GUIDANCE DOCUMENT #700

Division of Materials & Waste Management
Updated October 2014

Selecting Material for Cap Protection Layers

Applicable Rules

MSW: OAC 3745-27-08(D)(26)
OAC 3745-27-14(A)(2)
ISW: OAC 3745-29-08(D)(26)
OAC 3745-29-14(A)(2)
RSW: OAC 3745-30-09(F)(3)(b)
Tires: OAC 3745-27-72(C)(9)(f)&(g)
OAC 3745-27-74(A)(2)
C&DD: OAC 3745-400-07(G)(2)

DMWM Cross referenced guidance document:

#660 *Geotechnical and Stability Analyses for Ohio Waste Containment Facilities (GeoRG) Manual*

Purpose

This document provides suggestions regarding selection of material for protection layers in the composite cap system.

Detailed Discussion

The various landfill programs have different final cap design standards. The regulations for MSW, ISW, RSW, and C&DD landfills, and scrap tire monofills all require a protective layer. This layeris called the “cap protection layer” in the MSW and ISW regulations, a "vegetative layer" in the RSW regulations, a “frost protection layer” and a "vegetative layer" in the tire monofill regulations, and as either a standard cap system or a vegetative cap system in the C&DD regulations. In all of these regulations except the C&DD regulations the owner or operator is required to maintain the integrity and effectiveness of the cap system. The cost and ease in maintaining this system is greatly influenced by the characteristics of the soil used in the protective layer. The improper choice of soil can result in problems such as excessive erosion, inability to grow a good stand of vegetation, or even slope failures.

VEGETATIVE GROWTH

The MSW and ISW regulations require that the protective layer be constructed in a manner such that healthy grasses or other vegetation shall form a complete and dense vegetative cover within one year of placement. The RSW, scrap tire monofill, and C&DD regulations require that the vegetative layer portion of the protective layer be made up of soil of sufficient fertility to support vegetation.

Testing the soils of the protective layer to determine their fertilizer needs and, once the soils are placed, correcting any deficiencies in pH or nutrients, is highly recommended. Most testing labs will provide recommendations to correct soil deficiencies. For a list of soil testing laboratories, see Ohio State University Extension fact sheet HYG-1132-09 at *http://ohioline.osu.edu/hyg-fact/1000/pdf/1132.pdf.*

EROSION

The MSW, ISW, RSW, and scrap tire monofill regulations require that the protective layer “have a maximum projected erosion rate of five tons per acre per year.” The C&DD regulations require that the cap system be graded to minimize erosion.

Consultants typically use either the Revised Universal Soil Loss Equation (RUSLE) or the Water Erosion Prediction Project (WEPP) Model when designing the final cover. The RUSLE is available at: *http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm.* The WEPP model is available at: *http://www.ars.usda.gov/Research/docs.htm?docid=18084*.

In both of these models, protective layer material properties, slope configurations, typical rainfalls, and type of vegetation are inputted and the average annual soil loss is predicted. It is important that after determining what soils are available

for constructing the protective layer that these soils are evaluated to determine if the protective layer is able to meet the regulatory requirement. Designers may want to include this evaluation step as a requirement in their Quality Assurance/ Quality Control Plan in order to prevent using soils that will result in construction of a protective layer that does not meet the regulatory requirement.

Desiccation Cracking

Soils subject to excessive desiccation cracking are not recommended for use as protective layer. The detrimental effects of excessive desiccation cracking result in uncontrolled infiltration of surface water through cracks and easy access for burrowing animals. Uncontrolled infiltration of surface water can result in slope failures due to an excessive buildup of pore water pressure in the drainage layer and/or the protective layer.

"The amount of cracking will increase with the plasticity index (PI) of the soil." (Briaud et al, 2003) In Louisiana, it has been determined that many embankment failures are due to infiltration of surface water through desiccation cracks. The Louisiana Department of Transportation and Development (LA DOTD) has developed the following specification in an attempt to eliminate slope failures due to infiltration of surface water through desiccation cracks: "Usable soils shall have a PI of 25 or less, an organic content of 5 percent or less and a maximum silt content of 65 percent." (LA DOTD, 2000)

Shear Strength

Soils that have an interface or internal shear strength less than that required to maintain stability are not recommended for use. Ohio EPA recommends that shallow failure analysis be used to determine the minimum interface and internal shear strength of the cover system and its interfaces that are necessary to provide the required factors of safety. See the GeoRG Manual Chapter 9 for factors of safety and recommended analysis methods. This chapter of the policy is available at: *http://epa.ohio.gov/portals/34/document/guidance/gd_660_chapter_9.pdf .*

Mobility of Fines

Protective layer soils that are internally unstable, (i.e., soils that are susceptible to the movement of fines within their internal makeup) have been linked to several cap failures. These failures are attributed to pore water pressure buildup during storm events after the cap's filter layer or drainage layer was clogged with fines. Internally unstable soils typically have a low plasticity index (PI< 15) and are either gap-graded or broad-graded. "In a gap-graded soil . . . the coarse material simply floats in the matrix of fines. Consequently, the scattered coarse particles will not deter the migration of fines as they do in a well-graded material." (US Army Corps of Engineers, 2000) Broad-graded soils can have similar problems as gap-graded soils, but they are soils that have an evenly distributed particle size from coarse gravels to clay sized particles. The coefficient of uniformity C_u and the coefficient of curvature C_c are good index properties to determine if a soil will be internally unstable. If both of the following formulas are true, then mobility of fines may not be a problem:

$$C_u = \frac{D_{60}}{D_{10}} > 4 \; and \; 1 < C_c = \frac{D_{30}^2}{D_{10} \times D_{60}} < 3$$

D_{10} = the diameter at which 10 percent of the soil is finer.

D_{30} = the diameter at which 30 percent of the soil is finer.

D_{60} = the diameter at which 60 percent of the soil is finer.

C_u = the coefficient of uniformity, it quantifies distribution of particle sizes

C_c = the coefficient of curvature, it identifies internal soil stability

"The internal stability of the soil has a significant influence on the soil retention performance of the soil/geotextile system." (Bhatia and Huang, 1995) If a geotextile filter is used between the protective layer and the drainage layer, then the D_{85} of the protective layer should be 2 to 3 times greater than the apparent opening size (AOS) of the geotextile filter. This filter criterion is also appropriate for the upper geotextile of a geocomposite drainage net.

$$(2 \; to \; 3) \times \; D_{85pl} > AOS$$

D_{85pl} = the diameter at which 85 percent of the protective layer soil particles are finer.

See Design of Lateral Drainage Systems for Landfills, Richardson et al., 2000 for additional information.

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PERMEABILITY

The MSW, ISW, RSW, scrap tire monofill, and C&DD rules do not establish a permeability requirement for protective layer soils. The permeability of this layer is affected by years of root intrusion, freeze/thaw and wet/dry cycles. Studies show the permeability of protective layer can be increased by 1 to 3 orders of magnitude depending on soil type, vegetation, and weather.

References

Bhatia,S.K.and Huang, Q.,1995,Geotextile Filters for Internally Stable/Unstable Soils, Geosynthetics International,Vol.2,No.3,pp 537-565. *http://www.geosyntheticssociety.org/Resources/Archive/GI/src/V2I3/GI-V2-N3-Paper2.pdf*

Briaud, Jean-Louis, Zhang, Xiong and Moon, Sangho, 2003, Shrink Test-Water Content Method for Shrink and Swell Predictions, J. Geotech. and Geoenvir. Engrg. 129, 590 *http://ascelibrary.org/doi/abs/10.1061/(ASCE)1090-0241(2003)129%3A7(590)*

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United States Army Corps of Engineers, 2000, Engineering and Design - Design and Construction of Levees , EM 1110-2-1913, Department of the Army, Washington, DC
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Contact

If you have questions regarding this document or would like additional information, please contact:

Central District Office DMWM Supervisor (614) 728-3778

Northeast District Office DMWM Supervisor (330) 963-1200

Northwest District Office DMWM Supervisor (419) 352-8461

Southeast District Office DMWM Supervisor (740) 385-8501

Southwest District Office DMWM Supervisor (937) 285-6357

Central Office Authorizing Actions and Engineering Unit (614) 644-2621

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