STABILIZATION OF SEABED DREDGED MATERIALS

Supakij Nontananandh [1]
Prakit Kaewkaorop [2]
Thanet Thongdetsri [3]

[1] *Associate Professor, Dept. of Civil Engineering, Kasetsart University, fengskn@ku.ac.th*
[2,3] *Graduate Student, Dept. of Civil Engineering, Kasetsart University*

ABSTRACT : As concerning beneficial aspects, this research focused on the utilization of seabed dredged materials based on geo-environmental engineering viewpoint. The seabed dredged materials were in slurry state with extremely high water content. Their physical and engineering properties were not suitable for use as construction materials. Therefore, this research introduced the combination concepts of mechanical and chemical stabilizations to improve their major properties prior to utilization. The dewatering and cement stabilization techniques were applied and required properties for sanitary landfill liners such as strength and coefficient of permeability could be obtained. The experimental results revealed that unconfined compressive strengths were influenced by not only the cement content but also the initial water content before mixing. Based on w/c ratio analysis, in order to meet the requirement of strength (2 kg/cm^2) and coefficient of permeability (less than 10^{-7} cm/sec), the recommended w/c ratio suitable for stabilization of the dewatered seabed dredged materials should be within the range of 5.5 - 6.5.

KEYWORDS : Strength, Permeability, Dredged material, Soil stabilization, Cement

1. Introduction

In Thailand, Marine Department is responsible to periodic maintain the water ways by dredging in order to keep traffic operating efficiently. The huge quantities of dredged materials (approximately 8.4 millions cubic meters, Marine Department, 2005) are usually placed into the mud dump site in the sea which may cause adverse effects on environment. Therefore, by considering the utilization of based on the geo-environmental viewpoint can not only eliminate the negative effect on the environments but also can create new construction materials (Kamon, 1989; Nontananandh et. al., 2004). However, the seabed dredged materials have extremely high water content and very low strength, stabilization techniques are needed to improve such materials. Among many successful projects, it has been reported that ground improvement method using cement and lime is suitable to improve soft clayey ground having high water content and high compressibility (Nontananandh and Amornfa, 2002).

This research therefore introduced the combination concepts of mechanical and chemical stabilizations to improve their physical and engineering properties and to Potential use as bottom liners for landfill, based on geo-environmental engineering viewpoint, is also observed.

Experimentally, the approaches used in this study consisted of unconfined compressive strength test to evaluate hardening effects and permeability tests to investigate the improved engineering properties.

2. Materials and Methods

2.1 Materials

The seabed dredged materials used in this research were created during dredging operations of the 2nd water way of Bangkok seaport in Samutprakarn province, Thailand. They were dredged by self-propelled hopper dredge ship as shown in Figure 1.

Figure 1 Self-propelled hopper dredge ship during operation

Naturally, they were in slurry state with dark color and strong organic and salty smell. They contained very high water content (w_n approximately 200 - 300%). Liquid Limit (LL) was 100.67%, Plastic Limit (PL) was 36.88%, and Plasticity Index (PI) was 63.79%. Their particle compositions were 2-5 % sand, 23-25% silt and 64-67% clay. According to the Unified Soil Classification System (USCS), the dewatered dredged materials were classified as clay with high plasticity, CH. Since untreated seabed dredged materials were in liquid state, the undrained shear strength could not be measured.

Therefore mechanical and chemical stabilization were required to improve their major properties prior to utilization. The concepts of improvement are proposed as shown in Table 1.

Table 1 Technical concepts of Improvement of the seabed dredge materials

Step	Process	Purpose
1	On Site Dewatering	To reduce the surplus water in the seabed dredged materials.
2	Laboratory Dewatering	To adjust and obtain the suitable water content before mixing.
3	Mixing with cement	To improve physical and engineering properties as required specification.

On site and laboratory dewatering apparatus, as shown in Figure 2, were simply designed to reduce the surplus water and lower water content in order to obtain target water content. High mixing efficiency (consume relatively low energy) and homogeneous mixtures were considered to correlate with initial water content before mixing. The target water content after dewatering were within a range of 1.4 LL to 1.1 LL (approximately 140% and 110%, respectively).

Figure 2 On site and laboratory dewatering apparatus

2.2 Specimen preparation and tests

Then, the dewatered seabed dredged materials were stabilized with Ordinary Portland Cement type I. The cement contents for mixtures with initial water contents before mixing at 108.99% were 100, 125 and 150 kg/m^3 (SC108/100, SC108/125,and SC108/150, respectively). And, for those having initial water contents before mixing at 137.87%, the cement contents were 150, 200 and 250 kg/m^3 (SC137/150, SC137/200, and SC137/250, respectively). Samples were prepared based on the standard of JSF T821-1990 - practice of making and curing non compacted-stabilized soil specimens. Strength tests were performed based on the standard of ASTM D2166-91 for the unconfined compression tests. Permeability tests were performed based on ASTM D2434-68. The unconfined compression tests were performed after curing time 3, 7, 14, and 28 days. While the permeability tests were performed after curing time 7, and 28 days. The testing procedures are illustrated as shown in Figure 3.

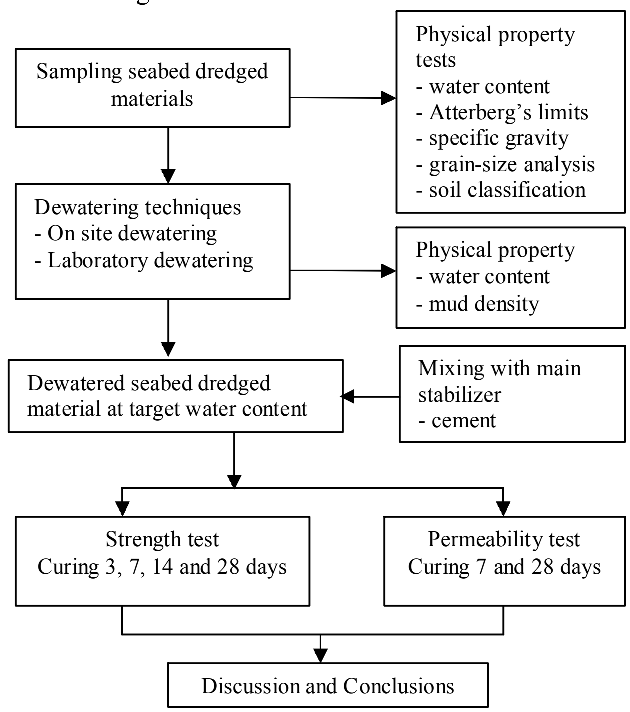

Figure 3 Flow chart of this study

3. Results and Discussions

3.1 Strength characteristics

The results from unconfined compressive strength test of dewatered seabed dredged material mixed with cement for all mixtures revealed that the unconfined compressive strengths (q_u strengths) increased with curing time. At early curing time (3 to 14 days), the q_u strengths increased markedly. In addition, the q_u strengths increased slightly at longer curing time (14 to 28 days), as shown in Figure 4 and Figure 5**.**

For initial water contents before mixing at 108.99% and a low to medium ratio of cement content (100 – 150 kg/m^3), the q_u strengths of these mixtures (SC108/150, SC108/125, and SC108/100) increased linearly with increase in cement content, as shown in Figure 6. For initial water contents before mixing at 137 % and a medium to high ratio of cement content (150 – 250 kg/m^3), as shown in Figure 7**,** the q_u strengths significantly increased when cement content is greater than 200 kg/m^3.

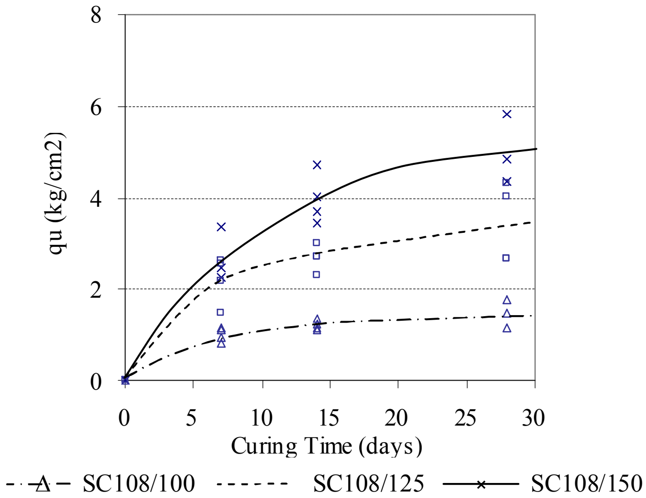

Figure 4 q_u strengths with curing time.
(Initial water content before mixing at 108.99%)

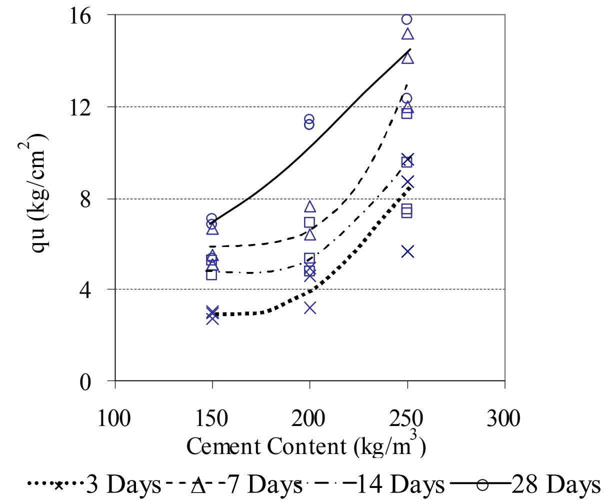

Figure 7 q_u strengths with cement content.
(Initial water content before mixing at 137.87%)

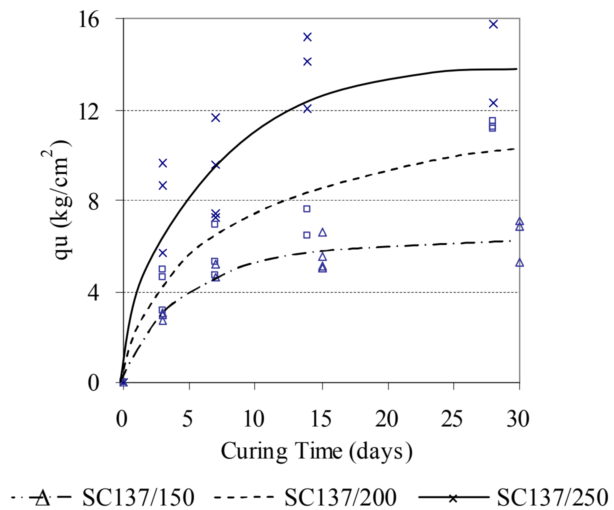

Figure 5 q_u strengths with curing time.
(Initial water content before mixing at 137.87%)

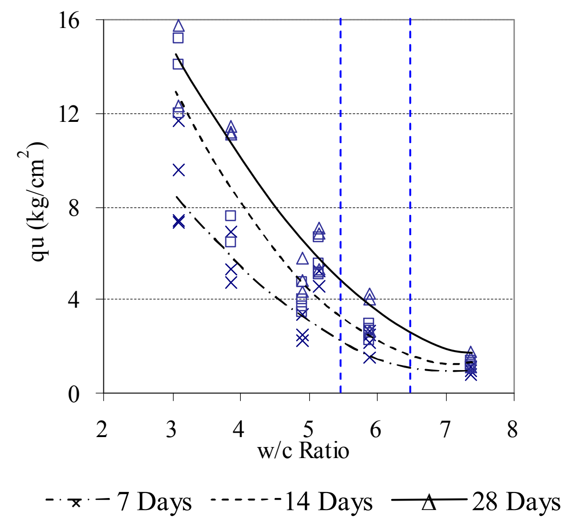

Figure 8 q_u strengths with w/c ratio.

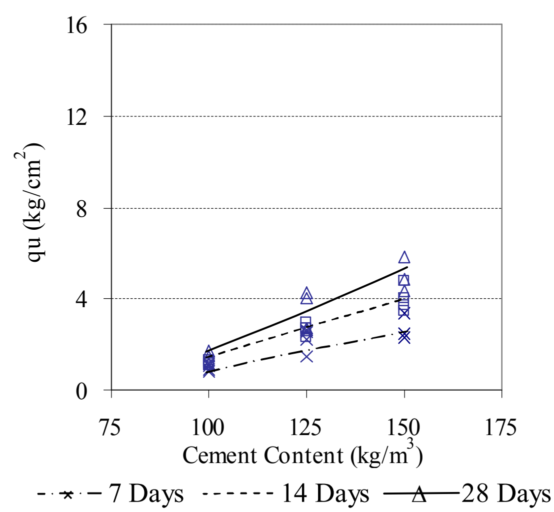

Figure 6 q_u strengths with cement content.
(Initial water content before mixing at 108.99%)

The results revealed that strengths development of the seabed dredged materials were not only influenced by the cement content but also is the initial water content before mixing. Therefore, analyses based on water to cement ratio (w/c) were performed to estimate the q_u strength development in this study. As illustrated in Figure 8, in order to meet the requirement of strength (2 kg/cm^2) for use as landfill liner, the recommended w/c ratio should be within the range of 5.5- 6.5.

3.2 Permeability

Based on the results of permeability tests, Figure 9 and Figure 10 revealed that the coefficients of permeability (k) of cement-stabilized dewatered seabed dredged materials markedly decreased for all cement contents at the early curing time. An average coefficient of permeability of the dewatered seabed dredged materials of 5.54x10^{-7} cm/sec decreased about 10 times after 7 days.

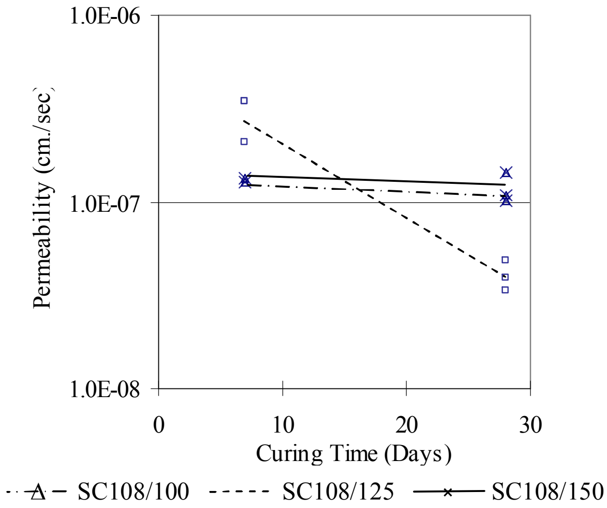

Figure 9 k with curing time.
(Initial water content before mixing at 108.99%)

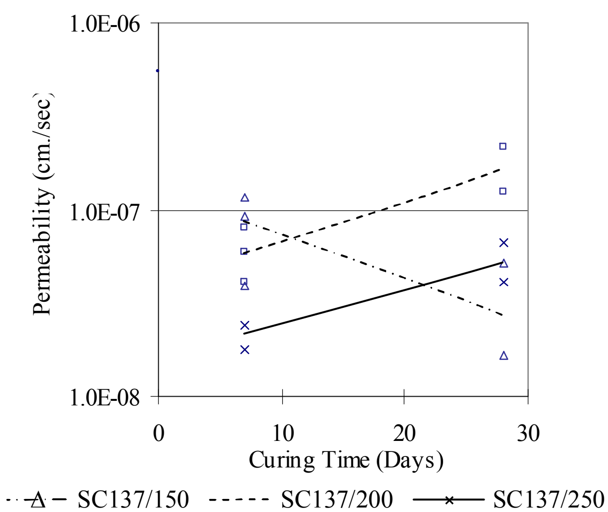

Figure 10 k with curing time.
(Initial water content before mixing at 137.87%)

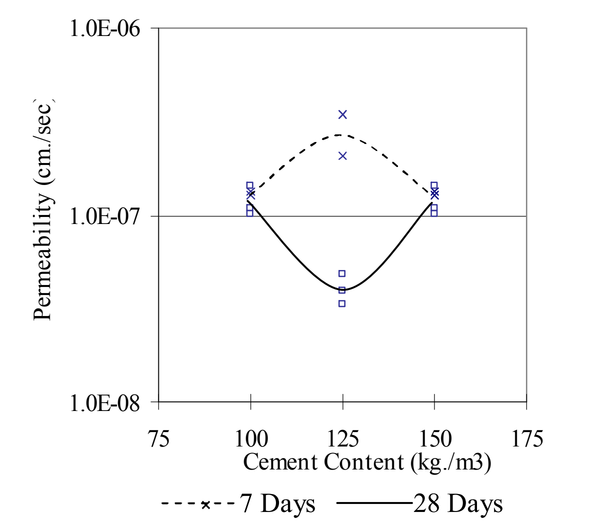

Figure 11 k with cement content.
(Initial water content before mixing at 108.99%)

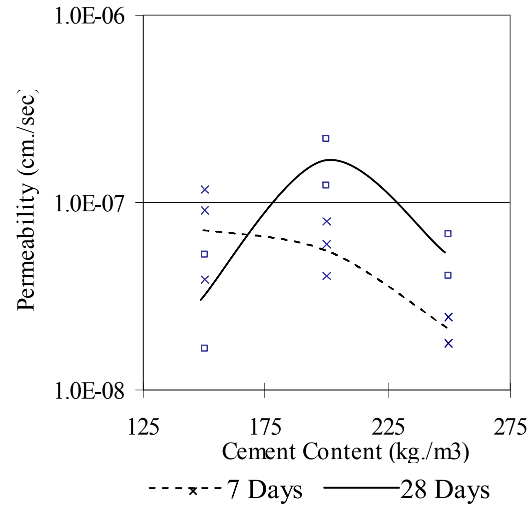

Figure 12 k with cement content.
(Initial water content before mixing at 137.87%)

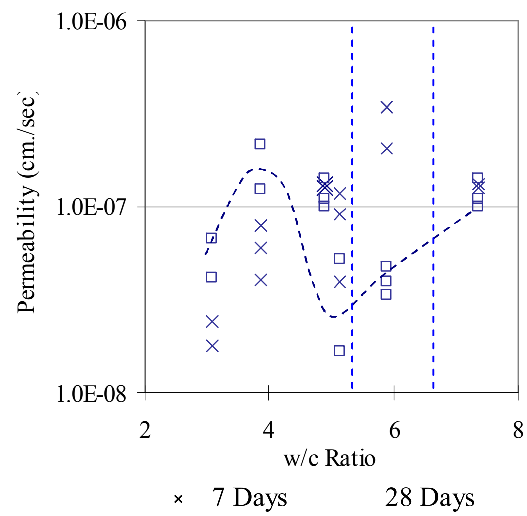

Figure 13 k with w/c ratio.

Figure 11 and Figure 12 illustrated evident that some certain cement contents could develop lower coefficients of permeability (k) at longer curing time (7 days to 28 days). As observed in Figure 13, for medium to low w/c (3 - 5), k seemed to be slightly increased greater than $1x10^{-7}$ cm/sec, while for medium to high w/c (5 – 7.5), k were markedly decreased with curing time (7 days to 28 days). It is therefore recommended that the suitable w/c for stabilization of the dredged materials in order to meet requirement for permeability were also within a range of 5.5 - 6.5, which were agreeable to requirement for strength.

4. Conclusion

Based on the results obtained from this research, it can be concluded that the seabed dredged materials possess high possibility to utilize as construction materials based on geo-environmental engineering viewpoint. The concepts of improvement using mechanical and chemical stabilization are proposed and fruitful results could be obtained. With appropriate selection of w/c ratio (5.5-

6.5), the stabilized seabed materials show potential for use as bottom liners in landfill since they become progressively stronger with low permeability. However, when these stabilized materials are exposed to change of environments such as repetition cycles of wetting and drying, volumetric shrinkage must also be evaluated.

5. Acknowledgement

The authors would like to acknowledge the International Graduate Program in Civil Engineering, Kasetsart University for providing partial fund for this research.

6. Reference

[1] Marine Department of Thailand 2005. http://www.md.go.th/plan/document/sea48.pdf

[2] Kamon, M. 1989. Definition of Environmental Geotechnology. Environmental Control and Waste Disposal, The 12th International Conference on Soil Mechanics and Foundation Engineering (ICSMFE), Discussion Session No.26, 5-9

[3] Nontananandh, S., Boonyong, S.,Yoobanpot, T. and Chantawarangul, K. 2004. Strength Development of Soft Marine Clay Stabilized with Cement and Fly Ash, Kasetsart Journal, Vol.38, No.4, 539-552.

[4] Nontananandh, S. and Amornfa, K.,2002.Stabilization of soft clayey soil using cement and lime, Proc. of the 8th National Convention on Civil Engineering, 2: GTE 120-125.

7. Biographies

Dr. Supakij Nontananandh was born in Bangrak, Bangkok in 1963. Present Positions: Associate Pofessor at the Department of Civil Engineering, Kasetsart University and Vice Dean at the Faculty of Science and Engineering, Chalermphrakiat Sakon Nakhon Province Campus

Mr. Prakit Kaewkaorop was born in Muang, Samut Prakan in 1979. Academic Background: B.Eng.(2001) and M.Eng.(2007) at the Department of Civil Engineering, Fac. of Engineering, Kasetsart University.

Mr. Thanet Thongdetsri was born in Muang, Phayao in 1981. Academic Background: B.Eng.(2004) at Department of Civil Engineering, Fac. of Engineering Naresuan University At present: Graduate Student (Master Degree) at the Dept. of Civil Engineering, Fac. of Engineering, Kasetsart University