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Development of a capping material for an Engineered Landfill in Wet zone of Sri Lanka

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Abstract: Capillary Barriers (CB) which consist of coarse sand overlain by a low permeable fine soil are low cost alternatives used in capping system for controlling the infiltration in a Landfill. In wet region, the durability of capping layer is questionable as due to high precipitation, capillary effect can reduce making the layer highly permeable. A potential solution is to alter the soil grains by mixing with a Hydrophobic Agent (HA) such as Oleic Acid (OA), so that the water repellent characteristics are introduced into the sand layer.

In this study, the hydrophobicity (water repellency) of CBs containing coarse sand mixed with OA was investigated. Hydrophobicity was evaluated by measuring the time taken for a water droplet to penetrate the surface of a compacted sand sample which is identified as the Water Drop Penetration Time (WDPT). Initially, dry coarse sand particles were hydrophobized by mixing-in coating method with different OA contents. In addition, the effect of moisture content of coarse sand particles on its hydrophobicity was also studied. The results show that WDPT for dry samples increased sharply with increasing HA content and reached a peak value of 4080 s at 3gkg^{-1} of sand and thereafter decreased. Irrespective of the OA content, an increase in moisture content decreased the water repellency. However, this decrease is less significant for the optimum value of OA content of 3gkg^{-1} within the range of moisture content tested. The impact of the slope angle on the water repellancy was also investigated by increasing the slope upto 1V:3H. Results showed a decrease in water repellency when the slope angle was increased. It was observed that water drop was spreading due to the effect of weight acting along the slope and as a result the WDPT time decreased due to less surface tension.

Keywords: Capillary Barrier, Capping material, Water Repellence

1. Introduction

An engineered landfill allows final disposal of solid waste to be placed in a secure manner by minimizing the impact on the environment. Once the final capacity is attained the closure of the landfill is done by installing a cover which functions in minimizing the infiltration and assisting in gas emissions. In this respect, although the modern techniques using geosynthetics are available, the developing countries like Sri Lanka cannot afford to use them as they are an imported material. Therefore, this study investigates the effectiveness of using locally available materials.

Capillary barriers consisting of a layer of fine grains underlain by a layer of coarse grains are commonly used. Since the wet zone has a heavy precipitation, application of such capillary barriers may not be effective. To overcome this problem coarse particle are mixed with a Hydrophobic Agent (HA) to introduce water repellence properties which results in less infiltration of water into the underlying waste (Subedi et al, 2012,[1]). In this study, Oleic acid (OA) is considered as the HA and its optimum content to be mixed with the capillary barrier system is determined.

2. Materials and methods

2.1. Sample preparation

River sand was sieved using sieves of sizes ranging from 0.6 mm to 2 mm in order to separate the coarse particles. It was then washed with a lowfoaming agent and rinsed thoroughly with distilled water several times, air dried and stored under 20°C climate controlled condition for two weeks.

2.2 Preparation of hydrophobized grains

OA used as the HA and the sample was prepared using mixing-in method (Subedi et al, 2012,[1]) where sand is mixed thoroughly with liquid OA in a plastic bag and stored under 20°C climate controlled condition to equilibrate. Air dried grains were mixed with different contents of Oleic Acid varying from 1 g/kg to 10 g/kg. These were called as "dry hydrophobized grains"

From the results of Water Drop Penetration Test (WDPT) on the dry hydrophobized sand, three samples with different OA contents were selected to investigate the effect of moisture content on the Hydrophobicity. For this purpose, a hydrophobized coarse sand specimen was prepared by mixing with an OA content corresponding to the peak value of WDPT and two specimens corresponding to an HA content from either side of the peak. Distilled water was added to these sand specimens to adjust the water content to predetermined values. These water added samples were mixed well and stored in plastic bags under 20°C climate controlled condition. These specimen were called as "wet Hydrophobized grains".

2.3. Water repellence measurement by WDPT test

The coated sample was packed into a 15 cm diameter, 2 cm high cylindrical ring to have a dry density of 1.6 g/cm^3 and the ring was removed carefully. A small drop of distilled water of volume 50μl was placed on the surface of the above sample using a special pipette as shown in Figure 1 and the time taken for the water drop to infiltrate (WDPT) the surface completely was recorded. For each sample three tests were carried out. This procedure was performed for both dry and wet Hydrophobized grains.

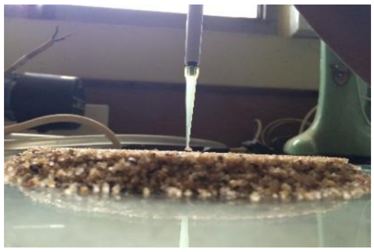

Figure 1: WDPT Test

Similar test procedure was followed to determine WDPT on the compacted dry and wet hydrophobised sand samples by varying the slope for three trial specimens of each sample.

3. Results and Discussion

The variation of WDPT with HA content is shown in Figure 2.

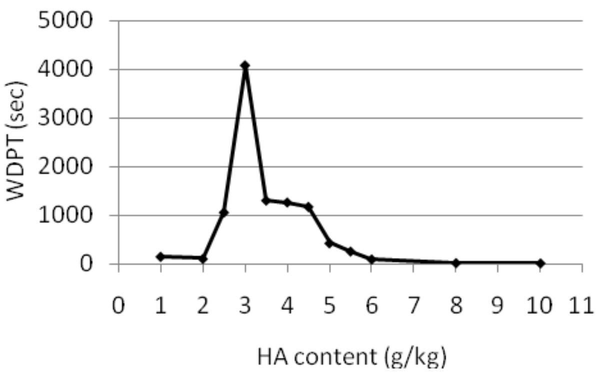

Figure 2: Variation of WDPT with HA content

Results show that the water repellency of compacted dry sand samples initially increased sharply with increasing OA content and reached a peak value and thereafter it decreased. With increasing HA content, the grain surface tends to become more hydrophobic, however, the measured WDPT values decreased after reaching the peak value of about 3g/kg, as a high amount of OA will reduce the contact angle at the grain water surface due to the multilayer coverage of the grain surface in which, a hydrophobic end may be facing the outside due to the excess OA. The peak value of 4080 seconds was obtained at a HA content of 3g/kg.

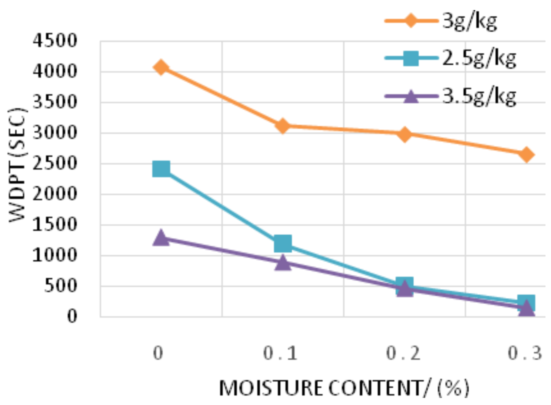

Figure 3: Variation of WDPT with moisture content

Variation of water repellence with moisture content is given in Figure 3. It shows that irrespective of the OA content an increase in moisture content has caused the water repellence to decrease. However, this decrease is less significant for the sand grains containing the optimum OA content for the range of moisture content tested.

The variation of WDPT with surface slope is shown in Figure 4.

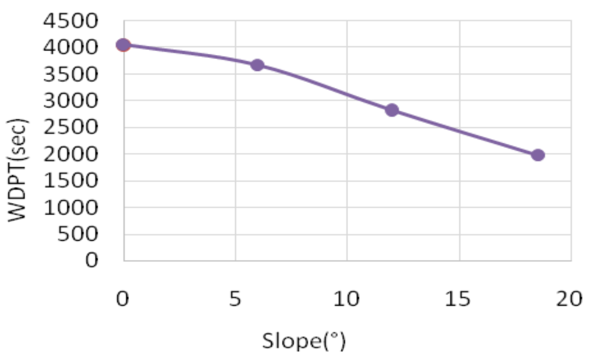

Figure 4: Variation of WDPT with surface slope

Results showed a decrease in water repellence when slope increases. It was observed that water drop was spreading, since the surface tension effect reduces, the WDPT time decreased.

5. Conclusions

It is possible to use locally available materials in a hydrophobised capillary barrier that can be developed as a low cost alternative to geosynthetics. From the results, it can be concluded that use of Oleic acid as a Hydrophobized Agent with an optimum mix ratio of 3g of HA per 1 kg of coarse sand in the capillary barrier, the water repellence is developed and it will help to minimize the water infiltration into the waste. At this optimum OA content, the influence of moisture content on the water repellency was insignificant for the range of moisture content tested.

Acknowledgements

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