

Introduction of a Novel Approach - Beneficial Reuse of CCP's to Dramatically Reduce Landfill Airspace Construction Costs

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ABSTRACT

Advanced Wall Technologies, LLC (AWT) has developed unique, patent pending methods of increasing disposal facility (landfill) airspace. Use of these methods can lead to significantly reduced costs as compared to expansion using conventional means partially as the result of beneficial reuse of coal combustion products (CCP's) and other materials. These materials, fully encapsulated in mechanically stabilized earth (MSE) berms and embankment berms, allow vertical and lateral expansion of the landfill with limited increase in the footprint. AWT methods are also particularly useful in the conversion of wet disposal to dry disposal CCP areas.

Proposed regulation changes will be made public in the near future by the United States Environmental Protection Agency (USEPA). AWT design and construction methods comply with the anticipated regulation change regardless of the final regulation requirements.

Using the AWT developed methods, the team of AWT, Geosyntec and Tensar are currently permitting and constructing the initial phase of a 50-acre MSW landfill expansion that provides 4 million cubic yards of airspace for a facility that is nearing full capacity and faced with closure while beneficially reusing 1 million CY's of CCP's in construction. The AWT expansion method allows the facility to remain open for an additional twenty years. Permitting for the expansion began in December 2009 and the first phase of expansion will be completed by February 2011, approximately fourteen (14) months after beginning the permitting process. This paper describes and details the design, permitting and construction of this expansion and the advantages provided by the AWT expansion methods.

1.0 INTRODUCTION

The number of landfills in the United States has declined significantly over the last twenty years. Industry experts estimate that the number of landfills in the United States has decreased from 8,000 in 1988 to less than 1,754 in 2007¹. Higher regulatory standards and local resistance to permitting landfills in the proximity of other development have accelerated this decline, thus increasing the value of permitted landfills and the tipping fees to customers. As the remaining landfills reach capacity, the need for innovative, cost-effective methods for creating new airspace has intensified. Greatly increased regulatory pressure is anticipated to be exerted on the coal fired utility industry in the management of their coal combustion products (CCP's) and the conversion of wet to dry disposal management.

This paper looks in general at the vertical expansion of waste facilities, new technologies to manage these expansions, and application of these technologies at a specific project currently under construction in the eastern United States. This project incorporates an innovative and much needed patent(s) pending expansion technology developed by Advanced Wall Technologies, LLC (AWT). The beneficial reuse of CCP's and their encapsulation is a major component of the technology. The usage of CCP's allows the CCP generator to expand its disposal facilities using their own CCP material as construction material. Additionally, the use of CCP's can allow those facilities that have no room for lateral expansion to export their material to expand other solid waste facilities via beneficial reuse of their CCP's. All AWT MSE berm cross sections (there are over 20 different cross sections) enclose CCP's or other material in a manner fully compliant with Subtitle D.

2.0 BACKGROUND

Some time ago, a municipal solid waste (MSW) landfill owner faced a difficult challenge. Their landfill was almost out of airspace, and the leadership was faced with closing the



landfill within 18 months at high cost and incurring ongoing long term transportation and disposal fees.

AWT management began considering certain criteria in evaluating expansion options at the site, including: how to increase airspace for the landfill, given that the existing permits and site limitations appeared to have no lateral expansion possibilities due to streams, 100-year floodplains, wetlands and industrial development encroachment, how to do it at a reasonable cost, and how to do it in a very short period of time. More importantly the solution led to the creation of dramatically cost-effective airspace, as compared to that generated via conventional solutions.

This expansion solution derived is directly applicable at many solid waste management facilities including coal combustion product disposal facilities. These same techniques are directly applicable for wet-to dry disposal and management area conversion. CCP facilities now have the option to use their own material to construct additional airspace. In 2009 alone, the American Coal Ash Association reported that 47,882,670 tons of fly and bottom ash were required to be disposed in some manner². Exporting these materials are cost prohibitive so effectively managing these materials on-site is cost efficient. In addition, these materials can be used to expand other landfill sites in a fully compliant manner.



To make vertical and lateral expansions more economically feasible, AWT developed patents pending designs for construction of MSE berms with an encapsulated section using backfill materials that are environmentally and regulatory agency acceptable. The AWT technology is a less expensive alternative than a lateral expansion because the large capital expenditures for property and infrastructure development are eliminated. Additionally, AWT technology can be

utilized for other embankment scenarios in which utilizing materials that are currently not allowable for construction would be deemed beneficial reuse.

The innovative and creative solution to the challenge presented by AWT resulted in:

- An expansion technology with the lowest possible cost due to off-setting construction cost with backfill material revenue in an MSW expansion.
- An expansion to the disposal facility that provided 15-20 years of additional life.
- Provides a host fee to an economically depressed community.
- Prevents the community from incurring an anticipated \$ 5M in closure/post-closure costs.
- Free disposal for the community for 15 years.
- Construction began within 8 months of regulatory permit amendment submittal.

3.0 MSE BERMS TECHNOLOGY BACKGROUND

A fundamental component of the innovative solution presented herein is the use of mechanically stabilized earth (MSE) technology. This technology as applied to waste containment facilities consists of utilizing geosynthetic reinforcing elements in combination with soil and a wide selection of facing elements to create safe, cost-effective grade separations for waste containment facilities.

MSE technology is well established: the first geosynthetically-reinforced grade separation structure worldwide was completed in France in 1973³ and in North America in Oregon in 1974⁴. In 1985, MSE technology was used for the first time in North America to create useful airspace within a waste containment facility⁵. MSE technology using geosynthetic reinforcing was introduced to the municipal solid waste market in 1996, with the design and construction of the first MSE berm at Pottstown Landfill in Pottstown, PA⁶. Since 1996, MSE berms have been constructed at 11 different landfills in Pennsylvania alone, with additional construction occurring in New York, Georgia, Maine, New Hampshire, Delaware, Maryland, Massachusetts, Florida, Alabama, Louisiana, and Kentucky. A recently constructed MSE berm is shown in Figure 1.



Continued use of accepted design guidelines, along with a preponderance of literature on all aspects of MSE berms, including stability^{7,8} and construction aspects⁹, have created an environment in which the use of MSE berms will continue into the foreseeable future.

4.0 PERMITTING CHALLENGES & TIMELINES

When proposing and completing an expansion project related to solid waste management, the permit type and permitting timelines are often a key factor. In fact, the decision of a new permit versus the amendment of an existing permit is a major differentiator on some projects. New permits require years to complete before construction, and therefore, before airspace gain can occur. There are often siting, local land use, design and wetland permits to obtain all of which require at least three years to obtain depending on the state. Permit amendments, on the other hand, have the distinct advantage of leveraging an existing permit during the vertical expansion rather than moving laterally. Permit amendments generally have a far shorter timeline for

approval as the waste footprint seldom or only marginally changes in a vertical expansion.

Factors, regardless of the requirement to obtain a new versus a permit amendment, that are generally required to be addressed include:

- Is construction to occur over completed disposal cells?
- If so, does the consolidation of the waste mass underneath adversely impact the existing or anticipated new liner system?
- Does the new technology fully protect the environment?
- Are groundwater, surface water, wetlands or 100-year flood plains impacted in an adverse manner?



The pictures contained throughout this paper were taken at a facility where an AWT vertical expansion CCP encapsulation berm is being constructed. By managing the issues noted above adequately Geosyntec and AWT were able to achieve the following timelines:

1. *The elapsed time from permit amendment submission to authorization to construct was 7.5 months.*
2. *The elapsed time from permit amendment preparation initiation to authorization to construct was 11.5 months.*

5.0 VERTICAL EXPANSION DESIGN CHALLENGES, CONSIDERATIONS & SOLUTIONS

In general, the placement of additional waste material over previously placed material (vertical expansion) encompasses many unique challenges and design considerations that are discussed in the following sections:

5.1 Piggybacking of Liner Systems Where Required

“Piggybacking” is the term generally given to the practice of placing additional waste over top of existing waste whether it is MSW, construction & demolition debris, industrial or coal combustion product waste. Each of these materials has their own unique characteristics. Regulatory agencies generally require a consolidation analysis and may

require additional liner systems placed between the vertical expansion materials and existing waste mass.

At the example landfill considered above a portion of the waste mass did not include base liner or leachate collection systems, and therefore, a piggyback liner system was required. An extensive geotechnical investigation was implemented to determine settlement and strength parameters of the waste and potential void locations with the goal of designing a liner system that would withstand the strains induced by overfilling the existing waste mass.

5.2 Existing and Future Property Limitations

Many sites, particularly in developed areas, have severe inherent limitations that hamper, if not eliminate, lateral expansion. These include the encroachment of industrial, commercial or residential areas on the site since the facility was originally constructed, limitations due to the locations of streams and/or wetlands adjacent to the waste management areas and the permitting difficulties and expanded permitting timelines resulting from their presence. In addition, most solid waste management regulations have very specific setbacks from property boundaries, wetlands, streams, residences, 100 year floodplains, etc.

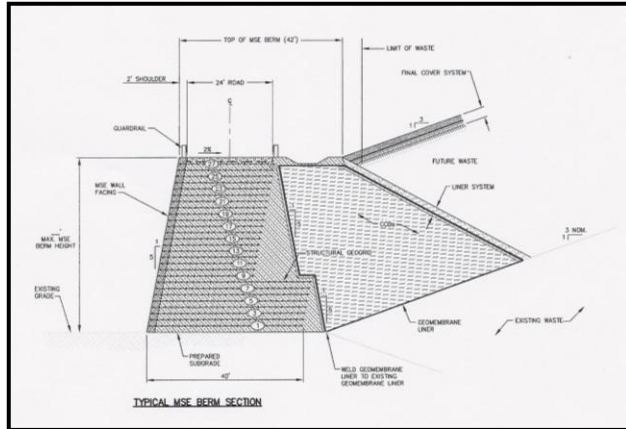
For the example landfill commercial and industrial properties are located to the south and west, a river is located to the north, and wetlands are located to the east of the property. Therefore, the only expansion possibility is to increase the airspace over the existing landfill footprint.

5.3 Appropriate Geogrid Reinforcement

MSE berms use geogrids to reinforce the soil used in construction to create a stable



berm. Moreover, it is the geogrid component that allows for the construction of a near vertical exterior wall that facilitates the largest amount of airspace without expanding laterally. Therefore, careful consideration must be given to the type, spacing and manufacturer/supplier of geogrid to provide a finished product that functions as designed.



Geogrids stabilize the MSE berm against multiple potential failure modes including external and internal stability and differential settlement. At the example landfill the limited space required the location of a portion of the MSE berm over the MSW waste mass, leading to significant differential settlement. The lower layers of geogrid were designed with a higher ultimate strength than the upper layers and were extended to mitigate the impacts of the calculated

differential settlement and to increase the factor of safety for the global stability of the berm.

5.4 Liquids Management

Almost all solid waste management facilities have specific regulatory requirements that must be considered during the permitting, construction and operational phases of development regarding liquids and their management. Leachate is the term generally given to water that has come into contact with a waste product, and it must be managed accordingly. It is generally treated as an industrial wastewater. Often, a “piggyback”



system has a collection zone to send the collected leachate to the leachate removal system, either an onsite tank or connection to the local wastewater treatment plant. In addition, during construction and during the life of a facility, stormwater management is critical to the long term function of an MSE berm system; therefore, a properly designed and maintained stormwater management system is critical to the berm’s stability.

AWT is a strong proponent of the utilization of CCP’s in the structures we build. Their usage, however, requires some important consideration. For example, due to the fine grained nature of CCP’s, a design that reduces the impact of stormwater run-on and, thus, development of pore water pressures is important. AWT berms incorporate CCP’s and fully encapsulate the CCP’s in a liner system to reduce the likelihood of leachate and/or stormwater from entering or exiting the system, leading to long term stability, safety and reliability.

6.0 CONSTRUCTION

Construction of an MSE berm involves two basic functions: earth moving with heavy equipment and berm reinforcement and facing installation with manual labor. Because landfills are typically regulated structures, construction quality assurance of the materials and construction procedures is required. Therefore, coordinated efforts between the contractor, owner, designer, and construction quality assurance engineer are an important part of the success of MSE berm construction. For the example landfill, AWT, Geosyntec, and Tensar have worked together with the earthworks contractor through the routine and the sometimes challenging portions of the berm construction to provide the owner with the airspace they need to continue operation of the landfill.

7.0 AWT VERTICAL EXPANSION ECONOMICS

Recently, AWT performed an economic analysis of various AWT MSE encapsulated berm configurations for utilization at CCP ash disposal facilities for an electric power generation company. The following tables are the direct result of the effort. Recent experience in construction costs related to the configurations as outlined below enabled us to accurately analyze these costs.

CCP Dry/Wet Disposal Facility Expansion Costs & Considerations -Utility Facility Expansion

Scenario No.	Disposal Volume Created (CY)	70 Acre (1500' X 2000')		Cost Range (\$/CY)
		Facility Life @ 350,000 CY/Year (Years)	Facility Life @ 700,000 CY/Year (Years)	
1	8,481,556	24.2	12.1	\$ 3.00 – 4.50
2	13,768,657	39.3	19.7	\$ 1.60 – 1.80
3A	5,287,101	15.1	7.6	\$ 3.50 – 3.75
3B	5,109,247	14.6	7.3	\$ 1.75 – 2.00
4	13,768,657	39.3	19.6	\$ 1.60 – 1.80

Note that the wide range for a new Subtitle D facility (Scenario No. 1) is because such development has generally far greater capital costs that are site and project specific due to:

- Property & Acquisition Costs
- Permitting Costs

- Infrastructure Costs (roads, possible rail spur, structures, disposal cells, industrial wastewater treatment facility, heavy equipment purchases, scales, etc.)
- Legal Fees
- Public Relations Management Costs

CCP Dry/Wet Disposal Facility Expansion Costs & Considerations – Scenario Descriptions

No.	Scenario Description	Advantages	Disadvantages	Notes
1	New Subtitle D Facility	Established method.	Property (70 acres) must be obtained and permitted. Permitting timeline 3-4 years. Does not use CCB's in construction	Traditional Subtitle D Disposal Cell Design.
2	New Subtitle D Facility with an AWT MSE Berm Added to Maximize Disposal Capacity	Low unit cost option. Uses CCB's in construction.	Property (46-140 acres) must be obtained and permitted. Permitting timeline 2-4 years.	Adds an AWT MSE berm to Scenario No. 1 and alters liner design.
3A	Vertical Expansion of Existing CCB Management or Disposal Facility with and AWT MSE Berm And A full Piggyback Subtitle D Equivalent Liner System	Significant airspace creation on existing footprint. No additional acreage required. Leverages existing permits. Decreases permitting from 2-4 years to 1 year. Uses CCB's in construction.	Highest unit cost. Requires piggybacking over existing fill.	Good option for facilities with little room for lateral expansion and faced with disposing CCB's offsite at a cost of \$10-30/CY.
3B	Vertical Expansion of Existing CCB Management or Disposal Facility with and AWT MSE Berm (Existing Liner System is Subtitle D Equivalent)	If acceptable liner is in place, piggyback lining costs are eliminated from 3A resulting in large savings. No additional acreage required. Decreases permitting from 2-4 years to 1 year. Uses CCB's in construction.		An even better option for facilities with little room for lateral expansion and faced with disposing offsite at a cost of \$20-30/CY.
4	Conversion of a Wet Disposal Facility To A Dry Disposal Facility with an AWT MSE Berm and a Subtitle D Equivalent Liner System	Eliminates potential future regulatory issues by conversion of wet to dry disposal of all <u>or a portion</u> of the basin. Low unit cost. No additional acreage required. Uses CCB's in construction. Can use current wet disposal area prior to full conversion to dry disposal.	Must create a sheet pile or interior berm divider for construction. Dewatering/ground improvements may be required	<i>Conversion of a wet disposal basin to dry disposal.</i>

8.0 CONCLUSIONS

Advanced Wall Technologies, LLC has patents pending for a method of increasing existing available disposal facility (landfill) airspace for municipal solid waste (MSW), construction/demolition/debris (CDD), special waste, industrial or CCP landfills at generally less than current costs for constructing airspace. The AWT method beneficially utilizes waste products such as CCP's as a construction material. These materials are fully encapsulated in MSE berms and embankment berms to allow vertical

and, in appropriate circumstances, lateral expansion. AWT was assisted by Geosyntec Consultants, Inc. a nationally respected engineering firm, in developing the method.

MSE berms have been used as an expansion technique where property constraints prevent lateral expansion or vertical expansion with non-reinforced berms. MSE berms are designed with reinforced earthen material(s) that provides significant grade changes in a limited space. The primary cost component of MSE berms is the procurement, transport, placement and compaction of the fill. Thus, any technique that minimizes the cost of this component can dramatically improve the economic benefits offered by MSE berms.

To make vertical expansions more economically feasible, AWT developed a design for construction of these berms using backfill materials that are more economical to purchase (or sometimes are free or generate additional revenue) and deliver to the facility while being environmentally and regulatory agency acceptable. In general, the AWT technology is a less expensive alternative than a lateral expansion because the large capital expenditures for property and infrastructure development are eliminated. Additionally, the AWT technology can be utilized for other embankment scenarios (roads, etc.) in which utilizing materials that are currently not allowable for construction would be beneficial.

Regulation changes are proposed and will be made public in the near future by the United States Environmental Protection Agency (USEPA) that will impact the means by which U.S. power generation companies manage CCP's. These regulations will likely impact companies that own and operate both wet ash ponds and dry ash landfills. Power generation companies now have the creative solution via AWT encapsulated berm technology to ensure their CCP management costs remain relatively unaffected. In addition they can export their CCP's for expansion of other landfills reducing long term liability, transportation and disposal costs. Power generation companies will have an option to increase their limited and critical airspace in a less costly manner.

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