

# **Engineered Reuse of DREDGED MARINE SOILS from Malaysian Waters 2**

## **Authors:**

Chee-Ming Chan<sup>1</sup>, Mohammad Zawawi Rosman<sup>2</sup>

## **Email:**

chan@uthm.edu.my<sup>1</sup>

**Abstract:** This is the second book in the series written to give an insight to some feasible techniques for reusing dredged marine soils. The reuse potential of the treated soils can be found in reclamation works as well as landfill liners. Admixed with stabilising agents and granular materials, the originally soft and weak dredged marine soils can be transformed into stable backfills in artificial land creation. The granular additions could be sourced from industrial or construction wastes, further enhancing the sustainable and responsible use of natural resources. For reuse in landfills, microbial activity in the soil serves as a bioindicator of contamination risks, especially from the leachate retention pond. In short, engineered solutions applied to the otherwise waste material could effectively give second lives to the dredged marine soils, minimising the need for customised dump sites, as well as additional transportation and operational costs in the long run.

**Keywords:** Reclamation, marine soil, granula, contamination



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**EDITORS**  
**CHEE-MING CHAN**  
**MOHAMMAD ZAWAWI ROSMAN**



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from Malaysian Waters **2**

EDITORS

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MOHAMMAD ZAWAWI ROSMAN



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# *Preface*

This is the second book in the series written to give an insight to some feasible techniques for reusing dredged marine soils. The reuse potential of the treated soils can be found in reclamation works as well as landfill liners. Admixed with stabilising agents and granular materials, the originally soft and weak dredged marine soils can be transformed into stable backfills in artificial land creation. The granular additions could be sourced from industrial or construction wastes, further enhancing the sustainable and responsible use of natural resources. For reuse in landfills, microbial activity in the soil serves as a bioindicator of contamination risks, especially from the leachate retention pond. In short, engineered solutions applied to the otherwise waste material could effectively give second lives to the dredged marine soils, minimising the need for customised dump sites, as well as additional transportation and operational costs in the long run.

# *Prologue*

In this compilation of research work on the dredged marine soils from Malaysian waters, readers are guided through a number of pre-treatment methods to make the materials safe and fit for engineered reuse. The techniques presented include induced cementation, with and without addition of granular materials derived from sand or industrial by-products. Passive self-cleansing of the soils via biological approach is also explored with a parametric study of microbial survivability in the displaced materials. Emphasis was put on the 'green' values in the chosen techniques, such as using locally available additive and waste materials, minimizing alteration of the soils to avoid incurrance of extra costs, among others. In a nutshell, this book illustrates the potentially effective mass adoption of 'green' pre-treatment, including induced solidification and biological passive self-cleansing, for improvement of the materials' engineering properties to ensure their suitability for second lives in various engineering applications.

# Chapter 1

## Induced cementation for improved load resistance

Amira Azhar  
Chee-Ming Chan

### 1.1 General

This chapter presents the results obtained from tests on dredged marine soil (DMS) samples treated with cement and bottom ash. As the DMS is of slurry form with limited shear strength for load-bearing, any attempts to reuse the material as a good engineering soil would require pre-treatment for strength enhancement. The discussion begins with description of the physical and chemical properties of DMS from different locations in Peninsular Malaysia, i.e. Marina Melaka (Marina) and Tok Bali (Tok Bali A and Tok Bali B). These properties are very important for describing and explaining the behaviour of DMS. The main focus of this study is to evaluate the effect on strength of DMS solidified with cement and bottom ash. Besides that, the geo-environmental impact of solidified DMS' application in the construction industry is also discussed in this chapter. It is crucial to identify the leaching properties of the solidified materials to prevent contamination of surrounding grounds when used for construction purposes.

### 1.2 Physical and Chemical Properties of Dredged Marine Soils (DMS)

#### 1.2.1 Physical Properties of DMS

Physical and chemical properties of the soil is required for making the decision of either to use or dispose of the DMS (Lee, 2004). Table 1.1 shows the physical characteristics of the three DMS samples examined in the present work. Based on the results obtained, the moisture content varies for each sample. For Marina, the value of

## Chapter 2

# Accelerated consolidation with light cementation and sand-admixing

Suaathi Kaliannan  
Chee-Ming Chan

### 2.1 General

In this chapter, analysis and discussions are presented on the one-dimensional compressibility test results of dredged marine soil (DMS) admixed with small dosage of cement and sand. The cement enabled stabilisation while the sand functioned as a filler material to form scaffolding for better structuring of the stabilised material. The relevant compressibility parameters, including consolidation rate, settlement reduction, permeability and stiffness were examined and elaborated. All in all, the light cementation with sand admixing transformed the otherwise highly compressible DMS into a structured sand-clay matrix held together by cementitious bond for improved deformation resistance upon loading.

### 2.2 Analysis of $t_{50}$ and $t_{90}$

Theoretically  $t_{50}$  and  $t_{90}$  are identified in all plots of settlement curves using the Casagrande (time on a log scale) or Taylor (square root of time) method, but practically  $t_{50}$  and  $t_{90}$  could not be determined in every plot of settlement curves due to irregularities of the plots. Figures 2.1 and 2.2 show examples of plots where  $t_{90}$  and  $t_{50}$  could not be derived. If the specimen has sustained a certain load previously, and a smaller or same load is being applied again, the settlement curve will not display immediate settlement, primary and secondary consolidation stages. The higher the percentage of binders, the higher the pressure needed to be applied for displacement to take place. This can be observed in the settlement-time plot, where it takes a larger load to induce a visible settlement. For example, for

## Chapter 3

# Enhanced solidification with waste granular materials (WGM)

Mohammad Zawawi Rosman  
Chee-Ming Chan

### 3.1 Introduction

In this chapter, investigation on the solidification effects of waste granular materials (WGM) admixed with dredged marine soil (DMS) is presented. Examination of the improved performance of dredged marine clay admixed with WGM is sub-divided into two parts in the chapter, namely preliminary and main test results. WGM used in the study are palm oil clinker, bottom ash and sand as control sample. The results of shear strength and shear resistance of cement and WGM admixed soil samples were acquired from the preliminary tests. The main findings for this study are the values of compressibility and settlement rate, which resulted from the oedometer test in the main test series. The summary of the cement and WGM effects on DMS is tabulated in Table 3.13 correlating all the parameters examined.

### 3.2 Physical and Chemical Properties of DMS

The basic physical properties of DMS in Kuala Muda, Kedah are tabulated in Table 3.1. The natural water content for this soil is 91.96%. Based on the Atterberg limit tests, the values of plastic and liquid limits are 31.50% and 47.70%, respectively. According to Unified Soil Classification System (USCS), the soil is classified as a low plasticity silt (ML). The obtained specific gravity value for this soil is 2.57. Figure 3.1 shows the particle size distribution of DMS and WGM. The DMS consists of 1% gravel, 41% of sand, 31% of silt and 27% of clay.

## Chapter 4

# Microbial survival study for self-cleansing potential of contamination

Nurasiah Mira Anuar  
Chee-Ming Chan

### 4.1 Introduction

This chapter presents the results obtained from laboratory tests of natural and treated dredged marine soil samples on the microbial survival study for self-cleansing potential of contamination. Table 4.1 summarizes glossary of all the specimens in this study. Table 4.2 shows the mass of dry clay ( $M_c$ ), mass of activated steel slag ( $M_s$ ), mass of dilution of NaOH ( $M_w$ ) used in this study.

### 4.2 Dredged marine soil physico-chemical characteristics

Analysis was conducted on the physico-chemical of marine soils samples dredged from two different dredged sites in Peninsular Malaysia, i.e. Marina Melaka (MM) and Tok Bali (TB). For appropriate understanding of the biological contamination level of the dredged marine soils, it is essential to identify the type of soil and its corresponding particle size, salinity, pH, moisture content as well as the chemical properties.

The results of the present study show that the physico-chemical characteristics of the dredged marine soil measured varied between the sites. Such variations in the characteristics from one location to another could be attributed to the local environment, as affected by various anthropogenic activities, micro-climate and disturbances (Hossain *et al.*, 2012).

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# *Epilogue*

In this book, pre-treatment techniques considered viable to transform the dredged marine soils into reusable materials in civil engineering field applications particularly are discussed. The techniques selected had the unique feature of being 'green', i.e. with environmental impact, adopting locally available materials and minimizing energy consumption. The pre-treatment methods examined were found to be potentially applicable in situ, though pilot study in the field would be necessary for further verifications.