Polyester Geogrid Requirements

SRW HISTORY ARTICLE SERIES

This is a new article in a series of technical articles on the history of segmental retaining walls.

Submittal Requirements for Polyester (PET) Geogrid Reinforcement

The NCMA Design Manual for Segmental Retaining Walls, 3rd Edition (Ref. 3), has been instrumental in the growth of geosynthetic reinforced soil walls in commercial markets by providing a fundamental geotechnical based method for structural stability analysis. Previous articles from NCMA have noted AASHTO Specifications and FHWA Guidelines have supported the design of geosynthetic reinforced soil structures in public sector markets including structures designed for State Highway Transportation Departments. All these documents provide specification and material testing requirements important to the long-term performance of the geosynthetic reinforcement, and they include specific guidelines relative to the long-term durability of geogrid reinforcement manufactured from polyester (PET) fiber.

This article discusses the importance of raw material certifications, presents a real-life scenario with structural steel, and outlines to the engineer, specifier and owner what is required to ensure the long-term durability performance of PET geogrid.

Steel or Geosynthetics – Should There Really be a Difference in Material Certifications?

The question above should not need to be asked, but what if you read an article about a cable-stayed steel suspension bridge that had been constructed with steel cables that had no quality control requirements or inspections at the time of fabrication? Or, what if the engineer failed to specify key performance requirements of the steel? Simple answer – you would question the long-term performance and safety of the structure.

For comparative reference, the purchase of steel fabricated in China for the San Francisco-Oakland Bay Bridge project drew considerable media coverage. The California Department of Transportation (CALTRANS) and California government officials were subjected to extensive scrutiny for their decision to award the contract to the low-bid, foreign supplier. Over 200 employees, consultants, and contractor representatives were dispatched to China to train workers and inspect steel fabrication. Their goal was simple: take the necessary steps to ensure the steel met the specifications.

So how does this apply to PET geogrid? This is a simple question with many answers, and one that specifiers, designers and suppliers should consider on each project. The answer is equally simple - "Specifiers need to take appropriate steps to ensure the quality of all construction materials in critical applications – including PET used in geogrid reinforcement."

Since the introduction of uniaxial geogrid reinforcement to the U.S. market in the early 1980's, the acceptance of the technology has grown exponentially worldwide and now represents state-of-practice for the majority of mechanically stabilized earth structures. Geogrid reinforced structures are typically used in critical long-term applications having design lives exceeding 75 to 100 years where the geogrid is under constant tension. Utilizing geogrid reinforcement, mechanically stabilized earth (MSE) technology has been used to successfully construct segmental block retaining walls (SRW) exceeding heights of 80 ft. (24.4m) and reinforced soil slopes (RSS) to heights of over 240 ft. (73.1m). The long-term performance of these structures is directly linked to the quality of the geogrid and more importantly, the quality of the polymer used to produce the geogrids.

The Required Properties for the Polyester Fiber in Geogrid Used to Reinforce the Soil behind MSE Structures is Seldom Specified, and Virtually Never Verified.

Today, there are many different international manufacturers of geogrid reinforcement. Quality control and a quality product on the job site are now more than ever a major concern. Access to the now "global" geosynthetic market is exploding and the availability of global sourcing of polyester fiber and the geogrid itself is becoming more and more an engineering question. No different from a structural engineer specifying steel bridge cable or Caltrans purchasing steel from a foreign source is the challenge for MSE designers and specifiers to ensure that the specified geogrid meets industry standards for chemical and molecular composition as well as other physical properties.

Anyone familiar with steel is aware of the many different "types" of commercial steel; stainless, low carbon, alloy carbon and list goes on. There seems to be almost endless alloy compositions that are used for different applications. There are also numerous finishing processes; hot rolled, cold rolled, annealed, hardened, tempered. Each of these "types" of steel has different chemical and physical properties. Polyester fiber, as well as most polymers, comes in many different "types". Each type has its own unique physical characteristics, and specific to PET fiber it is recognized that not all PET is appropriate for geogrid application. The molecular composition of PET fiber used to manufacture geogrid is the most important raw material consideration as it serves the basis for long-term performance, both chemical and mechanical.

In order to properly utilize geogrid in his or her project, the engineer must first understand how to design with them and ensure that the material installed meets the project specification. Verification of basic material properties used in critical construction projects has been standard practice for literally thousands of years.

Research Establishes PET Requirements

In the mid-1990s, the U.S. Federal Highway Administration undertook an extensive research effort to develop testing protocols and recommendations appropriate for durability of polyester geosynthetics. This multiyear FHWA study culminated in the establishment of parameters important to the long-term durability of polyester. The primary mechanism for PET degradation in naturally occurring soil is hydrolysis. Hydrolysis, usually associated with an alkali or high pH soil in a wet environment, is simply the rupture of molecular bonds resulting in a loss of strength over time. The FHWA identified three key factors affecting PET durability:

1. Soil pH combined with the presence of sufficient water (or moisture) – alkaline soil with a pH of 10 or above representing the environment with greater potential for degradation.
2. Polyester molecular weight – polymer molecular size has a significant influence on chemical durability.
3. Polyester carboxyl end group – PET with fewer "carboxyl end groups" in the molecular structure is less susceptible to degradation.

Molecular weight and Carboxyl End Group (CEG) are both specific characteristics of the PET fiber that can be tested and should be specified and verified prior to field installation.

NCMA States Minimum PET Requirements

The FHWA guidelines on PET durability are adopted by NCMA and state that polyester fiber for geogrid reinforcement used in long-term applications (75 or more years) shall have:

- CEG count less than 30 mmol/Kg as determined in accordance with ASTM D7409 (GRI-GG7). (Ref. 2)
- Molecular weight greater than 25,000 g/mol as determined by correlation using inherent viscosity under ASTM D4603 (GRI-GG8). (Ref. 1)

Certification Ensure Proper Materials

CEG and molecular weight data should be readily available from any PET fiber supplier used in the manufacturing of geogrid for soil reinforcement projects. It should be incumbent upon the project specifier/designer to require the PET fiber manufacturer's certification from the geogrid manufacturer. Given the influx of foreign manufacturers of geosynthetics into markets using the NCMA Guidelines, the engineer should require geosynthetic manufacturers to prove that the PET fiber used in the production and supplied indeed meets the minimums stated above. This approach to require PET fiber certifications by the PET fiber manufacturer is consistent with standards of certification applied to other construction materials, i.e. steel used in bridges. It is considered state-of-practice for professional engineers to require "mill certs" for any product component that is used in critical engineering structures. This should include any geogrid used for applications where polyester fiber is relied upon to sustain long-term loads.

Sample Specification

"All PET geogrid submitted for approval and delivered to the jobsite must be made from polyester fibers which meet durability specifications as follows:

Molecular weight > 25,000 g/mol
Carboxyl End Groups < 30 mmol/Kg

The contractor on the project must submit certifications on the specific lot of geogrid being proposed for use. The certification, obtained from the geogrid manufacturer, must originate from the actual manufacturer of the fiber, showing conformance to this specification, the date of manufacture, and the fiber production lot number (e.g. fiber merge number). Product labeling should reference the fiber production lot (e.g. fiber merge number) stated in the fiber manufacturer's certification. Failure to provide proper certification will disqualify the geogrid from use."

It should be noted a letter of certification from the PET fiber manufacturer, in addition to the PET geogrid manufacturer, is required. Additionally, there should be sufficient documentation supplied from the geogrid manufacturer that demonstrates the product supplied to the project incorporates the certified fiber. In combination, the documentation will assure the engineer and project owner there is full compliance with the industry standard.

A typical fiber certification looks like this:

Certification of CEG/MW

24 September, 2012

This letter certifies that the following polyester filament yarn shipped from XXXXXXX Corporation have a Carboxyl End Group content less than 30 mmol/kg and Molecular Weight greater than 25,000 g/mol.

1000 denier/192 filament [redacted] (Lot 1766)

Reference
-Test lab: [redacted]
-Date: September, 2012
-Report No. M215-12-04180
-Test Results:
1) Carboxyl End Group Content of PET Yarns (GRI-GG7) mmol/kg: 23.8
2) The number Molecular Weight (GRI-GG7) g/mol: 30,262.5

[redacted]
By: [redacted]
Name: [redacted]
Title: [redacted]

Documentation Ensures Success

In summary, PET geogrid is commonly used for critical soil reinforcement applications. Existing industry standards are in place to address durability and performance through verification of the PET fiber characteristics. Accordingly, the material components used in the construction of these structures require the owner, specifier and engineer to perform the necessary due diligence that ensures the system, including the geogrid, is acceptable for long-term (75 to 100 years) application. PET geogrid supplied to any project should be supported with CEG and molecular weight certifications.

Designers and specifiers can refer to the National Transportation Product Evaluation Program (NTPEP) for Geosynthetic Reinforcement, which has evaluated and compiled reports on commercially available geosynthetic reinforcement products, to facilitate product selection.

References

1. "Standard Test Method for Determining Inherent Viscosity of Poly(Ethylene Terephthalate) (PET) by Glass Capillary Viscometer", ASTM D4603, ASTM International (2011).
2. "Standard Test Method for Carboxyl End Group Content of Polyethylene Terephthalate (PET) Yarns", ASTM D7409, ASTM International (2007).
3. "Design Manual for Segmental Retaining Walls, 3rd Ed.," TR 127B, National Concrete Masonry Association, Herndon, VA. 2009.

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