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RECOMMENDATION OF PRE-SOLIDIFICATION PROCEDURE FOR HIGHLY ORGANIC SOILS AT VARIOUS DECOMPOSITION LEVELS

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SUMMARY

The peat, also known as soft soils in geotechnics, is highly compressible and soft. The solidification of peat has been studied for years by researchers all over the world. The solidification of peat is one option to sustain the population in peat area. Peat area is not a preferred inhabitants place due to limitation of the road network and infrastructure because of high possibility of settlement issue. The study on peat solidification needs the researcher to handle the peat sample carefully. The pre-solidification procedure is to ensure that the peat sample is prepared to the best condition before begin the mixing process. The preliminary test conducted prior the mixing process based on BS1377:1990. Basically, shear strength test using laboratory vane shear and moisture content test were used in the study. The moisture content and fiber content of peat at various decomposition levels were found to be the important parameter to be controlled during pre-solidification stage. These two parameters affect to the formation of unconfined compressive strength test sample which is the reliable test to measure the strength improvement after solidification. This paper recommends the procedure for pre-solidification process as a guideline for new researcher in this field.

Keywords: *peat, decomposition level, moisture content, shear strength, solidification*

INTRODUCTION

Peat is an important ecosystem that provides a significant contribution to the global climate stability (Adon *et al.,* 2012). Peat is known as soft soils in geotechnics. The treatment to solidify peat is commonly studied by researchers in this field (Wong *et al.,* 2008 and Ali *et al.,* 2010). High moisture content, acidic, porous and less minerals are the contribution factors that affect the peat solidifications. Different stabilizers or binders have been studied by Kalantari (2010), Kolay *et al.* (2011), and Wong *et al.* (2013), successfully improved the strength of peat from 4 kPa to 300 kPa thus proved that peat, at any decomposition levels are possible to be solidified. The concern of this study is to provide the useful solutions to new researcher in this field on how to work towards solidification and counter measures should be taken at this stage. The solidification process should start with understanding insight the nature of peat and all related parameters before mixing could be done.

UNDERSTANDING NATURE OF PEAT

Peat is formed by accumulation of decomposed materials. The decomposition process depends on the plant origin, climate and the microbial activity (Wong *et al.,* 2008). There are three groups of peat, according to its decomposition level. The less decomposed peat is known as fabric peat. The amount of fiber in fabric peat is high which is more than 67 % (USDA, 1999). The less decomposed material in fabric peat normally has large pore size and void in and between the fibers (Mesri and Ajlouni, 2007). The voids in the peat play the important role in holding water (Ali *et al.,* 2010,). It contributes to the high moisture content in peat. The fiber itself, as not fully decomposed, has tendency is to crush when certain force is applied. It makes the peat highly compressible and soft. When tested using vane shear, the fiber in fabric peat is tend to entangle on the vane blade thus lead to the failure of the test.

The moderately decomposed peat is known as hemic peat. The amount of fiber is between 33 - 67 % (USDA, 1999). The hemic peat has smaller void ratio compared to fabric peat. The fiber size is also smaller. This make the hemic peat, at the same sampling location should have retain less water than the fabric peat. The most decomposed peat, namely sapric peat normally has the least moisture content compared to fabric and hemic peat. As the fiber size is decreasing with increasing of the decomposition level, the tendency of the peat sample to be entangled during vane shear test is lower.

The structure of peat, together with the high moisture content; may up to 2000 % must be given serious consideration when doing mixing for solidification purpose. These two properties are the main concern and essential for the effectiveness of peat solidification.

The peat is naturally acidic with pH ranging 3-4 for most tropical area (Abd Rahman and Chan, 2013, Zainorabidin and Bakar, 2003 and Hashim and Islam, 2008). This can be considered as indicator when selecting binder for solidification purpose. The decompose process involves microbial activity. The microbe is understood to live in acidic environment. Therefore, the solidification should change the environment into alkaline state to freeze the decompose process and hinder the microbe from being active. Ordinary portland cement (OPC) is the popular binder that works well in solidification process (Kalantari and Huat, 2008). OPC is alkaline with pH 10-11. The OPC react with water to form ettringite through hydration process (Horpibulsuk, 2012). This ettringite bind the soil particles thus strengthen the peat.

The nature of peat is very important to be understood well by the researcher. The restrictions due to natural condition of the peat should be given rigorous consideration in order to ensure the mixing process went smoothly. In most solidification study, the improvements of strength of the solidified samples are tested using unconfined compressive strength (UCS) test (Wong *et al.*, 2008 and Kalantari, 2010). Therefore, the peat should be prepared to the best condition to ensure the UCS samples could be made.

METHODOLOGY

The pre-solidification is a crucial stage that often miss looked by new researcher. At this stage, the peat is prepared for a mixing. Mixing is the primary process in solidification work. The step-by-step of the process is shown in Figure 1.

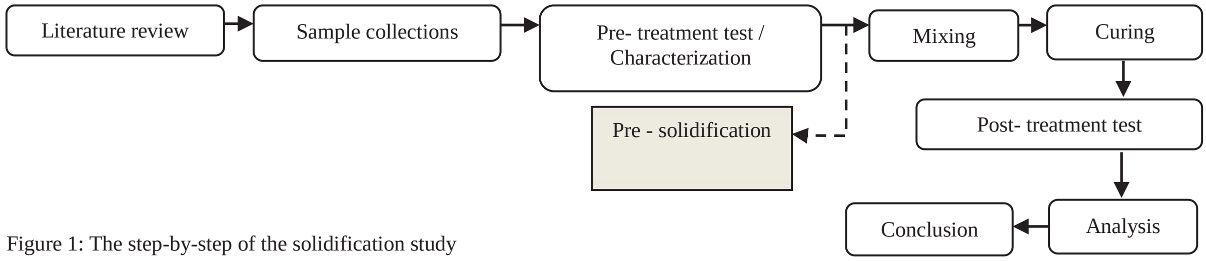
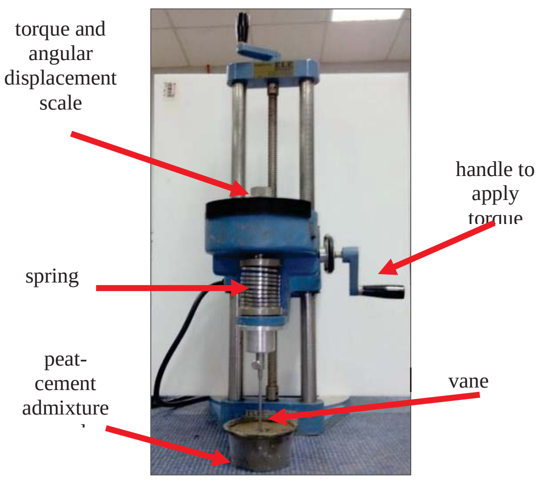


Figure 1: The step-by-step of the solidification study

EXPERIMENTAL TESTS

SHEAR STRENGTH TEST - LABORATORY VANE SHEAR (BS1377 PART 2 :1990)

Laboratory vane shear test was used to determine the strength of the pre-determined mixture as it requires only small amount of sample and can measure small strength. According to ASTM D4648, laboratory vane shear can be used to examine undrained shear strength of below 100 kPa (Figure 2).



The strength value, C_u is calculated using formula;

$$C_u = \frac{T}{\pi d^2}\left(\frac{h}{2} + \frac{d}{6}\right) \tag{1}$$

where;

T = Torque, kθf (Nmm)

h = vane height (mm), = 12.67 mm

d = vane diameter (mm), = 12.67 mm

Figure 2: Laboratory vane shear

MOISTURE CONTENT (BS1377 PART 2:1990)

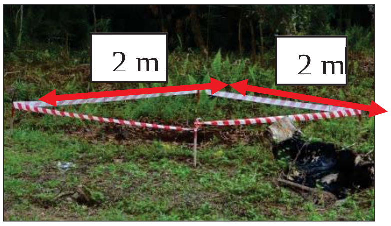
The standard method for determining moisture content of soils is the oven drying method. A drying temperature of 105-110^{o}C is specified in the standard procedure. Moisture content test was carried out to each pre-treatment and post-treatment sample.

DISCUSSION

The pre-solidification stage is prepared to ensure that the peat is fit enough for mixing process. This procedure started from sampling, storing, sorting and controlling the peat condition.

SAMPLING

The solidification work is a rough process. The peat sample can be taken as disturbed with minimal control on the way of handling on site. During sampling, the sampling area should be cleared at considerable area. The top layer of peat does not represent the actual peat condition at the respective area. Therefore, the first 30 cm of the soil layer should be removed from the area. The peat could be taken either manually excavate or using an excavator machine at required depth. Normally, the decomposition level of peat is higher at deeper location. The sample should be covered with a few layers of plastic bags to conserve the moisture content (Figure 3). A proper storage will kept the peat at its best original condition for about 1 year.
In this study, the peat was obtained from Pontian, Johor. The peat collected was observed as greyish dark brown and odourless. The labelling of the peat samples was made in accordance to the physical appearance as stated by Von Post Scale (1926). Table-1 describes the sample profile in detail. All bins of samples were placed in sample room with ambiance temperature.



a) The site area was enclosed by rope

b) Sample was covered with few layers of plastic bags

Figure 3: Sample collection

Table 1: Peat profile at Pontian site

	Fibrous	Hemic	Sapric
Picture			
Van Post scale	H3	H5	H8
Physical description	Very much wood, very much amount of brownish water	Half decomposed. Dark brownish water. Some peat leave brown traces at palm when squeeze	Very fine. Little amount of water. Felt-like clay when hold with hand.
Colour	Brown	Dark brown	Brown to red
Odor	Acceptable smell	Odorless	Odorless
Water retention	Very much	Moderate	Little

PREPARING THE PEAT

Any fiber larger than 1 cm should be removed from the container containing peat. Wet peat at controlled moisture content then sieved passed through 2 mm sieve size. The purpose of sieving the wet peat was to remove coarse materials such as roots, stones and large fibers greater than 2 mm size. The peat then mixed thoroughly by hand for about 3 minutes. This is to ensure that only homogenous wet peat is used for mixing.

The peat sample then mixed using food mixer at low speed for 1 minute followed by medium speed for another 4 minutes. The mixer is stopped and the material is scraped off the paddle and sides of the bowl before resuming mixing for another 3 minutes. This process is completed within 8 minutes duration. EuroSoilStab (2002) suggest 10 minutes of blending to achieve sufficiently uniform dispersion mixture. 30 g of peat is then taken for moisture content test. The peat is ready for mixing process.

CONTROL OF PEAT MOISTURE CONTENT

Compilation of previous study in Table 2 shows that no specific range found that relates moisture content with decomposition level of peat. Preliminary mix design with original water content of peat, gives a very weak sample that deformed when moulded into UCS specimen. However, the fresh hemic peat, which has moisture content of 417 %, can stand firmly when moulded into UCS sample.

According to Kosmatka and Farny (1997), a minimum ratio of water needed for hydration of OPC is 0.4. It means the water needed in a mixture is almost half of the amount of OPC. Due to high water content that lead to the deformation of UCS specimen, the fact that only certain amount of water needed for hydration and the water content in all peat types are varies, therefore it is possible to control the water content in the peat before proceed to mixing process.

Table 2: Physical and chemical properties of peat

Peat type	Natural water content (w,%)	Bulk density (Mg/m^3)	Specific gravity (Gs)	Acidity (pH)	Reference
Fabric	1168	-	1.44	5.3	O'Kelly and Pichan (2013)
Fabric	598.5		1.21	3.75	Kolay *et al*.(2011)
Fibric	605-1290	0.87-1.04	1.41-1.7	-	Moayedi *et al.* (2011)
Fibric	850	0.95-1.03	1.1-1.8	-	Asadi *et al*., (2009, 2010)
Fabric	700-850	1.59	1.343	4.6	Deboucha and Hashim (2009)
Fabric	668	-	1.4	3.51	Wong *et al.* (2008)
Hemic	230-500	-	1.48-1.80	-	Zainorabidin and Ismail (2003)
Fabric and hemic	1090-1210	-	-	-	Jelisic and Leppänen (2000)
Peat (Netherlands)	669	0.97	1.52	-	Termatt and Topolnicki (1994)
Fibric	660-1590	-	1.53-1.68	-	Lefebvre *et al.* (1984)
Peat portage	600	0.96	1.72	7.3	Edil and Mochtar (1984)
Fibric peat (Middleton)	510	0.91	1.41	7	
Coarse Fibric	202-1159	1.05	1.5	4.17	Berry (1983)
Fine Fibric	660	1.05	1.58	6.9	NG and Eischen (1983)
Fine Fibric	418	1.05	1.73	6.9	
Hemic granular	336	1.05	1.72	7.3	
Hemic peat	200-875	1.04-1.23	-	-	
Hemic to Fibric	850	-	1.5	-	Keene and Zawodniak (1968)
Hemic and Fibric	355-425	-	1.73	6.7	Adams (1965)
	500-1500	0.88-1.22	1.5-1.6	-	Lea and Browner (1963)

The original water content for Pontian peat was 860 % for fabric, 447 % for hemic and 602 % for sapric types. Figure 4 shows, to achieve a c_u of 12 kPa at the peat's natural water content, the amount of OPC needed for fabric peat is 1250 %. This amount is somehow not practical.

Kalantari (2010) suggested microwave heating to evaporate the moisture from peat. Despite losing its moisture, heating a peat will shrink the fiber sizes thus damage the original condition of peat. Drying of organic coarse particles causes shrinkage of thin-walled tissues and collapse of cell structure, thereby decreases particle porosity and water holding capacity (Tremblay *et al*., 2002 and Terzaghi *et al.*, 1996). The drying techniques at 100 ^{o}C for 4 hour successfully removed the water but it shrunk the peat and turned it into a very hard solid. The dry peat, when mixed again with water, failed to absorb the water and unable to form into its original condition. Peat will shrink extensively when dried. The shrinkage could reach 50% of the initial volume, but the dried peat will not swell up upon re-saturation because dried peat cannot absorb water as much as initial condition; only 33% to 55% of the water can be reabsorbed (Mokhtar, 1998).

There is different with air dry technique, where the peat can still maintain the original condition with less water content. Therefore, the air drying technique is chosen. The sample is mixed thoroughly by hand for 2 minutes and left uncovered indoor at ambient temperature. The mixing process repeated 3 times a day. Moisture content of the mixed peat is recorded daily.

The process is repeated till the desired moisture content is achieved. Figure 5 shows the moisture content versus time taken for controlling the water content of peat using this technique.

Overall, one week is needed to reduce the moisture content of about 100 kg of sample. When the desired moisture content is achieved, the sample then covered with a few layer of plastic bags to maintain the moisture content and ready for mixing process.

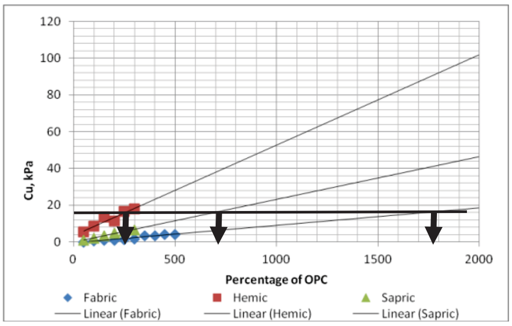


Figure 4: Projection of undrained shear stress versus percentage of OPC

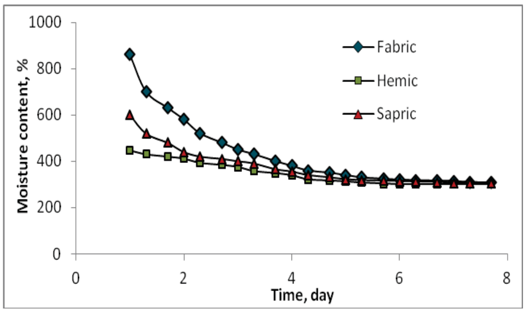


Figure 5: Moisture content versus time taken for controlling the water content of peat using air drying technique

CONCLUSION

The pre-solidification procedure for peat samples at various decomposition levels should be;
1) Sampling - chose the right peat sample for respective study and kept the peat at its original condition.
2) Preparing the peat - Ensure the peat samples to be less than 2 mm. Too much of coarse element will affect the formation of UCS sample.
3) Control the moisture content - for the formation of UCS sample

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