Geosynthetics for the Management, Containment and Closure of Coal Combustion Residual Disposal Facilities

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Background

Coal combustion residuals (CCR) management and disposal facilities are facing an onslaught of increased regulations and scrutiny regarding environmental concerns. The municipal solid waste disposal industry is certainly familiar with these circumstances, and for years has turned to geosynthetic materials for solutions. Geosynthetic materials have consistently provided engineered solutions for decades for a wide variety of industries including municipal waste disposal and have been proven to be cost effective in their use and implementation. In fact, some of the proposed regulations are based almost entirely on those regulations currently in place for the municipal solid waste industry. As CCR disposal and management facilities increasingly turn to geosynthetic materials, the geosynthetics industry is answering this call with an even wider range of products, and often these products are being specifically tailored for marketing to the coal residuals industry.

This paper will discuss a wide variety of geosynthetics and their potential use in the CCR management and disposal industry and is offered as an overview rather than a detailed discussion of any particular geosynthetic technology. Materials included for general discussion will include, but not necessarily be limited to geomembranes, geotextiles, geocomposites, geosynthetic clay liners, geogrids, erosion control blankets, synthetic turf systems, and geotubes. Applications discussed will include base liner containment systems, closure systems, and operational systems. The presentation will further discuss the latest developments in the geosynthetics industry and their relevance to the CCR management and disposal industry, and recent trends where these two industries intersect. The discussion is categorized by geosynthetic type as follows:

Geomembranes

Typically there are no significant differences required for geomembranes used in CCR management and disposal and those used for similar applications in the municipal waste market. Over the past 25 years geomembranes have become the predominant choice for barrier/containment layers in the disposal industry. Polyethylene (PE)
Geomembranes comprise the overwhelming majority of these with high density polyethylene (HDPE) being the predominant choice for base liners and linear low density (LLDPE) for final cover systems. PVC geomembranes currently comprise a much smaller share of the geomembrane market in municipal waste disposal. Federal regulations governing the municipal solid waste market (Subtitle D) specify that the base liner shall be a minimum of 30mils thick unless HDPE, which shall be a minimum of 60mils thick. The trend for PE geomembranes for closure is for a minimum thickness of 40mils. Subtitle D regulations also require the use of a composite liner where the geomembrane is complimented by a clay component. In contradiction to the US market, European containment facilities have traditionally relied on geomembranes with a minimum thickness of 100mils.

PE geomembranes are currently produced by two methods, flat die calendar extrusion and blown film. Both methods allow for the production of textured liners for stability against potential veneer failures of the geosynthetic system, however only calendared extrusion allows for the production of structured liners which will be discussed in more detail later in this paper. Textured geomembranes exhibit roughened, sandpaper-like surface(s) on one or both sides, and structured liners utilize large spikes, drainage studs and grid patterns (or a combination of these surfaces) for applications where a more aggressive approach for stability design is required or where drainage is required.

As part of any design effort, interface friction/shear strength values for each of the proposed geosynthetic interfaces must be taken into consideration as early as possible in the design process. The site-specific soils and unique geosynthetic material layering must be taken into consideration for each site design. As the characteristics of the soils may change as well as the degree of texturing can vary in geomembrane production, it is important to be aware of the potential for material changes and to conduct additional tests as necessary.

Co-extruded black/white liners are sometimes used to minimize the thermal expansion and associated wrinkling of geomembranes. They also aid in the detection of damage and associated repairs.

In recent years the technology behind leak detection surveys and conductive liners has improved significantly, and as a result these materials and services are being marketed more for liner systems in both the CCR and municipal waste sectors. Since it is estimated that the vast majority of holes or damage to geomembranes occurs during the placement of protective cover materials, many installers are increasingly interested in conducting leak detection surveys to prove the integrity of their installation and minimize their liability.

While electronic liner integrity surveys can and have been used successfully on standard geomembranes for a number of years, recent developments in conductive geomembranes are reported to improve improved leak detection signal strength by as much as 10 times. This technology uses a conductive layer on the bottom of the geomembrane rather than relying on intimate contact with the naturally conductive
underlying soils. This technology is specifically noted as being advantageous in leak detection where the following circumstances occur: in the presence of wrinkles or other bridging over the subbase soils, in areas with dry subgrade or encapsulated geosynthetic clay liners, on slopes, and in double-lined facilities. It also allows for limited leak detection of a geomembrane after placement of the protective cover.

However, some in the geosynthetics industry that believe the additional expense of conductive liners could be better spent in other areas. For instance thicker liners such as those used in the European market could potentially eliminate, but most certainly minimize the number of potential holes. Also, conductive liners operate by introducing a thin layer (2-3mils) of a special formulation of 12% carbon black. Concentrations of carbon black greater than 3% may begin to have adverse effects on the performance of the geomembrane and in some circles are considered to be a contaminant in the geomembrane resin. Other considerations or concerns include field safety issues in the electrical testing, issues with false positives, and the potential for false sense of security that may be afforded through the testing – While the technology is proven it is always susceptible to the operator’s attention to detail.

Geotextiles

Geotextiles are the widest used type of geosynthetics with an extreme variety of applications both in the environmental and disposal arenas and beyond. Applications include filtration, separation, stabilization, dewatering, cushioning, and erosion control, all of which can play critical roles in CCR containment and management.

Geotextiles have traditionally been classified as either woven or nonwoven, but the emergence of composite geotextiles appears to offer some additional beneficial applications for combining strength and filtration. These composite geotextile materials are of particular interest for applications in the CCR marketplace which will be discussed in more detail as part of their use in drainage geocomposites.

Soil and waste mass stabilization is also of critical importance in CCR management and containment facilities. From this standpoint, geotextiles can be used in mechanically stabilized earth (MSE) retaining walls which are increasingly being used in CCR landfills and impoundments. High-strength geotextiles can also provide increased subbase stability for poor underlying soils or an existing waste mass. Geotextiles can also be used within an unstable or poorly drained waste mass to increase the stability.

The use of geotextiles for filtration and dewatering is also of critical importance in CCR management facilities. Geotextiles in geocomposite drainage nets, wick drains and chimney drains can provide much needed dewatering of saturated wastes to increase consolidation and stability. CCR’s present a challenge for filtration due to their fine particle size and gradation.
Finally Geotextiles are used for cushioning and erosion control. A common example of cushioning is the use of thicker geotextiles to prevent potential damage to or puncture of a geomembrane barrier layer.

**Geonets/Geocomposites**

Geonets and geocomposites provide for the efficient transfer and removal of liquids and/or gases within a waste mass or soil or at a barrier layer such as a geomembrane or geosynthetic clay liner. Geonets typically provide the primary flow path structure in a geocomposite. Geotextiles are laminated to one or both sides of the geonet to provide filtration and/or interface shear strength.

Geocomposites are used for leachate collection and detection in primary and secondary base liner systems. In addition, they are used in for stormwater drainage in closure/cover systems and for groundwater suppression and gas venting in underdrain systems. Geocomposites are also being used for gas collection and relief in municipal and industrial disposal applications as well as leachate recirculation in municipal disposal applications. In CCR applications, however, GCL’ecomposites can also be used for dewatering within the waste mass.

Geocomposites are available in bi-planar and tri-planar/tri-axial configurations depending on the specified performance standards required of the geocomposite. Various bi-planar configurations and thicknesses currently comprise the majority of the geocomposite market and typically range in thickness from 200mils to 300mils. Tri-planar/Tri-axial geocomposites are available for higher-end applications where additional performance is required.

However, the configuration and thickness of the drainage structure are merely tools used by the manufacturer to meet site-specific transmissivity requirements under specified loading, gradient and boundary conditions. In addition to thickness, geotextile variations and geonet strand shapes and alignments can also make significant performance improvements. In almost all circumstances the specified transmissivity governs the particular geocomposite to be used for an application.

Due to the typical gradation characteristics of CCR’s, geocomposite manufacturers are working to provide products to provide adequate filtration for the fine particle sizes present. Recent innovations include the utilization of composite (woven/nonwoven) geotextiles to provide additional strength and filtration³.

**Structured Geomembranes**

Structured geomembrane are produced through a flat die calendared extrusion process and incorporate drainage studs, large spikes, grid patterns, or other larger protrusions from the core geomembrane, both studs and spikes or other combinations. When
produced with large aggressive spikes a structured geomembrane provides some of the best interface friction angles in the industry for a soil/geomembrane interface.

Structured liners can also be manufactured with drainage studs such as Agru’s Drain Liner® or Super Grip Net® which essentially combine the performance aspects of a geomembrane barrier layer with a geonet drainage layer. Either alone or combined with a geotextile, these structured drainage liners can be utilized in base liner systems, double-lined systems, and capping systems for equivalent performance with significant cost savings. By combining the performance of two materials into a single material significant cost savings can be realized in both material installation and shipping.

These structured drainage liners have primarily been used in low load applications. However, in direct response to the needs of the CCR industry, recent analyses of structured drainage liners overlain with a composite geotextile under high-load conditions have indicated exceptional transmissivity as well as other performance values.

Geosynthetic Clay Liners

As noted earlier, Subtitle D regulations require a composite liner system utilizing a clay component in conjunction with the geomembrane. Geosynthetic Clay Liners (GCL’s) have emerged as an acceptable alternative to the compacted clay liner (CCL) component of this composite system, as well as in other applications such as closure caps and pond liners.

GCL’s are comprised of a layer of granulated or powdered sodium bentonite sandwiched between two geotextiles or adhered to a geomembrane. The bentonite layer has an extremely high hydration capacity and when hydrated the GCL has a very low permeability. In most instances the two encapsulating geotextiles are needle-punched together to increase the internal shear strength of the material and the resulting overall stability of the completed facility. Varying degrees of needle punching and various geotextile components can provide varying degrees of shear strength which can be witnessed through the variety of GCL products on the market.

Almost all GCL’s are amended through the addition of a variety of polymers in the base bentonite core. However, the recent trend is towards the development of specialized polymer additives to create “designer GCL’s” specifically tailored for specific industries such as CCR disposal. Many of these special polymer amended materials available to all of the GCL manufacturers although they may be trademarked or identified independently by each GCL manufacturer.

Due to the significant potential for differential settlement in CCR disposal and management facilities and the resulting affects on CCL’s, GCL’s are typically highly recommended as the preferred choice over CCL’s⁴.
Geogrids

Similar to geotextiles, geogrids offer soil and waste mass stabilization solutions which are of such critical importance in CCR management and containment facilities. Geogrids are commonly used in mechanically stabilized earth (MSE) retaining walls and subbase stability, both of which are increasingly being used in CCR landfills and impoundments.

Synthetic Turf Systems

In recent years, synthetic turf systems have entered into the disposal marketplace as alternative final and interim landfill closure systems, erosion control systems, and for aesthetics and erosion control in MSE retaining wall systems.

ClosureTurf™ is an alternative final closure system which integrates a structured geomembrane (Agru Super Grip Net®) with a specially designed synthetic turf to provide a long-term, high performance, low maintenance closure system which is also aesthetically pleasing.

ClosureTurf™ greatly improves on the concept of both traditional and/or exposed geomembrane capping systems in numerous areas including the following:

- Cap and LFG system accessibility
- Performance in extreme weather conditions
- Overall aesthetics
- UV resistance/life expectancy
- Overall Stability
- Erosion/Run-off Control
- Ability to efficiently close smaller areas
- Annual and long-term maintenance

Similar synthetic turf systems, HydroTurf™ and VersaCap™ are designed for high velocity erosion control and interim landfill closure systems, respectively.

Additional Geosynthetic Materials

High strength geotextiles can be fabricated into containers or units called geotubes. Geotubes can be used in dredging applications, erosion control, shoreline protection, as well as other applications. However, their use in waste and sludge dewatering applications appear to offer solutions for the CCR management and disposal industry.

Erosion control blankets/mats are also available for slope and channel stabilization. These mats are typically available in three basic categories:

- Temporary erosion control mats (straw or fiber mats)
- Permanent erosion control mats
• Hard Armor mats.

The decision on which erosion control mat to be used for each specific application should be based on the anticipated flow rates and velocities along with the site specific soils to be used.

Conclusion

A wide variety of geosynthetics are already available for use in the management and disposal of CCR's. While most of these technologies transferred from the municipal and industrial disposal arenas, the CCR management industry is challenging these materials for new and innovative uses. And in response the geosynthetics industry is modifying its products and developing new alternatives specifically intended for the CCR industry.

REFERENCES


