Landfill Disposal Cell Base Slope – Transmissivity Value and Design Considerations

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Typical designs of landfill disposal cells include two slopes, one at the base and the other along the leachate collection pipe. The drainage layer covering the entire cell base area follows the slope of the base toward the leachate collection pipe, and the flow in the leachate collection pipe follows the pipe slope. With the growth in application of geosynthetics in the landfill industry, a majority of modern landfill designs include a geocomposite drainage layer, unless granular material is readily available at an economically viable cost in the area of the landfill, which can replace the geocomposite material.

Base slopes are designed to maintain a positive flow toward the leachate collection pipe after long-term settlements of the foundation. In addition to this requirement, sometimes solid waste rules require either a minimum slope at the time of the design or a minimum slope after foundation settlement. These requirements ought to be considered during the design of the base slope.

Cell base area under construction with specified slopes.

Regulatory agencies normally go through a comprehensive review process to make sure that such matters are addressed in a landfill permit application involving design of new disposal cells. However, sometimes designers propose slopes that seem to be significantly steeper than the minimum values required in the rules with no supporting foundation settlement analysis to justify the need for the steeper slopes. Slopes steeper than what is required (technically or regulatory wise) have two draw backs: 1) loss of the airspace which otherwise would have been captured with less steep slope; 2) lower hydraulic transmissivity in the geocomposite drainage layer. Laboratory experiments have shown that hydraulic transmissivity of geocomposites reduce as gradient increases. This phenomenon may be related to higher turbidity in the flow of leachate through the geocomposite voids. The flow path of liquids within the geocomposite structure includes vertical and horizontal barriers that liquid flows around or over within the geocomposite thickness. Steeper slopes increase velocity of liquids through the geocomposite, and higher velocity makes the flow more turbulent; and the higher turbulence reduces hydraulic transmissivity.

One of the most important regulatory requirements on landfill bottom lining system drainage layer is that the maximum head of leachate over the liner should not exceed 1 ft. When this requirement was developed, the general consensus was that the drainage layer consisted of granular materials. Later, when geonets and geocomposites entered the market, the unwritten consensus among solid waste engineers and regulators was that the maximum head of leachate at the base should not exceed the thickness of the geonet or geocomposite drainage layer. With that in mind, the reduction in hydraulic transmissivity of geocomposite laid over steeper slopes can adversely impact the maximum leachate head over the liner. Maximum leachate head is normally calculated from the theoretical model (along with some simplifications to disregard very small terms in the theoretical model) developed by C. A. Moore, J.P. Giroud, B. M. McEnroe, and others. One of these models was later incorporated into the Hydrologic Evaluation of Landfill Performance (HELP) model that is currently used by almost all solid waste engineers in the industry. Such models include a parameter called hydraulic conductivity which is calculated from the hydraulic transmissivity value of the geocomposite drainage layer.

When hydraulic transmissivity value reduces due to steeper slope at the base, the hydraulic conductivity reduces in turn as well. In the Moore's and Giroud's models, the maximum head of leachate is somewhat inversely proportional to the square roots of the hydraulic conductivity, which means the reducing hydraulic conductivity results in an increase in the maximum head of leachate passing through the geocomposite. The relationship between the leachate maximum head and the hydraulic conductivity is a lot more complicated in McEnroe's model.

It is recommended that the minimum base slope to be initially determined based on foundation settlement. Then, the calculated minimum slope compared to the required value in the solid waste regulations, if any. If the rules require a minimum slope at the time of the design, pick the regulatory value if higher than the calculated minimum slope; otherwise, pick the calculated minimum slope. If the rules require a minimum slope after foundation settlement, then add the calculated minimum slope to the minimum slope in the rules and use that in the design.

A 1 percent slope at the base, provided all requirements are met, seems to be a suitable slope. The geocomposite hydraulic transmissivity at 1 percent is higher than the hydraulic transmissivity at 2 percent, and the space difference between the 1 percent and 2 percent slopes can be added to the landfill airspace for waste disposal.

Sewing of the upper geotextiles of adjacent geocomposite panels.

Geocomposite drainage layer in place.

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Geocomposite drainage material delivered to site.

Geocomposite drainaeg material during installation.

Geocomposite drainage layer installation above geomembrane.

Installation of geocomposite in progress.