

Geosynthetic for Effective Geo-Solutions in Malaysia

Editor:

CHAN CHEE MING

E-mel:

chan@uthm.edu.my

Abstract: This is a book which gathers the best practices and research endeavours from both industry and universities in Malaysia, to showcase the advances in design, construction, applications and testing of geosynthetics in the country. The 15 chapters present interesting technical innovations in the field, refinement of the understanding in geosynthetic-soil interaction and mechanisms, as well as geo-environmental troubleshooting and solutions. This inaugural Technical Compilation by MyIGS aims to serve as a useful guide and reference for practitioners, researchers and academics alike, to position the effective use of geosynthetics for the present, and into the future.

keyword: advances in design, construction, applications and testing of geosynthetics

MyIGS

International Geosynthetic Society
Malaysia Chapter

The background of the cover features a close-up, high-angle view of a black and white geosynthetic fabric with a diamond-shaped grid pattern. The fabric is laid out on a light-colored surface, and the perspective creates a sense of depth and texture. The overall design is accented with large, expressive brushstrokes in shades of teal and light blue, particularly along the top and bottom edges.

GEOSYNTHETICS

for Effective Geo-Solutions in Malaysia

A Technical Compilation

Editor
CHEE-MING CHAN



GEOSYNTHETICS

for Effective Geo-Solutions in Malaysia

A Technical Compilation

Editor
CHEE-MING CHAN


**Penerbit
UTHM**
2024

© Penerbit UTHM
First Published 2024

Copyright reserved. Reproduction of any articles, illustrations and content of this book in any form be it electronic, mechanical photocopy, recording or any other form without any prior written permission from The Publisher's Office of Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor is prohibited. Any negotiations are subjected to calculations of royalty.

Editor:
Chee-Ming Chan

Published by:
Penerbit UTHM
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja,
Batu Pahat, Johor
Tel: 07-453 8698/8529
Fax: 07-453 6145

Website: <http://penerbit.uthm.edu.my>
E-mail: editor.uthm@gmail.com
<http://e-bookstore.uthm.edu.my>

Penerbit UTHM is a member of
Majlis Penerbitan Ilmiah Malaysia
(MAPIM)



Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available
from the National Library of Malaysia

ISBN 978-629-490-008-0

TABLE OF CONTENTS

<i>Preface</i>	<i>ix</i>
CHAPTER 1 THE FUNDAMENTALS AND APPLICATIONS OF GEOSYTHETICS	1
<i>Ching-Joo Jong</i>	
CHAPTER 2 METHANE RECOVERY FROM PALM OIL MILL EFFLUENT USING FLEXIBLE GEOMEMBRANE COVER	37
<i>Hermann HB Ng & Soon-Onn Lai</i>	
CHAPTER 3 CHARECTERIZATION OF 8-SHAPED EXPANDED POLYSTRYNE-FERROCEMENT GEOMAT	57
<i>Fauziah Ahmad and Chun-Hean Lau</i>	
CHAPTER 4 EFFICACY OF NON-WOVEN GEOTEXTILE AS SEPARATOR FOR DRAINAGE MEDIA SANDWICHING DREDGED MARINE CLAY	79
<i>Siti Farhanah S.M Johan & Chee-Ming Chan</i>	
CHAPTER 5 REINFORCED-SOIL USING RANDOMLY DISTRIBUTED COCONUT COIR FIBRE (CCF)	97
<i>Aina' Najwa Zainuddin, Tuan Noor Hasanah Tuan Ismail,</i> <i>Yasmin Yuriz, Nur Faezah Yahya4 & Mohd Faizal Riza</i> <i>Kamian</i>	

CHAPTER 6 EFFECT OF POLYPROPYLENE FIBRE REINFORCEMENT ON THE AND COMPRESSIBILITY OF DREDGED MARINE SOIL	109
<i>Mohammad Zawawi Rosman & Chee-Ming Chan</i>	
 CHAPTER 7 THE USE OF GEOSYNTHETICS FOR THE REPAIR OF FAILED SLOPES IN MALAYSIA	 127
<i>Chin-Boon Chan & Choon-Heng Tee</i>	
 CHAPTER 8 PERFORMANCE OF POLYMERIC STRIP USED IN THE REINFORCED EARTH WALL SYSTEM AT THE AMPANG WATERFRONT PROJECT	 141
<i>Hsui-Han Wong and Mohd Rizal Ahmad</i>	
 CHAPTER 9 CASE HISTORIES OF SLOPE PROTECTION BY HDPE GEOCELLS	 155
<i>Cheng-Aik Neoh, Lian-Yoon-Kim Har, Siti Farhanah S.</i> <i>M Johan & Poi-Cheong Tan</i>	
 CHAPTER 10 BAMBOO-GEOTEXTILE BUOYANT SYSTEM (GEOBAMTILE) TO SUPPORT ROAD EMBANKMENT OVER DEEP SOFT GROUND	 167
<i>Nasfiza Mokhtar, Adnan Zainorabidin & Kaw-Sai Low</i>	
 CHAPTER 11 PERFORMANCE OF A 37 M HIGH GEOGRID REINFORCED SOIL STRUCTURE CONSTRUCTED OVER A DISUSED SEWAGE TREATMENT POND	 181
<i>Eng-Choy Lee, Cheng-Aik Neoh & Eric CW Chung</i>	

CHAPTER 12 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF DYNAMIC LOADING ON RAFT FLOATING FOUNDATION REINFORCED AND SEPARATED BY GEOTEXTILE IN COAL BOTTOM ASH REINFORCED-PEAT	193
---	-----

Ahmed Imad, Vivi Anggraini & Bujang B.K Huat

CHAPTER 13 INVESTIGATION ON EFFICIENCY OF ALTERNATIVE GRANULAR AND GEOSYNTHETIC FILTERS AS SLOPE DRAINAGE SYSTEM	217
---	-----

*Siti Noor Linda Taib, Muhammad Asyraf Mohd Zaideen
& Onni Sahaiza Selaman*

CHAPTER 14 MAN-MADE LAKE FROM SCIENCE TO DESIGN AND A STRATEGY FOR FLOOD MITIGATION IN URBAN MAN- MADE LAKES	235
---	-----

Kok-Hong Ng & Eric C-W Chung

CHAPTER 15 STUDY ON TENSILE STRENGTH BETWEEN FIBREGLASS AND SCRAP TYRE STRIPS	249
--	-----

F. Ahmad, A. Safari & A.S. Yahya

Chapter 16 USE OF FINITE ELEMENT ANALYSIS (FEA) TO ESTIMATE THE THICKNESS OF MECHANICALLY-STABILIZED WORKING PLATFORMS	265
---	-----

Mahesa Bhawanin & Elaine Teo Wan Zhi

<i>Biography</i>	281
------------------	-----

<i>Index</i>	283
--------------	-----

PREFACE



Pertubuhan IGS Malaysia (MyIGS)

I would like to introduce you to our MYIGS (International Geosynthetics Society Malaysian Chapter) research book entitled **Geosynthetics for Effective Geo-Solution in Malaysia - A Technical Compilation**, which showcases the excellent related work that has been done in Malaysia. The work comprises of design, construction, application and testing of geosynthetics and its related material that are used for ground Improvement. The study shows that some works were innovative and the applications were designed to cater solving problems and carry out improvement techniques for most of geotechnical engineering projects.

Each chapters demonstrates the use of geosynthetics based on the Malaysian soil conditions case study, research-related and ground improvement techniques used. This is the first series of research book of its kind where the knowledge sharing will be useful as reference point and to educate others on the use of geosynthetics for geotechnical engineering applications.

I hope this Research Book will be useful and enlightens the usage of geosynthetics to academics, engineers, contractors and developers either in government or public agencies.

In addition I would like to take this opportunity to express my appreciation to all the writers and editorial board in engaging this work and materialising the compilation, which I believe it to be truly invaluable knowledge dissemination, in particular for the use of geosynthetics at present and for the future.

Yours sincerely,

A handwritten signature in black ink, appearing to be 'Fauziah', written over a diagonal line.

Prof. Dr. Fauziah Ahmad (USM)
President
MyIGS Malaysian Chapter

THE FUNDAMENTALS AND APPLICATIONS OF GEOSYNTHETICS

*Ching-Joo Jong*¹

¹TenCate Geosynthetics Asia Sdn. Bhd., Shah Alam, Selangor, Malaysia

ABSTRACT

Geosynthetics were introduced to the construction industry in the 1970s and have now become the third-largest construction material after concrete and steel. The rapid demand and acceptance of geosynthetics for their versatile solutions in the industry are applied in various civil engineering disciplines - geotechnical, hydraulic, environmental, transportation and more. The first part of this chapter describes the essential fundamentals of geosynthetics, including definitions, types of raw materials (monomer and polymer), history, classifications, functions, properties and testing. Subsequently, the applications of geosynthetics in civil engineering industry will be covered in the second part of this chapter. This will enable readers to have a clear understanding of the relationship between the applications of geosynthetics and their essential fundamentals (such as functions, properties and testing). Readers will also be able to gain practical insights into geosynthetics' on-site applications through Solmax Geosynthetics and TenCate.

Keywords: Geosynthetic, civil engineering, application

METHANE RECOVERY FROM PALM OIL MILL EFFLUENT USING FLEXIBLE GEOMEMBRANE COVER

Hermann HB Ng¹ & Soon-Onn Lai²

¹ Senior Technical Manager, Solmax Geosynthetics Sdn. Bhd., Selangor, Malaysia

² Deputy Dean, Department of Chemical Engineering, Universiti Tunku Abdul Rahman (UTAR), Selangor Darul Ehsan, Malaysia

ABSTRACT

Oil palm is one of the most versatile crops in the tropical region. The extraction of palm oil from the fruit involves a number of processing stages, requires a large quantity of water and half of the water ends up as palm oil mill effluent (POME). POME is a highly harmful pollutant, and hence needs to be treated properly in order to minimize the deterioration of water quality, conserve the environment and ecology. The most common method used for POME treatment in palm oil mills involves series of pond systems with different biological processes, namely anaerobic, facultative, and aerobic treatments and it is at the anaerobic stage large amount of methane is released to the atmosphere and the major reduction of POME polluting strength occurs. High organic content in POME is a good source to generate methane via anaerobic digestion, which can be used to generate electricity. With its watertightness and outstanding performance in various aspects, high density polyethylene (HDPE) geomembrane is a suitable lining material that meets the Kyoto-driven green-house gas emission restrictions and Malaysian Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977. The paper summarizes the experiences of installed biogas covers on POME lagoons to achieve benefits of using engineered geomembrane for methane gas recovery, energy

CHARACTERIZATION OF 8-SHAPED EXPANDED POLYSTYRENE-FERROCEMENT GEOMAT

Fauziah Ahmad and Chun-Hean Lau

School of Civil Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Nibong Tebal, Penang,
Malaysia

ABSTRACT

In this study, preventive measures for landslide activity are being addressed and 8-shaped geomat is proposed to curb this problem. The mechanical properties such as resistance to compression, flexural and pull-out resistance of 8-shaped expanded polystyrene (EPS)-ferrocement are to be determined. End result is compared to previous study made of different materials. 8-shaped geomat is developed by using hand plaster method. Two types of mixture proportion are produced namely as EPB10 and EPB30 signifying that the mortar's sand mix proportions are partially replaced with 10% and 30% of expanded polystyrene beads respectively. Compression and flexural is tested with Universal Testing Machine (UTM). Pull-out test is performed in pull out box with sand as the backfill material. Test results show that both EPB10 and EPB30 have similar test results. Comparing to 8-shaped geomat made of fiberglass, used tires and ferrocement, expanded polystyrene based ferrocement has similar compressive strength, lower flexural force and lower pull-out force.

Keywords: 8-shaped geomat, expanded polystyrene, expanded polystyrene beads, ferrocement, compressive strength, flexural force, pull out force

EFFICACY OF NON-WOVEN GEOTEXTILE AS SEPARATOR FOR DRAINAGE MEDIA SANDWICHING DREDGED MARINE CLAY

Siti Farhanah S.M Johan¹ & Chee-Ming Chan²

^{1&2} Department of Civil Engineering Technology,
Faculty of Engineering Technology, Universiti Tun
Hussein Onn Malaysia, Johor, Malaysia

ABSTRACT

Geotextile had been used widely in the constructions and functioning as separator, filtration and reinforcement. This study work on the experimental on the dredged sediments from dredging activities. The sediments were called as dredged marine soils (DMS) which is too soft, slurry and have poor engineering properties. Therefore, it considered as geo-waste. Laboratory testing was performed to determine the preliminary effect on both conditions of drainage layer, either with or without separator between POC or RPM drainage layer and DMS. The results showed that non-separator have more settlement compared to specimens with separator. In addition, RPM (separator) dissipates water faster compared to others specimens. Although POC are known to be good drainage, crushing tendency of POC influenced the time of consolidation, which almost like POC (non-separator). In conclusion, the use of geotextile indicates a good potential to be applying on the land reclamation and embankment as well.

Keywords: Geotextile, separator, dredged marine soils, drainage, POC, RPM, oedometer and consolidation

REINFORCED-SOIL USING RANDOMLY DISTRIBUTED COCONUT COIR FIBRE (CCF)

Aina' Najwa Zainuddin¹, Tuan Noor Hasanah Tuan Ismail², Yasmin Yuriz³, Nur Faezah Yahya⁴ & Mohd Faizal Riza Kamian⁵

^{1,3,4,5} Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia

² Sustainable Engineering Technology Research Centre, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia

ABSTRACT

Road construction presents the most significant challenge, especially when dealing with soft soil due to its inadequate properties to support pavement structure self-weight and traffic loads. Such soils must be strengthened in order to resist loads/stresses placed on them. Soil reinforcement by natural fiber is currently gaining interest among researchers and engineers as alternative reinforcing materials in improving the characteristic properties of soft soil. Where reinforcing elements in the soil mass will increase the tension force and reinforced soil's shear resistance. Hence, this study takes an innovative approach to strengthen the soil performance by using coconut coir fibre (CCF) towards a sustainable geotechnical solution. This paper aims to investigate the CCH content that needs to be mixed with soil to achieve its optimal strength. CCF was randomly mixed with the soil at varying percentages of 0, 0.25, 0.5, 0.75 and 1.0% by the weight of dry soil. The potential of CCF-reinforced soil was then examined via compaction test and unconfined compressive strength (UCS) test. The findings show that the optimal moisture content (OMC) increases, and the maximum dry density (MDD) decreases

EFFECT OF POLYPROPYLENE FIBER REINFORCEMENT ON THE SETTLEMENT AND COMPRESSIBILITY OF DREDGED MARINE SOIL

Mohammad Zawawi Rosman¹ & Chee-Ming Chan²

¹ & ² Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, Johor, Malaysia

ABSTRACT

Fiber as a soil reinforcement is not a new concept in civil engineering. The inclusion of fiber in the soil helps to improve the engineering properties of the soil. Dredged marine soil (DMS) is a geo-waste that was produced during maintenance dredging. It is unlikeable to the geotechnical engineer as the soil is weak and low in bearing capacity. However, the poor engineering properties of DMS can be improved by soil reinforcement. So far, there has been little study on high water content DMS in terms of compressibility. A series of oedometer tests were conducted on the reinforced DMS to determine the compressibility behavior such as settlement and compression index (c_c). The results are influenced by the water content, soil properties, and PP fiber content from the study. Reinforced DMS with excessive moisture has poor soil structure. High plasticity soil tends to be more compressible. Lastly, DMS with the optimum fiber content of 0.5% is less compressible and stiffer than natural and 1.0%.

Keywords: Dredged soil, soft soil, polypropylene fiber, soil reinforcement, compressibility, consolidation

THE USE OF GEOSYNTHETICS FOR THE REPAIR OF FAILED SLOPES IN MALAYSIA

Chin-Boon Chan¹ & Choon-Heng Tee²

^{1 & 2} Mega Geosolutions Sdn. Bhd.

ABSTRACT

Slope failure is a common occurrence in many parts in Malaysia. During the monsoon seasons with incessant rain extended over long period of time, the frequency of occurrence of slope failure increases. The infiltration of rainwater causes the reduction of soil suction, rise in water table and reduction of the shear strength of soil. In the case of manmade slope which is poorly compacted, it can lead to slope failure when the slope is supersaturated. Many natural slopes are in fact in limiting equilibrium state, cutting in slope reduces the stability of slope. Certainly, surface water is an important factor in causing instability of slope. Surface runoff must be effectively discharged away from the slope as quickly as possible. Reinforced soil is a very versatile solution for slope rehabilitation. The stability of slope can be increased by the introduction of geosynthetics as soil reinforcement. It is safe, economical, sustainable and efficient. This paper discusses the various case histories of slope repair with the application of geogrids in the slope rehabilitation and their performances.

Keywords: Slope failure, water table, surface water, geosynthetics, soil reinforcement, slope rehabilitation

PERFORMANCE OF POLYMERIC STRIP USED IN THE REINFORCED EARTH WALL SYSTEM AT THE AMPANG WATERFRONT PROJECT

Hsui-Han Wong and Mohd Rizal Ahmad

Reinforced Earth Malaysia Sdn Bhd

ABSTRACT

Since early times, rivers play an important role in the development of the communities. Many of these waterways flow right through the urban areas providing a unique feature to the landscape of the towns (The Sustainable City-Waterfront, 2008). Upgrading works of these waterways are important to create an advancement of lifestyle and development of local communities. In Malaysia, Ampang river was one of the waterways which was upgraded to construct a commercial development. Reinforced Earth Wall and box culverts were introduced to replace the natural embankment of the river. This helps to reduce the overall surface erosion and potential scouring which may occur at various sections of the Ampang riverbank. Polymeric reinforcement strips were used as reinforcements for the construction of the Ampang Riverbank Reinforced Earth Wall. This type of strip unaffected by corrosion damage help maintain the internal stability of the Reinforced Earth Wall system. Overall, this paper discusses on a case study of performance of polymeric strip used in the Reinforced Earth Wall system at Ampang Waterfront Project.

Keywords: Hydraulic RE Wall, water table, surface water, geosynthetics, soil reinforcement, commercial development, Ampang Waterfront, sustainable systems

CASE HISTORIES OF SLOPE PROTECTION BY HDPE GEOCELLS

Cheng-Aik Neoh¹, Lian-Yoon-Kim Har², Siti Farhanah S. M Johan² & Poi-Cheong Tan³

¹E-Geo Consultant Sdn. Bhd., ²MTS Fibromat (M) Sdn. Bhd. & ³Reinforce Soil Engineering Sdn. Bhd.

ABSTRACT

It has been widely reported that infiltration accounts for 90 % of slope failures (NAHRIM, 2021). Proper and effective slope protection can reduce infiltration significantly. In fact, bare or poorly protected slopes have 3 to 5 times higher rate of infiltration when compared with well protected slopes. Cut slopes with difficult and adverse conditions such as high cut slopes with acidic graphitic phyllite or schist or highly erodible sandy silt or rocky slope, etc., cannot be effectively protected by normal slope protection methods such as hydroseeding or turfing. Though guniting or sprayed concrete can be effectively used to protect such difficult cut slope conditions, the ungreen or unaesthetic or unenvironment-friendly appearance is generally and increasingly not acceptable by general public and government authorities including JKR Malaysia. Recently, geosynthetic product with generic name called HDPE (high density polyethylene) geocells have been proposed and accepted to be used to vegetate difficult steep acidic and rocky slopes successfully in respect to reduce infiltration to practically nil and to provide green pleasing slope finishes. Unlike normal polymers, HDPE is a durable polymer, inert to chemical attacks and its strength is practically unaffected by UV rays or acids. It is found that HDPE geocell confinement system

BAMBOO-GEOTEXTILE BUOYANT SYSTEM (GEOBAMTILE) TO SUPPORT ROAD EMBANKMENT OVER DEEP SOFT GROUND

*Nasfiza Mokhtar¹, Adnan Zainorabidin² &
Kaw-Sai Low³*

¹ Senior Engineer, Road Division of PWD Malaysia

² Research Centre for Soft Soil (RECESS), Universiti
Tun Hussein Onn Malaysia

³ Director, Advanced Clarity Hectares Sdn. Bhd.

ABSTRACT

Road surface profile failure is often a major issue for roads. This paper will present a way of providing support beneath the road embankment between the over deep soft ground which is referred to as “Geobamtile.” It is designed and constructed to prevent failure due to the type of subsoil that accommodates the entire structure of the road itself. The construction of roads, whether new roads or upgrading existing roadways are bound to the alignment that has been determined by the authority. There are also cases of land acquisition involving new land areas that are explored and identified as the route of the new alignment of the road is allocated at problematic land which needs appropriate treatment before any structures can be built. Maintenance and operation costs throughout and after the construction period will require high costs. A way of providing geobamtile is being studied and developed in Malaysia and has made it possible to safely build road embankments over extremely soft and deep sub grades areas without creating significant post-construction settlements, such as tall highway embankments and building platforms. These useful advantages are made possible by the extraordinary tensile and bending capabilities of bamboo in bundles. The area and amount of buoyancy characteristics can be easily adjusted by the number

PERFORMANCE OF A 37 M HIGH GEOGRID REINFORCED SOIL STRUCTURE CONSTRUCTED OVER A DISUSED SEWAGE TREATMENT POND

Eng-Choy Lee¹, Cheng-Aik Neoh² & Eric CW Chung³

^{1&3}Emas Kiara Marketing Sdn. Bhd., Malaysia

²E-Geo Consultant Sdn. Bhd., Malaysia

ABSTRACT

The development of a housing scheme on a hill site project in Cheras, Selangor, Malaysia necessitated the construction of a reinforced soil structure. The base of the structure was partially founded on a disused sewage treatment pond. The pond was reclaimed where soft unsuitable materials were excavated and replaced with rock compacted to form a firm base. A 17m high geogrid reinforced soil structure was subsequently constructed on the rock fill foundation. This reinforced soil structure, sloped at 4v:1h, supports another fill of 20m height sloped at 1v:1.7h. The total length of the structure is approximately 120m. The geogrid used was manufactured from polyester yarn and was pvc-coated to reduce the deterioration due to exposure to ultraviolet radiation during construction. The geogrid reinforced earth structure was constructed as a wrap-around system where the facing was hydro seeded with suitable vegetation. The backfill material used in the construction of the structure is composed of weathered residual soil and weathered rock fill of granite. Instrumentation in the form of inclinometers, pneumatic piezometers and settlement markers were installed at various locations in the structure to monitor its performance during and after construction. Principally the parameters measured are the horizontal and vertical movements

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF DYNAMIC LOADING ON RAFT FLOATING FOUNDATION REINFORCED AND SEPARATED BY GEOTEXTILE IN COAL BOTTOM ASH REINFORCED-PEAT

Ahmed Imad¹, Vivi Anggraini² & Bujang B.K Huat³

¹ & ² Civil Engineering Discipline, School of Engineering, Monash University Malaysia

³ Geotechnical Professor (retired), Bangi Selangor, Malaysia

ABSTRACT

This paper presents the experimental investigation of the settlement behavior of a light-weight sustainable floating foundation under dynamic loading in peat. A lightweight foundation made from bamboo culms and plastic bags was developed to make use of the large water content in peat to generate buoyancy to reduce the settlement in peat. In addition, the improvement of bearing capacity and stability of peat using coal bottom ash (CBA) as a mechanical stabilizer and reinforced and separated by geotextile was investigated in this research. California bearing ratio (CBR) tests proved that using 40% CBA on peat improves the CBR of the soil to nearly 10%. Albeit low compared to typical CBR values of high-quality subgrade materials, this makes peat more viable for use as a subgrade material. The settlement behavior of mechanically stabilized peat was then compared to pure peat, under dynamic loading applied to a lightweight, sustainable floating foundation. The tests showed that the maximum settlement under dynamic loading was significantly lower for stabilized peat (-34.56 mm) compared to pure peat (-69 mm). The tests also showed that the final displacement of the foundation was lower than the maximum displacement experienced during the load cycles, with final

INVESTIGATION ON EFFICIENCY OF ALTERNATIVE GRANULAR AND GEOSYNTHETIC FILTERS AS SLOPE DRAINAGE SYSTEM

Siti Noor Linda Taib, Muhammad Asyraf Mohd Zaideen & Onni Suhaiza Selaman

Department of Civil Engineering, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak.

ABSTRACT

This paper investigates the design of a component in a subsurface slope drainage system which is the filter materials. The main focus in this study is to achieve efficient water discharge and sediment trapping in subsurface drainage system in slope that is the horizontal pipe drains. Installation of horizontal drains in slope is one of the common methods used to lower the high ground water table and thus study on the water discharge rate and amount of sediment discharged are investigated through a number of experiments. Alternative granular filter materials which are quarry gravel and oil palm shell were tested. Layer of either geosynthetic or cloth netting as external filter enveloping the granular filter was also introduced in the test program. Each experiment was conducted in sand with dry soil density of 1200 kg/m^3 . Drainage system was installed in the center of a model box at angle of 5° inclined from horizontal in each experiment. From the results and data obtained, it can be concluded that the oil palm shell filter shows high average discharge rate which is 8.28 % higher compared to quarry gravel filter within first 7 minutes but was not maintained in longer period. In addition, the external cloth netting envelope with quarry gravel filter shows higher average discharge rate of the three tests which is $2.30 \times 10^{-5} \text{ m}^3/\text{s}$. The reduction in groundwater level for external cloth

MAN-MADE LAKE: FROM SCIENCE TO DESIGN AND A STRATEGY FOR FLOOD MITIGATION IN URBAN MAN-MADE LAKES

Kok-Hong Ng¹ & Eric C-W Chung²

¹Principal, Asia Eco Ponds (formerly known as Ayer Matahari Sdn Bhd), No.7-8, One Petaling Residences, No.2, Jalan 1C/149, Taman Castlefield, 57100 Kuala Lumpur, Malaysia.

²Project Manager, (B. Eng) Emas Kiara Marketing Sdn Bhd, Lot 13A, Jalan RP3, Rawang Industrial Estate, 48000, Rawang, Selangor Darul Ehsan, Malaysia

Abstract

This chapter discusses the increasing popularity towards the integration of artificial aquatic waterbody into property development. Components of a healthy man-made waterbody are explained along with the strategy for flood mitigation of the waterbody. The waterbody design incorporated several key features, which includes blending in with the surrounding environment, providing adequate water holding as well as storage capacity, and serving as a viable recreational site to the local community.

Keywords: artificial waterbody, natural and self-sustaining management (NSM), bio-filtration, macrophytes, aquatic plant, HDPE geomembrane, flood mitigation

STUDY ON TENSILE STRENGTH BETWEEN FIBREGLASS AND SCRAP TYRE STRIPS

F. Ahmad, A. Safari & A.S. Yahya

School of Civil Engineering, Engineering Campus,
University Sains Malaysia, 14300 Nibong Tebal,
Penang, Malaysia

ABSTRACT

Scrap tyres have been used in many geotechnical engineering construction projects such as soil improvement, soil erosion and slope stability. Scrap tyres mainly in chip and shredded form are highly compressible under low and normal pressures. This characteristic would cause challenging problems in some applications such as retaining wall and river bank projects. Regards to the high tensile stress and low tensile strain of fibreglass, it would be a good alternative for scrap tyre in some cases. To evaluate fibreglass as an alternative for scrap tyre, this paper focused on two series of tensile tests which have been carried out on fibreglass and scrap tyre strips. Fibreglass samples were produced from chopped cstrand fibre mat, a very low-cost type of fibreglass, which is cured by resin and hardener. Fibreglass samples in the thickness of 1 mm, 2 mm, 3 mm and 4 mm were developed 100 mm × 300 mm pieces. It was found that 3 mm fibreglass exhibited the maximum tensile load (MTL) and maximum tensile stress (MTS) greater than other samples. Statistical analysis on 3 mm fibreglass indicated that in the approximately equal MTL fibreglass samples experienced 2% while tyre samples experienced 33.9% ultimate tensile strain (UTST) respectively. The results also showed an approximately linear relationship between stress and

USE OF FINITE ELEMENT ANALYSIS (FEA) TO ESTIMATE THE THICKNESS OF MECHANICALLY-STABILIZED WORKING PLATFORMS

Mahesa Bhawanin¹ & Elaine Teo Wan Zhi²

¹ & ² Tensar International Limited, Malaysia

ABSTRACT

The proliferation of construction projects over area where soils are weaker necessitates more efficient and cost-effective temporary works measures to ensure safe access and operation of construction plant. Geosynthetics have been used for decades to improve the performance of working platforms, allowing for reductions in working platform thickness, increased factors of safety or some combination of the two. An alternative method of modelling the effects of geosynthetics, particularly mechanical stabilisation has been developed recently to allow for more efficient working platforms derived from rigorous finite element analysis (FEA) called the T-Value method. The T-Value method has been validated against full-scale field tests and allows for accurate prediction of platform behaviour and greater economy. This paper presents an implementation of this method in a windfarm working platform in Vietnam.

Keywords: working platform, wind farm, bearing capacity, geosynthetics, mechanical stabilisation, temporary works

today, where embankments are made more durable even on soft soil deposits, retaining walls are recording greater heights with enhanced stability, landfills are safeguard against contamination with greater confidence, and subsurface drainage systems are performing more effectively over long periods of time. This book celebrates the contribution of the major players in the field of geosynthetics, from industry and academia alike in recent years, in the collective effort to make geosynthetics more versatile, more adaptive and more resilient towards sustainable infrastructure development in Malaysia.

BIBLIOGRAPHY

- 'BR 470 working platforms for tracked plant - use of "structural geosynthetic reinforcement". BRE review seven years on', BRE [u.a.], United Kingdom, 2011.
- A. Lees, 'Rigorous Design of Thinner Working Platforms Stabilised By Multi-Axial Geogrid', in *Piling 2020: Proceedings of the Piling 2020 Conference*, 2021, pp. 335-341.
- A. S. Lees and J. Clausen, 'Strength envelope of granular soil stabilized by multi-axial geogrid in large triaxial tests', *Can. Geotech. J.*, vol. 57, no. 3, pp. 448-452, Mar. 2020, doi: 10.1139/cgj-2019-0036.
- A. S. Lees, 'The bearing capacity of a granular layer on clay', *Proceedings of the Institution of Civil Engineers - Geotechnical Engineering*, vol. 173, no. 1, pp. 13-20, Feb. 2020, doi: 10.1680/jgeen.18.00116.
- Abd-Aziz, S., Hassan, M. A., Shirai, Y., & Sulaiman, A. (2009). Energy recovery from palm oil mill effluent (POME) in Malaysia. International conference on sustainability science in Asia, Universiti Putra Malaysia.
- Abdelouhab, A., et al., Numerical analysis of the behaviour of mechanically stabilized earth walls reinforced with different types of strips, *Geotextiles and Geomembranes* (2010), doi:10.1016/j.geotextmem.2010.10.011
- Abdi, M.R., Parsapajouh, A. and Arjomand, M.A. (2008). Effect of random fiber inclusion on consolidation, hydraulic conductivity, swelling, shrinkage limit and desiccation cracking of clays. *International Journal of Civil Engineering*, Vol. 6(4), pp. 284-292.
- Abdi, M.R., Parsapajouh, A. and Arjomand, M.A. (2008). Effects of random fiber inclusion on consolidation, hydraulic conductivity, swelling, shrinkage limit and desiccation cracking of clays. *International Journal of Civil Engineering*, Vol. 6(4), pp. 284-292.
- Abdullah, A., & Ali, A. (1984). Development of Basic Mechanical Tests for Malaysian Bamboos. *Test*, 7(2), 13-17.
- Abutaha, F., Razak, H. A. and Kanadasan, J. (2016). Effect of palm oil clinker (POC) aggregates on fresh and hardened properties of concrete. *Journal of Construction and Building Materials*, Vol. 112, pp. 416-423.
- ACI (1999). *ACI manual of concrete practice*, American Concrete Institute.

- ACI COMMITTEE (2003). Guide for structural lightweight aggregate concrete. ACI 213R-03, Farmington Hills, Mich.
- ACI COMMITTEE 549R, F. State-of-the-art Report on Ferrocement. (1997). American Concrete Institute.
- Ahmad, A.L., Ismail, S., and Bhatia S. (2003). Water recycling from palm oil mill effluent (POME) using membrane technology. *Desalination* 2003,157 (1-3), pp. 87-95.
- Ahmad, F., Mujah, D., Hazarika, H. and Safari, A. (2012). Assessing the potential reuse of recycled glass fibre in problematic soil applications. *Journal of Cleaner Production*, Vol. 35, pp. 102-107.
- Akbulut, S., S. Arasan and E. Kalka, (2007). Modification of clayey soils using scrap tyre rubber and synthetic fibers. *Applied Clay Sci.*, 38: 23-32.
- Alejandro, M-P., Alex, V-G. and Pedro J. H-F. (2013). Effect of fiber surface treatments on the essential work of fracture of HDPE-continuous henequen fiber-reinforced composites. *Polymer Testing*, Vol. 32(6), pp. 1114-1122.
- ALEX, A. A. R. (2011). Soil Improvement using Ferrocement Geomat. University Sains Malaysia
- Allgood, C., Weppler, L., Lien, B., Fox, N., (2003). "Case Studies for Building Foundations over Soft Organic Soils and Peat". Nottingham Problematic Soils Conference, July 2003.
- AN OIL PALM INDUSTRY 2020. https://bepi.mpob.gov.my/images/area/2020/Area_summary.pdf
- Anagnostopoulous, C.A., Tzetzis, D., and Berketis, K. (2013). Shear strength behaviour of ASTM D2487-11. (2011). Unified Soil Classification System, American Society for Testing and Materials.
- and Khan, R. A. (2019). Natural fiber reinforced polymer composites: History, types, advantages and applications. *Material Engineering Research*, Vol. 1(2), pp. 69-85.
- Arif, S. and Tengku Mohd Ariff T.A. (2001). The Case Study on the Malaysian Palm Oil. Regional Workshop on Commodity Export Diversification and Poverty Reduction in South and South-East Asia, UNCTAD/ ESCAP Bangkok, 3-5 April 2001.
- ASTM D 6392. Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-

Fusion Methods, American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA.

ASTM. 2007. D4595-05. Standard Test Method for Tensile Properties of Geotextile by the Wide-Width Strip Method. in.

Ayeldeen, M. and Kitazume, M. (2017). Using fiber and liquid polymer to improve the behaviour of cement stabilized soft clay. Geotextiles and Geomembranes, Vol. 45, pp. 592-602.

B.M. Das, Shallow foundations: bearing capacity and settlement, Third edition. Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2017.

Balchand, A.N. and Rasheed, K. (2000). Assessment of short environmental impact on dredging in a tropical estuary. Terra et. Aqua, Vol. 79, pp.16-26.

Bilida, G.V., (1971). Strength and deformation of fibreglass under shear. Problemy Prochnosti, 7: 6.

Bortone, G. and Palumbo, L. (2007). Sediment and dredged material treatment. Sustainable Management of Sediment Resources, 1st Ed. Elsevier. BS1377:(1990), Methods of test for soils for civil engineering purposes, United Kingdom: British Standard Institution

Bosscher, P.J., T.B. Edil and S. Kuraoka, (1997). Design of Highway Embankments Using Tyre Chips. Journal of Geotechnical and Geoenvironmental Engineering, 123(4): 295-304.

Brand, E.W. and Premchitt, Jerasak and Phillipson, H.B. (1984). Relationship between rainfall and landslides in Hong Kong. Proceedings of the 4th International Symposium on Landslides. Toronto. 1984. pp. 276-284.

Bray, R.N. (2008). Environmental Aspects of Dredging, Taylor and Francis, Netherlands, UK.

Brochure: Reinforced Earth in Ampang Waterfront (<https://reinforcedearth.com.my/downloads/AmpangWaterfront-brochure>)

BS 1377 (1990). Code of Practice for tests in soils for civil engineering purposes. British Standards Institution

BS 1983. Testing Concrete, Part 108, Method for Making Test Cubes from Fresh Concrete. British Standards Institution, London.

- BS 8006 (1996). Code of Practice for Strengthened reinforced soils and other fill. British Standards Institution
- BS 8006-1:2010 Code of practice for strengthened/reinforced soils and other fills
- BS1377: Part 2. (1990). Methods of test for soils for civil engineering purposes: Classification Tests, United Kingdom: British Standards Institution.
- BS1377: Part 5. (1990). Methods of test for soils for civil engineering purposes: Compressibility, permeability and durability tests, United Kingdom: British Standards Institution.
- BS8006-1: (2021), Code of practice for strengthened/ reinforced soils and other fills, United Kingdom, London: British Standard Institution.
- Bushra, L. and Robinson, R.G. (2010). Strength behavior of cement stabilized marine clay cured under stress. Indian Geotechnical Conference, pp. 601-604.
- Cadersa, A., Seeborun, A. and Chan Chim Yuk, A. (2014). Use of Coal Bottom Ash as Mechanical Stabiliser in Subgrade Soil. Journal of Engineering, 2014.cp
- Carter, M., Bentley, S. (2016). Soil properties and their correlations. John Wiley & Sons, Ltd.
- Cenergi RE - Case Studies (2017), CENERGI SEA Sdn. Bhd., <http://www.cenergi-sea.com/wp-content/uploads/2017/09/cenergi-re-case-studies-2.pdf>
- Centexbel: (2014), European and international geotextile standards- a short guide, United Kingdom, Brussels: Centexbel.
- Cetin, H., M. Fener and O. Gunaydin, (2006). Geotechnical properties of tyre-cohesive clayey soil mixtures as a fill material. Engineering Geol., 88(1-2): 110-120.
- Chai, J.C. (2016). Geotextiles: from Design to Application, Chapter 13- Geotextiles used in drainage, Woodhead Publishing, Elsevier, USA, pp. 277-303.
- Chan S.F. (2000). "Reinforced Soil Structures Using Geogrids". Geosynthetics Asia 2000, Proceedings of the 2nd Asian Geosynthetics Conference Kuala Lumpur, Malaysia, 29-31 May 2000, pp 95-110.
- Chan, C. M., & Ch'ng, S. S. (2010). Preliminary study of s-wave velocity

and unconfined compressive strength of cement-pulp stabilised kaolin. *International Journal of Integrated Engineering*, 2(2).

Chan, C-M. and Yusof, M.N.M. (2015). Remoulded strength of high plasticity marine silt retrieved from maintenance dredging. *Modern Applied Science*, Vol. 9(6), pp. 13-19.

Chen, M., Shen S.L., Arulrajah, A., Wu, H.N., Hou, D.W. and Xu, Y.S. (2015). Laboratory evaluation on the effectiveness of polypropylene fibers on the strength of fiber-reinforced and cement stabilized Shanghai soft clay. *Geotextiles and Geomembranes*, Vol. 43, pp. 515-523.

Chin, F.K., Chan S.F., Faisal Ali, Tee, H.E. (1989). "The use of a reinforced soil wall in rehabilitation of a high slope failure", *Proceedings of the Symposium on the Application of Geosynthetic and Geofibre in South East Asia, August 1989, Petaling Jaya, Malaysia*, p. 2/10 - 2/18.

Christ, M. and J.B. Park, (2010). Laboratory determination of strength properties of frozen rubber-sand mixtures. *Cold Regions Science and Technol.*, 60(2): 169-175.

Client / Main Contractor: Ahrmaz Enterprise

Client / Main Contractor: Anthosma Landscape Sdn Bhd

Client / Main Contractor: Dofort Earthworks Sdn Bhd

Client / Main Contractor: Ekovest Construction Sdn Bhd

Client / Main Contractor: Menta Construction Sdn Bhd

Client / Main Contractor: Paramount Property (Utara) Sdn Bhd

Client / Main Contractor: Perwira Landscape Sdn Bhd

Coduto, D.P. (2011). *Geotechnical Engineering Principles and Practices* 2nd Ed., Pearson, USA.

CUR (2012). *Durability of geosynthetics*, Publication 243, CUR Publication, Netherlands.

Dai, J.C. and J.T. Huang, (1999). Surface modification of clays and clay-rubber composite. *Applied Clay Sci.*, 15(1-2): 51-65.

Danso, H. (2016). Use of agricultural waste fibres as enhancement of soil blocks for low-cost housing in Ghana. *School of Civil Engineering and Surveying, University of Portsmouth: Doctoral dissertation.*

- Deboucha, S., Hashim, R., & Alwi, a. (2008). Engineering properties of stabilized tropical peat soils. *Journal of Geotechnical Engineering*, 13, 1-9.
- distributed polypropylene microfibrer shear strength behaviour of soils. *Geosynthetics International*, Vol. 18(1), pp. 2-11.
- Domski, J., Katzer, J., Zakrewski, M. and Poikiewski, T. (2017). Comparison of the mechanical characteristics of engineered and waste steel fiber used as reinforcement for concrete. *Journal of Cleaner Production*, Vol. 158, pp. 18-28.
- Edil, T.B. and P.J. Bosscher, 1994. Engineering properties of tyre chips and soil mixture. *Geotechnical Testing J.*, 17(4): 11.
- EN, B. 1999. 1015-3: (1999). Methods of test for mortar for masonry part 3: Determination of consistence of fresh mortar (by flow table).
- Eujine, G. N., Chandrakaran, S. & Sankar, N. (2017). Accelerated subgrade stabilization using enzymatic lime technique. *Journal of Materials in Civil Engineering*, 29(9), 4017085.
- Falocra, I.M.C.F.G and Pinto, M.I.M. (2011). Effect of short, randomly distributed polypropylene microfibers on shear strength behavior of soils. *Geosynthetics International*, Vol. 18(1), pp. 2-11.
- Falocra, IMCFG. and Pinto, MIM. (2011). Effect of short, randomly
- Fatahi, B., Khabbaz, H. and Fatahi, B. (2012). Mechanical characteristics of soft clay treated with fibre and cement. *Geosynthetics International*, Vol. 19(13), pp. 252-262.
- Festugato, L., Menger, E., Benezera, F., Kipperm, E.A. And Consoli, N.C. (2017). Fiber-reinforced cemented soils compressive and tensile strength assessment as a function of filament length. *Geotextiles and geomembranes*, Vol. 45, pp. 77-82.
- Fibreglass-Wikipedia. (2010). < <http://en.wikipedia.org/wiki/Fibreglass>>. in.
- Frederico, A., Vitone, C. and Murianni, A. (2015). On the mechanical behaviour of dredged submarine clayey sediments stabilized with lime or cement. *Canadian Geotechnical Journal*, Vol. 52(12), pp. 2030-2040.
- Fundamentals of Ecology by Eugene P. Odum John. N.W.M., Geotextiles, Lecturer in Civil Engineering, Queen Mary College, University of London. Published in USA by Chapman and Hall

- Gaffney, D.A. and Goleski, E.S. (2005). Dewatering and amending dredged material for beneficial use, Innovations in Grouting and Soil Improvement, ASCE.
- Garden Pond Management from Science to Design. LA! Landscape Magazine No. 27 Spring 2010 India.
- GEO (2000). "Highway Slope Manual". Geotechnical Engineering Office, Hong Kong.
- Ghavami, K. (1995). Ultimate load behaviour of bamboo-reinforced lightweight concrete beams. Cement and Concrete Composites, 17, 281-288.
- Ghazavi, M. and M.A. Sakhi, (2005). Influence of Optimized Tyre Shreds on Shear Strength Parameters of Sand. International J. Geomechanics, 5: 58-65.
- Ghulam Kadir, A.P. (2020), Overview of the MALAYSI
- Golestanian, H., (2007). Experimental Determination of Fiber Mat Permeability of Chopped Fibreglass Mats. in: E.E. Gdoutos (Ed.) Experimental Analysis of Nano and Engineering Materials and Structures, Springer Netherlands, pp: 105-106.
- Gray, D. H. & Sotir, R. B. (1996). Chapter 1 Introduction to Biotechnical Stabilization. Biotechnical and soil bioengineering slope stabilization: a practical guide for erosion control. Wiley-Interscience.
- GRI - GCL3: (2019) Standard specification for test methods, required properties and testing frequencies of geosynthetics clay liners (GCLs) rev. 5,. USA, Pennsylvania: Geosynthetic Institute.
- GRI - GM13 Standard Specification for "Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes", Rev.16 (2021). Geosynthetic Institute, PA, USA.
- GRI-GM13: (2021) Standard specification for test methods, test properties and testing frequency for high density polyethylene (HDPE) smooth and textured geomembranes rev. 16, USA, Pennsylvania: Geosynthetic Institute.
- Grubb, D.G., Wazne, M., Jagupilla, S.C. and Malasavage, N.E. (2011). Beneficial use of steel slag fines to immobilize arsenite and arsenate: slag characterization and metal thresholding studies. Journal of Hazardous, Toxic and

Radioactive Waste, Vol. 15, pp. 130-150.

Guidelines for Installation of: HDPE and LLDPE Geomembrane Installation Specification (2015). International Association of Geosynthetic Installers (IAGI), Roxborough, CO, USA.

Guthrie, S.W., Cooley, D. and Eggett, D.L. (2007). Effect of reclaimed asphalt pavement on mechanical properties of base materials. Transportation Research Record 2005, Transportation Research Board, Washington, D.C., pp. 44-52.

Hamer, K. and Karius, V. (2002). Producing bricks from dredged harbour sediments- An industrial scale experiment. Waste management, Vol. 5, pp. 521-530.

Hansen, K.R. and Copeland, A. (2014), Annual asphalt pavement industry survey on recycled materials and warm-mix asphalt Usage: 2009-2012. National Asphalt pavement Association (NAPA), Washington
FHWA (2008). User guideline for by products and secondary use materials in pavement construction. FHWA-RD-97-148, U.S. Department of Transportation, Retrieved on July 15, 2016 from <http://www.fhwa.dot.gov/pavement>

Hataf, N. and M.M. Rahimi, (2006). Experimental investigation of bearing capacity of sand reinforced with randomly distributed tyre shreds. Construction and Building Materials, 20(10): 910-916.

Hejazi, S. M., Sheikhzadeh, M., Abtahi, S. M., & Zadhoush, A. (2012). A simple review of soil reinforcement by using natural and synthetic fibers. Construction and Building Materials, 30, 100-116.

Hejazi, S.M., Sheikhzadeh, M., Abtahi, S.M., and Zadhoush, A. (2012). A simple review of soil reinforcement by using natural and synthetic fibers. Construction and Building Materials, Vol. 30, pp. 100-116.

Herman, A. (1999). Floating Covers Usage for Tanks Is Growing, Geotechnical Fabrics Report (GFR), Vol. 17, No. 7, pp. 26-29.

Howard, I.L., Vahedifard, F., Williams, J.M. and Timpson, C. (2017). Geotextile tubes and beneficial reuse of dredged soil: applications near ports and harbours. Ground Improvement, Proceedings of the Institution of Civil Engineers (ICE), pp. 1-14.

Huat, B.B.K., A.A. Aziz and L.W. Chuan, (2008). Application of

Scrap Tyres as Earth Reinforcement for Repair of Tropical Residual Soil Slope. in: *Electronic J. Geotechnical Engineering* pp: Bund. B.

Huat, B.B.K., Prasad, A., Asadi, A., & Kazemian, S. (2014). *Geotechnics of Organic Soils and Peat* (1st ed.). CRC Press. <https://doi.org/10.1201/b15627>

Humphrey, D.N. and W.P. Manion, (1992). Properties of Tyre Chips for Lightweight Fill. *Proceedings of Grouting, Soil Improvement and Geosynthetics*, pp: 1344-1355.

Humphrey, D.N., (1999). Civil engineering application of tyre shreds. in: *Proceedings of the Tyre Industry Conference*, Clemson University, South Carolina, pp: 3-5.

Ibrahim, A., Lightweight Buoyant Foundation On Peat Soil Using Bamboo Culms And Plastic Bags, September 2017. Universiti Putra Malaysia

Ibrahim, H. A. and Razak, H. A. (2016). Effect of Palm Oil Clinker Incorporation on Properties of Previous Concrete. *Construction and Building Materials*, Vol. 115, pp. 70-77.

IGS (2018). *Guide to the specification of geosynthetics 2018*, Texas: International Geosynthetics Society.

IGS (2020). *Preparing the ground for a brighter future- how geosynthetics have been serving society for half a century*, Texas: International Geosynthetics Society.

International Standards Organisation, 'Geosynthetics Part 1: Terms and definitions (DIN EN ISO 10318-1:2015 + AMD 1:2018)', 2018.

Ismail, T.N.H.T. (2017). A critical performance study on innovative lightweight fill to mitigate settlement of embankment constructed on peat soil. Universiti Tun Hussein Onn Malaysia: PhD Thesis.

ISO/TS13434: (2008), *Geosynthetics – guidelines for the assessment of durability*, Switzerland, Geneva: International Organization for Standardization.

ISO10318-1: (2015), *Geosynthetics-Part 1: Terms and definitions*, Geneva: International Organization for Standardization.

Ivy, N. & Corrigan, C. (2000). Animal Waste Containment Using Geosynthetics, *Geotechnical Fabrics Report (GFR)*, Vol. 19, No. 5, pp. 30-33.

Jain, V.K., Dixit, M. and Chitra, R. (2015). Correlation of plasticity index and compression index of soil. *International Journal of Innovations*

in Engineering and Technology, Vol. 5(3), pp. 263-270.

- Jeon, H-Y. (2016). Geotextiles: from Design to Applications, Chapter 18-Geotextiles composites having multiple functions, Woodhead Publishing, Elsevier, USA, pp. 413-425.
- Jones, J. (2017). California bearing ratio typical values. [online] Cbrtesting.com. Available at: <https://www.cbrtesting.com/california-bearing-ratio-typical-values/> [Accessed 10 Oct. 2017].
- Jong, S.Y. and Chan, C-M. (2013). The fundamental compressibility characteristics of solidified dredged marine soil. *Advancements in Marine and Freshwater Sciences*, pp. 597-603.
- K. Watts and C. Jenner, 'Large-scale laboratory assessment of geogrids to reinforce granular working platforms', 2008.
- Kaliannan, S. (2016). Light solidification of Kuala Perlis dredged marine soil via admixtures of GGBS-cement and sand: 1D compressibility study. Thesis book of UTHM.
- Kan, A. & Demirboğa, R. (2007). Effect of cement and EPS beads ratios on compressive strength and density of lightweight concrete. *Indian journal of engineering & materials sciences*, 14, 158-162.
- Kerja Berkaitan Di Institut Penyelidikan Air Kebangsaan Malaysia (NAHRIM) (2021)
- Kerja-Kerja Penstabilan Dan Membaikpulih Cerun Serta Lain-Lain
- Keya, K. N., Kona, N. A., Koly, F. A., Maraz, K. M., Islam, M. N.
- Kitazume, M. and Terashi, M. (2013). *The Deep Mixing Method*, Taylor and Francis, Netherlands, UK.
- Koerner, R. M. (2012). *Designing with Geosynthetics* (6th edition), Vol.2. Xlibris Corp. ISBN-13: 978-1465345257
- Koerner, R.M. (2012a). *Designing with geosynthetics-Vol. 1*, 6th Edn. Xlibris Corporation, Indiana, USA.
- Koerner, R.M. (2012a). *Designing with geosynthetics-Vol. 2*, 6th Edn. Xlibris Corporation, Indiana, USA.
- Koerner, R.M. (2016). *Geotextiles: from design to applications*. Woodhead Publishing, Duxford, UK.
- Koerner, R.M. and Welsh, J.P. (1980). *Construction and Geotechnical Engineering Synthetic Fabrics*, J. Wiley and Sons, New York, USA.

- Kumar, A., Walia, B. S., & Mohan, J. (2006). Compressive strength of fiber reinforced highly compressible clay. *Construction and building materials*, 20(10), 1063-1068.
- Lakkad, S. and Patel, J. (1981). Mechanical properties of bamboo, a natural composite. *Fibre Science and Technology*, 14(4).
- Lawson, C.R. (2008). Geotextile containment for hydraulic and environmental engineering, *Geosynthetics International*, 15 (6), pp. 384- 427.
- Lawson, C.R. (2016). Chapter 20: Geotextiles in marine engineering. Elsevier, pp.435-482.
- Lawson, C.R. (2020). Reinforced Soil Case Studies, 2nd Edn. TenCate Geosynthetics Asia.
- Lawson, C.R. (2021, April). Soft Site Impoundment Closures Using Geosynthetics'. [PowerPoint slides]. TenCate Geosynthetics Asia.
- Lekha, K. R. (2004). Field instrumentation and monitoring of soil erosion in coir geotextile stabilised slopes—A case study. *Geotextiles and Geomembranes*, 22, 399-413.
- Lim, L. Q. (2010). Comparative Study of an Open Lagoon with High Efficient Methane Free Treatment Plant and CDM Project in Palm Oil Mill Effluent. Thesis of Universiti Malaysia Pahang.
- Loh, S.K., Nasrin, A.B., Mohammad Azri, S., Nurul Adela, B., Muzzammil, N., Daryl Jay, T. and Stasha Eleanor, R.A. (2017). Biogas Capture - A Means of Reducing Greenhouse Gas Emissions from Palm Oil Mill Effluent, *Oil Palm Bulletin* 75 (November 2017), pp. 27-36.
- Ludin, N.A., Bakri, M.A.M., Hashim, M., Sawilla, B., Menon, N.R. and Mokhtar, H. (2004). Palm oil biomass for electricity generation in Malaysia. *Jurutera* 11, pp.16-20.
- Lydon, F. D. (1982). Chapter 9 Lightweight aggregate concrete. *Concrete Mix Design* 2nd Edition. London and New York: Applied Science Publishers.
- Maher, N. and Ho, Y. (1993). Behavior of fiber-reinforced cemented sand under static and cyclic loads. *Geotechnical Testing Journal*, Vol. 16(3), pp. 330-338.
- Malekzadeh, M., & Bilsel, H. (2012). Effect of polypropylene fiber on mechanical behavior of expansive soils. *EJGE*, 17, 55-63.
- Marandi, S. M., Bagheripour, M. H., Rahgozar, R., & Zare, H. (2008). Strength

and ductility of randomly distributed palm fibers reinforced silty-sand soils. *American Journal of Applied Sciences*, 5(3), 209-220.

- Marefat, V. and H. Soltani-Jiagheh, (2011). Laboratory Behavior of Caly-Tyre Mixture. *World Applied Sciences J.*, 13(5): 1035-1041.
- Martho, A., Kasim, F., Othman, B.A., and Bakar, I. Comparison of Field Performance between Bamboo-Geotextile Composite Embankment and High Strength Geotextile Embankment, November 2012. <https://www.researchgate.net/publication/272613872>
- Matthew Stovall, P. & King, B. (2011). *Geosynthetics in Articulating Concrete Block Section Design*.
- McCarthy, D.F. (2007). *Essentials of Soil Mechanics and Foundations: Basic Geotechnics 7th Ed.*, Pearson Prentice Hall, USA.
- Menaiktaraf Laluan Persekutuan 12 (FR12) Dari Gambang, Pahang Ke Segamat, Johor (Fasa 1) (2019)
- Metcalf & Eddy (2002). *Wastewater engineering treatment and reuse*. New York, USA: McGraw-Hill ISBN-13:978-0071241403.
- Michalowski, R. and Cermak, J. (2003). Triaxial compression of sand reinforced with fibers. *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 129(2), pp. 125-136.
- Miller, C.J. and Rifai, S. (2004). Fiber reinforcement for waste containment soil liners. *Journal of Environmental Engineering*, Vol. 130(8), pp. 981-985.
- Mirzababaei, M. Arulrajah, A., Horpibulsuk, S. and Aldava, M. (2017). Shear strength of a fiber-reinforced clay at large shear displacement when subjected to different stress histories. *Geotextiles and Geomembrane*, Vol. 45, pp. 422-429.
- Mirzababaei, M., Arulrajah, A., Haque, A., Nimbalkar, S. and Mohajerani, A. (2018). Effect of fiber reinforcement on shear strength and void ratio of soft clay. *Geosynthetics International*, Vol. 25(4), pp. 471-480.
- Mohamad, N. O., Razali, C. E., Hadi, A. A. A., Som, P. P., Eng, B. C., Rusli, M. B., & Mohamad, F. R. (2016). Challenges in construction over soft soil-case studies in Malaysia. In *IOP Conference Series: Materials Science and Engineering*, 136(1), 012002.
- Mohammad, S., Baidurah, S., Kobayashi, T., Ismail, N. and Cheu, P.L. (2021). Palm oil mill effluent treatment processes - A review.

Processes 2021, 9(5), 739, 22 pages.

Mohsenian, S., Eslami, A., & Kasaei, A. (2011). Geo-Frontiers 2011 © ASCE 2011 56. Foundations, 56-65

Moon, H., Kim, J.H. Kim, Lee, J.Y., Kim, S.G. and Chung, C.W. (2017). Evaluation of pozzolanic activity for effective utilization of dredged sea soil. International Journal of Concrete Structures and Materials, Vol. 11(4), pp. 637-646.

Morgenstein, M. and Redmont, C. (1998). Mud-brick typology, sources, and sedimentological composition: A case study from Tell el-Muqdam, Egyptian Delta. Journal of the American Research Center in Egypt, Vol. 35, pp. 129-146.

Munro, R. (2004). Dealing with bearing capacity problems on low volume roads constructed on peat: including case histories from roads projects within the ROADDEX partner districts. Inverness, Scotland. The Highland Council Transport, Environmental & Community Services.

Murugesan, S., & Rajagopal, K. (2010). Studies on the Behavior of Single and Group of Geosynthetic Encased Stone Columns. Journal of Geotechnical and Geoenvironmental Engineering, 136(1), 129-139

Nagavally, R. R. (2016). Composite materials: History, types, fabrication techniques, advantages and applications. International Journal of Advances in Science Engineering and Technology, Vol. 4(3), pp. 87-92.

Narayanan, A. (2010). Properties and Applications of Ferrocement Concrete [Online]. Ezine Articles. Available: <http://ezinearticles.com/?Properties-and-Applications-of-Ferrocement-Concrete&id=5188237> [Accessed 17 May 2013].

National Academy Of Sciences, A. H. P. O. T. U. O. F. I. D. C. & Assistance, U. S. A. F. I. D. B. F. T. (1976). Chapter 2 Background Information. Ferrocement: applications in developing countries. National Academies.

NCMA: (1997), Design Manual for Segmental Retaining Walls (DMSRW), 2nd Edn. Virginia: The National Concrete Masonry Association.

Nicholson. (2015). Chapter 8, Geosynthetics for filtration, drainage and seepage control, Soil Improvement and Ground Modification Methods

O'Shaughnessy, V. and V.K. Garaga, (2000). Tyre-reinforced earthfill.

Part 2: Pull- out behavior and reinforced slope design Canadian Geotechnic J., 37: 97-116.

Olst J. T., Fishman S. and Wright G. (2000). GCLs for Animal Waste Containment, Geotechnical Fabrics Report (GFR), Vol. 18, No. 5, pp. 30-33.

Oreste, P.P., (2009). . Face stabilisation of shallow tunnels using fibreglass dowels.

Orlov, D.L. and A.E. Gorin, (1999). Application of fibreglass frit in construction engineering. Glass and Ceramics, 56: 199-203.

Park, S. G. & Chisholm, D. (1999). Polystyrene aggregate concrete. BRANZ.

Patel, S. K., & Singh, B. (2014). Unconfined compressive strength behaviour of fibre- reinforced lateritic soil. J. Civil Eng. Environ. Technol, 1(4), 93-8.

Petani, Kedah (2019)

Phase 1A (Package 1) At Setia Eco Templer, Selangor (2019)

Ple, O., Le, T.N.C. and Abu Aisha, M.S. (2012). Landfill clay barrier: Fibre reinforcement technique. Advanced Materials Research, Vol.378-379, pp. 780-784. polypropylene fibre reinforced cohesive soils. Geomechanics and Geoengineering, Vol. 9(3), pp. 241-251.

Poh, P.E. and Chong, M. F. (2009). Development of anaerobic digestion methods for palm oil mill effluent (POME) treatment. Bioresource Technology, 100, pp. 1-9.

Prabakar, J. and Sridhar, R.S. (2002). Effect of random inclusion of sisal fiber on strength behavior of soil. Construction and Building Materials, Vol. 16(2), pp. 123-131.

Pradhan, P.K., Kar, R.K. and Naik, A. (2012). Effect of random inclusion of polypropylene fibers on strength characteristics of cohesive soil. Geotechnical Geology Engineering, Vol. 30, pp. 15-25.

Proceedings of the Institution of Civil Engineers Geotechnical Engineering pp: 162.

Project Reference: Prosper - Rompin Palm Oil Mill, GLT Renewable Sdn. Bhd., <https://glt.my/rompin-palm-oil-mill/>

Proposed Completion of Site Clearing, Main Drain, Detention Pond and Other Related Infrastructure Works (Pakage 1) on

PTD 190807 & PTD 5377, Mukim Pulai, Daerah Johor Bahru, Jhor for Messrs, Bandar Nusajaya Development Sdn Bhd-Supply and Install Fibrocell (2020)

Proposed Fourth Lane Widening From Shah Alam Interchange to

- R.B. Bonnell, R.S. Broughton, G.F. Bolduc. Hydraulic failure of the soil-drain envelope interface of subsurface drains. *Can. Water Resour. J.*, 11 (3) (1986). pp. 24-34.10.4296/cwrj1103024.
- Rahardjo, H., Amalia, V., Song, Y., & Juay, C. (2011). Performance of horizontal drains in residual soil slopes. Singapore: Nanyang Technological University.
- Rahardjo, H., Hritzuk, K. J., Leong, E. C., & Rezaur, R. B. (2002). Effectiveness of horizontal drains for slope stability. *Engineering Geology*, 295-308.
- Rahardjo, H., Lee, T.T., Leong E.C., & Rezaur, R.B. (2005). Response of a residual soil slope to rainfall. *Canada Geotech Journal*. pp. 340-351.
- Rahman, Z.A., Yaacob, W.Z.W., Rahim, S.A., Lihan, T., Idris, W.M.R. and Sani. W.N.F.M. (2013). Geotechnical characterization of marine clay as a potential liner material. *Sains Malaysiana*, Vol. 42(8), pp. 1081-1089. Sasanian, S. and Newson T.A. (2014). Basic parameters governing the behavior of cement-treated clays. *The Japanese Geotechnical Society*, Vol. 54(2), pp. 209-224.
- Rao, G.V. and R.K. Dutta, (2000). Compressibility and Strength Behaviour of Sand-tyre Chip Mixtures. *J. Geotechnical and Geological Engineering*, 24 7:11-724.
- Rao, T. C., Rao, T. G. & Rao, N. R. (2008). An Experimental Study on Ferro Cement Channel Units Under Flexural Loading. *International Journal of Mechanics and Solids*, 3, 195-203.
- Rathod, S. D., Kamble, B. M. & Phalke, D. H. (2008). Effect of sub-surface drainage (SSD) system with different filters (envelopes) on hydraulic properties of salt affected and water logged soil. *International Journal of Agricultural Engineering* 2008 Vol.1 No.2 pp.97-99.
- Rawang/Jalan Duta Toll Plaza And Nilai (U) To Seremban (2012)
- Sadlier, M.A., Russell, J. and Harris, M. (1994). Innovative Geosynthetic-Based Wastewater Treatment Systems, *Proceeding of Fifth*

International Conference on Geotextiles, Geomembranes and Related Products, Singapore, pp. 1057-1062.

Sai, L. K., & Heng, T. N. (2016). Bamboo-Geotextile Buoyant System For Hefty Construction Over Deep Soft Subgrade.

Sakr, M., M.H. El Naggar and M. Nehdi, (2005). Lateral behaviour of composite tapered piles in dense sand. *Geotechnical Engineering*, 158: 145-157.

Salim, W.S.W., Sadikon, S.F., Mohd Salleh, S. Mohd Noor, N.A., Arshad, M.F. and Wahid, N. (2012). Assessment of physical properties and chemical composition of Kuala Perlis dredged marine sediment as a potential brick material. *IEEE Symposium on Business, Engineering and Industrial Applications*

Saradhi Babu, D., Ganesh Babu, K. & Wee, T. H. (2005). Properties of lightweight expanded polystyrene aggregate concretes containing fly ash. *Cement and Concrete Research*, 35, 1218-1223.

Sarani, N.A. (2019). Properties and environmental impact of fired clay bricks incorporated with palm oil waste. Thesis Book of UTHM.

Shahid, K.A., Syed Mohsin, S.M and Ghazali, N. (2015). The potential of cooling effect using palm oil clinker as drainage layer in green roof system. *Proceedings of Engineering Technology Int. Conf. (ETIC)*.

Shahrokhbadi, S. and Nazeryadeh, N. (2013). Efficacy of resinous polypropylene (PP) fibers on strength behavior of reinforced soils. *Advanced Materials Research*, Vol. 787, pp. 75-80.

Sharma, V., Vinayak, H.K. and Marwaha, B.M. (2015). Enhancing compressive strength of soil using natural fibers. *Construction and Building Materials*, Vol. 93, pp. 943-949.

Shaukat, A. K., & Kamal, M. A. (2010). Study of visco-elastic properties of shoppers' waste for its reuse as construction material. *Construction and Building Materials*, 24(8), 1340-1351

Shukla, S.K. (2012). *Handbook of geosynthetic engineering*, 2nd Edn. ICE Publishing, London, UK.

Singh, H. P., & Bagra, M. (2013). Improvement in CBR value of soil reinforced with jute fiber. *International Journal of Innovative Research in Science, Engineering and Technology*, 2(8), 3447-3452.

- Singh, M. and Siddique, R. (2013). Effect of coal bottom ash as partial replacement of sand on properties of concrete. *Resources, Conservation and Recycling*, 72.
- Sivakumar B. G. L., Vasudevan, A. K., & Sayida, M. K. (2008). Use of coir fibers for improving the engineering properties of expansive soils. *Journal of Natural Fibers*, 5(1), 61-75.
- Slope Failure At Royal Chulan Cheratang, Pahang (2020)
- Slope Protection and Revegetation Works At Bukit Banyan, Sungai
- Smolar, J., Mladenovic, A. and Petkovsek, A. (2013). Stabilization of Soft Marine Sediments from the Port of Koper (Slovenia). *Proceedings of the 5th International Young Geotechnical Engineers Conference*, IOS Press, USA, pp. 138-142.
- Soganci, A. (2015). The effect of polypropylene fiber in the stabilization of expansive soils. *International Journal of Environmental, Chemical, Ecological and Geophysical Engineering*, Vol. 9(8), pp. 956-959.
- Soganci, A. (2015). The effect of polypropylene fiber in the stabilization of expansive soils. *International Journal of Environmental, Chemical, Ecological and Geophysical Engineering*, Vol. 9(8), pp. 956-959.
- Soleimanbeigi, A. and Edil, T.B. (2015). Compressibility of recycled materials for use as a highway embankment fill. *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 141(5).
- Sri Ravindrarajah, R. & Tuck, A. (1994). Properties of hardened concrete containing treated expanded polystyrene beads. *Cement and concrete composites*, 16, 273-277.
- Sridhar, J. & Malathy, R. (2011). Study on Compressive Strength of Cement Mortar with Partial Replacement of Fine Aggregate by Steel Slag for Ferrocement Laminates. *Earth Sciences and Engineering*, 04, 1139-1144.
- Sridhar, R. (2017). A review on performance of coir fiber reinforced sand. *International Journal of Engineering Technology*, Vol. 9(1), pp. 249-256.
- Stuyt, L.C.P.M. (1989). Drain envelope research Project. Confidential report 1985-1988. Part: text. pp. 67.
- Swamy, R. (1983). Expanded polystyrene concrete. In: COOK, D. J. (ed.) *Concrete Technology Design and New Concrete Materials*. Surrey

University Press.

- Tang, C.S., Wang, D.Y., Cui, Y.J., Shi, B. and Li, J. (2016). Tensile strength of fiber-reinforced soil. *Journal of Material and Civil Engineering*, Vol. 28(7), pp.1-13.
- Tay, J-H. (1990). Ash from oil-palm waste as concrete materials. *Journal of Materials in Civil Engineering*, Vol. 2 (2), pp. 94-105.
- Teja, M.S. (2016). Soil stabilization using polypropylene fiber materials. *Engineering and Technology*, Vol. 5(9), pp. 18906-18912.
- Teja, M.S. (2016). Soil stabilization using polypropylene fiber materials. *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 5(9), pp. 18906-18912.
- Terzaghi, K. (1929): Effects of minor geological details on the safety of dams. Technical publication, AIME.
- The French Ministry of Transport (Direction Des Routes), September 1979
- The Sustainable City-Waterfront regeneration as a sustainable approach to city development in Malaysia- Written by S. Shamsuddin, N.S Abdul Latip and A.B. Sulaiman University Teknologi, Malaysia City Campus, Kuala Lumpur, Malaysia, International Islamic University of Malaysia, Malaysia.
- Timothy, J. and A. Pillip, (2005). Balancing Pipe and Backfill Requirements in difficult Installation Conditions. *Pipelines*, pp: 954-664.
- Timuran Engineering. (2013). Fibre for concrete solutions. [Brochure]. Timuran Engineering Sdn. Bhd.
- Touze, N. (2021). Healing the world: A geosynthetics solution, *Geosynthetics International*, 28 (1), pp. 1- 31.
- Uddin, N. (2013). Development in Fiber-Reinforced Polymer (FRP) Composites for Civil Engineering, Woodhead Publishing Series in Civil and Structural Engineering, Elsevier, USA.
- Vidal, H. (1969). The principle of reinforced earth. *Highway Research Record*, Vol. 282, pp. 1-16.
- Whitlow, R. (2004). Basic Soil Mechanics, Fourth edition. Jurong, Singapore:Prentice Hall.
- Wichtmann, T.(2005), "Explicit accumulation model for non-cohesive soils under cyclic loading", Doctoral Dissertation, Heft-38, Ruhr-

Universität Bochum.

- Widodo, S. (2013). Analysis of dynamic loading behaviour of pavement in soft soil. Ph.D. Technische, Universität Bergakademie Freiberg.
- Willardson, L.S. (1987). Drain envelope drainage design and management, Proceeding of the Fifth National Drainage Symposium. American Society of Agricultures Engineers. Publ.07-87. St Joseph Michigan USA, pp. 13-18.
- Working platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground-supported working platforms, Reprint. Garston: BRE [u.a.], 2007
- Wu, T.Y., Mohammad, A.W., Jahim, J.M. and Anuar, N. (2010). Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes. Journal o f Environmental Management 2010, Vol. 91 (7), pp. 1467-1490.
- Xu, G.Z. and Yin, J. (2015). Compression behavior of secondary clay minerals at high initial water contents. Marine Georesources & Geotechnology, Vol. 34(18), pp. 721-728.
- Xu, Y., Jiang, L., Xu, J. & Li, Y. (2012). Mechanical properties of expanded polystyrene lightweight aggregate concrete and brick. Construction and Building Materials, 27, 32-38.
- Yacob, S., Hassan, M.A., Shirai, Y., Wakisaka, M. and Subash, S. (2005). Baseline study of methane emission from open digesting tanks of palm oil mill effluent treatment. Chemosphere Vol. 59, Issue 11, pp. 1575-1581.
- Yee, T.W. (2017, October) Basics of Geosynthetics. [PowerPoint slides]. TenCate Geosynthetics Asia.
- Yeoh, B. G. (2004). A Technical and Economic Analysis of Heat and Power Generation from Biomethanation of Palm Oil Mill Effluent. International Energy Journal, Volume 6, No.1, pp. 3-15 - 3-27.
- Yohanes, B. S. (2010). Rubberise Geo-Mat for Soil Improvement. University Sains Malaysia.
- Yong K. Y., Chang M. F. & Tang S. K. (2007). "Forty Years of Geotechnical Developments in Singapore". 40th Anniversary of SEAGS, commemorative volume on Development, Advancement and Achievements of Geotechnical Engineering in Southeast Asia, Kuala Lumpur, pp 417-441.

- Yoon, Y.W., S.B. Heo and K.S. Kim, (2008). Geotechnical performance of waste tyres for soil reinforcement from chamber tests. *J. Geotextile and Geomembranes*, 26: 100-107.
- Yunus, N. Z. M., Marto, A., Pakir, F., Kasran, K., Jamal, M. A. A., Jusoh, S. N., & Abdullah, N. (2015). Performance of lime-treated marine clay on strength and compressibility characteristics. *International Journal of GEOMATE*. <https://doi.org/10.21660/2015.16.4132>
- Yusoff, S. (2006). Renewable energy from palm oil - Innovation on effective utilization of waste. *Journal of Cleaner Production* 2006, Vol.14, No.1, pp. 87-93.
- Z20 Issa, M., R. Sen, D. Mariscal and M. Shahawy, (1994). Static response of fibreglass pretensioned columns *J. Structural Engineering*, 120: 3634-3648.
- Zaimoglu, A.S. and Yetimoglu, T. (2012). Strength behavior of fine grained soil reinforced with randomly distributed polypropylene fibers. *Geotechnical Geology Engineering*, Vol. 30, pp. 197-203.
- Zainorabidin, A., Zolkefle, S. N. A., Meng Siang, A. J. L., Mohamad, H. M., & Mohd Razali, S. N. (2015). Comparison Study of the Dynamic Loading Characteristics between Peat and Sand Based on its Physical Properties. *Applied Mechanics and Materials*, 773-774, 1460-1465.
- Zakaria, S & Sufian, Z. (2009). Public Works Department Malaysia Construction and Maintenance Ensuring Road Quality in Malaysia. Public Works Department.
- Zigang, Liu Xintu, L. (n.d.). The Global Distribution of Peat. *Encyclopedia of Life Support Systems*, II, 1-5
- Zorenberg, J.G., R.B. Christopher and C.J. LaRocquc, (2004). Application of Tyre Bale in Transportation Projects. *J. Recycled Materials in Geotechnics*, pp: 42-60.

GEOSYNTHETICS

for Effective Geo-Solution in Malaysia

A Technical Compilation

This is a book which gathers the best practices and research endeavours from both industry and universities in Malaysia, to showcase the advances in design, construction, applications and testing of geosynthetics in the country. The 15 chapters present interesting technical innovations in the field, refinement of the understanding in geosynthetic-soil interaction and mechanisms, as well as geo-environmental troubleshooting and solutions. This inaugural Technical Compilation by MyIGS aims to serve as a useful guide and reference for practitioners, researchers and academics alike, to position the effective use of geosynthetics for the present, and into the future.



ISBN 978-629-490-008-0



For more information,
please scan the code

