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A study of the effect of various curing techniques on the strength of stabilized peat

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ABSTRACT

This article describes a laboratory study on the effects of various curing techniques adopted for the stabilization of peat with cement. The change in the strength of the samples was evaluated using the Unconfined Compressive Strength (UCS) test. Cement at 15%, 30%, and 50% weight was added to stabilize the peat samples. The peat samples were then cured using three different methods. The methods of curing used in the study were: air curing, moist curing, and moist curing with surcharge load. The UCS test was conducted on stabilized samples of peat after curing for 28, 90 and 180 days. It was observed from the test results that samples stabilized with 15% OPC (Ordinary Portland Cement) showed a much lower UCS value. With air curing, although samples with 50% OPC showed the highest UCS values, there was not much increase in UCS values compared to samples with 30% OPC. With moist curing, the samples showed an increase in strength with an increase in OPC content. Also, the percent increase in UCS values is the most with 50% OPC. For the samples stabilized with moist curing together with surcharge load, the highest UCS values were obtained with 50% OPC. The use of the moist curing technique for all the samples, regardless of OPC content or curing periods provides the lowest UCS values when compared with the same type of samples used in the other two curing techniques. 50% OPC and moist curing with surcharge load technique shows the highest percent increase in UCS values.

Introduction

Peat is an accumulation of partially decomposed and disintegrated plant remains under conditions of incomplete aeration and high water content. Peat covers extensive areas in the tropics, particularly near the coastal plains, and is generally formed in natural environments that do not allow for the rapid decay of materials. Soils with high organic content are generally associated with high compressibility, high rates of creep, and unsatisfactory strength characteristics; and it these that increase the risk of inadmissible settlement and/or foundation failure. Peat is an extreme form of soft soil, and is subjected to instability such as localized sinking and slip failure, and massive primary and long-term settlement when subjected to even moderate load increase. In addition, peat is difficult to sample (von Post, 1922; MacFarlane, 1969; Terzaghi et al., 1996; Denhaan, 1997; Huat, 2004; Mesri and Ajlouni, 2007). Whenever possible, the engineers seek to avoid building on this problematic ground. The most common method among engineers in dealing with peat deposits have been either to remove peat and replace it with suitable soil or to drive piles (end bearing) through the peat layer to the more supportive soil layers below.

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Much laboratory research has been conducted examining the effect of stabilizing peat by mixing it with cement and other binders, and evaluating the change in strength by using various tests such as unconfined compressive strength, triaxial, and consolidation (Hampton and Edil, 1998; den Haan, 2000; Hwan Lee and Lee, 2002; Tremblay et al., 2002; Ramirez, 2005; Hwang, 2006; Axelsson et al., 2002; Duraisamy et al., 2009; Wong et al., 2009; Hebib and Farrell, 1999; Kalantari and Huat, 2008).

Several researchers have conducted laboratory experiments to study the effect of binders on the shear strength of peat. Skels et al. (2013) reported an improvement in the engineering properties (unconfined compressive strength) of cement stabilized peat. Hernandez-Martinez and Al-Tabbaa (2004) have also studied in the laboratory the strength correlations for cement-treated peat. The authors developed a correlation of the unconfined compressive strength of treated peat-cement samples. The results obtained show both the effect of the cement quantity and the effect of two specimen sizes on strength. Generally, the more cement that is added to the peat, the greater the strength.

Studies have been carried out to stabilize peat with cement, and other binders, and comparing the results (Eades and Grim, 1960; EuroSoilStab, 2002; Hayashi and Nishimoto, 2005; Åhnberg, 2006; Kolay and Pui, 2010; Kalantari et al., 2010; Kalantari, 2011). Cortellazon and Cola (1999) used cement, fly ash, hemi-hydrate gypsum and hydraulic lime as binders and the curing setting consisted of storing the sample at 18–22 °C under a pressure of 18 kPa and exposing the bottom and top of the specimens to water. The authors reported that the shear strength reached its maximum value after about 30 days of curing after which the variation was minimal. Some studies were also undertaken with the stabilization period of fibrous peat with curing varying from 28 to 240 days. These studies reported that the minimum dosage for peat soil activation is 150 kg/m^3 (Hebib and Farrell, 1999).

A detailed study was also carried out by Hwang et al. (2004), stabilizing organic soils by using ordinary Portland cement, lime, high calcium flue dust, Marblehead Buffington dust and bentonite as binder. The study was not only concerned with the effects of binder dosages but also with the surcharge applied during curing (48, 96, 145 kPa) and the length of time for the curing stage (1, 7, 14, 28 days). From the obtained results, cement was established as the most effective chemical additive for the given chemical composition of the soil.

Research has also been carried out on the effect of binders and fillers on the strength of stabilized peat. Wong et al. (2008) reported on the use of sodium bentonite to maximize the filler and pozzolanic effects of peat stabilized with cement. To develop the optimal mix design, specimens of stabilized peat were tested in unconfined compression, direct shear and falling head tests. It was found that test specimens of stabilized peat containing 10% partial replacement of Portland composite cement (PCC) with sodium bentonite had the maximum UCS after 7 days of curing in water and under the application of 50 kPa initial pressure. The UCS of stabilized peat increased to 142.5 kPa at the minimum dosage of 250 kg/m^3 for 75% cement and 25% slag, and to 178.6 kPa using 300 kg/m^3. This amount of binder is confirmed by Axelsson et al. (2002) who observed that the dosage of 400 kg/m^3 presents a lower strength than 250 kg/m^3, which shows that the water binder ratio has a significant effect on the shear strength of stabilized peat.

The effect of fillers on the strength of stabilized peat was also studied by Dehghanbanadaki et al. (2013). The authors studied the effects of natural fillers mixed at various dosages with cement treated peat in order to evaluate the UCS. Four types of natural fillers containing well graded sand (SW), poorly graded gravel (GP), coarse poorly graded sand (C-SP), and fine poorly graded sand (F-SP), were used in this study. Cement peat specimens with 300 kg/m^3 of cement yielded UCS values of 112.5, 163.7 and 170.93 kPa at 14, 28 and 90 days, respectively, which increased the UCS of undisturbed peat up to 850%. The results also indicate that the mix design of 300 kg/m^3 cement, with 125 kg/m^3 of well graded sand by mass of wet peat, gave the highest UCS (188.5 kPa) after 90 days of curing. Other fillers decrease the strength of stabilized peat. According to Chen and Wang, (2006), the peat strength of 300 kPa could not be reached at the cement ratio of up to 30% with the deep mixing method at a foundation reinforcing project on peat.

The stabilization of an organic soil such as peat is affected by a number of factors, namely: water content; physical, chemical, and mineralogical properties; character and amount of organic content, and the pH of the pore water (Aagnostopoulos and Chatzianglou, 2008). The cement-stabilized peat's gains in strength will also depend upon the decomposition of the organic compound to organic acid due to the effects of biological influence, its specific surface area, and cation exchange capacity (CEC). In most of the studies involving peat and cement (as binder), it is reported that the samples were mixed with desired amount of binder (cement in most cases) and cured for varying periods normally from 28–240 days (Tremblay et al., 2002; Ramirez, 2005; Kalantari, 2011; Duraisamy et al., 2007). Therefore, choosing an appropriate quantity of binder is of significance for the improvement of peat soils for construction.

Sing et al. (2008) have used cement to stabilize peat, and curing was done at various stress levels. On the other hand, research has been carried out to discover ways to strengthen peat deposits. These methods include peat stabilization using a mixture of various binders such as cement or lime, and different admixtures such as fly ash and blast furnace slag (Bergado et al., 1996; Janz and Johansson, 2002; Hughes and Glendinning, 2004; Black et al., 2007; Alwi, 2007). However, studies of peat stabilized with binders and cured by different methods to evaluate the effects of curing methods are rare.

In this experimental study, the effects of three curing techniques on the strength of peat stabilized with cement were evaluated. The curing techniques used in the study were air curing, moist curing, and moist curing with a surcharge load of 10 kPa. The curing periods of samples were 28, 90, and 180 days. The change in strength of the cement stabilized peat samples cured for various durations was evaluated by the UCS test.