Effects of Hydrated Lime – Pond Ash Admixtures on the Compaction Characteristics of Treated Peat Soils

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ARTICLE INFO

Article history:
Received 28 September 2015
Accepted 15 November 2015
Available online 24 November 2015

Keywords:
Compaction test, maximum dry density (MDD), optimum moisture content (OMC), peat soil, pond ash (PA) and hydrated lime (HL).

ABSTRACT

Background: Peat soil is categorized as a problematic soil due to its high compressibility, low shear strength and low specific gravity. Because of these special characteristics, peat soil is considered to be unfavorable foundation for any superstructure unless a suitable soil treatment was applied. Instead of strength, the characteristics become other important parameters to be considered during the construction stages. Objectives: In this paper, the results of compaction on the treated Klang peats subjected to various compositions of pond ash (PA) and hydrated lime (HL) were investigated. The effects of these admixtures on the maximum dry density (MDD) and optimum moisture content (OMC) were determined. Five different mixes of treated peats were prepared and tested accordingly. The results: The peat treated with 6% of HL and 10% of PA gave the higher MDD whereby soil with 3% of HL and 10% of PA presented the lowest MDD. Besides that, the maximum dry density (MDD) decreases with increases of PA and HL accordingly, while the optimum moisture content (OMC) increases with PA and HL. Conclusion: The compaction curve of each sample was developed then the MDD and OMC was determined accordingly. It revealed that the MDD increase with increase of PA and HL while the OMC decrease with PA and HL.

INTRODUCTION

In Civil Engineering works, engineers face challenges to design structures on the problematic ground, thus requires a suitable ground improvement method. Recently, many ground improvement methods are rapidly developed. However, many of them are very limited and costly, especially for peat soil due to its natural characteristics like high compression, high organic content and high water table (Kolay, P.K., 2011; Boobathiraja, S., 2014). As an alternative, the used of byproduct material and sustainable become more preferable. According to (Abubakar, A.U. and K.S. Baharuddin, 2012; Gupta, S., 2013), hundred thousand tonnes of byproducts (pond ash) from thermal power plants in Malaysia were stockpiled and dumped in a large scale pond as a waste. Most of the researchers have reported that PA can be applied as a Geotechnical foundation. They identify that the MDD increase while the OMC decreases with the increasing of PA content (Abubakar, A.U. and K.S. Baharuddin, 2012; Gupta, S., 2013). Besides, the addition of PA in natural peat has increased the physical strength. Attempt to use the PA and HL to treat fine sand by showed that the MDD increase with lime content due to interlocking of lime particles in voids of fine sand. Even though a chemical reaction of lime normally needs specific time to complete, but the addition of different percentages of HL into the peat soil gives effective results in negligible changes in MDD and OMC (Nikookar, M., 2013).

Methodology:

The samples of peat soil were obtained from MARDI Station, Jalan Kebun, Klang, Selangor, Malaysia located at latitude of N03°00’ and longitude of E101°30’. The high water level presented the soil in fully saturated condition. A visual observation shown the peat soil is dark brown color. The undisturbed samples were carefully taken using a thin wall sample of 100 mm diameter. PA sample was taken from the disposal filed at Jimah Energy Venture Thermal Power Plant, Negeri Sembilan, Malaysia which is located at latitude 2.5916° and longitude of 101.7246° coordinates. It was extracted about 0.3 to 1 m below the ground surface. The samples were oven dried to a 105 °C, sieved and collected for size of particles passing the 2 mm sieve. HL in the forms of powder was
obtained from the local supplier factory. Natural peat soil was prepared accordingly for physical properties test. For compaction purposes, the peat which passing 4.75 mm sieve and oven dried was prepared in five different mixes including the natural peat as a reference sample. Peat with 10% of PA was mixed with 3, 6 and 9% of HL and labelled as 3HL10PA, 6HL10PA and 9HL10PA accordingly. For another batch, peat with 6% of HL was mixed with 5 and 15% of PA and labelled as 6HL5PA and 6HL15PA accordingly. The laboratory testing approach for the physical, engineering and compaction properties were in accordance with ASTM and BS 1377 standards.

RESULTS AND DISCUSSION

Table 1 presents the physical and engineering properties of the untreated peat soil of the study. The results have shown a good agreement with what have been published by previous researchers for local peat soil. Meanwhile Figure 1 shows a typical sample of treated peat that was prepared for compaction test.

Figure 2 presents compaction curves of five types of threats peat, including the untreated sample. The upper curves are represented by 9HL10PA sample, followed by 6HL15PA, 6HL10PA, 6HL5PA and 3HL10PA samples. The untreated peat (original only) exhibited the lowest compaction curves. From the curve, the OMC and MDD for each sample are determined accordingly. For 9HL10PA sample, the OMC and MDD result was determined as 0.71 Mg/m$^3$ and 9% respectively. For 6HL15PA sample, it was 0.69 Mg/m$^3$ and 9%. While the MDD and OMC experiment was determined as 0.68 Mg/m$^3$ and 11%, 0.66 Mg/m$^3$ and 13%, 0.62 Mg/m$^3$ and 16% for 6HL10PA, 6HL5PA and 3HL10PA samples respectively. For original peat, it was 0.616 Mg/m$^3$ and 20%. In order to observe the effect of HL on MDD and OMC, Figure 3 is plotted. With constant PA of 10%, the increase of HL by 3, 6 and 9% shows the significant effect on the MDD and OMC. The MDD increased from 0.62 Mg/m$^3$ to 0.67 Mg/m$^3$ and 0.71 Mg/m$^3$ with HL contents. At the same time, the OMC decreased from 16% to 11% and 9%. On the other hand, Figure 4 is plotted for constant HL of 6% with 5, 10 and 15% of PA. It presented that the MDD increased from 0.66 Mg/m$^3$, 0.68 Mg/m$^3$ to 0.69 Mg/m$^3$ and the OMC decrease from 13%, 11% to 9% with PA contents. It indicated that the presence of HL in peat has bonded the PA and peat particles to form a stiffer material, thus increased the density of the samples. The more the HL content, the higher the density of treated peat. Meanwhile the presence of PA in peat has occupied the voids between the particles of peat, thus increase the density of the treated peat soil. The more of the content PA was given the higher the density of treated peat. Since the OMC is inversely proportional with MDD, it decreases with increase of HL and PA. Practically, the MDD and OMC are the two important parameters to be considered during compaction of soil at the site. Ninety percent of MDD always adopted as a controlled value to be achieved with suitable moisture content.

Conclusion:

A series of compaction curves for treated and untreated peat were developed and the compaction parameters; maximum dry densities and optimum moisture contents were determined. The effect of pond ash content and hydrated lime on MDD and OMC was identified. The MDD increase and the OMC decrease with HL content. Similar trends also occur for increment of PA content.

Table 1: Physical and engineering properties of peat soil.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content, w</td>
<td>100 – 117%</td>
<td>Organic content</td>
<td>78%</td>
</tr>
<tr>
<td>Specific gravity, G,</td>
<td>1.25 – 1.47</td>
<td>Color</td>
<td>Brown to black</td>
</tr>
<tr>
<td>pH</td>
<td>5.17 – 5.16</td>
<td>LL</td>
<td>128.7%</td>
</tr>
<tr>
<td>OMC (Untreated)</td>
<td>20%</td>
<td>PL</td>
<td>Non plastic</td>
</tr>
<tr>
<td>Degree of decomposition</td>
<td>H3</td>
<td>MDD (untreated)</td>
<td>0.616 Mg/m$^3$</td>
</tr>
</tbody>
</table>

Fig. 1: Typical samples for compaction.
Fig. 2: Compaction curves of treated peat.

Fig. 3: MDD and OMC subjected to HL.

Fig. 4: MDD and OMC subjected to PA

ACKNOWLEDGEMENT

The authors thank to Olivia and Ain for their dedicated work in collecting data used in this article as a part of the objective of our research for rehabilitating the degraded peat land areas.

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