STUDY ON THE CHARACTERISTIC OF MARINE DREDGED SEDIMENT AT LUMUT USING ADMIXTURE.

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SCHOOL OF CIVIL ENGINEERING
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By

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I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

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ABSTRAK

Proses pengorekkan atau melombong tanah dari laut dilakukan setiap tahun di perkarangan pelabuhan untuk memastikan kedalaman yang mencukupi untuk kapal berlabuh di pelabuhan. Di Malaysia hasil tanah penggorekkan diklasifikasikan sebagai barang buang dan tidak berguna, ianya dibuang balik kedalam laut atau dikumpulkan di suatu tempat. Tanah pengorekkan ini boleh digunakan balik dan dikitar semula sekiranya ciri ciri tanah ini tidak merbahaya dan boleh diubahpakai. Kajian ini bertujuan untuk mencari sifat atau ciri ciri fizikal dan kimia untuk tanah penggorekkan ini dan ianya distabilkan menggunakan bahan tambah. Bagi tujuan kajian ini sampel tanah diambil dari jeti Lumut (Perak) dan perbandingan sifat tanah pengorekkan di buat dengan kajian dahulu yang menggunakan sampel tanah dari Lumut (Perak), Marina (Melaka) dan Tok Bali (Kelantan). Sampel tanah ini distabilkan menggunakan simen (OPC) dan buih yang dihasilkan menggunakan mesin. Ujian kekuatan mampatan dan ujian pisahan tegang digunakan untuk mencari kekuatan sampel tanah yang distabilkan. Hasil dari ujian sifat fizikal, tanah jenis ini adalah pasir yang rapi dan ianya berbeza dengan sampel tanah yang diuji sebelum ini. Ciri kimia mendapati silika dan aluminium mengekploitasi sampel tanah ini. Hasil dari penstabilan untuk menjadi blok pejalan kaki tidak menjadi, mungkin disebabkan kandungan kimia yang bertindak balas,pengubahsuaian diperlukan dalam sampel ini untuk memastikan sampel tanah ini dalam boleh dipakai untuk masa hadapan.

ABSTRACT

Dredge marine sediment commonly extracted from the marine every annum via dredging process. In Malaysia dredge sediment considered as a waste material and this material dump back at sea shore or dumping site after dredging works. Dredge material can beneficially use depending their characteristic, hence this study to determine the characteristic of dredge marine sediment using admixture. Physical and chemical characteristic of dredge marine sediment is carried using the dredge sample taken from Terminal Jetty Lumut Perak and its compared to previous study carried at Lumut (Perak), Marina (Melaka) and Tok Bali (Kelantan). This sample stabilized using ordinary Portland cement (OPC) and chemical foam, hence strength measurement test such as cube compression test and tensile split test carried. The physical characteristic determined and its considered as well graded sand and different with previous study. The chemical characteristic shown a lot of chemical compound found in this sample such as silica, aluminium and also gold oxide found. The mixture of dredge marine sediment with OPC to produce pave walk didn't give a good results, and mixture of dredge sample with Foam didn't work out, hence some recommendation given to make sure perfect mixture of pave walk produced such as mixing lime and kaolin in this sample and using geotechnical strength testing such as unconfined compression test to determine the strength of this material.

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LIST OF ABBREVIATIONS

DMS	**D**redge **M**arine **S**ediment
OPC	**O**rdinary **P**ortland **C**ement
USCS	**U**nified **S**oil **C**lassification **S**ystem
ASTM	**A**merican **S**ociety for **T**esting and **M**aterial
XRF	**X**-**R**ay **F**luorescence Test
LOI	**L**oss **O**f **I**gnition
BS	**B**ritish **S**tandard

CHAPTER 1

INTRODUCTION

1.1 Background

Dredge material is sediment that taken from marine via dredging process. The dredged sediment is considered as waste materials that need to be disposed at dumping site or inland containment facilities. This material also can beneficially use depending on the physical and chemical and also contaminant level in dredged sediment (Tsuchida, et al., 2001). Naturally dredged sediment requires removal, handling, and placement of earthen materials. Dredge marine sediment, composed of soil and rock, play an important role in the dredging operations conducted worldwide on a daily basis. Testing method and experiment need to be considered in identification and characterization of the geotechnical engineering properties of marine dredging sediment.

Statistic from Malaysian Maritime & Dredging Corporation in year 2010, Malaysia produced nearly 4 million m^3 of sediment in port and jetty during maintenance dredging works. The dredging material was disposed to offshore designated dumping site. The dumping site must be at least 20m deep to make sure minimize disruption to the surrounding waters. The dumping cost preferably 20% high than dredging operation cost (Amira et al,.2014). Apart of cost implication, the dredging sediment can give problem to environment such as pollution, hence stabilisation of dredged soil can avoid negative dumping effects and introduce alternative product for construction purposes. In previous study carried by Dhanya et al. (2011) stated stabilization of dredge marine material can be used in construction field such as backfill material. Moreover, Tsuchida et al. (2001) also stabilized dredge

marine sediment using Ordinary Portland Cement (OPC) and air foam to produce light weight block that can used for construct wall.

In Malaysia, there are several places that routinely doing dredging works, such as Lumut (Perak), Marina (Melaka), Tok Bali (Kelantan), and others. Previous research that has been done clarified that the dredged from this three site is good in environmental view. Lumut, Perak offshore that produce 120 000 m^3 within 8-12 m depth, Marina Melaka near shore within marina Melaka produce 120 000 m^3 within 4 m depth and Tok Bali Kelantan near river mouth produce 140 000 m^3 within 3-5 m depth are some of the locations mentioned by per year (Chan, 2014).

1.2 Study area

The dredging material used in this study was taken from Lumut marine terminal port located at Perak, Malaysia. The Lumut Port is well known for industrial shipping activities and was constructed on 1995 by government of Perak. Lumut port designed and equipped to handle the dry bulk, liquid bulk, break bulk and all conventional cargo and project cargo (Lumut Maritime Terminal). The exact terminal location coordinates latitude 040 08.7’ North (N) and longitude 100°37.3’ East (E) at Lumut Marine. The sample taken by dredging suction hopper and transported to Lumut port by using ship, its routinely done to make sure proper depth for ship navigation in ports. Furthermore, sample for research taken from port and transported to the PPKA laboratory in Universiti Sains Malaysia for testing.

1.3 Problem Statement

Dredging is a process to excavate and removal of sediment from bottom of sea. In Malaysia, dredging works mostly done at ports that involve in shipping and ferry activities that need to maintain their suitable depth and also to enlarge water bodies (Chan, 2014). Dredging is important to flood mitigation and to remove sediments from basin and water bodies. Hence, dredge soil removal need to be done from port area. Dredge soils are mostly dumped back at sea or placed at dumping site it's because of the bad odour produced and it is harmful to human being. Every year, almost hundred million cubic meters of dredge marine sediment produced in dredging works (Chan, 2014).

Furthermore, dredge sediment that produced due to dredging process may affect the environment. It can also create air pollution from bad odour in dredge sediment (Chan, 2014). Dredge marine sediment can be beneficially used in construction purposes depending with physical and chemical characteristics according to Tsuchida et al. (2011) Stabilization of dredge marine sediment by using admixture can be used for construction purposes.

1.4 Objective of Study

The objectives of this research are:

- To determine basic characteristic of marine dredge soil.
- To determine the strength of marine dredge soil.
- To determine optimum mixture of marine dredge soil with additive.

1.5 Scope of Study

The study on this research mainly focuses on the understanding on the basic characteristic and strength of dredge marine sediment in Lumut, Perak. Moreover, additives are used to determine the optimum mixture of marine dredge. The dredging works mostly carried at port area, where Marine Department of Malaysia involves in this dredging works. First of all, the disturbed sample was taken from site at Lumut, Perak and brought to laboratory for testing to determine the basic characteristics of dredge marine sediment. For determining the strength of dredge sample, shear strength of soil was determined by using direct shear test. For understanding the basic characteristic of dredge soil, basic laboratory test carried such as specific gravity, moisture content, particle size distribution by sieve analysis, and proctor compaction test. Strength determination test will required to stabilized dredge marine sediment using Ordinary Portland Cement (OPC) and Foam and tested using compression test and tensile split test.

1.6 Dissertation Study

These dissertation studies consist of five major chapters, where every chapter in this study explaining different part of this study. In chapter one (1) focusing on the background of study, study area, problem statement, objective and the scope of study that will help to give clear image on what study will be. In chapter two (2) it's explaining about the literature review and the characteristic of dredge marine sediment, chemical characteristics, stabilization of dredge marine sediment and strength test for dredge sample. In chapter three (3) the stages of work and testing carried for dredge marine sample stated and including the procedure of works. In chapter four (4) results and discussion obtained from laboratory test carried out including tables, graph and

figure are listed. Chapter five (5) is the final conclusion and recommendation regarding the testing and for improvement in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Dredge Marine Sediment

Dredging works define by Leimera et al. (2010) as expanding and deepen access of water channels, by achieve suitable and exact water depth along marine and waterside facilities to make sure appropriate navigation, this work required to carry maintenance activity in many ports around the world. Continuation of dredging work such as removing accumulated sediments and particles from the bottom of seashore of ports is also necessary. From the previous research in Turkey by Erdogan et al. (2016) around 3 million of marine dredged sediment produced every year from routine dredging activities that carried out at marinas, ports and harbours. Finally this dredged marine sediment will dumped at sea depends by its condition. However, the unrestrained discharge of dredge material into the marine can lead to harmful impacts with physical, chemical or biological risks on marine ecosystems.

Dumping back at sea obviously considered as last option in dredge marine sediment management compared to upland disposal that required high costing, large spaces and long time consuming (Erdogan et al., 2016). Dredging works needed extra vehicle and transportation system during placement of dredge marine sediment in land, such as ship, lorry and back pusher to monitoring DMS. Due to yearly dredging activities, the minimization of dredge marine sediment is not relevant as most prioritized option. There is beneficial used that stated by Erdogan et al. (2016) by utilized dredge marine sediment as a raw material to produce a productive material and provides environmentally friendly, economic and social advantages use.

As stated in according to Waste Framework Directive (2008/98/EC), dredge marine sediment classify as a waste with the waste codes of 17 05 05 (polluted sediment). The fatigue of natural tendency to provide sustainable development approach, the beneficial use of dredge marine sediment has accepted commonly in different application areas such as land development, seashore nourishment, coastal protection, landfill cover, environmental enhancement, wetland creation, sediment cell preservation and construction fill material (Erdogan et al., 2016).

Dredge marine sediment (DMS) that produced by dredging works can be used in multiple purpose depending the condition of dredge (Chan, 2014). After treat the dredge material can be used in some purposes such as upland uses include construction fill, such as highway / road / airport, earthen slopes, mine shaft fill, daily landfill cover, or earthen slopes; soil products, such as landscaping soil, agricultural soil, or bagged soil; and manufactured products such as additives in brick or asphalt manufacturing (Chan, 2014). Wetland uses include construction of wetland, native seed source, berm construction, or bio filters for leachate. Aquatic uses of dredged material include capping of open-water placement sites; filling in-water mining sites; berm construction; or creation of islands, sea grass meadows, and oyster beds.

2.2 Dredging Work Process

Dredging is a procedure to dig up or removing sediments and particle from the underneath of waterways and seashore locations. It is necessary for the preservation of existing navigation channels system or construction of new port and harbour amenities. In Malaysia, dredging works started since 1913 from tin mining industry in Kuala Lumpur (Chan, 2014). To maintain the suitable depth of seashore, most of ports in

Malaysia carried out dredging activity under supervision of Malaysian Maritime & Dredging Corporation.

Figure 2.1: Dredging works carried out at Lumut Port 2015
(Source: https://www.pulse/my-first-project-construction-3000-mt-jetty-shazmier-shah)

The dredging works need to perform by removing the marine soils from the port area by using trailing suction hopper (Chan, 2014). This equipment will be used in port area to excavate the dredge marine sediment and transfer it to ship, than send it to land disposal area. Every year, around hundred million cubic meters of dredge marine sediments (DMS) are produced by dredging works (Malaysian Maritime & Dredging Corporation, 2010). Mostly the dredge material that considered as desecrate will be deserted at sea or placed at dumping site. Previous statistic, nearly 300,000 m^3 volume DMS dredged out from Kuala Perlis alone within two to three years which cost about RM 20 – RM 30 million. In Malaysia there are most of ports currently doing dredging works such as Lumut (Perak), Kuala Perlis (Perlis), Marina (Melaka), Tok Bali (Kelantan), and Pulau Jerejak (Pulau Pinang). In Malaysia DMS considered as a waste material and it was dumped back to sea until 50m depth of sea mean level because of its bad odour and risk to human health (Chan, 2014).

2.2.1 Application of Dredge Marine Sediment in Current Industry

There is a prospective advantageous uses of dredged marine sediments that can be separated into two categories, which is non-structural and structural applications according to Chan (2014). Non-structural applications mostly do not required high loading place upon the fill material, such as golf courses, recreational fill, or landfill applications and for structural applications may consist of roadway sub-base, embankments, or as protective medium.

In the research study of Amira et al. (2014) there is some option need to be consider for soil placing because it's contain contaminants, hence the placement of dredge marine sediment should considered in term of environmental sensitivity and responsibility. In the previous research done by Limeira et al. (2011) stated that, apart from land reclamation and beach sand replenishment, it's also have been used as marine aggregates in specific civil construction at many countries. Experimental studies about dredge marine sediment by Limeira et al. (2011) stated that DMS material extracted from European and American coasts are suitable as construction material for base and sub base pavement.

Moreover, Limeira et al. (2011) also stated dredge marine sediment that deposits around the coasts of great Britain are used in concrete production for several decades, for example the well known structure made by dredge marine sediment concrete are construction of Rotterdam Harbor (Netherlands), the Great Belt Bridge (between Denmark and Sweden), and the Thames Barrier, London's National Theatre, and also at Hong Kong airport and Palm island in Dubai.

(Delta Proof Stova company, 2008) which is expert in reuse dredge material have mentioned that they are re use of dredge material in Netherland as a resource for

construction. Reuse of dredge material can be reduce the cost of construction material when. This help contractor to combine projects and construction activity in effective way, its tend to save cost and environmental friendly.

2.3 Characteristic of Dredge Marine Sediment

Previous study by Chan (2014) stated that dredge marine sediment (DMS) can be considered as a natural resources and a reusable product in construction industry unless it's contained by other bad or any industrial pollutant. For instance, if the dredge consists of coarse particles, it can be used for landfill while fine particle can be used for landscape or agricultural purpose; it depends by characteristic of DMS.

Dredged marine sediment also has poor engineering properties whichever in wet or dry condition. DMS controlled for usage due to some possible contaminant. As mentioned by Chan (2014) dredge marine sediment mostly in grey and black colour with high plasticity index and it's considered as silty clay. According to Unified Soil Classification System (USCS), the DMS was classified as high plasticity clay (CH) stated in research study (Amira et al., 2014). In previous research carried has been determined that the plastic limit and plasticity index were considerably high and the optimum moisture content was below plastic limit for DMS, it's also shown that dredge material are low engineering properties.

Figure 2.2: Dredge Marine sediment in grey colour
(Source: http://article.sapub.org/10.5923.c.jce.201402.07.html)

There is a most advantageous solution for dredge marine sediment by treat it using pozzolonic additive Chan (2014) to reduce the moisture content of DMS and recover its engineering properties. Quality of dredge marine sediment reflects the environment by origin of this material and related contamination from local or distance sources of this material. Moreover, dredge marine sediment also contained clean gravel and sands or contaminated fine- grained soils, with its own properties. The fine grained soils might give high risk to human health and also surrounding environment Amira et al. (2014) hence there is stabilization method or removal treatment for DMS to make sure it's suitable to use.

DMS considered as valuable resources can be used due to its characteristics can be stabilized. DMS can give a big contribute to sustainable development by reduce the amount of natural resources such as soil and minerals that used for construction and habitat creation, for example Japan have utilised 90% of dredge marine sediment for lots of purposes (Amira et al., 2014).

2.4 Material Properties of Dredge Marine Sediment

According to research study carried by Amira et al. (2014) dredge marine sediment have been collected around Malaysia at three different places with different type of dredge sample. The location sample taken are from Lumut (Perak), Marina (Melaka) and Tok Bali (Kelantan). The sample taken from different place get their own specific characteristic and it's symbolise different localities that have different anthropogenic activity in their location (Amira et al., 2014). This all variety locations were distributed around the west and east coast of Peninsular Malaysia. Grubb et al. (2010) mentioned fresh dredge material classified as CH/OH soil following United Soil Classification system (USCS) (ASTM 2487).

This sample used for research study of dredge marine sediment characteristics purpose. Marine Department of Malaysia are respective and responsible for any dredging works around Malaysian ports Amira et al. (2014) include Lumut, Marina and Tok Bali.

Figure 2.3: Location of Dredge Material sample Taken (Amira et al., 2014)

According to Chan (2014) there some special techniques used to collect the dredge sample at this three location such as sample at Lumut collected by using Trailing Suction Hopper Dredger at the specific depth at 8 – 12m depth from sea level. Dredge marine sediment from Marina Melaka was collected by using cutter suction dredger at the specific depth of 3.5 – 6.5m from sea level. Meanwhile at Tok Bali dredge marine sediment was collected by using backhoe dredger or grab equipment machineries at the specific depth 3.5 – 5.0m.

In Table 1 it's clearly shown the amount of dredge marine sediment that collected from these locations in the year 2013. As mentioned by Amira et al. (2014) the entire sample taken for testing was protected and put in sealed plastics bag to avoiding any losses in moisture during transportation. These samples was stored inside the laboratory to avoiding direct sunlight and heat on samples, it's because high temperature surrounding can obliterate organic matter and results to mass loss.

Table 2.1: Volume of dredged every year (Marine Department of Malaysia, 2013) (Amira et al., 2014)

Port	Volume of DMS (m^3)
Lumut	120, 000
Marina	120, 000
Tok Bali	140, 000

Dredge marine sediment produced all around the world, lots of research carried by the Wang et al. (2010) regarding solidification and stabilization of dredge marine sediment to use for construction purpose. As mentioned in research in France nearly 50 x 10^6 m^3 of DMS produced yearly from 17 commercial ports and 5 huge maritime ports. Moreover in America alone, about 300 x 10^6 m^3 of dredge marine

sediment excavated every year from US waterway channel and also near 46 x $10^{\wedge 6}$ m^3 of DMS disposed to seashore (Wang et al., 2010).

2.4.1 Method of Testing To Determine Characteristic of Dredge Material

Previous research conducted by Amira et al. (2014) mentioned that, there is test carried to determine physical and chemical properties of dredged marine sediment followed to British Standard 1377:1990 and American Society for Testing and Material (ASTM). According ASTM standard moisture content of dredged marine sediment defined as the ratio of weight of water to the weight of dry soil in a given soil mass. Moisture content for dredge marine sediment can determined by using oven dry method with the temperature 105 (+ or -) 5°C. According to Chan (2014) the plastic limit test used to determine the soil changes from semi-solid state to plastic state. As mention in ASTM standard for plastic limit test, the sample was roll till become thread at least 0.3mm of diameter. Furthermore, liquid limit test also used to determine the characteristic of DMS; it's helpful to determine the changes in soil from plastic state to liquid state.

Amira et al. (2014) used wet sieving and hydrometer test to determine particle size distribution of dredge marine sediment. Particles density test obtained using small Pcynometer test and also mass loss on ignition (LOI) measured by heating the dredge marine sediment at 440°C; it's used to determine the organic content of DMS. To determine the chemical composition and characteristic in sample, X – Ray fluorescence (XRF) method is required, hence the sample for XRF analysis prepared by using 7g of sample mixed with 3g of wax.

2.5 Physical Characteristic of Dredge Marine Sediment

Every sample taken from any location get their own characteristic, hence geotechnical characterization is must to determine and predict dredge marine sediment material properties. Moreover geotechnical characterization also required before making decision on DMS either want to use it or dispose to sea shore or disposal site (Amira et al., 2014). Every sample gets their own characteristic depending their origin location of dredge material taken, such as Wang et al. (2010) research experiment on DMS at Dunkirk harbour, France resulting the physical characteristic such as water content using drying method is 106.5% at 40°C shown that water content high than Liquid limit for DMS (Wang et al., 2010). For liquid limit test, the water content between liquid and a plastic state are 51.4% by using percussion cup method. The rolling sediment method to determine plastic limit give result transition from plastic to semi solid around 25.6% (Wang et al., 2010).

Table 2.2: physical Characteristic of DMS from Dunkirk Harbour, France (Wang et al., 2010)

Parameters	Value
Initial water content (%)	106.5
Absolute density (g/cm3)	2.58
Methylene blue value (g/100 g)	2.2
Organic matter content (%)	4.4
Particle size distribution (%)	14.5
grain size < grain size	63μm
Liquid limit (%)	51.4
Plastic limit (%)	25.6
Plasticity index (%)	25.8

In Malaysia as mentioned before there is some research have been done by some researchers regarding dredge marine sediment. According to Amira et al. (2014) there is results for DMS such as moisture content for Lumut (L) value obtained is 166.16%, for Marina Melaka (M) is 142.97% and 92.33 % for Tok Bali (T), hence Lumut Port dredge consisting high moisture content value compared to other two location. Grubb et al. (2010) as mentioning the DMS moisture content value around 100 – 200%. Furthermore, liquid limit is water content between semi liquid and plastic state, while plastic limit is moisture content from semi solid to plastic state. In experiment carried by Amira et al. (2014) the liquid limit for sample L,M and T are 95.80%, 65.00% and 36.90% while plastic limit value are 34.40%, 50.46% and 25.83%, hence the plasticity index are 61.40%, 14.54% and 11.70% for sample location Lumut, Marina and Tok Bali.

According to Amira et al. (2014) particle density amorphous as an average density of solid particles in a sample of soil where volume include voids that contained in soil particles. Previous research shown the value of particle density for every location varied such as 2.60 for Lumut, 2.56 for Marina and 2.41 for Tok Bali. Furthermore, particle size distribution results get from wet sieving and hydrometer analysis hence the from the test passing percentage for L DMS sample are gravel, sand, silts and clay 3%, 14%, 8%, and 75% its classified as highly plasticity clay (CH) based on USCS. For sample M consist gravel, sand, silts, and clay with 3%, 9%, 18% and 66%, it's classified as low plasticity clay (CL) (Amira et al., 2014). Moreover for sample T it's consisting of 5% gravel, 20% of sand, 16% of silts and 59% of clay hence it's classified as silt (ML). According to Amira et al. (2014) percentage silt and sand sediment high for Marina and Tok Bali compared to Lumut, its might different due to the origin of ports and their anthropogenic activities in that area, such as mining

activity at Sungai Semerak, Tok Bali increase silts and sand particles in DMS. In Marina the location located nearby with shore hence sedimentation of sand beach might occur, its increase silts and sand particles. The plasticity index of Marina and Tok Bali decrease with increasing sand and silts particles, because it will lower plasticity compared to clay. There are table 3 showing the result tabulation for DMS by (Amira et al., 2014).

Table 2.3 : Physical properties of DMS in Malaysia (2014)

(Amira et al., 2014)

Properties	Lumut	Marina	Tok Bali
Moisture Content (%)	166.16	142.97	92.23
Liquid Limit (%)	95.80	65.00	36.90
Plastic Limit (%)	34.40	50.46	25.83
Plasticity Index (%)	61.40	14.54	11.07
Particle Density (%)	2.60	2.56	2.41

As mentioned by Chan (2014) in texture of DMS, from PSD data dredge material are fine grained soils with small amount of sand. In geo mechanical soil behaviour shown sample > 75% contained silt and clay fraction. According Chan (2014) water content naturally more than liquid limit, this transformed the sediment into soft, fluid mass inadequate for any load bearing purpose. UCCS used as reference to determine the physical properties that shown silt and clay mainly play the major role in DMS at these locations. According Chan (2014) presence of clay in DMS as indicator to site Lumut with high plasticity index.

2.6 Chemical Characteristic of Dredge Marine Sediment

Chemical characteristic of Dredge marine sediment, DMS must be conduct according to the British Standard 1377:1990 and American Society for Testing and Material (ASTM) by Amira et al. (2014). According to Chan (2014) sample that taken from Lumut, Marina and Tok Bali have been tested to determine chemical properties using X-Ray Fluorescence (XRF) element technique, its show the component contained in DMS. In dredge material the major portion element are Silicon (Si) roughly 56-63 % (Chan, 2014). Due to presence of quartz in DMS its produce most of amount of Si, it's a most common mineral found in earth. Si is a most considerable mineral for all rocks such as igneous, sedimentary and metamorphic rocks that become a parent material for all soils. According to Maren et al. (2015) silicones are deriving from sand and silt while for clay fraction aluminium plays the major role. Overall chemical composition of the sample shown that illite, an aluminium silicate was found to be main clay mineral that detected by XRF. Hence table 4 show the composition of chemical component in DMS at location Lumut, Marina and Tok Bali.

Table 2.4: Chemical properties in Dredge Marine Sediment in 3 Location (Chan, 2014)

Element Oxides (%)		Samples	
	Lumut (L)	Marina, Melaka (M)	To Bali (T)
Aluminium Oxide (Al_2O_3)	17.10	20.73	21.10
Calcium Oxide (CaO)	3.25	2.58	4.19
Iron Oxide (Fe_2O_3)	4.60	6.50	7.50

Potassium Oxide (K_2O)	2.24	2.81	2.75
Magnesium Oxide (MgO)	2.44	2.30	2.20
Silicon dioxide (SiO_2)	63.40	55.67	55.67
Sulphur trioxide (SO_3)	1.66	1.53	1.84
Titanium dioxide (TiO_2)	0.68	0.96	0.91
Sodium oxide (Na_2O)	1.67	2.49	1.57

Moreover there is some more test carried to determine chemical properties of DMS by Amira et al. (2014) such as organic content, loss of ignition test was carried into DMS, hence LOI value for Lumut is 6.33, Marina 9.49 and Tok Bali 4.78. Furthermore, in geotechnical engineering term, organic content more than 20% only can classified as organic soils. The value of LOI for this 3 location are less than 20%, its will be classified as inorganic soil (Huat, 2011). Sea creature such as sea grasses, shells and other organism that decomposed to produce organic content in marine soil within low percentage. To determine the value of alkalinity and acidity ph used at certain material, table 5 used to tabulate the value of ph for this three location.

According to Amira et al. (2014) research study shown the value of pH concentration greater than 7 for all three locations, hence it's proved dredge marine sediment at Malaysia are alkaline. X-ray fluorescence method (XRF) used to determine the chemical component of DMS, from the test carried by Amira et al. (2014) has mentioned that dredge marine sediment are major contained with alumina, silica, and iron oxide.

Table 2.5 : Loss of ignition and pH of DMS at Lumut, Marina and Tok Bali (Amira et al., 2014)

Chemical Properties		Sample	
	Lumut	Marina	Tok Bali
Loss on ignition	6.33	9.49	4.78
pH	8.22	8.32	8.51

Comparing from research carried by Amira et al. (2014), there is some other research carried at other country using DMS. According to Grubb et al. (2010) in his previous research about DMS sample, its consist CH/Oh from U.S. Army Corps of engineers Craney Island that disposed at Hampton Roads, Virginia. All the testing method and procedure for organic content followed the by ASTM D2974 (ASTM 2000c) (LOI 450°C), are 3.3% less than organic content in three location in Malaysia, it's proved that DMS contain inorganic content.

Figure 2.4 : DMS sampling event, USACE Craney Island, Hampton Roads, VA (Grubb et al., 2010)

2.7 Physico – Chemical Properties of Samples from Lumut, Marina and Tok Bali

Previous study has been done to determine the physical and chemical properties of dredge marine sediment at Lumut, Marina and Tok Bali samples. The results of dredge marine sediment for physical and chemical properties compared to results from Kuala Perlis and Craney Island. Grubb et al. (2010) have been mentioned the properties of physical and chemical from Craney Island. Hence there is comparison between Kuala Perlis and Craney Island with this three location shown in table 7 by (Amira et al., 2014). DMS at Lumut, Marina and Tok Bali get similarities in properties with Kuala Perlis and Craney Island. According to Limeira (2011) mostly moisture content of DMS are high, its seem cause low strength of sample.

As a result of experiment carried by Amira et al. (2014) particle size distribution show each sample consist sands, clay and silt. Moreover, plasticity index in sample Lumut, Kuala Perlis and Craney Island high than Marina and Tok Bali, it might be a reason due to high contaminated of silt in sample compared to clay (Grubb et al., 2010). Silt is low plasticity compared to clay. In table 7 XRF results compared with previous research, it's summarized that chemical composition from Lumut, Marina Melaka and Tok Bali has similar chemical composition, but DMS at Kuala Perlis does not have sulphur trioxide and DMS at Craney Island does not have titanium dioxide.

Table 2.6 : Comparison of physical and chemical properties in DMS

(Amira et al., 2014)

Properties	Lumut	Marina	Tok Bali	Kuala Perlis	Craney Island
Moisture Content	166.16 %	142.97%	92.23%	66.13%	117.8%

Liquid Limit	95.80%	65.00%	36.90%	71.05%	62.00%
Plastic Limit	34.40%	50.46%	25.83%	39.13%	26%
Plasticity Index	61.40%	14.54%	11.07%	31.77%	39%
Particle Density	2.60	2.56	2.41	2.15%	2.75
Loss on Ignition	6.33	9.49	4.78	11.98%	3.3
pH	8.22	8.32	8.51	6.7	6.9 – 7.4

According to the test carried by Amira et al. (2014) there is the value comparison shown similarities between the values among previous study. The organic content also shown that DMS are inorganic component.

Table 2.7 : Comparison XRF results from this three location with others (Amira et al., 2014)

	Lumut	Marina	Tok Bali	Kuala Perlis	Carney Island
AI_2O_3	17.1	21.60	21.10	17.40	12.95
CaO	3.25	1.93	4.04	0.7	4.01
Fe_2O_3	4.59	7.33	7.05	5.26	6.14
K_2O	2.24	2.97	2.64	2.08	2.46
MgO	2.44	2.18	2.24	2.48	1.77
SiO_2	63.40	57.00	57.00	57.88	58.01
SO_3	1.66	1.37	1.87	-	1.41
TiO_2	0.675	1.03	0.85	0.79	-
Na_2O	1.67	1.66	1.26	1.44	1.82

2.8 Biological Characteristic of Dredge Marine Sediment

In previous research study carried by Chan (2014) on dredge marine sediment from Lumut (L), Marina Melaka (M) and Tok Bali(T) to determine the biological characteristic of DMS. As following British standard 6068 “British Standard water Quality,” part 4: Microbiological method enumeration of E.coli and total coli form was conducted, hence the results tabulated in table 2.8 (Chan, 2014).

This test proved that dredge marine sediment in peninsular Malaysia contained E. Coli below EPA’s recommendation under safe level = 2.35 x 10^2 cfu/ml moreover Tok Bali record are high compared to other two Chan (2014), its due to anthropological and human dwellings works nearby the location of sample taken. In table 8 all the results about biological activity was stated. Contained of biological compound in DMS might give a risk to health, especially when it’s reused for creation new landform for human usage.

Table 2.8 : Biological Properties of three locations at Malaysia (Chan, 2014)

Biological Properties	Samples		
	Lumut (L)	Marina Melaka (M)	Tok Bali (T)
E. Coli Total Coliform	n.d 3.1 x 10^2	1.0 x 10^2 2 x 10^2	2.0 x 10^2 n.d
Microbes	Serratia Plymuthica Vibrio Alginolyticus Corynebacterium genitalium	Serratia Marcescens Vibrio vulnificus Edwardsiella Tarda Bacillus cerues Escherichia coli	Escherichia coli

2.9 Solidification and Stabilization of Dredge Marine Sediment using Binders

Dredging works are involved with loosen and dislodge the particle material from ports and disposed it at designated sites such as offshore or and any land (Dhanya et al., 2011). It's involved with land reclamation due to lack of land area, hence its enlarging area at sea side for developments. However, the dredge sample that reclaimed and excavated need to reuse but it's required some pre treatment, to improving its poor engineering properties. Chan (2014) used some application on DMS with improve its properties with enhanced soil strength and reduced vulnerability to water.

According to Grubb et al. (2010), in term of magnitude of soil type, deep soil mixing is carried in Louisiana for foundation improvement to dikes, levees and water control to stabilize the dredge marine sediment. Hence, for pre treatment of DMS option is induced cementation, where hydraulic binder used in DMS as additive to make sure the partial solidification and stabilization.

2.9.1 Hydraulic Binders Used for Solidification of DMS

In the previous test carried by Chan (2014) they induced to use hydraulic binders to stabilize the dredge marine sediment. Hence Ordinary Portland Cement used as primary binders and also some other industrial waste. Chan (2014) stated that industrial waste used to show the greenery and recycle value in revived dredge material. Example such as bottom ashes and fly ashes used that produce from combustion in a coal power plant, and steel slag produced from the steel industry was collected for a part as binders. According Chan (2014) bottom ash and steel slag get