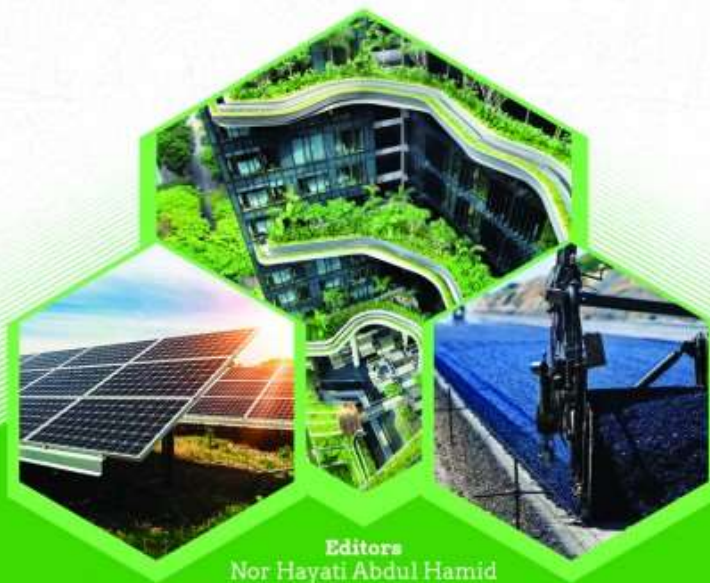


# GREEN

## Infrastructure

Material and Techniques



**Editors**

Nor Hayati Abdul Hamid  
Ahmad Kamil Arshad  
Muhd Norhasri Muhd Sidek  
Shamilah Anudai@Anuar

# **GREEN** **Infrastructure** **Material and Techniques**

Editors

Nor Hayati Abdul Hamid  
Ahmad Kamil Arshad  
Muhd Norhasri Muhd Sidek  
Shamilah Anudai @ Anuar

Penerbit Universiti Malaysia Perlis  
Kangar • 2020

First Published 2020

© Universiti Malaysia Perlis, 2020.

All rights reserved. No part of this book may be reproduced or transmitted in any forms by any means, electronic, mechanical, or otherwise, whether now or hereafter devised, including photocopying, recording, or by any information storage and retrieval system without express written prior permission from the publishers.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

GREEN Infrastructure : Materials and Techniques / Editors: Nor Hayati Abdul Hamid, Ahmad Kamil Arshad, Muhd Norhasri Muhd Sidek, Shamilah

Anudai@ Anuar.

ISBN 978-967-0922-90-4

1. Sustainable construction.
  2. Sustainable construction--Materials.
  3. Sustainable buildings--Materials.
  4. Sustainable development-- Materials.
  5. Government publications--Malaysia.
- I. Nor Hayati Abdul Hamid. II. Ahmad Kamil Arshad.  
III. Ahmad Kamil Arshad. IV. Shamilah Anudai@ Anuar.

696

**Diterbitkan oleh:**

Penerbit UniMAP  
Universiti Malaysia Perlis  
Tingkat 10, Bangunan KWSP,  
Jalan Bukit Lagi, 01000 Kangar,  
Perlis, MALAYSIA

Tel: +6(04) 977 5159 & Fax: +6(04) 977 5135  
e-mel: penerbitan@unimap.edu.my

**Ahli Majlis Penerbitan Ilmiah Malaysia (MAPIM)**

**Atur Huruf & Reka Letak:**  
Penerbit UniMAP  
Universiti Malaysia Perlis

**Dicetak oleh:**  
Percetakan Mofad  
No 18, Taman Suria 2,  
06000 Jitra ,  
Kedah Darulman.

Muka Taip: Athealas  
Saiz Huruf: 11/30 pt

# CONTENTS

<b>LIST OF ABBREVIATIONS</b>	ix
<b>LIST OF CONTRIBUTORS</b>	xiii
<b>PREFACE</b>	xvii
<b>INTRODUCTION</b>	xxi

## **1. SURFACE TREATED RECYCLED CONCRETE AGGREGATE (RCA) AS GREEN CONSTRUCTION MATERIALS**

Aiman Alodain, Ahmad Ruslan Mohd Ridzuan, Mohd Afiq Mohd Fauzi, Nor Hayati Abdul Hamid and Mohd Shafee Harun

1.1	Introduction	1
1.2	Characteristics of RCA Concrete	5
1.3	Properties of RCA Concrete	6
1.4	High Performance RCA Concrete	22
1.5	Treatment of RCA	24
1.6	Conclusions and Recommendations	26
	References	27

## **2. USAGE OF RECYCLED CONCRETE FINES IN GREEN ENGINEERED CEMENTITIOUS COMPOSITES**

Lee Siong Wee, Ahmad Ruslan Mohd Ridzuan, Fauzilah Ismail and Oh Chai Lian

2.1	Introduction	33
2.2	Experimental Investigations	35
2.3	Test Results and Discussion	39
2.4	Conclusion	44
	References	45

### **3. COLD IN-PLACE RECYCLING FOR FLEXIBLE PAVEMENTS**

Ahmad Kamil Arshad, Ekarizan Shaffie, Fauzilah Ismail and Ramadhansyah Putra Jaya

3.1	Introduction	49
3.2	Advantages and Disadvantages of CIPR	50
3.3	Selection Criteria of Pavement Candidate	51
3.4	Cold in-Place Recycling Process	53
3.5	Mix Design	64
3.6	Construction	67
3.7	Quality Control	71
3.8	Conclusion	76
	References	76

### **4. WORKABILITY AND COMPRESSIVE STRENGTH OF PALM OIL FUEL ASH (POFA) CONCRETE**

Norisham Ibrahim, Muhd Norhasri Muhd Sidek, Nelson Padang and Genesis Kiai

4.1	Introduction	79
4.2	Literature Review	80
4.3	Research Methodology	83
4.4	Results and Discussion	86
4.5	Conclusion	92
	References	93

## **5. CHEMICAL AND PHYSICAL CHARACTERISTIC OF NANO CHARCOAL ASH FROM COCONUT SHELL IN BITUMEN AS ALTERNATIVE BINDER**

Ramadhansyah Putra Jaya, Siti Nur Amiera Jeffry, Norhidayah Abdul Hassan, Haryati Yaacob, Ekarizan Shaffie and Ahmad Kamil Arshad

5.1	Introduction	97
5.2	Materials and Method	99
5.3	X-Ray Fluorescence (XRF) Test	101
5.4	Nanoparticle Size Analysis Test	102
5.5	Dynamic Shear Rheometer (DSR)	104
5.6	Results and Analysis	105
5.7	Discussion	115
5.8	Conclusions	116
	References	117

## **6. STRUCTURES PERFORMANCES OF PRECAST COMPONENTS UNDER IN-PLANE LATERAL CYCLIC LOADING**

Nor Hayati Abdul Hamid, Shamilah Anudai@Anuar, Kay Dora Abd Ghani, Nor Mayuze Mohamad and Nurliza Jasmi

6.1	Introduction	121
6.2	Tilt-up Precast Shear-Key Wall Panels	123
6.3	Design and Construction of Double Storey House	125
6.4	Experimental Test-up and Experimental Results	126
6.5	Precast Beam-column Joints with Corbels	133
6.6	Design and Construction of Exterior Beam-Column Joints with Corbels	134
6.7	Experimental Set-Up and Visual Observations of Damages	136

6.8	Experimental Results and Discussions	139
6.9	Tunnel Form Buildings as Industrialized Building System (IBS)	142
6.10	Design and Construction of Single Unit Tunnel Form Building	143
6.11	Experimental Set-up and Experimental Results	144
6.12	Conclusions	149
	References	150

## **7. WOOD-WOOL CEMENT BOARD (WWCB) AS A SUSTAINABLE GREEN INFRASTRUCTURE MATERIALS**

Zakiah Ahmad, Lum Wei Chen, Norshariza Mohamad Bhkari, Anizahyati Alisibramulisi and Mohammad Soffi Md Noh

7.1	Introduction	155
7.2	Manufacturing and Properties of Wood-wool Cement Board	156
7.3	Failure Mechanism of Wood-wool Cement Board (WWCB)	162
7.4	Applications of Wood-wool Cement Board (WWCB) in Construction Sector	166
7.5	Challenges and Limitations	171
7.6	Conclusions	173
	References	174
	<b>INDEX</b>	<b>179</b>

# LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ARRA	Asphalt Recycling and Reclaiming Association
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
CCSA	Charcoal Coconut Shell Ash
CIPR	Cold In-Place Recycling
CMA	Coarse Mixed Aggregate
DAD	Damage Avoidance Design
DCP	Dynamic Cone Penetrometer
DSR	Dynamic Shear Rheometer
ECC	Engineered Cementitious Composites
EMV	Equivalent Mortar Volume
EVA	Ethylene Vinyl Acetate
FCA	Fine Ceramic Aggregate
FHWA	Federal Highway Administration
FWD	Falling Weight Deflectometer
GGBS	Ground Granulated Blast Furnace Ash
HCL	Hydrochloride Acid
HPC	High Performance Concrete
ITS	Indirect Tensile Test
IBS	Industrialized Building System
LDPE	Low-density Polyethylene
MCE	Maximum Considered Earthquake