. Manda

Structural Performance Material Engineering (SUPREME), Faculty of Mechanical & Automotive Engineering Technology, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia

M. S. Manda, M. R. M. Rejab & Ma Quanjin

Centre for Composites, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia

Shukur Abu Hassan

School of Mechanical Engineering, Ningxia University, Ningxia, China

M. R. M. Rejab

Corresponding author

Correspondence to [M. R. M. Rejab](#).