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Optimization of Polymer-Amended Fly Ash and Paper Pulp Millings Mixture for Alternative Landfill Liner

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Abstract

In 2012 the City of Flagstaff partnered with researchers at the Dept. of Civil and Environmental Engineering at Northern Arizona University to successfully develop a mix design utilizing sludge derived from the manufacturing of recycled paper pulp sludge (PPS) and fly ash as a component of a landfill cap. This research has been extended to explore the addition of polymers to the mix of waste materials in order to optimize a design that would be suitable as a component for an EPA Subtitle D-approvable landfill liner. Cinder Lake Landfill (CLL) serves several communities in Northern Arizona and is managed by the City of Flagstaff. CLL does not have a reliable source of clay needed to construct a required landfill liner, which is necessary for the upcoming 108-acre landfill expansion. However, CLL receives approximately 80 tons of recycled PPS daily from the local tissue manufacturing plant. PPS is currently used as daily cover and was tested for use as part of a landfill cap, as noted above. Incorporating polymers in alternative materials such as PPS and fly ash has the potential to meet performance criteria and be approved by state and federal regulators, and has the potential to save the City millions of dollars over conventional composite liners of geomembrane and clay. Different mixtures of PPS, fly ash and three different polymers are currently being subjected to testing for the following: Water Content, Specific Gravity, Porosity, Organic Content, Atterberg Limits (plasticity), Proctor Compaction, Consolidation, California Bearing Ratio, Shear Strength, Gas Permeability, and Liquid Permeability. The optimal mixture of PPS and fly ash will be blended with a range of polymer concentrations. The goal is to find an optimal mix of PPS, fly ash, and polymer to achieve regulatory standards related to permeability, along with other desirable properties such as strength and flexibility. The optimum mixture(s) will then be subjected to field trials, scheduled to begin in 2016, in which test cells will be created at CLL. The liner will be constructed with the optimized mixture(s), and the cells will be operated as landfills for 1-2 years. Results from lab and field testing will be submitted to federal and state regulators for consideration as an alternative liner approach.

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1. Introduction

This paper will look at the effects polymers have on a mixture of Paper Millings (PPS) and Fly Ash (FA). The test results reported here are for Organic Content, Specific Gravity, Proctor Compaction, and Direct Shear. The material being tested is being considered for use in a landfill liner and ideal properties would include a high angle of friction, high shear strength, liquid permeability less than $1x10^{-7}$, and be cost efficient. Determining a high unit weight of a material mixture at a lower optimum moisture content will help reduce the cost of constructing the landfill liner. Figure 1a below shows what typical landfill liners should look like, Figure 1b shows a proposed landfill liner with the PPS replacing the foundation layer and the HDPE layer, and Figure 1c shows a remolded PPS sample.

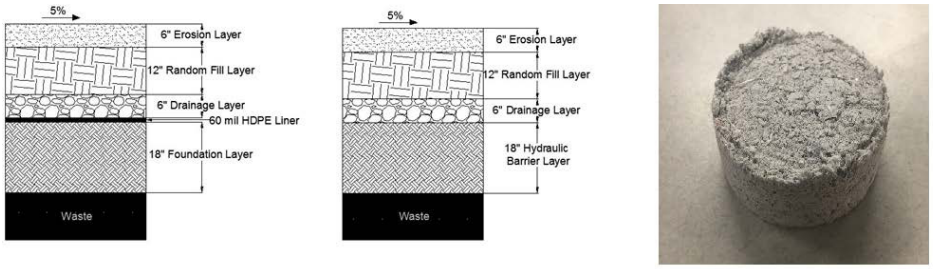

Figure 1a: Typical Landfill Liners [1], Figure 1b: Proposed Landfill Liner [1], Figure 1c: Molded PPS sample.

The 18" Hydraulic Barrier in Figure 1b will consist of a mixture of the PPS and FA waste products.

2. Materials

The Fly Ash (FA) and Paper Millings (PPS) were provided by Cinder Lakes Landfill (CLL) and the 3 polymers were donated by vendors. The Fly Ash provided was Class C Fly Ash. Class C Fly Ash contains a higher concentration of lime (CaO) and has cementing characteristics [2]. FA has shown an ability to improve structural strength, water retention, and aeration [3, 4, 5]. FA is currently a waste product and can substantially reduce costs [6], but FA is starting to be utilized and may increase in price. Paper Millings (PPS) is a waste product from recycling and reprocessing paper [7]. PPS have similar characteristics to clay or organic soil [8, 9]. PPS are highly compressible, and have low shear strengths [10], and should not be constructed on slopes greater than 1:4 [11]. The primary purpose of this research is to increase the potential to use this mixture as a hydraulic barrier in the form of a landfill liner. The most effective decrease in hydraulic conductivity is around a load of 80 kpa [12]. The polymers are proprietary and will not be discussed in detail.

3. Test Method

The preparation of samples is slightly different for each test method specified. When adding polymer to a mixture we use 1%, 3%, or 5% of the water weight and add that quantity of polymer to the water, then adding it to the sample mixture. The FA and PPS were weighed out in small individual sample batches to help control the quality and then mixed by hand until the samples looked homogenous.

3.1 Moisture Content and Organic Content

The moisture content of the material will vary greatly considering the PPS is stored in the open air. The field moisture content will need to be considered when adding polymer to the material during construction. The organic content is expected to be in a range between 35%-56% [8]. Moisture Content was tested in accordance with ASTM