

OEDOMETRIC STUDY OF DREDGED MARINE SOILS ADMIXED WITH SAND FOR SETTLEMENT REDUCTION

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ABSTRACT: Dredged marine soils (DMS) can be reused as fill materials for land reclamation project other than dump back to the open sea. However, in Malaysia, dredged marine soils were considered as a geowaste because of it has poor engineering properties. In the present study, dredged marine soils were excavated from the dredging works near the jetty of Kuala Perlis, Malaysia. To investigate the settlement reduction of DMS, a sand-mixed was used in this study and these results were compared with natural DMS (without sand). Oedometer test were conducted to calculate the consolidation properties of DMS and k -value can be obtained from the test. The test results showed that the dissipation of water from soils occurs faster in the sand-mixed compare to the control sample (without sand) due to the drainage path that have been reduced (two-way drainage).

Keywords: Dredged Marine Soils, Sand, Consolidation, Oedometer Test, Permeability

1. INTRODUCTION

Dredged marine soils (DMS) are originated come from dredging activities. Most dredging is carried out to maintenance the navigation channels by removing the siltation from the seabed. Every year, dredging works creates large amount sediments because of the increasing of urbanization and industrialization along the harbour or ports. IADC [1] stated apart from the maintenance the vessels, several benefits can gain such as the country economics, the population growth, coastal protection, tourism and environment.

China and United States of America had contributed about 100 million m³ and 300 million m³ of sediments every year respectively [2], [3]. Malaysia produce about 3.5 million m³ [4] of dredged marine soils for dredging activities near the ports with cost about RM 20 – 30 million [5]. All the sediments which been remove from the seabed are generally classified as a waste material (geo waste) that required special disposal procedure [6]. Unfortunately, the disposal method by dumping back to the open sea at designated locations is not environmentally sound.

Dredged marine soils are usually have low shear strength, low permeability, high water contents, and high compressibility which are susceptible to have large settlements. The activities from dredging can cause the soil to have loss of bonding stress and fines with water [7]. The initial water content can be influenced the low pressure. On the other hand, when in high pressure the compressibility become less significant because

the c_v do not change in low pressure but increase after the high pressure been applied [8]. This can be done by reducing the pore water pressure and volume of voids in the soil by adding other materials to overcome this problem [9].

Sand is an important material used in a wide spectrum of industrial practices and occupied a very important place in construction work. Sand naturally occurs as granular material composed of broken rock fragments and mineral particles. The increased excess pore water pressure is quickly drained out because of the permeability due to the sand materials [10].

In the present study, the properties of DMS from Kuala Perlis samples such as Atterberg limits, particle size distribution and specific gravity are determined in the laboratory as tabulated in Table 1. Meanwhile, the oedometer tests were conducted to assess the consolidation characteristics of DMS. The results between DMS only and the sand-mixed are compared and discussed in detail.

2. MATERIALS AND METHODS

2.1 Materials

Dredged marine soils in this study were collected from Malaysian waters in Kuala Perlis near the Terminal Jetty of Kuala Perlis. Fig. 1 shows the excavation dredger on the barge which was used to collect the samples. The soils were excavated from a depth of 4 – 6 m below the chart datum at the dredging site. DMS samples (Fig.2) were placed in doubled-layer of sampling bags, sealed inside the pail and labelled before being

transport to the laboratory. Note that the samples need to be stored in a room temperature average 30°C.

In this study, method of wet sieve and hydrometer was conducted to determine the particle size distribution of the samples. This test is necessary for soils which contain mainly of silt, clay or both. Briefly, the experiment commenced with mixing the sample with a solution of sodium carbonate (CaCO₃) and sodium metaphosphate (NaPO₃). The solution was used to separate discrete particles of the samples.

Physical characterisations are important for describing the properties of DMS. Table 1 shows the properties of DMS sample. Based on the results obtained the value of moisture content is 218.07 %. It shows that the soil is in slurry and liquefied. The obtained specific gravity of the sample is 2.68. With liquid and plastic limits of 66.5 % and 55.8 % respectively. According to Unified Soil Classification System (USCS), the DMS is classified as a high plasticity of silt (MH). The previous studies by Salim *et al.* [5] and Kaliannan [11], have much lower w_c with 66.13 % and 147 % respectively. This indicated that the space of time did influence the water content due to the settlement of sediments. Furthermore, dredged marine soils can retain water due to the arrangement of the soil particles.

Fig. 3 shows grain size distribution for DMS and sand. DMS consists of sand and silt with 63 % and 37 % with respectively. Naturally, sand comes from granular materials, which are usually broken rock fragments and mineral particles. The type of sand used in present study was mining sand. The sand particle sizes ranged between 2 – 2.36 mm.



Fig. 1 Excavation dredger on the barge in Kuala Perlis, Malaysia



Fig. 2 Dredged marine soils (DMS)

Fig. 3 Grain size distribution of DMS and sand

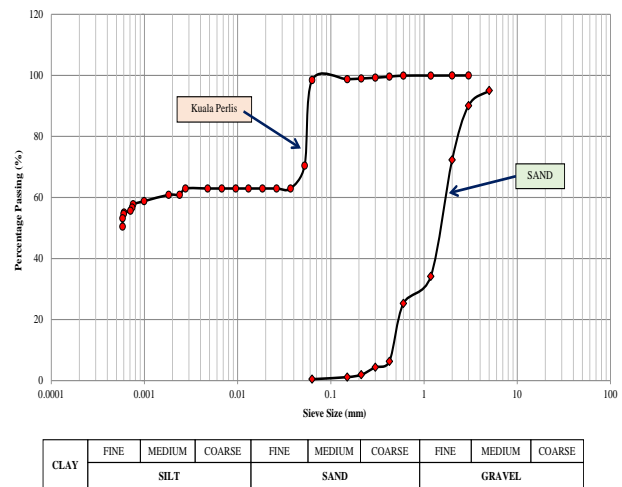


Table 1 DMS characterization for Kuala Perlis

Properties	DMS Kuala Perlis
Initial water content, w_c	218.07 %
Specific gravity, G_s	2.68
Liquid limit, LL	66.5 %
Plastic limit, PL	55.8 %
Plasticity index, PI	10.69
pH	8.0
Soil classification (USCS)	MH (high plasticity silt)

2.2 Specimen Preparation and Test Methods

Considering that the soil samples were disturbed but representative of the field conditions, they were remoulded by manual and mechanical mixing prior to use in the test series. The soil sample was first manually hand-kneaded, followed by mechanical mixing in a mixer. The samples need to be prepared as in Fig. 4. The proportion of sand and DMS content is determined in percent respect to dry weight of soil. The purpose of mixing with kitchen mixer was to make sure the samples are

uniform. The homogenous mixture was then transferred into a metal ring of oedometer mould (75 mm dia. x 20 mm thick).

Oedometer test was carried out by following the procedure prescribed in BS 1377 [12]. The ring containing the cured specimen was placed between the two porous stones, one at the top of the specimen and another at the bottom. Incremental vertical stress was applied as follows: 5, 12.5, 25, 50, 100, 200, 400 and 800 kPa, with each load being maintained for 24 hours.

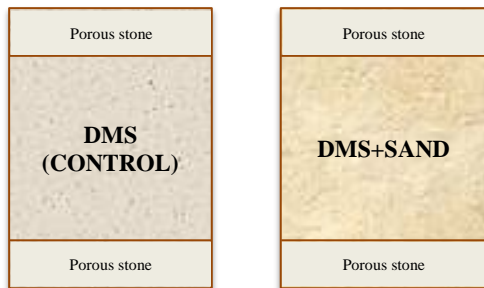


Fig. 4 Illustration of samples

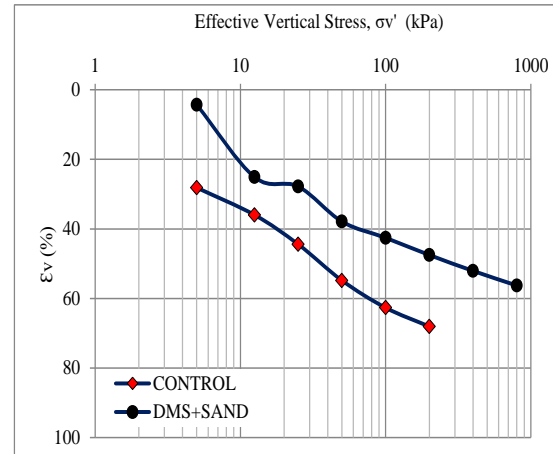
3. RESULTS AND DISCUSSIONS

Fig. 5 shows the settlement curves for Kuala Perlis samples, as recorded in oedometer tests. The compression curves show the dredged marine soils as a control samples and DMS admixed with sand. From these findings, it can be concluded that the percentage of settlement have reduced significantly for DMS admixed with sand in homogenous state. This suggests the granular admixture also affects the strength improvement of the sample due to the changes of structure of soil-sand particles under the same effective vertical stresses (σ_v').

The consolidation properties of DMS significantly change with effective vertical stress. During the earlier stress increments ($\sigma_v' = 5$ kPa), the c_v value of control specimens slightly increase with the effective vertical stress and then reach the peak at 100 kPa with 16.6 m^2/yr . Totally different for sand admixed specimens, σ_v' at 25 kPa, the c_v increase gradually but then decrease at 50 kPa with 20.7 m^2/yr and slightly increase again at the end with 6.9 m^2/yr . The sand admixed could speeding up the consolidation process, hence from the laboratory results can be predicted that the field c_v values could be higher.

The coefficient of volume compressibility (m_v) Fig. 7 values for the control decrease largely $\sigma_v' > 5$ kPa. Contrary to the sand admixed, which increase for smaller values $\sigma_v' < 12.5$ kPa but then reduces gradually parallel with the control. The permeability, k_{avg} , of specimens for control and

sand admixed as shown in Fig. 8 are 9.46×10^{-9} m/s and 7.87×10^{-9} m/s respectively. Seems that the dissipation of water from soil occurs faster in the admixed sand compare to the control sample (without sand) due to the drainage path have been



reduced (two-way drainage).

Fig. 5 Compression curves

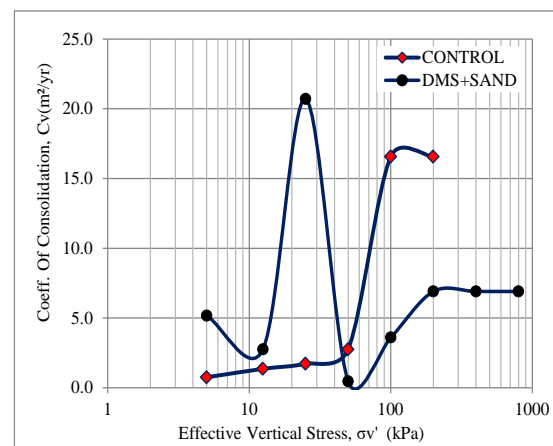


Fig. 6 Coefficient of consolidation (c_v) vs Effective vertical stress (σ_v')

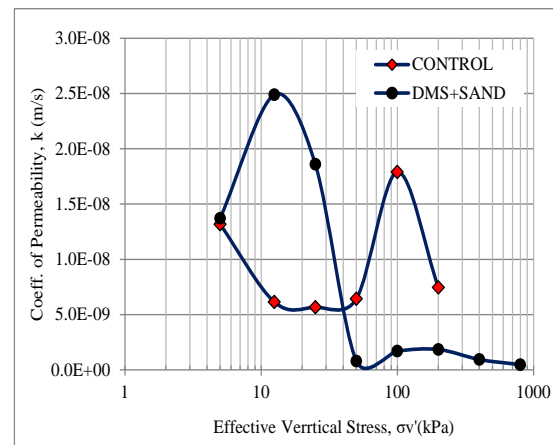


Fig. 7 Coefficient of volume compressibility (m_v)

vs Effective Effective vertical stress (σ_v')

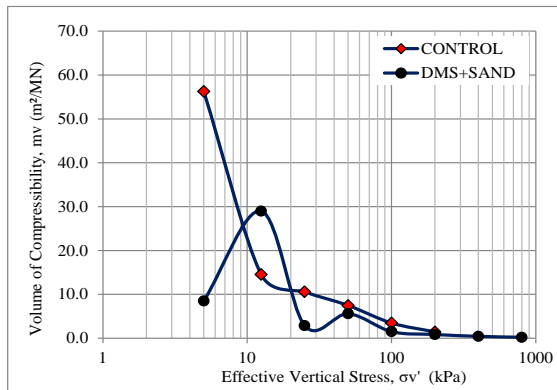


Fig. 8 Coefficient of permeability (k) vs Effective vertical stress (σ_v')

4. CONCLUSIONS

In this study, the water content for sample in Kuala Perlis is 128.07 %. The soil is in liquefied flow nature with W_c/LL value is 3.3 times of liquid limit. The oedometric study of dredged marine soils (DMS) was one-dimensional consolidation, which takes into consideration on its characteristics of remoulded sand admixed and DMS. Both samples were assessed and compared the parameters from the laboratory tests. From these findings, the settlement is highly influenced by the permeability coefficient by using the granular materials (sand) with ratio 1.2 times faster. Further work could include more detailed with other configurations or percentage of sand and DMS used in homogenous state as well as the other granular materials such as recycled materials.

5. ACKNOWLEDGEMENT

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