TenCate
Mirafi®

REINFORCEMENT

Case Study

application	Steepened Slopes
location	Baltimore, MD
product	Miragrid® 5XT (103,000 SY), 7XT (126,000 SY), 10XT (106,000 SY)
job owner	Loyola College
engineer	Haley & Aldrich, Inc.
contractor	GC – Whiting Turner
date of installation	Spring/Summer 2008

TenCate develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

THE CHALLENGE

When Loyola College of Baltimore, MD sought to expand their academic space, they determined that moving their athletic complex to an off-site location might be the best option. As a result, the University purchased a nearby 52-acre parcel that was a former landfill site. Although it's feasible to construct a "state of the art" athletic complex on a site with difficult topography and poor subsurface conditions, there would be many challenges. Beginning in the 1930's, and with portions staying open until 1985, the MSW (Municipal Solid Waste) in the landfill ranged in depths from 10'-215'. It was planned that much of the complex would be built on and around these MSW fill areas. Using the guidance of previous geotechnical investigation reports provided by the owner, the City of Baltimore Department of Public Works, a plan was developed to include an additional 82 borings and 47 test pits for review.

A further challenge for the designer was the requirement of the civil and municipal authorities that the site be "balanced" with no export of waste material.

Due to the steep topography of the site and compressible subsurface conditions, it was determined that flexible grade separation structures were needed which could withstand differential settlement and also be "green" to blend in with the native surroundings.

THE DESIGN

Upon determining the key project requirements - a flexible grade separation structure that providing grade changes of 60'-80' and a "green" solution - a Vegetated Reinforced Soil Slope (VRSS) was selected and designed for the project. Besides the "green" advantages of such a structure, a geosynthetic reinforced structure is also considered very economical.

Since the VRSS needed to achieve heights up to 60'-80', a major consideration that the designers needed to evaluate was settlement, both immediate and long-term. Immediate settlements can take place during construction, while long-term settlements can take place over 50 years or more. With modifications to well-established soil mechanics/geotechnical engineering theories for settlement of compressible soils, designers calculated and estimated both the immediate and long-term settlement of the MSW. Using these methods it was determined that portions of the VRSS would experience immediate settlement up to 8.4' and 7.5' to 20' for long-term settlement.

To provide an additional level of certainty, the structures were required to achieve a minimum factor of safety of 1.5 for global stability, base sliding, and geogrid reinforcement strengths. Vegetation of the face of the VRSS was achieved through the design of a bioengineered facing system. The bioengineered facing system was comprised of an Erosion Control Blanket (ECB) wrapped inside of the primary geogrid reinforcement and welded wire forms with grasses and shrubs planted in the horizontal steps of the structure. The welded wire forms that were specified and installed for the project met ASTM A185 with 4-gauge steel, constructed with 4" apertures and dimensions of 18"x 18"x10'. These steel baskets were used as form work for construction and are not needed for long-term stability at the face of the structure. Depending on the desired slope of the VRSS, the welded wire forms are set back horizontally from the form immediately beneath. It's within these horizontal setbacks where the vegetation is planted. Depending on available space, the slopes for the five VRSS structures on the project range from 0.5:1 to 1.5:1. In other words, the individual wire forms were setback 9" to 27" from one another.

The vegetation specified for the bioengineered face of the project included: Aronia arbutifolia, Clethra alnifolia, Comptonia peregrine, Cornus racemosa, Hypericum calycinum, Panicum virgatum, Rhus aromatic, and Viburnum acerfolium.


Northwest side of VRSS-2.


Southeast side of VRSS-2.

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THE CONSTRUCTION

In order to uniformly compact and densify the VRSS subgrade areas and wide area foundations located over MSW, the application of Deep Dynamic Compaction (DCC) was employed. Heavy DCC for this project specified five (5) 60' drops of a 15 ton weight on an 8.5' x 8.5' grid pattern with a repeating pattern, which varied slightly depending on the cut or fill scenario. Once DCC was completed, construction of the VRSS began. The reinforced slopes were installed using standard installation methods for these types of structures. Due to the balanced site requirement, some of the proposed backfill was not ideal material. Therefore, lime treatment of the soil was used to improve the engineering properties of the backfill. The addition of lime in the soil backfill can increase the pH level of the soil. However, with polyester (PET) geogrid reinforcement this can be accounted for in the design. TenCate Miragrid® geogrids have been used with backfill with pH values as high as 12 without any problems. Construction of the facility began in the spring of 2006 with substantial completion of the VRSS by August of 2008.

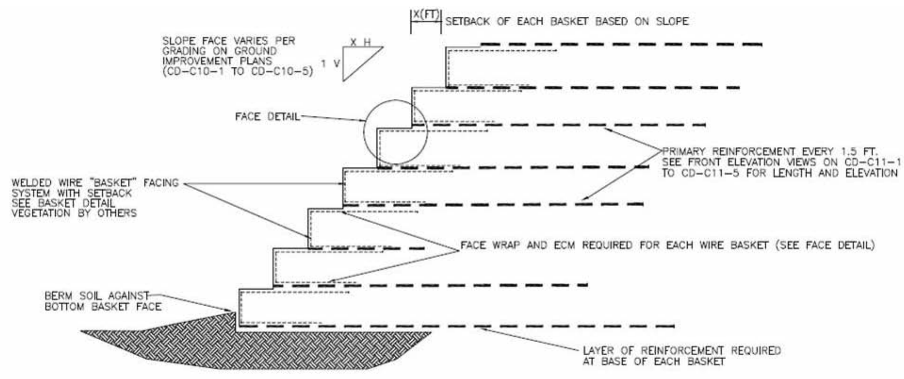
THE PERFORMANCE

To monitor performance of the VRSS, several types of instrumentation were installed in and around the structures. The instrumentation included several settlement plates that were installed in a fashion that could be monitored by optical survey, horizontal inclinometers, vertical inclinometers, and a Sondex settlement system. As of April 2012, all VRSS were performing well and as expected.

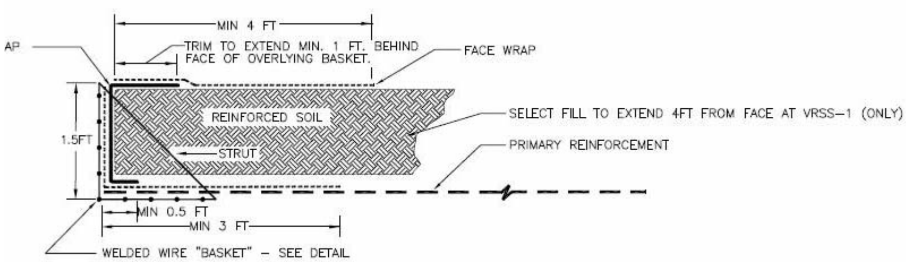
Miragrid® polyester geogrids were used successfully to meet the unique challenges of this project and site. Furthermore, Miragrid® geogrids proved to be the most cost effective product for the project.The official grand opening of the sports complex was held on March 13, 2010.

Quoting University President Brian F. Linnane, S.J.,"This highly anticipated facility represents an extraordinary step forward for Loyola's already outstanding athletics program. This state-of-the-art complex will allow us to continue to attract student-athletes of the highest caliber, host a broader range of post-season events, enhance pride in Loyola and the Greyhounds, and create new opportunities to connect with our neighbors in Baltimore."

Aerial view of complex. VRSS-2 on the left connecting to VRSS-3.



TYPICAL CROSS SECTION
NOT TO SCALE



FACE DETAIL
NOT TO SCALE

Reference: Shelton, A Derrick, Schoenwolf, A David, Mohanan, P Nisha "Redevelopment of a Municial Solid Waste Landfill: Engineering Design Challenges." 6th International Conference on Case Histories in Geotechnical Engineering, Arlington, VA August 11-16, 2008.

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