PANEL LEADERSHIP CHANGES IN 2005

Due to the retirement of Dave Suits in 2005, a new geotextile panel chair was appointed – Tony Allen (WSDOT). A new vice-chair was also appointed, specifically, Jim Curtis (NYDOT). Jim Curtis also took over responsibility for the geotextile testing conducted at NYDOT.

2005 ACTIVITIES - GEOTEXTILES

During calendar year 2005 there were 70 geotextiles (55 under prime manufactures; 15 under private label agreements) submitted for testing in the program. They came from 19 companies.

The 26th edition of the report, containing all current test results through the April 2005 submissions, was published in January 2006. This report contains results for 34 companies and 294 product designations. This represents an addition of 14 designations over 2005. This report was published as a PDF only. The 27th edition, published in hard copy form in May 2006, contained test results for submissions up through September 2005. Testing for geotextiles submitted up through January 2006 has been completed, but not reported as yet.

As was true in 2004, reports for testing of products submitted during each testing period during 2005 and the first part of 2006 have not been as timely as desired. With the retiring of the chairman of this panel last year (Dave Suits), calendar year 2005 has been a year of transition, both for the primary lab doing the testing (NYDOT), and for the panel leadership due to the learning curve required. While there were some delays due to the need to fit the scheduling of state personnel to visit the sites where the samples are to be obtained into their already overloaded schedule, the main problem was simply due to the transition to new panel leadership.

2005 ACTIVITIES – GEOSYNTHETIC REINFORCEMENT

Calendar year 2005 was a year for laying the final ground work regarding the geosynthetic reinforcement program. During this time, the testing program was established, a testing lab identified (Texas Research International, or TRI), a contract established, and a fee schedule developed. In accordance with the established work plan for the geosynthetic reinforcement program, the NTPEP testing lab was audited on site by the new panel chairman (Tony Allen, WSDOT), and as a result of the audit findings, some minor corrections in TRI’s testing practices made. The audit also showed that some refinements and clarifications to the primary testing protocol for evaluation of geosynthetic reinforcement, WSDOT Standard Practice T925, were needed. Those
changes were implemented in T925 in November 2005, and the revised protocol published on the NTPEP web site.

Manufacturers of geosynthetic reinforcement can enter the NTPEP program either through the conducting of the full product qualification program, or through “grandfathering” recent test data that meets the product qualification testing requirements, and only having product quality assurance testing conducted by NTPEP for the first testing cycle. A call to all known geosynthetic reinforcement manufacturers regarding the availability of this new NTPEP program went out by e-mail and phone in late 2004/early 2005. In response, four geosynthetic reinforcement manufacturers went through the grandfathering process, but only two of the four had data that was acceptable for that purpose. At this point (July 2006), only two of the manufacturers have proceeded with the reinforcement product testing to complete the program, and the other two who initially submitted have decided to wait to proceed with the sampling and testing until their product lines are in the form that they want them to be in for long-term market implementation. Several others have indicated they plan to submit soon, once their product lines are ready.

The specific process for submitting geosynthetic reinforcement products for the NTPEP program, and the timeline and steps in the NTPEP testing and evaluation process, were established. This process will be included on the NTPEP geosynthetic reinforcement web page for anyone who is interested.

PANEL MEETING FORMAT CHANGES FOR 2006 ANNUAL CONFERENCE

This year two separate meetings were held for the Geotextile Panel. The first meeting was for the geotextile program. The second meeting was for the geosynthetic reinforcement program.

DISCUSSIONS AT THE 2006 MEETING - GEOTEXTILES

The meeting began with the introduction of the new panel leadership, and a review of the 2005 activities (see above). The status of the current round of geotextile testing (i.e., up through January 2006 submissions) was summarized. Jim Curtis (NYDOT) indicated that testing for submissions through January 2006 is complete, and the results have been supplied to NTPEP administration for reporting purposes. It was noted that the new 50 mm puncture test (ASTM D6241), approved as a revision to the geotextile work plan in 2005, was used for this round of testing, and will be used for all future testing rounds.

A presentation on DataMine and how it has been recently applied to the geotextile testing program, was made by Mike McGough (NTPEP staff). After the presentation, it was pointed out the advanced search function had some serious flaws that could mislead users of DataMine regarding products that meet or do not meet a desired specification value. First, the advanced search function is set up to retrieve all products that meet a range for a given property in comparison to a specification value (e.g., AASHTO M288). It would be more useful if the search obtains products that meet a certain minimum value, or in
some cases, a maximum value. Furthermore, the search should not be conducted based on the average value of the actual NTPEP test results. Instead, a field should be added to include the minimum certifiable value or MARV, and the search conducted based on the minimum certifiable value. Since the NTPEP test results should in theory always be higher than the certifiable minimum value, searching based on the NTPEP test results could result in products appearing to meet the desired specification value in which the certifiable minimum value did not meet the desired specification. Making this change is not a trivial effort, but all agreed that it needs to be done. Mike McGough agreed to eliminate the advanced search function for geotextiles for now, until this issue can be resolved.

It was also noted that new reports of geotextile test results, as well as DataMine, should clearly indicate the change in the puncture resistance method, as the new method will produce significantly larger puncture resistance values.

A proposal to split the geotextile panel into two panels, one for the geotextile testing program and one for the geosynthetic reinforcement program, was discussed. The split is needed due to the different needs of these two testing programs, that for the most part, the two programs involve different sets of manufacturers, and overall volume of work for the panel to run both programs. The panel chair called for a vote of the panel to move this proposal to the NTPEP committee for voting. However, it was discovered that the only two panel members present were the panel chair and vice chair. The other panel members were in another parallel panel session. While there were a significant number of people present at the meeting (32 attendees), the audience consisted of manufacturers and other state DOT representatives. There is obviously the need for more panel members to be active participants in this particular panel. There may be some scheduling issues for panel sessions at the conference that need to be addressed as well. In any case, Tony Allen forwarded this request for a ballot item to the NTPEP staff.

**DISCUSSIONS AT THE 2006 MEETING – GEOSYNTHETIC REINFORCEMENT**

The meeting began with the introduction of the new panel leadership, and a review of the 2005 activities (see above). After this, Sam Allen (TRI), as a representative of the laboratory conducting the testing for this program, summarized the testing conducted up to the time of the conference. So far, testing from two product lines (Two manufacturers) has been initiated. Primarily, index property testing and some preliminary creep testing has been conducted. Preliminary reports summarizing all of the index testing and shorter term performance tests (installation damage, CEG/molecular weight, short-term creep tests) should be available to the manufacturers who made the submissions by some time in July. Issues encountered thus far include:

- The states doing the on-site sampling were not familiar with the specific requirements of geosynthetic reinforcement testing. The sampling needs for geosynthetic reinforcement are significantly different than what has been used
for geotextiles. This learning curve caused some delays in getting the testing programs going.

- One of the reinforcement manufacturers is located in Asia, which added some additional logistics to getting the sampling conducted. However, a local sampler was obtained through TRI. Some initial communication problems with the reinforcement manufacturer also occurred due to the language barrier, but those problems have been overcome so far.
- With regard to use of “grandfathered” data, the importance of making sure that the products sampled for quality assurance testing are essentially the same products as were tested to produce the grandfathered data needs to be emphasized with the reinforcement manufacturers.

Sam Allen continued by presenting a brief summary of the results thus far regarding the refinement of the CEG protocol. Most of the work needed to refine the protocol so that consistent results are obtained has been completed, and the final report should be available by late summer 2006. Next steps to implement the new protocol include working with the originating organization (Geosynthetic Research Institute) to modify their published test procedure, and concurrently, work with ASTM to begin the process of getting it accepted as an ASTM procedure. Round robin testing between TRI and the polymer suppliers using the revised protocol also needs to be conducted.

Tony Allen continued with a presentation of what the states and manufacturers should expect regarding geosynthetic reinforcement test reports and their application. The final report format is yet to be fully developed, but the presentation provided the key concepts that need to be understood to apply the test results that will be obtained through this testing program. A copy of the PowerPoint presentation will be put up on the NTPEP website for anyone who is interested.

Due to the amount of time it took to get the geosynthetic reinforcement testing program fully underway, there is little time left for manufacturers to take advantage of the “grandfather” provision in the NTPEP work plan, as that opportunity was to expire in June 2006. Tony Allen (WSDOT) proposed that the opportunity to use “grandfather” provision be extended to the end of 2006 because of the delay in getting the program started. As was true in the geotextile panel session, no other geotextile panel members, other than the panel chair and vice chair, were present. However, there were 29 attendees at the panel meeting, mostly consisting of manufacturers and other state DOT representatives. Therefore, Mr. Allen said that he would move this proposed work plan modification to the full NTPEP panel for voting.
NTPEP Geosynthetic Reinforcement Program Evaluation Process

1. The manufacturer submits an application for their product or product line. The manufacturer should somehow indicate on the form if they are submitting existing data for evaluation to meet the "grandfathering" requirements.

2. AASHTO NTPEP invoices the manufacturer for the grandfathering plus administration fee, if the manufacturer has indicated that they are submitting data for evaluation for the purpose of grandfathering.

   2.a. Once the grandfathering plus administration fee is received from the manufacturer, AASHTO NTPEP will formally notify the manufacturer that the product(s) are in the program and will be evaluated for grandfathering purposes. The evaluation process begins at this point. The data to be evaluated will, at that point, then be sent to the NTPEP lab for evaluation.

   2.b. The NTPEP lab will have up to 2 weeks to provide an evaluation of the data proposed for grandfathering, indicating which data are acceptable, and what testing for the full evaluation program can be eliminated. A revised fee schedule for the full evaluation program will be included with the evaluation. The product panel chairman will review the report and discuss with the applicant any testing options that should be considered that will affect the final amount. Once the manufacturer has selected the desired options and the final amount is determined, the panel chairman forwards that information to the NTPEP manager, and the invoice for those testing fees will be sent by AASHTO NTPEP to the manufacturer.

   2.c. The manufacturer will have up to 2 weeks to respond to NTPEP as to whether or not they wish to proceed with the full evaluation program. Assuming that they wish to proceed, the manufacturer will submit a check in the amount of the fee required for the modified full evaluation program at that time with a request to proceed with the testing.

   2.d. AASHTO NTPEP will notify the manufacturer, upon receiving the check for the full evaluation, that the full evaluation program will now proceed.

3. If the manufacturer does not wish to grandfather existing data, AASHTO NTPEP invoices the manufacturer the full evaluation fee and administrative fee amount upon receipt of the application form. Once the fee is received from the manufacturer, NTPEP formally notifies the manufacturer that the product(s) are in the program and will be evaluated. The evaluation process begins at this point.

4. In either scenario, once the manufacturer has been given notice that the full evaluation will begin, the NTPEP panel will make arrangements with the manufacturer to perform the necessary sampling so that testing can begin. Sampling is to be completed, and the samples sent to the NTPEP lab, within one month of the notice to begin the evaluation.
5. Once the samples are received by the NTPEP laboratory, the NTPEP laboratory will provide a short-term testing report in 2 months. An initial creep data report will be sent out within 6 months after sampling, and the final report will be completed 1.2 years after sampling by the NTPEP lab.
NTPEP Geosynthetic Reinforcement Evaluation Program

by
Tony M. Allen

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Olympia, WA
Geosynthetic Reinforcement Concepts

• Geosynthetics are used as layers within the soil mass to reinforce the soil
  – The presence of the layers enable the soil to stand more steeply than would be otherwise possible by imparting tensile strength to the soil mass
  – The concept is similar to reinforcing concrete with steel rebar

• Geosynthetic reinforcements can consist of either geotextiles or geogrids, or a combination of the two

• They are made from polymers such as PET, HDPE, or PP (e.g., “plastics”)
  – Consist of long molecular chains entangled with one another or forming crystalline structures
  – Their properties tend to be strongly time and temperature dependent
Examples of Geosynthetic Reinforcement Materials

- Geogrid
- Needle punched non-woven
- Slit film woven
Typical Reinforcement Applications

- Geosynthetic wall
- Reinforced Slope
- Base Reinforcement
- Geosynthetic
- $T_{max}$
Overview of Geosynthetic Reinforcement Design

- Goal is to make sure that:

\[ T_{\text{max}} \leq \frac{T_{\text{ult}}}{RF_{ID} \times RF_{CR} \times RF_{D} \times FS} \]

- \( RF_{ID}, RF_{CR}, \) and \( RF_{D} \) reflect actual long-term strength losses, analogous to loss of steel strength due to corrosion

NTPEP program focus is to obtain these values
Overview of NTPEP Geosynthetic Reinforcement Program

• Evaluation is based on WSDOT Standard Practice T925
• Two level evaluation process:
  – Product qualification evaluation, performed every 6 yrs
  – Quality assurance evaluation, performed every 3 yrs, to verify product properties are consistent with product qualification evaluation
• Testing conducted by independent NTPEP approved lab (TRI is only lab so far), sampled by independent sampler at supplier’s manufacturing facility or warehouse (typically a state DOT)
• Must be a product that is in production (not experimental products)
• Focus is on the product line
Long-Term Strength Concepts

- Immediate loss due to installation stresses and abrasion
- Long-term loss due to creep and chemical degradation (assumes constant load near creep limit applied)

\[ T_{ult} \]

\[ T_{ult}/RF_{ID} \]

\[ T_{ult}/(RF_{ID}RF_{CR}RF_{D}) \]
Current Focus of Durability Evaluation

- Ultimate limit state design (i.e., prevent rupture and collapse)
- Adequate reinforcement strength must be available throughout lifetime of structure
- Installation damage – reinforcement must be capable of resisting installation stresses and abrasion without excessive strength loss
- Creep – the reinforcement must not rupture under constant load within the design lifetime
- Durability – the reinforcement must have minimal strength losses over the design lifetime due to exposure to chemical environments common in soils (pH, oxygen, etc.)
What is a Product Line?

• “A series of products manufactured using the same polymer in which the polymer for all products in the line comes from the same source, the manufacturing process is the same for all products in the line, and the only difference is in the product weight/unit area or number of fibers contained in each reinforcement element.”

• Long-term strength testing is focused on the product line, providing the ability to only test representative products to characterize the line.
Product Qualification Testing

• Product dimensions and general index properties (product weight/unit area, coating weight for PET geogrids, tensile strength, polymer classification, geogrid bend test per WSDOT T926, etc.)
• Full scale installation damage testing
• Long-term creep rupture and low strain creep stiffness testing
• Chemical durability index testing
  – UV resistance
  – Molecular weight and CEG content for PET geosynthetics
  – Oven aging screening tests for polyolefins
Installation Damage Testing

• Focus is to establish the likely magnitude of strength loss that occurs during installation in backfill soil in reinforced soil structures

• General procedure:
  – Place pad of backfill soil, place geosynthetic, and place and compact backfill soil over the top of the geosynthetic
  – Exhume geosynthetic layer, perform tensile tests, compare results to tensile strength before damage
  – Perform for soil gradations (typically a minimum of 3 gradations are used to facilitate interpolation to other gradations) that are similar to what is typically expected for backfill (characterize based on d_{50} size)
  – Testing is conducted on products representative of the product line, using interpolation (based on strength, weight, or coating weight) to establish installation damage strength losses for products in the line not tested
Installation Damage Test: Field Exposure
Installation Damage Test: Compaction of Soil over Geosynthetic
Installation Damage Evaluation: Calculation of Strength Retained

\[ RF_{ID} = \frac{T_{lot}}{T_{dam}} \]

- \( T_{lot} \) is the lot specific tensile strength of the material used in the installation damage tests, but prior to exposing the material to installation.
- \( T_{dam} \) is the tensile strength of the material after exposure to installation (i.e., in a damaged condition).
- In both cases, testing is in accordance with ASTM D4595 or ASTM D6637 (single rib tests on geogrids are not acceptable).
Example Installation Damage Data

Note: \( RF_{ID} = 1/P \)

\( W = \) weight/unit area

\( d_{50} = \) sieve size at which 50% of soil passes by weight

\( W_3 < W_2 < W_1 \)

All products are from the same product line.
Example Installation Damage Data, Continued

Note: $RF_{ID} = 1/P$

- $P_d$
- $W_d$
- $d_{50d}$

Strength Retained $P_r, (%)$

Product Unit Weight, $W$ (g/m$^2$)
Creep Testing

• One of two approaches may be used:
  – Conventional creep testing
  – Combination of Stepped Isothermal Method (SIM) and conventional creep testing

• Focus of testing is to:
  – Establish rupture limit for a given design life, and
  – To establish low strain creep stiffness values

• Testing is conducted on products representative of the product line, using interpolation (usually using $T_{ult}$) to establish creep limits for products in the line not tested
Creep Testing – “Conventional”

• AASHTO incorporates Elias, et al., 2001 (Report No. FHWA-NHI-00-043) by reference
  – Focus is stress rupture testing and evaluation
  – WSDOT Standard Practice T925 is virtually identical (T. Allen wrote both), but in addition contains guidance for creep strain data evaluation

• Creep rupture testing and evaluation
  – Test in accordance with ASTM D5262
    • Minimum of 12 to 18 rupture points to establish envelope
    • Must have a few data points to 10,000 hrs duration, and a minimum duration of 5 to 10 hrs
    • Rupture points must be evenly distributed among log cycles of time
  – Extrapolation procedures
    • Extrapolate using temperature, or
    • Extrapolate statistically up to two log cycles of time for PET, or up to one log cycle of time for HDPE/PP, without temperature acceleration
Stress Rupture Extrapolation Using Temperature – “Conventional” Approach

Temperature: $T_1 < T_2 < T_3$

Note: Log load level works best for HDPE and PP, and arithmetic load level works best for PET.
Stress Rupture Extrapolation Using Temperature – “Conventional” Approach

Temperture: $T_1 < T_2 < T_3$

Note: Log load level works best for HDPE and PP, and arithmetic load level works best for PET. Entire envelope at a given temperature is shifted by a single shift factor (assumes shift factor is not load level dependent).
Stress Rupture Extrapolation Using Temperature – Stepped Isothermal Method

- The difference between “conventional” approach (ASTM D5262) and Stepped Isothermal Method (SIM – ASTM D6992)
  - Conventional – individual specimens are subjected only to a single temperature – shift factors are then used to relate the creep rupture times obtained at different temperatures
  - SIM – a single specimen is subjected to stepped increases in temperature
    - The creep strain response at each temperature is matched together using time shift factors to produce a single smooth creep curve at the initial temperature, but extrapolated in time
    - The rupture that occurs at the highest temperature tested in effect is already extrapolated in time, even though the test was done in a matter of days
- For SIM, time shift factors are not affected by specimen to specimen variability, and different time shift factors can be used for different load levels
- SIM tends to be less conservative than conventional method
Creep Testing - SIM

Environmental Chamber

Close-up of Specimen
Single specimen Subjected to stepped temperatures

A different shift factor is used for Each temperature step

Same specimen after time shifting
Creep Rupture Envelope Using SIM

- Conventional creep rupture points at reference temperature
- SIM rupture points, shifted to reference temperature

Graph showing time to rupture, $t$ (hrs), vs. load level, $P$ (%), with different symbols and lines representing the conventional and SIM rupture points.
Use of SIM Data

- Use SIM data as supplementary to “conventional” data obtained at the design temperature
  - Obtain a minimum of 6 “conventional” stress rupture points evenly distributed among the log cycles of time
  - Two of the data points must be at more than 2,000 hours (unshifted)
  - In effect, the SIM data is used to extrapolate the conventional stress rupture data

- If the SIM stress rupture envelope is outside of the 95% lower bound confidence limit based on the “conventional” unshifted creep data extended up to 50,000 hrs duration, the SIM data should not be used without more extensive investigation
How is $RF_{CR}$ Calculated?

- Calculate $RF_{CR}$ using the following equation:

$$RF_{CR} = \frac{T_{lot}}{T_l} = \frac{T_{lot}}{\left(\frac{P_{cl}}{1.2^{(x-1)}}\right)}$$

- $T_{lot}$ = average lot specific tensile strength of material used in creep testing
- $T_{ult}$ = MARV of tensile strength
- $T_l$ = factored creep limited tensile strength at design life
- $P_{cl}$ = creep limited strength measured directly from extrapolated creep data
- $x$ = number of log cycles of time of extrapolation beyond time shifted data
  = $\text{Log } t_d - \text{Log } t_{max}$
- If $x < 1$, set $x-1 = 0$
Creep Stiffness Testing

• Focus is stiffness at 2% strain level at 1,000 hrs
• Determined using combination of short-term ramp and hold (1,000 second) tests and 1,000 hr low strain creep tests
• Provides data needed to design using K-Stiffness Method for MSE walls as well as to address serviceability for reinforced soil structures
Chemical Durability Testing

• General approach
  – Index tests that provide indication of long-term durability
    • Only applicable for nonaggressive environments (pH of 4.5 to 9, organic content is 1% or less, effective design temperature for site < 30°C)
  – Long-term performance tests

• Specific index test requirements
  – UV (ASTM D4355), thermo-oxidation (oven aging screening test per ENV ISO 13438:1999), and hydrolysis resistance (molecular weight per GRI:GG8 and CEG content per GRI:GG7)
  – If requirements are met, can use default $RF_D$ of 1.3 (cooler climates) to 1.5 (warmer climates)

• If index test requirements are not met, must conduct long-term performance tests
  – Oven aging or high oxygen pressure testing (PP, HDPE)
  – Elevated temperature immersion tests for hydrolysis (PET)
  – Rarely done due to time and expense required
### AASHTO Chemical Durability Index Test Requirements

<table>
<thead>
<tr>
<th>Polymer Type</th>
<th>Property</th>
<th>Test Method</th>
<th>Criteria to Allow Use of Default $RF_D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP and HDPE</td>
<td>UV oxidation resistance</td>
<td>ASTM D4355</td>
<td>Min. 70% strength retained after 500 hrs in weatherometer</td>
</tr>
<tr>
<td>PET</td>
<td>Hydrolysis resistance</td>
<td>Inherent viscosity (ASTM D4603 and GRI-GG8)</td>
<td>Min. number average molecular weight (MW) of 25,000</td>
</tr>
<tr>
<td>PET</td>
<td>Hydrolysis resistance</td>
<td>GRI-GG7</td>
<td>Max. carboxyl end group content (CEG) of 30</td>
</tr>
<tr>
<td>All</td>
<td>% Post-consumer recycled material</td>
<td>Certification of materials used</td>
<td>Maximum of 0%</td>
</tr>
</tbody>
</table>
Inherent Viscosity Determination

Correlations can are used to estimate MW from the inherent viscosity for a given solvent and temperature.

Note that the viscosity measurement performed here is similar to what is done for asphalt testing, but due to the lower viscosity of the PET solution, the tube diameter must be smaller to keep the rate of flow from being too fast.
CEG testing is simply an acid-base titration. CEG’s form an acid, and NaOH is added to neutralize the solution, as measured by a pH meter.
Product Quality Assurance (QA) Testing

• Similar to product qualification testing, except:
  – Fewer products in the product line are tested
  – Testing is shorter term (typically 2,000 hrs or less)

• All index tests are still conducted as part of QA testing program (tensile strength, UV resistance, CEG and MW for PET geosynthetics, oven aging screening test for polyolefins)

• Focus is whether or not difference between QA and product qualification testing results is statistically significant based on predefined criteria
QA Acceptance Criteria

• QA test results must meet QA statistical insignificance criteria to maintain presence on NTPEP geosynthetic reinforcement evaluation report or to avoid need to immediately conduct product qualification testing

• Criteria are as follows:
  - Mean of QA tensile strength test results must be greater than MARV assigned to product
  - For installation damage, and the strength retained in the oven aging screening test, the difference between the mean of the QA and product qualification test results must not be greater than what is defined as statistically insignificant based on a one-sided student-t distribution at a level of significance of 0.05
  - For creep, QA tests performed at a load level that results in rupture at approximately 500 hrs and at 100,000 hrs after time shifting to the reference temperature must have a rupture time that is greater than the lower 95% prediction limit based on the student’s-t distribution
Illustration of Creep Rupture QA Criteria

Load or Load level, \( P \)

Rupture Time (after time shifting), \( t \) (hrs)

Regression line for product qualification data

95% prediction limit for product qualification data

- from qualification testing

x – from QA testing

\( P_{500} \)

\( P_{100,000} \)
Use of Standard Practice T925 at WSDOT

- It was born out of the need to provide a level playing field for geosynthetic reinforcement products
- It has allowed us to design geosynthetic reinforced structures generically and allow open competition
- WSDOT uses it as the basis for adding reinforcement products to our Qualified Products List (QPL)
- It has been in use since 1997
- WSDOT has reviewed and approved 63 reinforcement products from 8 suppliers
- It is affecting product submission and approval worldwide, and now forms the basis of a proposed ISO standard
Application of NTPEP Geosynthetic Reinforcement Results to WSDOT Program

• An NTPEP evaluation will be required (by mid-2007) for inclusion of geosynthetic reinforcement on the WSDOT QPL (must also be kept current)

• From NTPEP results, WSDOT will obtain the following information and include it in our QPL (Appendix D):
  – $T_{ult}$ (MARV)
  – Long-term design strength, $T_{al} = \frac{T_{ult}}{RF_{ID}RF_{CR}RF_{D}}$
    • $RF_{ID}$ is determined at $d_{50} = 4.75$ mm (corresponds to WSDOT gravel borrow) from strength retained vs. $d_{50}$ plots for each product tested in the line, interpolated to other untested products in the product line using the recommended interpolation procedure (i.e., unit weight, coating weight, etc.)
    • $RF_{CR}$ is determined at 75 yr design life from creep rupture envelope
    • Default value of 1.3 is used for $RF_{D}$ if all index test criteria are met
  – 2% creep stiffness at 1,000 hrs, $J_{2\%}$
Issues Where Some Judgment will Be Needed to Apply NTPEP Results

• For determination of $R_{FD}$, interpolation between tested products to untested products within a product line may not be straightforward, especially for PET geogrids – NTPEP may have additional products tested because of this, or an upper bound approach may be taken (see T925)

• WSDOT has historically used $R_{FD}$ of 1.1 instead of 1.3 for HDPE due to well known exceptional durability of that material

• The 1.3 default value is really aimed at PP geosynthetics, due to smaller thickness of ribs fibers and relatively greater susceptibility to oxidation of PP relative to HDPE

• Oxidation resistance of PP geosynthetics is difficult to accurately quantify and to detect changes in product antioxidant formulations and polymer structure – current test protocols should be considered approximately representative of potential long term durability for PP
WSDOT Application of Design Strengths Obtained from NTPEP Testing to Design and Construction Specifications

- Standard Plan geosynthetic walls
  - From line and grade wall plans, contractor identifies wall design height and surcharge conditions
  - Contractor goes to Standard Geosynthetic Wall Plans to get minimum $T_{al}$ (i.e., design strength) needed
  - Contractor goes to QPL to identify products that have $T_{al}$ values greater than or equal to $T_{al}$ required in Standard Plans for the design wall height and surcharge conditions
  - Contractor informs WSDOT project office of choice of product(s)
  - WSDOT inspector obtains samples from roles of geosynthetic shipped to site and submits samples to HQ Materials for testing (primarily tensile strength per ASTM D6637 or ASTM D4595, and geogrid bend test per WSDOT T926)
WSDOT Application of Design Strengths Obtained from NTPEP Testing to Design and Construction Specifications, Cont.

- Preapproved proprietary MSE walls
  - Wall supplier uses published QPL design strengths ($T_{al}$) to determine strength and spacing of reinforcement required
  - WSDOT Bridge Office and Geotechnical Division review wall supplier’s shop drawings for walls to be built in construction project for acceptability - see WSDOT Geotechnical Design Manual Chapter 15 and appendices for review criteria and preapproved wall details at [http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manu als/2005GDM/GDM.htm](http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/2005GDM/GDM.htm)
  - WSDOT inspector obtains samples from roles of geosynthetic shipped to site and submits samples to HQ Materials for testing (primarily tensile strength per ASTM D6637 or ASTM D4595, and geogrid bend test per WSDOT T926)
  - For modular block faced walls, connection strength handled separately through wall preapproval process
WSDOT Application of Design Strengths Obtained from NTPEP Testing to Design and Construction Specifications, Cont.

- Project specific geosynthetic reinforced structures (reinforced slopes, and non-Standard Plan geosynthetic walls)
  - Engineer determines design strength required per AASHTO and WSDOT GDM using LRFD approach (i.e., $T_{\text{max}}\gamma/\varphi = T_{al}$) for MSE walls, or using allowable stress design and FS value for reinforced slopes and fills over soft ground
  - $T_{al}$ as a function of reinforcement spacing and structure/fill height is provided in the Special Provisions as a table – the Contractor can select products from the QPL that meet requirements in table
  - WSDOT inspector obtains samples from roles of geosynthetic shipped to site and submits samples to HQ Materials for testing (primarily tensile strength per ASTM D6637 or ASTM D4595, and geogrid bend test per WSDOT T926)
WSDOT Application of Design Strengths Obtained from NTPEP Testing to Design and Construction Specifications, Cont.

• Application to reinforcement of fills over soft ground
  – Geosynthetic must function temporarily until soft soil gains adequate strength (typically a few months to a few years)
  – $T_{al}$ is determined as $T_{ult}/RF_{ID}RF_{CR}$, where $RF_{CR}$ is determined for a much shorter temporary life (obtain $RF_{CR}$ from NTPEP creep rupture plot at the desired design life)
  – In the reinforced fill application, $RF_D$ is not a significant consideration for such a short design life

• Application to temporary geosynthetic walls
  – $T_{al}$ is determined as above, but for anticipated design life of temporary structure, or alternatively, a default overall strength reduction factor of 2.5 to 4 applied to $T_{ult}$ could be used
Questions? Comments?

Don’t Be Left Out!