2011 NTPEP Report Series

NTPEP Report REGEO-2011-01-001

LABORATORY EVALUATION OF GEOSYNTHETIC REINFORCEMENT

FINAL PRODUCT QUALIFICATION REPORT FOR MIRAGRID XT GEOGRID PRODUCT LINE

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American Association of State Highway and Transportation Officials (AASHTO)

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2011 NTPEP Report Series

National Transportation Product Evaluation Program (NTPEP)

NTPEP Report REGEO-2011-01-001

LABORATORY EVALUATION OF GEOSYNTHETIC REINFORCEMENT

2011 PRODUCT SUBMISSIONS
SAMPLED JUNE 2011

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PROLOGUE

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- This report contains product data that are intended to be applied to a product line, based on the test results obtained for specific products that are used to represent the product line for the purposes of NTPEP testing. It is expected that the User will estimate the properties of specific products in the line not specifically tested through interpolation or a lower or upper bound approach.
- It is intended that this data be used by the User to add products to their Qualified Products or Approved Products List, and/or to develop geosynthetic reinforcement strength design parameters in accordance with AASHTO, FHWA, or other widely accepted design specifications/guidelines. It is also intended that the User will conduct further, but limited, evaluation and testing of the products identified in this report for product acceptance purposes to verify product quality.
- Products included in this report must be resubmitted to NTPEP every three (3) years for a quality assurance evaluation and every six (6) years for a full qualification evaluation in accordance with the work plan. Hence, all product test results included in this Report supersede data provided in previous Editions of this report.
- The User is guided to read the document entitled "Use and Application of NTPEP Geosynthetic Reinforcement Test Results" (see NTPEP website) for instructions and background on how to apply the results of the data contained in this report.

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Executive Summary

This test report provides data that can be used to characterize the short-term and long-term tensile strength the Miragrid polyester, PVC coated geogrid reinforcement XT product line using testing conducted on representative products within the product line. The purpose of this report is to provide data for product qualification purposes.

The test results contained herein were obtained in accordance with WSDOT Standard Practice T925 and the NTPEP work plan (see www.NTPEP.org) and can be used to determine the long-term strength of the geosynthetic reinforcement, including the long-term strength reduction factors RF_{ID}, RF_{CR}, and RF_{D}, and also used to determine low strain creep stiffness values. All testing reported herein was performed on the materials tested in the direction of manufacture, i.e., the machine direction.

Product Line Description: The product line evaluated includes the following specific polyester, PVC coated geogrid reinforcement products:

Miragrid 2XT, 3XT, 5XT, 7XT, 8XT, 10XT, 20XT, 22XT, and 24XT.

This product line was evaluated through detailed testing of three representative products in the Miragrid XT product line, and very limited testing of the other remaining products in the product line. Miragrid 8XT was used as the primary product for product line characterization purposes (i.e., the baseline to which the other products were compared), and Miragrid 2XT and 24XT were used as secondary products to evaluate the properties of the range of products in the Miragrid XT product line. Samples of these products were taken by an independent sampler on behalf of NTPEP on June 8, 2011, at the Miragrid manufacturing plant located in Pendergrass, GA.

An on-site audit to verify the consistency of the Miragrid XT product line was conducted at the Miragrid manufacturing plant on June 8, 2011, in accordance with the REGEO work plan. The audit verified that the materials and processing used to manufacture each product in the line are consistent and meet the definition of a product line in the NTPEP work plan and WSDOT T925. The audit report is available separately upon request to those who are authorized to have access to the audit report (i.e., members of state departments of transportation, NTPEP staff, and the manufacturer of the product line).

Statistical Validation of Use of SIM and Validation of Product Line: The creep rupture test results obtained were evaluated in accordance with T925 to assess the validity of using SIM to extend the creep rupture data and to assess the validity of treating the products submitted as a single product line. The following was verified:

i. Validation of the use of SIM to extend the creep rupture data was conducted previously as reported in the 2008 NTPEP report for this product line. The results of that validation from this previous testing are summarized in Figure F-21 in Appendix F. Revalidation of the use of SIM for this product line was considered unnecessary in accordance with the NTPEP work plan and WSDOT T925, since it was determined that the product line has not significantly changed in its creep tests were conducted to make a quantitative statistical analysis), the new SIM data continued to be consistent with the real time creep data obtained.

ii. Based on the available creep data for all the products tested, the product line submitted by the manufacturer statistically qualifies to be a product line and can therefore be represented using test results from representative products in the product line (see Figure F-23 in Appendix F for details). Recommendations on application of the representative product data to the rest of the product line for installation damage, durability and creep stiffness are provided in their respective report sections and summarized below in this executive summary.

Test Results for T_{ult}: All wide width test results (ASTM D6637) obtained for this product line through the NTPEP testing were greater than the minimum average roll values (MARV's) provided by the manufacturer (see Table 3-1).

Test Results for RF_{ID}: Installation damage testing on this product line resulted in values of RF_{ID} that ranged as follows:

$$RF_{ID} = 1.04 \text{ to } 1.61$$

The highest values of RF_{ID} occurred when the coarse gravel gradation was used.

The values of RF_{ID} for all of the products tested did demonstrate a trend of decreasing RF_{ID} as product unit weight/tensile strength increases, at least for the coarse gravel gradation, that would allow interpolation of RF_{ID} to products not tested. Therefore, interpolation of these test results to products in the line not tested is feasible. This trend was not as clear for the other, less coarse, gradations. In general, as the test material gradation becomes more coarse, the value of RF_{ID} increased. Therefore, interpolation of this data to intermediate gradations appears to be feasible. See Table 4-3 and Figures 4-5 through 4-8 for details. Laboratory installation damage test data in accordance with ISO/EN 10722 are also provided for future use in comparison to quality assurance testing (see Table 4-6).

It should be noted that the installation damage testing conducted represents an increase in compaction and spreading equipment size (i.e., a 15,000 lb wheeled front end loader – Caterpillar 416E, and a 25,000 lb single drum vibratory roller) and a reduced aggregate lift thickness over the geogrid of 6 inches relative to the installation damage testing reported in previous NTPEP test reports. Therefore, the decrease in strength retained values relative to previous NTPEP test reports for this product line does not represent a change in the products, but instead is the result of the more severe installation damage conditions which represent a likely upper bound installation condition for geosynthetic reinforced soil structures. Actual RF_{ID} values could be lower if installation conditions are less severe (e.g., greater initial lift thickness over the geogrid, use of lighter weight equipment, etc.). Actual RF_{ID} values could be higher if the spreading or compacting equipment tires or tracks are allowed to be in direct contact with the geosynthetic before or during fill placement and compaction, if the thickness of the fill material between the equipment tires or tracks is inadequate (especially for high tire pressure equipment such as dump trucks), or if excessive rutting of the first lift of soil over the geosynthetic (e.g., due to soft subgrade soil) is allowed to occur.

Test Results for RF_{CR}: The creep rupture testing conducted indicates that the following value of RF_{CR} may be used:

$$RF_{CR} = 1.45$$

This value of RF_{CR} is applicable to a 75 year life at 68° F (20° C), and may be used to characterize the full product line as defined herein. See Figure 5-1 for detailed creep rupture envelope or to obtain values for other design lives.

Test Results for RF_D: The chemical durability index testing results meet the requirements in WSDOT T925 to allow use of a default reduction factor for RF_D. See Table 6-2 for specific test results, and see WSDOT T925 or the document entitled "Use and Application of NTPEP Geosynthetic Reinforcement Test Results" (www.NTPEP.org) for recommended default reduction factors for RF_D. The UV test results (ASTM D4355) for this product line, as represented by the lightest weight product in the line, indicate a strength retained at 500 hours in the weatherometer of 85%. This value of UV strength retained should be considered to be a lower bound value for the product line.

Test Results for Creep Stiffness: The 1000 hr, 2% strain secant stiffness ($J_{2\%,1000hr}$) test results ranged from 17,000 lb/ft for the lowest strength style to 170,000 lb/ft for the highest strength style. There exists a strong linear relationship between creep stiffness and the short-term tensile strength (T_{lot}), therefore the 1000 hr, 2% strain secant stiffness can be reasonably expressed for any product in the product line as:

$$J_{2\%,1000\,hr} = 5.501(T_{lot}) - 57.378$$

Where, T_{lot} is the roll/lot specific single rib tensile strength per ASTM D6637. See Table 7-2 and Figure 7-1 for details. Note that once the stiffness is determined from this equation, an equivalent MARV for this property can be determined by multiplying the stiffness by the ratio of T_{MARV}/T_{lot}.

1.0 Product Line Description and Testing Strategy

1.1 Product Description

The **Miragrid XT Series** family of geogrids are high-strength woven, PVC coated geogrids. The product line evaluated consists of the products as manufactured by TenCate Geosynthetics listed in Table 1-1.

Table 1-1. Product designations included in product line.

Miragrid Reinforcement Product Designations (i.e., Styles)		
Miragrid® 2XT	Miragrid® 7XT	Miragrid® 20XT
Miragrid® 3XT	Miragrid® 8XT	Miragrid® 22XT
Miragrid® 5XT	Miragrid® 10XT	Miragrid® 24XT

The scope of the evaluation is limited to the strength in the machine direction (MD). The cross-machine direction (XD) was not specifically evaluated.

An on-site audit to verify the consistency of the Miragrid XT product line was conducted at the Miragrid manufacturing plant on June 8, 2011, in accordance with the REGEO work plan. The audit verified that the materials and processing used to manufacture each product in the line are consistent and meet the definition of a product line in the NTPEP work plan and WSDOT T925. The audit report is available separately upon request to those who are authorized to have access to the audit report (i.e., members of state departments of transportation, NTPEP staff, and the manufacturer of the product line).

1.2 Product Line Testing Approach

This product line was evaluated through detailed testing of three representative products in the Miragrid XT product line, and very limited testing of the other remaining products in the product line. Miragrid 8XT was used as the primary product for product line characterization purposes (i.e., the baseline to which the other products were compared), and Miragrid 2XT and 24XT were used as secondary products to evaluate the properties of the range of products in the Miragrid XT product line. Samples of these products were taken by an independent sampler on behalf of NTPEP on June 8, 11 at the Miragrid manufacturing plant located in Pendergrass, GA.

Photographs of all the products tested are provided in figures 1-1 through 1-9

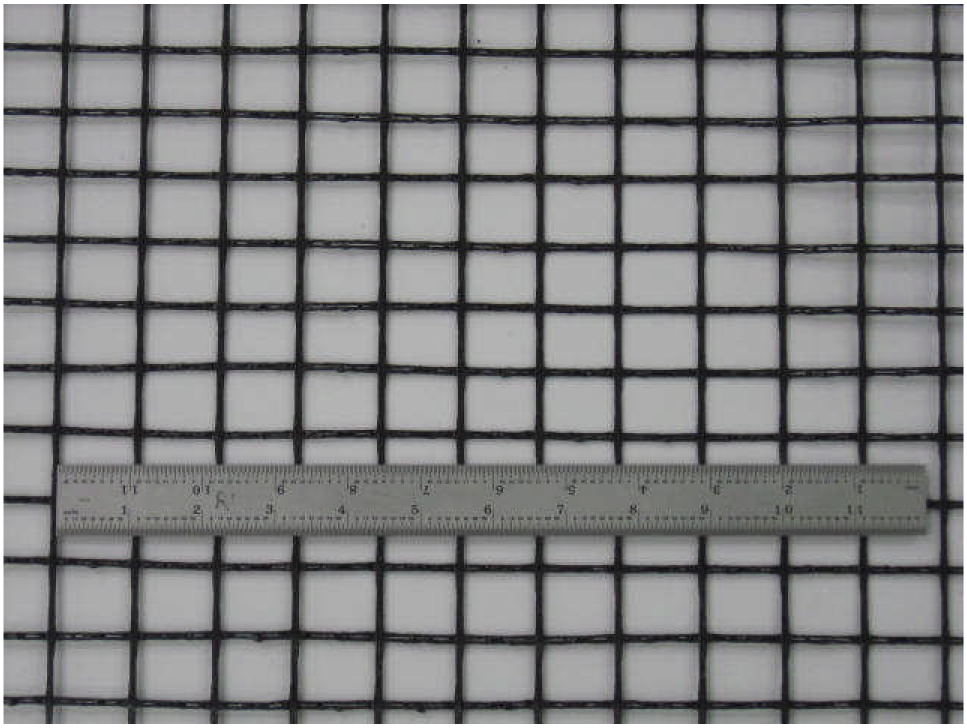


Figure 1-1. Photo of Miragrid 2XT (machine direction is perpendicular to ruler shown).

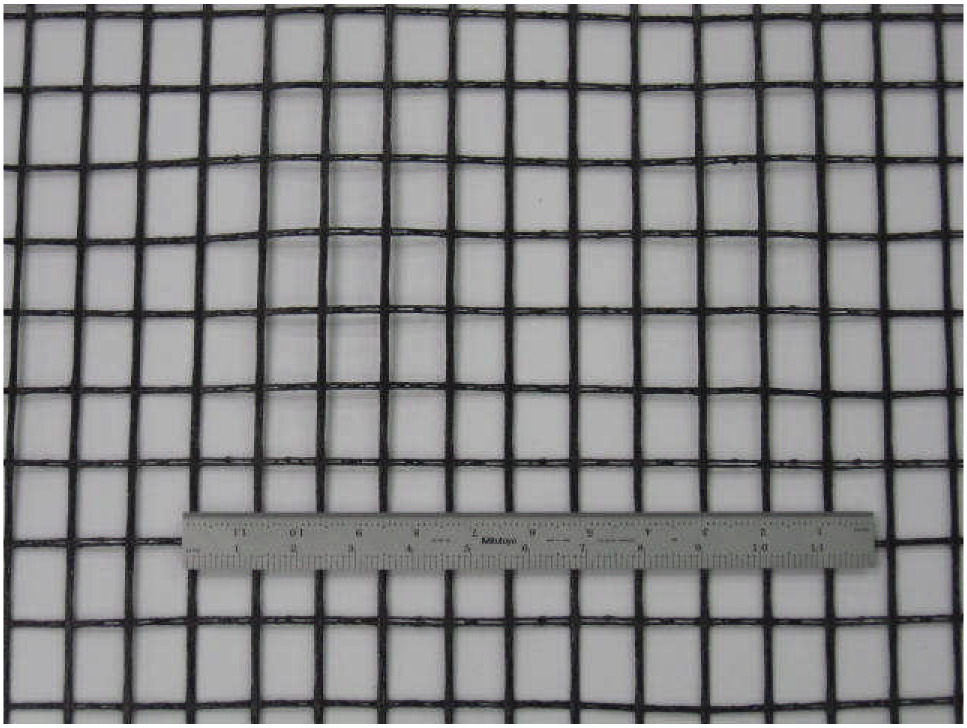


Figure 1-2. Photo of Miragrid 3XT (machine direction is perpendicular to ruler shown).

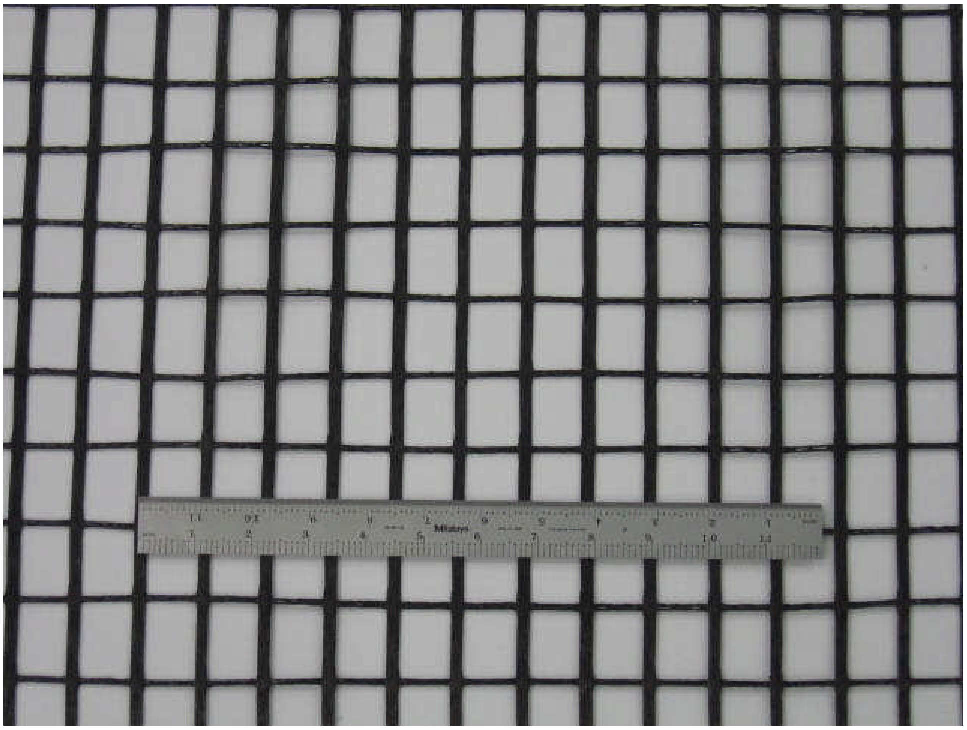


Figure 1-3. Photo of Miragrid 5XT (machine direction is perpendicular to ruler shown).

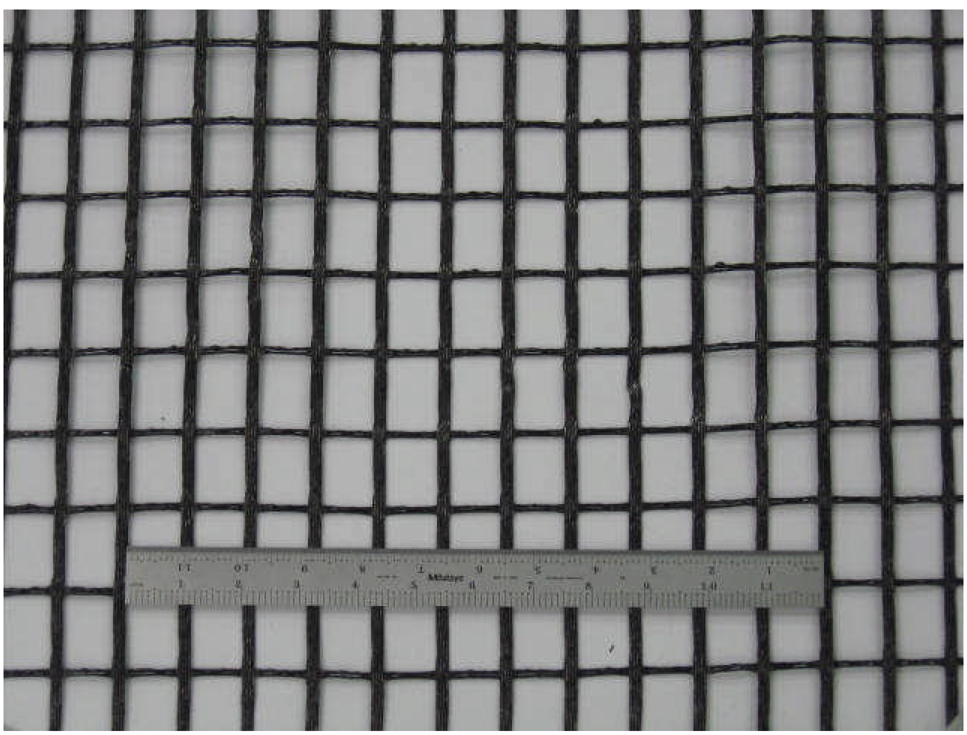


Figure 1-4. Photo of Miragrid 7XT (machine direction is perpendicular to ruler shown).

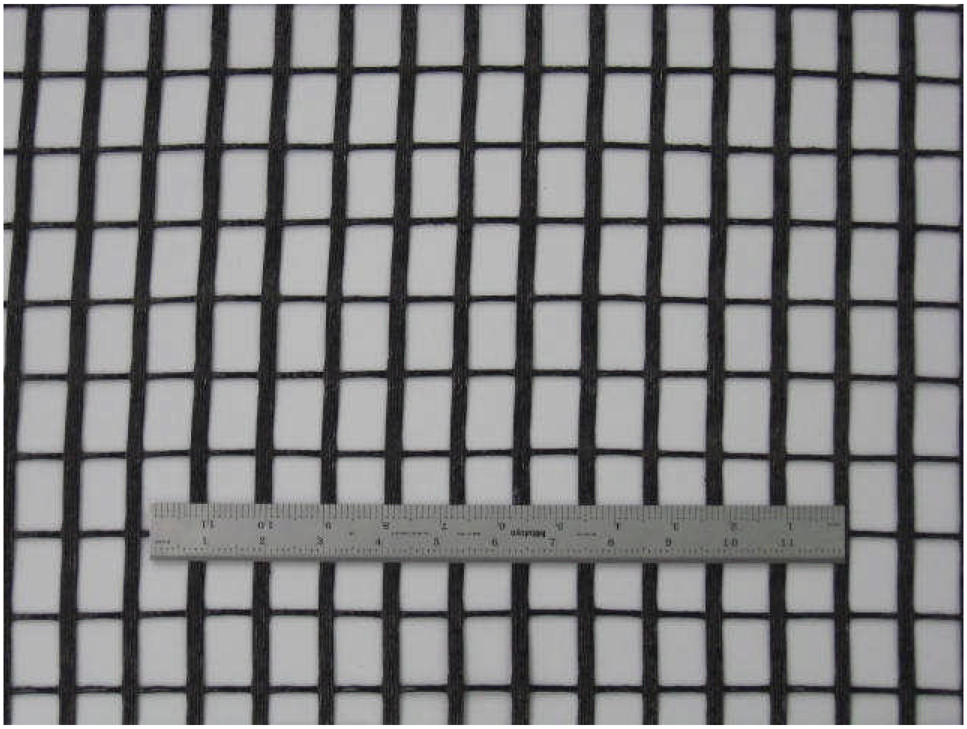


Figure 1-5. Photo of Miragrid 8XT (machine direction is perpendicular to ruler shown).

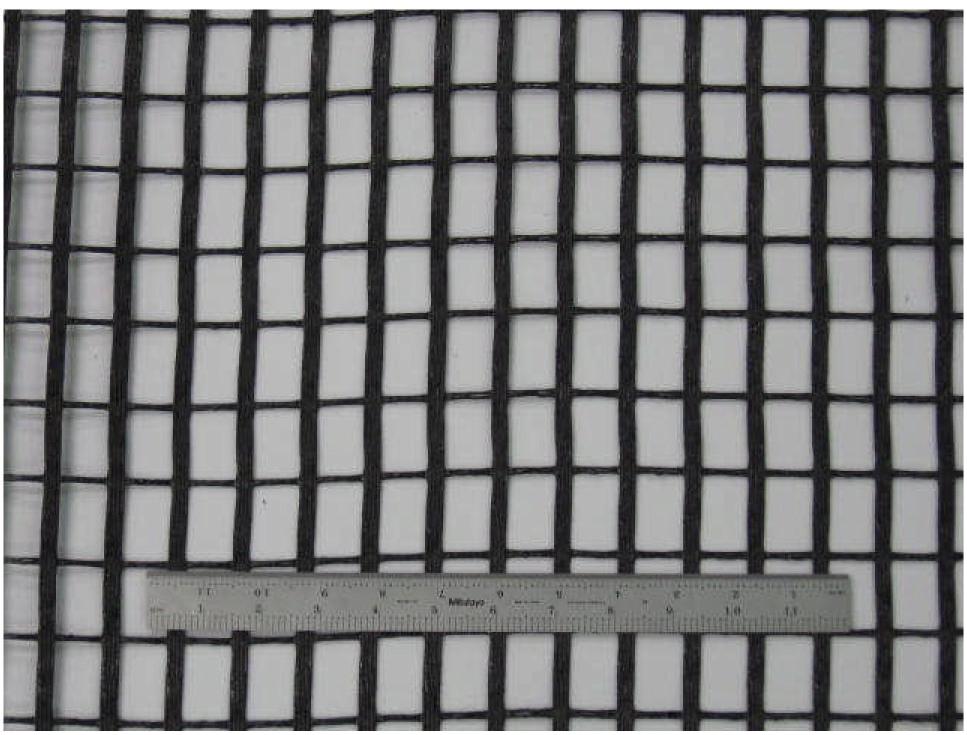


Figure 1-6. Photo of Miragrid 10XT (machine direction is perpendicular to ruler shown).

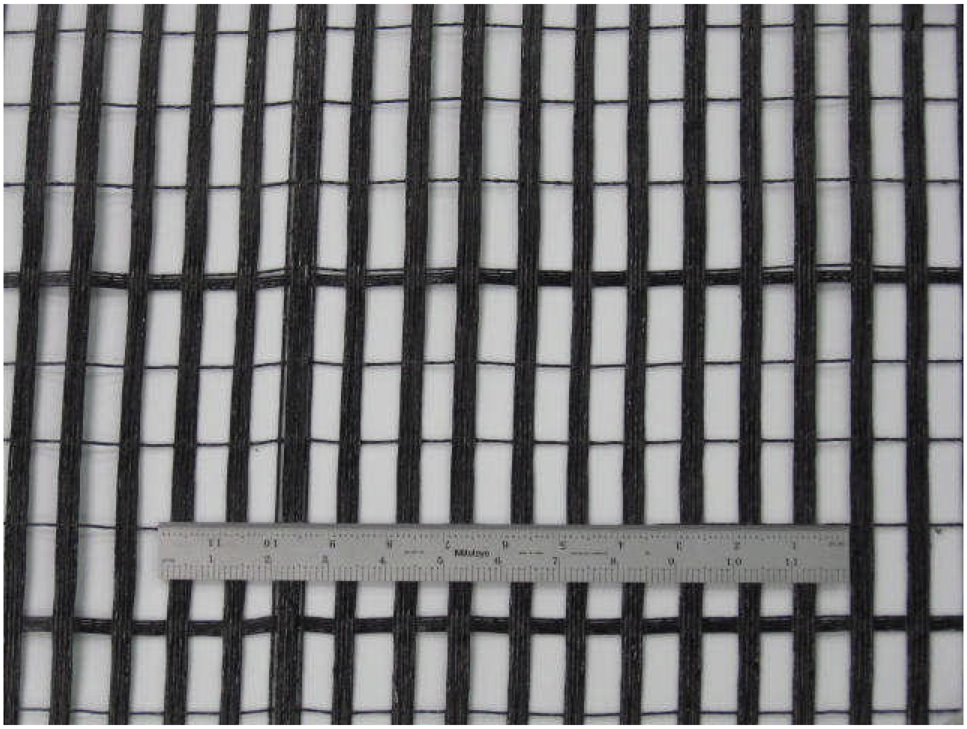


Figure 1-7. Photo of Miragrid 20XT (machine direction is perpendicular to ruler shown).

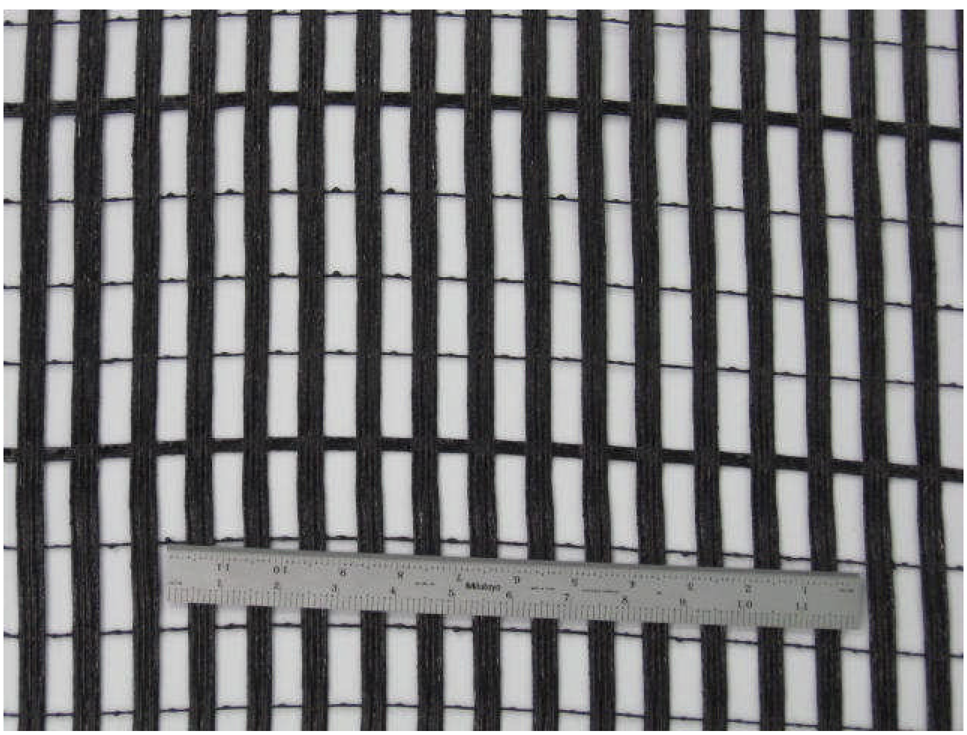


Figure 1-8. Photo of Miragrid 22XT (machine direction is perpendicular to ruler shown).

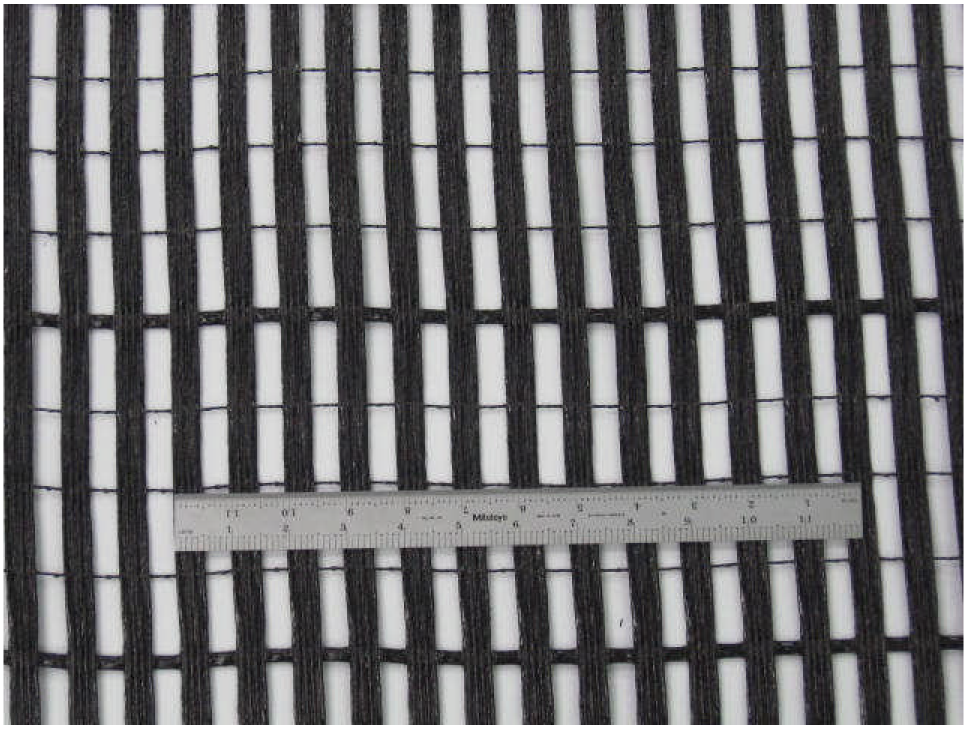


Figure 1-9. Photo of Miragrid 24XT (machine direction is perpendicular to ruler shown).

2.0 Product Polymer, Geometry, and Manufacturing Information

2.1 Product/Polymer Descriptors

Yarn used in all **Miragrid XT Series** geogrids is a high molecular weight, low CEG, high tenacity polyester (PET) with UV inhibitors. Source of Yarn – confidential. Coating used in all **Miragrid XT Series** geogrids is a PVC-based coating with no post-consumer recycled materials. The coating target weight per unit area is between 50-57% of the total weight of the finished product. Source of Coating – confidential

For the PET yarns, key descriptors include minimum production number average molecular weight (GRI-GG7 and ASTM D 4603) and maximum carboxyl end group content (GRI-GG8):

- Minimum Molecular Weight > 25,000 (Measured value is 34,855)
- Maximum CEG < 30 (Measured value is 15.2)
- % of regrind used in product: 0%.
- % of post-consumer recycled material by weight: 0%

2.2 Geometric Properties of Geogrids

Rib width, spacing, thickness, and product weight/unit area vary depending on geogrid style. While such data are generally not used for design, it can be useful for identification purposes, and to be able to detect any changes in the product. Measurements of geogrid rib spacing are also used to convert tensile test results (i.e., load at peak strength, T_{ult}, and load at a specified strain to obtain stiffness, J) to a load per unit width value (i.e., lbs/ft or kN/m). Detailed measurement results, as well as the typical values supplied by the manufacturer for each product, are provided in Appendix B, Section B.1.

2.3 Product Production Data and Manufacturing Quality Control

Geogrid roll sizes and weights, lot sizes, and a summary of the manufacturer's quality control program are provided in Appendix B, Sections B.2 and B.3. Such information can be useful in working with the manufacturer if product quality issues occur.

3.0 Wide Width Tensile Strength Data

Minimum average roll values supplied by the manufacturer and test results obtained on all the products in the product line for this NTPEP testing program are provided in Table 3-1. Wide width tensile tests were conducted in accordance with ASTM D6637. The measured geogrid dimensions discussed in Section 2 and provided in Appendix B, Section B.1, were used to convert test loads to load per unit width values. Note that the independently measured T_{ult} values only indicate that the sampled products have a tensile strength that exceeds the Manufacturer's minimum average roll values (MARV's). As such, these independently measured T_{ult} values should not be used directly for design purposes. However, these independently measured T_{ult} test results have been used as roll specific tensile strengths used for developing installation damage and creep reduction factors. Detailed test results are provided in Appendix C.

Table 3-1. Wide width tensile strength, T_{ult}, for the Miragrid Geogrid XT product line.

Product Style/Type	Test Method	MARV for T_{ult}, in MD (lb/ft)	T_{ult}, Independently Measured in MD (lb/ft)*
2XT	ASTM D 6637	2,000	2,691
3XT	ASTM D 6637	3,500	
5XT	ASTM D 6637	4,700	
7XT	ASTM D 6637	5,900	
8XT	ASTM D 6637	7,400	8,463
10XT	ASTM D 6637	9,500	
20XT	ASTM D 6637	13,705	
22XT	ASTM D 6637	20,559	
24XT	ASTM D 6637	27,415	29,809

(Conversion: 1 lb/ft = 0.0146 kN/m)
MD = machine direction
*Average of 5 specimens obtained during NTPEP testing.

4.0 Installation Damage Data (RF_{ID})

4.1 Installation Damage Test Program

Installation damage testing and interpretation was conducted in accordance with WSDOT Standard Practice T925, Appendix A, except as noted herein. Samples were exposed to three "standard" soils: a coarse gravel, a sandy gravel, and a sand. Additional laboratory installation damage testing in accordance with ISO/EN 10722 was also conducted. The specific installation damage test program is summarized in Table 4-1.

Table 4-1. Independent installation damage testing required for NTPEP qualification.

Manufacturer: TenCate Geosynthetics **PRODUCT Line:** 2XT to 24XT			
Tests Conducted	**Qualification (every 6 yrs) / QA (every 3 yrs)**		
	Products Tested		**# of Tests (see Note 1)**
	Qualification	**QA**	
Index tensile tests on undamaged material (ASTM D 6637)	2XT, 8XT, 24XT	NA	3
Three field exposures, including soil characterization and compaction measurements (ASTM D5818)	2XT, 8XT, 24XT in Types 1, 2, and 3 soils	NA	9
Tensile tests on damaged specimens (ASTM D 6637)	2XT, 8XT, 24XT in Types 1, 2, and 3 soils	NA	9
Laboratory installation damage testing –as basis for future QA and to help interpolate full scale field results to products ont full scale field tested (ISO/EN 10722)	2XT, 3XT, 5XT, 7XT, 8XT, 10XT, 20XT, 22XT, 24XT	NA	9
Note 1 Each test is performed using the number of specimens required by the test standard. For example, for index tensile testing, a test is defined 5 to 6 specimens. See the specific test procedures for details on this.			

4.2 Installation Damage Full Scale Field Exposure Procedures and Materials Used

Three “standard” soils were used for the field exposure of the geogrid samples to installation damage. Soil gradation curves for each soil are provided in Figure 4-1. Photographs of each soil illustrating particle angularity are provided in figures 4-2 through 4-4. LA Abrasion tests conducted to characterize the backfill materials indicted a maximum loss of 20%, which is well within the requirements stated in T925. Note that the photograph of the Type 2 soil only shows the coarser particles since the percentage of sand in that soil is relatively small, and the sand particles have slipped into the voids in this poorly graded gravel just below the stockpile surface at the time this photograph was taken.

The approach specifically used for applying installation damage to the geosynthetic samples that allows for exhumation of the test samples while avoiding unintended damage was initially developed by Watts and Brady[1] of the Transport Research Laboratory (TRL) in the United Kingdom. The procedure generally conforms to T925 and ASTM D 5818 requirements.

Since compaction typically occurs parallel to the face of retaining walls and the contour lines of slopes, the machine direction was placed perpendicular to the running direction of the compaction equipment. To initiate the exposure procedure, four steel plates each measuring 42-inches x 52-inches (1.07 m x 1.32 m), equipped with lifting chains, were placed on a flat clean surface of hardened limestone rock. The longer side of the plates is parallel to the running direction of the compaction equipment. A layer of soil/aggregate was then placed over the adjacent plates to an approximate compacted thickness of 6 inches (0.15 m). Next, each of four coupons of the tested geosynthetic sample was placed on the compacted soil over an area corresponding to an underlying steel plate. To complete the installation, the second layer of soil was placed over the coupons using spreading equipment and compacted to a thickness of 6 inches (0.15 m) using a vibratory compactor. The spreading equipment used included a wheeled front end loader and a 25,000 lb single drum vibratory roller with pneumatic rear wheels. The front end loader was allowed to spread the aggregate by driving over the geosynthetic with an 6 inch aggregate lift between the wheels and the geosynthetic.

The following construction quality control measures were followed during exposure:

- Proctor and sieve analyses were performed on each soil/aggregate, when possible. (Proctors could not be performed on Gradations 1 and 2.)
- Lift thickness measurements were made after soil/aggregate compaction.
- When possible, moisture and density measurements were made on each lift using a nuclear density gage to confirm that densities >90% of modified Proctor (per ASTM D 1557) were being achieved.

To exhume the geosynthetic, railroad ties were removed and one end of each plate was raised with lifting chains. After raising the plate to about 45°, soil located near the bottom of the leaning plate was removed and, if necessary, the plate was struck with a sledgehammer to loosen

[1] G.R.A. Watts and K.C. Brady (1990), *Site Damage trials on geotextiles*, Geotextiles, Geomembranes and Related Produts, Balkema Rotterdam.

the fill. The covering soil/aggregate was then carefully removed from the surface while "rolling" the geosynthetic away from the underlying soil/aggregate. This procedure assured a minimum of exhumation stress. Photographs of the installation damage field exposures are provided in Appendix D. A detailed tabulation of each soil gradation is provided in Appendix D, Table D-10.

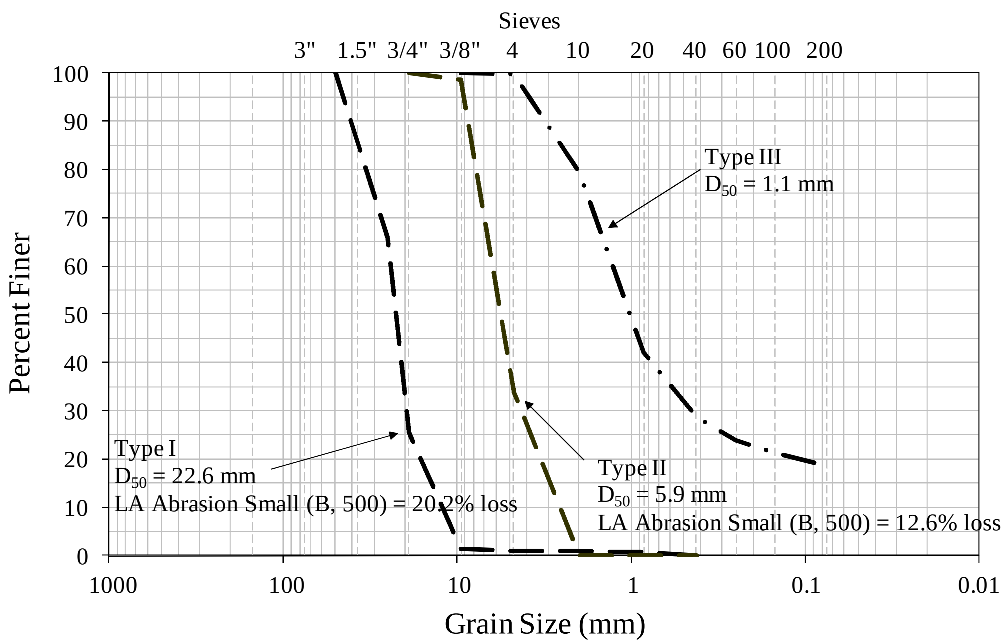


Figure 4-1. Test soil grain size distribution.

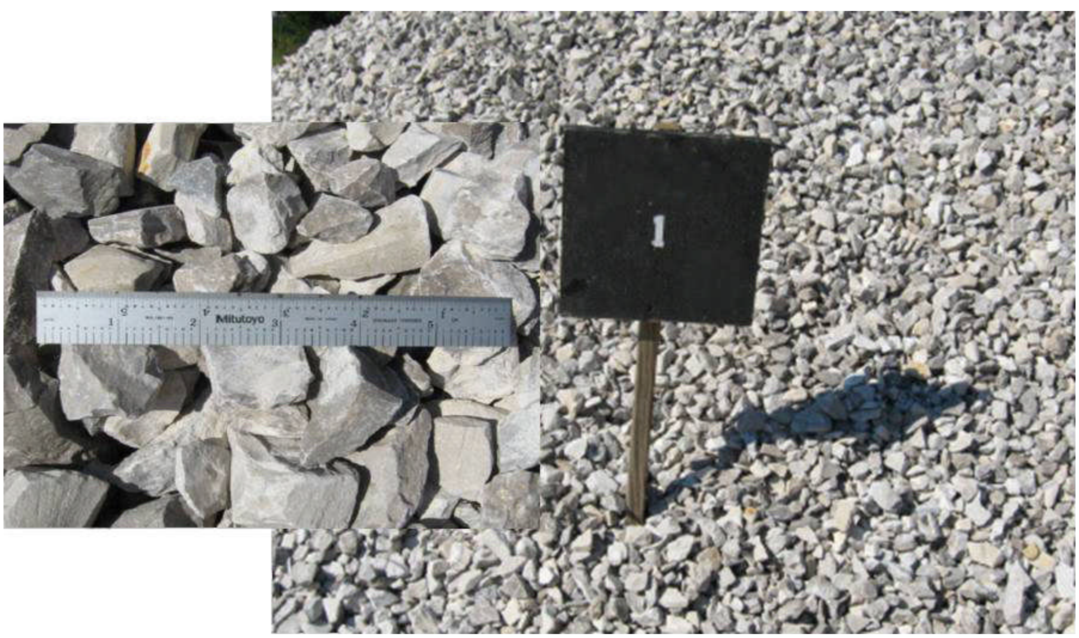


Figure 4-2. Installation damage Type 1 test aggregate.

Figure 4-3. Installation damage Type 2 test aggregate.

Figure 4-4. Installation damage Type 3 test aggregate.

4.3 Summary of Installation Damage Full Scale Field Exposure Test Results

The roll specific ultimate tensile strength (ASTM D6637) test results for the baseline, T_{lot} (i.e., undamaged tensile strength tested prior to sample installation in the ground) and the ultimate tensile strength of the installation damaged geogrid samples, T_{dam}, are provided in Table 4-2. RF_{ID}, calculated using the results shown in Table 4-2, are summarized in Table 4-3. Strength retained is calculated as the ratio of the average exhumed strength T_{dam} divided by the average baseline strength T_{lot} for the product sample. RF_{ID} is the inverse of the retained strength (i.e. 1 / 0.779 = 1.28). Detailed test results for each specimen tested are provided in Appendix D, Tables D-1 through D-9.

Table 4-2. Summary of installation damage tensile test results.

Backfill Type	Style	Baseline		Exhumed	
		[1]T_{lot} (lb/ft)	COV (%)	[2]T_{dam} (lb/ft)	COV (%)
Type 1 Coarse Gravel (GP)	2XT	2,691	0.9	1,671	18.4
	8XT	8,463	1.2	5,309	8.9
	24XT	29,809	1.2	22,129	4.3
Type 2 Sandy Gravel (GP)	2XT	2,691	0.9	2,584	2.2
	8XT	8,463	1.2	7,384	3.2
	24XT	29,809	1.2	27,576	1.6
Type 3 Silty Sand (SM)	2XT	2,691	0.9	2,567	7.5
	8XT	8,463	1.2	7,517	3.5
	24XT	29,809	1.2	27,269	2.9

[1]Average of 5 specimens.
[2]Average of 10 specimens.
(Conversion: 1 lb/ft = 0.0146 kN/m)

Table 4-3. Measured RF_{ID}.

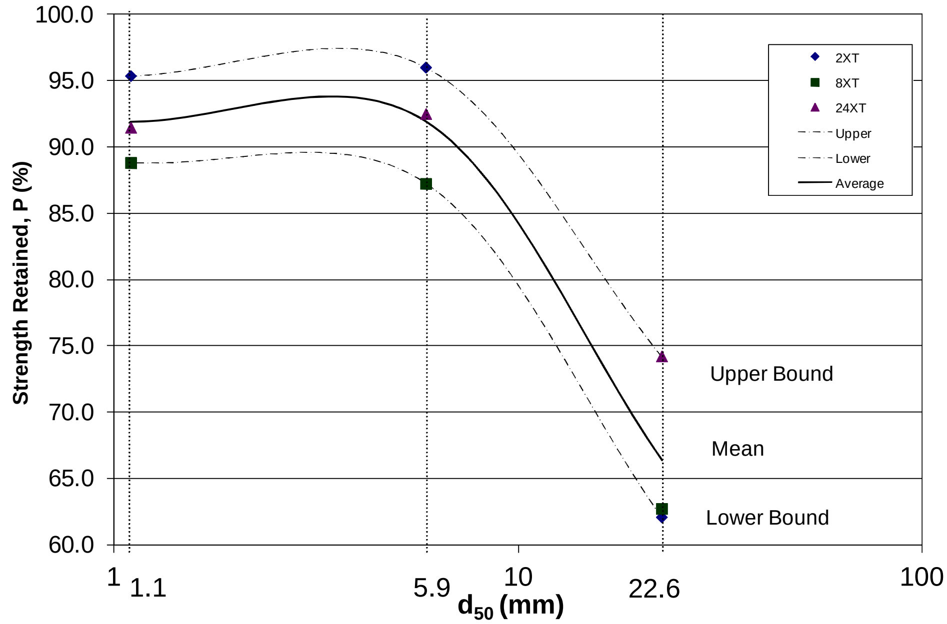
Style	Mass / Area (oz./yd^2)	Type 1 Coarse Gravel		Type 2 Sandy Gravel		Type 3 Silty Sand	
		% Retained	RF_{ID}	% Retained	RF_{ID}	% Retained	RF_{ID}
2XT	7.21	62.2	1.61	96.0	1.04	95.4	1.05
8XT	11.23	62.7	1.59	87.2	1.15	88.8	1.13
24XT	30.27	74.2	1.35	92.5	1.08	91.5	1.09

4.4 Estimating RF_{ID} for Specific Soils or for Products not Tested

In general, as the test material gradation becomes more coarse, the value of strength retained decreased (i.e., RF_{ID} increased). Trend lines plotted in Figure 4-5 for the mean, upper bound and lower bound for all the installation damage data obtained for the product line illustrate the general trend of the installation damage data with regard to soil d_{50} size. Interpolation of this data to intermediate gradations appears to be feasible based on these test results, though the scatter in that trend should be recognized when estimating values of RF_{ID} for specific soils.

The Miragrid XT product line generally exhibited moderately strong relationships between the weight or the tensile strength of the product and the strength retained after installation damage for the coarsest gradation (gradation 1) but showed no consistent relationship with product weight or tensile strength for the finer gradations. See figures 4-6 through 4-8 for illustrations of those relationships. Therefore, interpolation of these test results to products in the line not tested based on product weight or strength may only be feasible for the coarsest soil tested, though caution should be exercised and appropriate judgment applied to insure a safe estimate of RF_{ID} each product.

For coated geogrids, the coating weight/thickness can have a significant influence on the resistance of the geogrid to installation damage as described in WSDOT T925 Appendix A. Since only representative products from the product line were field tested for installation damage, all of the products in the product line were tested using ISO/EN 10722 (see Section 4.5 of this report) to investigate relative resistance to installation damage for all the products. As shown in Section 4.5, installation damage resistance of all of the products in that test was reasonably consistent. Furthermore, the products subjected to full scale field installation conditions also had the lowest installation damage strength retained values in the ISO/EN 10722 test. Therefore, for products in the product line not tested in the full scale installation damage tests, for the two finer soil gradations, use of a lower bound value of strength retained for the products not tested in the full scale installation damage tests (i.e., (P_{dmin} in figures 4-7 and 4-8) appears to be appropriate for design.



Note: $RF_{ID} = 1/P$; d_{50} = sieve size at which 50% of soil passes by weight

Figure 4-5. Miragrid XT product line installation damage as a function of soil d_{50} size.

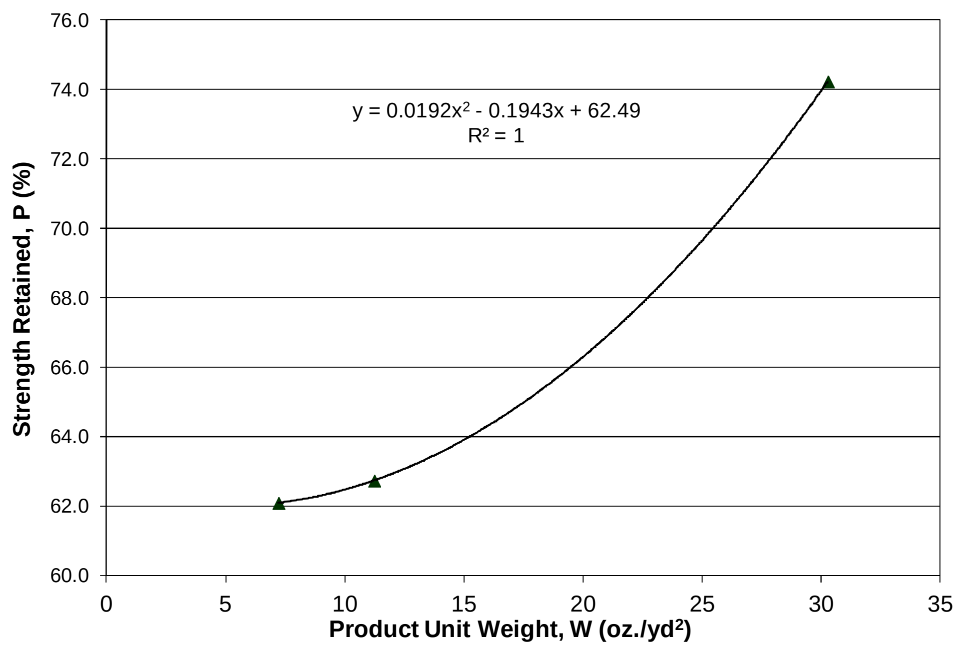


Figure 4-6. Miragrid XT product line installation damage as a function of product unit weight for type 1 soil (coarse gravel - GP).

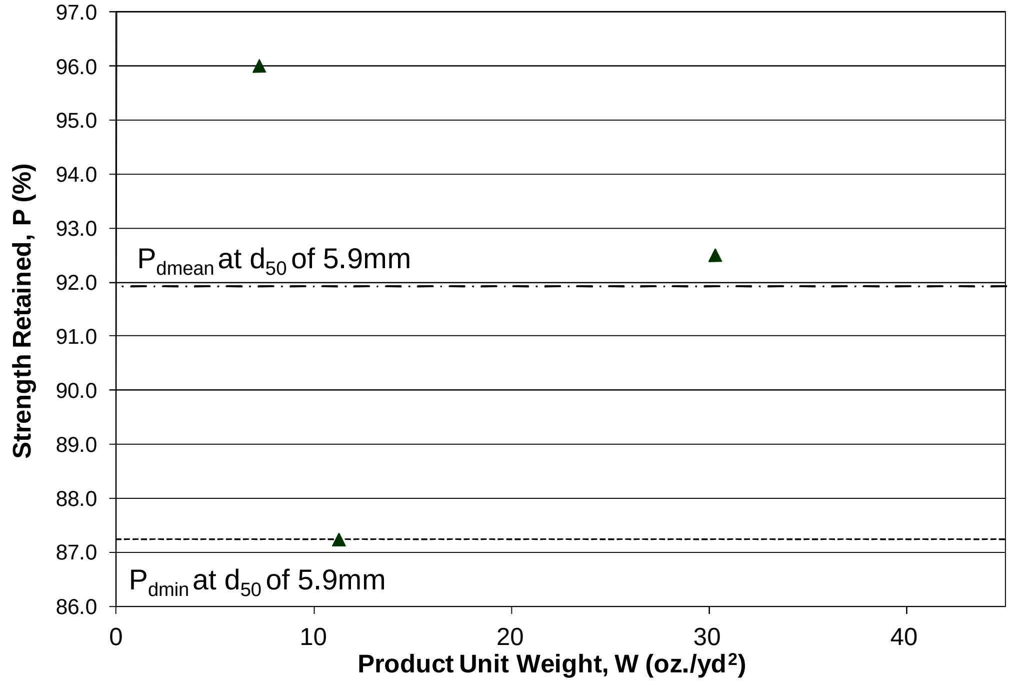


Figure 4-7. Miragrid XT product line installation damage as a function of product unit weight for type 2 soil (sandy gravel - GP).

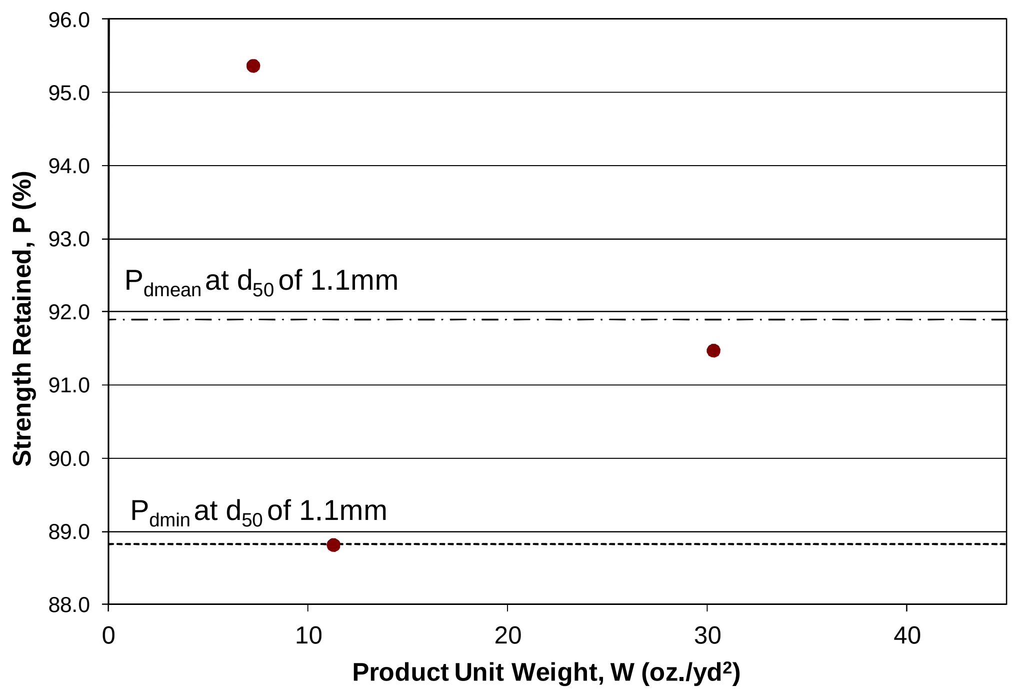


Figure 4-8. Miragrid XT product line installation damage as a function of product unit weight for type 3 soil (silty sand – SM).

It should be noted that the installation damage testing conducted represents an increase in compaction and spreading equipment size (i.e., a 15,000 lb wheeled front end loader – Caterpillar 416E, and a 25,000 lb single drum vibratory roller – a 10,000 lb roller was used in past testing) and a reduced aggregate lift thickness over the geogrid of 6 inches (an 8 inch lift thickness was used in past testing) relative to the installation damage testing reported in previous NTPEP test reports. Therefore, the decrease in strength retained values relative to previous NTPEP test reports for this product line does not represent a change in the products, but instead is the result of the more severe installation damage conditions which represent a likely upper bound installation condition for geosynthetic reinforced soil structures. Actual RF_{ID} values could be lower if installation conditions are less severe (e.g., greater initial lift thickness over the geogrid, use of lighter weight equipment, etc.). Actual RF_{ID} values could be higher if the spreading or compacting equipment tires or tracks are allowed to be in direct contact with the geosynthetic before or during fill placement and compaction, if the thickness of the fill material between the equipment tires or tracks is inadequate (especially for high tire pressure equipment such as dump trucks), or if excessive rutting of the first lift of soil over the geosynthetic (e.g., due to soft subgrade soil) is allowed to occur.

4.5 Laboratory Installation Damage Test Results per ISO/EN 10722

Laboratory Installation damage testing and interpretation was conducted in accordance with ISO/EN 10722. In this procedure, geosynthetic specimens are exposed to simulated installation stresses and abrasion using a standard “backfill” material in a bench scale device. Once exposed, they are tested for tensile strength to determine the retained strength after damage. Five baseline and five exposed specimens from each product were tested. The test results are summarized in Table 4-4. Detailed test results are provided in Appendix E, as well as a photograph of the test set-up and a close up of the standard backfill material used.

This procedure is intended to be a reproducible index test to assess relative susceptibility of the geosynthetic to damage. In this NTPEP testing program, the results from this test are primarily intended to be used for future quality assurance to assess the consistency in the product’s susceptibility to installation damage. It is not intended to be used directly in the determination of RF_{ID} for a given soil backfill gradation.

Table 4-4. Summary of laboratory (ISO procedure) installation damage test results.

Miragrid XT Style	Mean Baseline Tensile Strength (lb/ft)	Coefficient of Variation (%)	Mean Exposed Tensile Strength (lb/ft)	Coefficient of Variation (%)	Strength Retained (%)
2XT	2,744	1	1,884	8	93
3XT	4,089	1	4,000	2	98
5XT	5,214	1	4,998	2	98
7XT	6,393	2	5,785	5	91
8XT	8,426	2	7,735	5	92
10XT	10,623	3	9,708	3	91
20XT	16,680	2	15,790	2	95
22XT	23,794	4	15,441	2	93
24XT	29,796	4	26,520	1	89

(Conversion: 1 lb/ft = 0.0146 kN/m)

5.0 Creep Rupture Data (RF_{CR})

5.1 Creep Rupture Test Program

Creep testing and interpretation has been conducted in accordance with WSDOT Standard Practice T925, Appendices B and C. A baseline (i.e., reference) temperature of 68° F (20° C) was used. Miragrid 8XT was used as the primary product to establish the creep rupture envelope, with limited creep testing of the other Miragrid geogrids (i.e., 2XT and 24XT) to verify the ability to interpolate creep rupture behavior to the XT geogrid products not specifically tested (i.e., to treat all the products submitted for evaluation as a product line per T925 and the NTPEP work plan).

The creep rupture testing program is summarized in Figure 5-1. Creep testing was conducted using both ASTM D5262 (termed "conventional" creep testing) and ASTM D6992 (i.e., the Stepped Isothermal Method - SIM). A limited number (6) of tests using ASTM D5262, conducted only at the reference temperature of 68° F (20° C) for up to a minimum time of 1,000 hrs were used for comparison purposes to verify the accuracy of the SIM creep tests. Since single rib tensile tests were used for SIM (ASTM D6992) and conventional creep tests (ASTM D5262), only single rib short-term tensile tests were conducted for each product. This was done to ensure that the correct index tensile strength is used, since the creep load is expressed as a percent of T_{ult}.

Table 5-1. Independent creep rupture testing required for NTPEP qualification.

Manufacturer: TenCate Geosynthetics **PRODUCT Line:** 2XT to 24XT			
Tests Conducted	**Qualification (every 6 yrs) / QA (every 3 yrs)**		
	Products Tested		**# of Tests (see Note 1)**
	Qualification	**QA**	
Index single rib tensile tests on lot specific material (ASTM D 6637)	2XT, 8XT, 24XT	NA	3
Index wide width tensile tests on lot specific material (ASTM D 6637)	NA	NA	0
PRIMARY PRODUCT 6 Rupture Points – Conventional Creep testing up to 1000 hrs (ASTM D5262)	8XT @ 6 load levels	NA	6
PRIMARY PRODUCT 6 Rupture Points – Accelerated Creep rupture testing (SIM). (ASTM D6992)	8XT @ 6 load levels	NA	6
SECONDARY PRODUCT(S) Conventional Creep Testing (ASTM D5262)	None	NA	0
SECONDARY PRODUCT(S) Accelerated Creep rupture testing (SIM). (ASTM D6992)	2XT and 24XT @ 4 load levels	NA	8
Note 1: Each test is performed using the number of specimens required by the test standard. For example, for index tensile testing, a test is defined 5 to 6 specimens. See the specific test procedures for details on this.			

5.2 Baseline Tensile Strength Test Results

All creep testing using SIM (ASTM D6992) and conventional (ASTM D5262) creep tests were performed on single rib specimens. To facilitate use of both single rib to wide width specimens for the creep testing, rapid loading tensile and creep tests were conducted, in accordance with T925. Sample specific geogrid dimensions were used to convert tensile test loads to load per unit width values. Data from testing conducted previously and reported in NTPEP Report 8505.3 indicated that single rib and multi-rib tensile tests provide adequately similar results, therefore additional conventional creep testing using multi-rib specimens was not required. The tensile test specimens tested were taken from the same rolls of material that were used for the creep testing. The measured geogrid dimensions discussed in Section 2 and provided in Appendix B, Section B.1, were used to convert tensile test loads to load per unit width values.

Table 5-2. Ultimate tensile strength (UTS) and associated strain.

Product	Single Rib UTS per ASTM D6637, T_{lot} (lb/ft @ % Strain)
2XT	2,678 @ 10.8%
8XT	8,714 @ 12.8%
24XT	30,714 @ 14.8%

(Conversion: 1 lb/ft = 0.0146 kN/m)

5.3 Creep Rupture Test Results

A total of 14 Stepped Isothermal Method (SIM) tests and 6 conventional creep tests were run to fulfill the qualification requirements. Table 5-3 summarize the tests performed and their outcomes. Detailed test results, including creep curves for each specimen tested, are provided in Appendix F, Figures F-1 through F-20.

Table 5-3. Creep rupture test results for all tests conducted.

Style & Test Type	Creep Load (% of T_{lot})	Time to Rupture (log hrs)
2XT - SIM	70.00	5.5711
2XT - SIM	73.99	3.7918
2XT - SIM	76.99	2.7248
2XT - SIM	80.00	1.9786
8XT - SIM	64.35	6.8129
8XT - SIM	69.30	5.8708
8XT - SIM	71.77	4.6272
8XT - SIM	74.25	3.9427
8XT - SIM	76.73	4.1056
8XT - SIM	79.20	2.4988
8XT - Conv.	78.00	3.1714
8XT - Conv.	78.00	2.8178
8XT - Conv.	80.00	2.4203
8XT - Conv.	80.00	2.3436
8XT - Conv.	82.00	2.3395
8XT - Conv.	82.00	1.5999
24XT - SIM	68.00	6.3928
24XT - SIM	71.00	5.4707
24XT - SIM	75.00	4.2798
24XT - SIM	79.00	2.8434

5.3.1 Statistical Validation to Allow the Use of SIM Data to Establish Rupture Envelope

Validation of the use of SIM to extend the creep rupture data was conducted previously as reported in the 2008 NTPEP report for this product line (NTPEP Report 8505.3). For convenience, the results of that validation from this previous testing are summarized in Figure F-21 in Appendix F. Revalidation of the use of SIM for this product line was considered unnecessary in accordance with the NTPEP work plan and WSDOT T925, since it was determined that the product line has not significantly changed in its formulation and processing relative to the product line as previously tested and reported in the 2008 NTPEP report.

Figure F-22 provides a plot of the creep rupture envelope for the conventional creep and SIM creep data performed as part of the current testing program. Visually the conventional and SIM data are reasonably consistent. Thus, the conventional and accelerated (SIM) data may be used together to construct the characteristic creep rupture curve of the primary product, and SIM data may also be used for creep testing of the other two geogrid products to evaluate the potential to construct a composite creep curve for the product line.

5.3.2 Statistical Validation to Allow the Use of Composite Rupture Envelope for Product Line

Details of the confidence limits evaluation for the product line conducted in accordance with T925 are contained in Appendix F. Figure F-23 provides a plot of the creep rupture envelope with the confidence limits and the rupture envelopes for the primary product and the other tested products (i.e., 2XT and 24XT), illustrating this statistical test. Detailed calculation results for this statistical analysis are provided in tables F-2 and F-3, and summarized in Table F-5. The results indicate that the rupture envelopes for the 2XT and 24XT products are within the specified 90% confidence limits of the primary product (i.e., 8XT) creep rupture data, meeting T925 requirements. Thus, all the XT products tested (i.e., 2XT, 8XT, and 24XT) can be used to construct a composite creep rupture envelope representing the entire product line. The calculation results for the statistical analysis and regression to create the full composite creep curve are provided in Table F-4.

5.4 Creep Rupture Envelope Development and Determination of RF_{CR}

In consideration of the statistical validation described in Section 5.3 of this report, a composite creep rupture envelope, using log-linear regression, was constructed as shown in Figure 5-1. The mix of conventional and accelerated (SIM) creep rupture test data points meets T925 requirements. Based on this plot of all data, the regression of the data shows that the r^2 value is 0.95 (see Table F-4 in Appendix F for details). Per T925, this degree of scatter in the data is acceptable for a composite rupture envelope.

The creep rupture envelope in Figure 5-1 should be considered valid for the entire Miragrid XT geogrid product line evaluated in this report. Since the temperature accelerated creep results produced through the SIM testing allowed time shifting of the creep rupture data points to over

1,000,000 hours (i.e., 114 years), no extrapolation uncertainty factor in accordance with T925 need be applied. Table 5-4 provides the estimated value of RF_{CR} for **Miragrid XT Series** geogrids based on the reported testing for a period of long-term loading of up to 75 years. This rupture envelope can be used to determine RF_{CR} for times other than 75 years, if desired.

Table 5-4. RF_{CR} value for Miragrid XT series geogrids for a 75 yr period of loading/use.

Period of Use (in years)	RF_{CR} for Rupture – All XT Styles
75	1.45

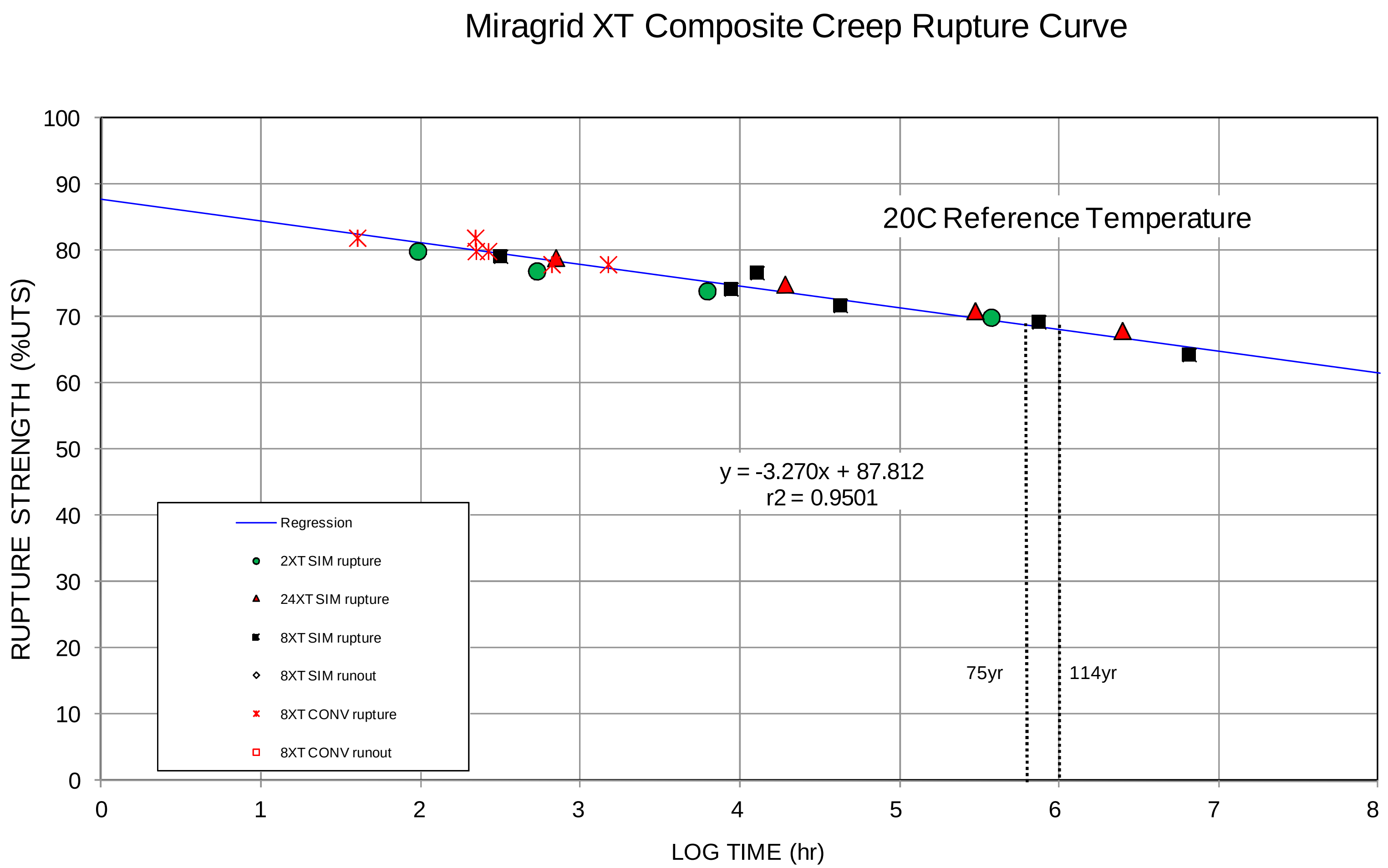


Figure 5-1. Composite creep rupture data/envelope for the Miragrid XT geogrid product line.

6.0 Long-Term Durability Data (RF_D)

6.1 Durability Test Program

Basic molecular properties relating to durability were evaluated, allowing a "default" RF_D to be used in accordance with WSDOT Standard Practice T925, provided that the long-term environment in which the geosynthetic is to be used is considered to be non-aggressive in accordance with the AASHTO LRFD Bridge Design Specifications and T925. A non-aggressive long-term environment is described in these documents as follows:

- A soil ph of 4.5 to 9.0,
- A maximum particle size of 0.75 inches or less unless installation damage effects are specifically evaluated using full scale installation damage testing in accordance with ASTM D 5818,
- A soil organic content of 1% or less, and
- An effective design temperature at the site of 86^{o}F (30^{o}C) or less.

Other specific soil/environmental conditions that could be of concern to consider the site environment to be aggressive are discussed in Elias, et al. 2009[2].

The index properties/test results obtained can be related to long-term performance of the polymer through correlation to longer-term laboratory durability performance tests and long-term experience. Note that long-term durability performance testing in accordance with T925 and the NTPEP work plan to allow direct calculation of RF_D was not available from the manufacturer, nor evaluated as part of the testing program for this product line.

For polyester (PET) geosynthetics, key durability issues to address include hydrolysis and ultraviolet (UV) oxidative degradation. To assess the potential for these types of degradation, index property tests to assess molecular weight, carboxyl end group content, and ultraviolet (UV) oxidative degradation are conducted. Criteria for test results obtained each of these tests are provided in T925 as well as the AASHTO LRFD Bridge Design Specifications.

The UV degradation tests were conducted on the lightest weight product in the product line (Miragrid 2XT) as recommended in T925. Since UV degradation attacks from the surface of the geosynthetic, the heavier the product, the more resistant it will be to UV degradation. Therefore, UV testing the lightest weight product should produce the most conservative result.

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[2] Elias, V., Fishman, K.L., Christopher, B.R., and Berg, R.R. 2009, *Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, No.* FHWA-NHI-09-087, Federal Highway Administration, 142pp.

The molecular weight and carboxyl end group content tests are conducted on the base yarn for the product series. Since for a product line the base yarn used must be the same for all products in the line, these tests on the base yarn will be applicable to all products in the product line.

Table 6-1. Independent durability testing required for NTPEP qualification.

Manufacturer: TenCate Geosynthetics **PRODUCT Line:** 2XT to 24XT			
Tests Conducted	**Qualification (every 6 yrs) / QA (every 3 yrs)**		
	Products Tested		**# of Tests (see Note 1)**
	Qualification	**QA**	
All polymers, resistance to weathering @ 500 hrs (ASTM D4355), including before/after tensile strength	2XT	NA	1
For polyesters, molecular weight determination (ASTM D4603 and GRI-GG7) – **on yarn/strip**	2XT yarn	NA	1
For polyesters, carboxyl end group content determination (GRI-GG8) – **on yarn/strip**	2XT yarn	NA	1
CEG-MW Testing Coating Removal, if necessary	2XT yarn	NA	1
Brittleness (WSDOT T926)	NA	NA	0
For polyolefins, long-term evaluation via Oxidative degradation (ISO/EN 13438:1999)	NA	NA	0
For polyesters, long-term evaluation via Hydrolytic degradation (WSDOT T925)	None	None	0
For polyolefins, long-term evaluation via Oxidative degradation (WSDOT T925)	NA	NA	0
Note 1: Each test is performed using the number of specimens required by the test standard. For example, for index tensile testing, a test is defined 5 to 6 specimens. See the specific test procedures for details on this.			

6.2 Durability Test Results

A summary of the test results is provided in Table 6-2. This table also includes the criteria to allow the use of a default reduction factor for RF_D provided in T925 and the AASHTO LRFD Bridge Design Specifications. Detailed durability test results are provided in Appendix G.

Table 6-2. NTPEP durability test results for the Miragrid XT geogrid product line and criteria to allow use of a default value for RF_D.

Polymer Type	Property	Test Method	Criteria to Allow Use of Default RF*	Test Result Obtained as Part of NTPEP Program
PP and HDPE	UV Oxidation Resistance	ASTM D4355	Min. 70% strength retained after 500 hrs in weatherometer	NA
PET	UV Oxidation Resistance	ASTM D4355	Min. 50% strength retained after 500 hrs in weatherometer if geosynthetic will be buried within one week, 70% if left exposed for more than one week.	85% strength retained
PP and HDPE	Thermo-Oxidation Resistance	ENV ISO 13438:1999, Method A (PP) or B (HDPE)	Min. 50% strength retained after 28 days (PP) or 56 days (HDPE)	NA
PET	Hydrolysis Resistance	Inherent Viscosity Method (ASTM D4603 and GRI Test Method GG8)	Min. Number Average Molecular Weight of 25,000	34,855
PET	Hydrolysis Resistance	GRI Test Method GG7	Max. Carboxyl End Group Content of 30	15.2

Note: PP = polypropylene, HDPE = high density polyethylene, PET = polyester

Based on these test results, all products in the product line meet the minimum UV requirement shown in Table 6-2. Regarding hydrolysis resistance, these test results shown in Table 6-2 indicate that this product line has adequate long-term resistance to hydrolysis to justify the use of a default value for RF_D, meeting the requirements in T925.

Note that while no specific tests, other than installation damage, were conducted to evaluate the durability of the PVC coating, because the hydrolysis resistance characterization was determined based on the base polymer, any potential coating degradation should have very little effect on the long-term durability of the geogrid product and the default value of RF_D selected. Typically, a default value of 1.3 for RF_D is selected. See WSDOT Standard Practice T925, or the document entitled "Use and Application of NTPEP Geosynthetic Reinforcement Test Results" (www.NTPEP.org), for guidance on the selection of a default value for RF_D.

7.0 Low Strain Creep Stiffness Data

7.1 Low Strain Creep Stiffness Test Program

Creep stiffness testing was conducted in accordance with WSDOT Standard Practice T925 and the NTPEP work plan. The creep stiffness determination was targeted to 2% strain at 1,000 hours.

Products selected to represent the XT product line (i.e., 2XT, 8XT, and 24XT) were tested for creep stiffness. Roll specific single rib short-term rapid loading tensile strength tests (T_{lot}) were conducted for each product for correlation purposes and to calculate load levels. A total of nine Ramp and Hold (R&H), 1,000 second creep tests, were conducted on each product. Three specimens were R&H tested at each of the following stresses: 5, 10 and 20% of the ultimate tensile strength (UTS). A linear regression based on %UTS and % strain at 0.1 hour was used to normalize strain curves to reduce the variability of the elastic portion of the strain curve. The % UTS required to obtain 2% strain at 1,000 hours was then determined. Three R&H tests and two 1,000 hour conventional creep tests (ASTM D5262, but as modified for low strain in WSDOT Standard Practice T925 and using a single rib specimen) were conducted at this load. All tests were conducted at 68^{o} F (20^{o} C).

7.2 Ultimate Tensile Test Results for Creep Stiffness Test Program

The values provided in Table 7-1 represent the baseline, roll specific, ultimate tensile strength used to normalize the load level for the creep stiffness testing. Sample specific geogrid dimensions were used to convert tensile test loads to load per unit width values.

Table 7-1. Ultimate tensile strength (UTS) & associated strain.

Product	T_{lot} for Single Rib (lb/ft @ % Strain)
2XT	2,678 @ 10.8%
8XT	8,714 @ 12.8%
24XT	30,714 @ 14.8%

(Conversion: 1 lb/ft = 0.0146 kN/m)

7.3 Creep Stiffness Test Results

Detailed test results are provided in Appendix H. Table 7-2 provides a summary of the creep stiffness values obtained. Note that the creep stiffness values at 1,000 hours and 5%UTS, 10%UTS and 20%UTS represent stiffness values at strains other than 2% strain. See Appendix H for details. Figure 7-1 shows the relationship between the measured tensile strength and the creep stiffness. Considering the strong linear relationship between the creep stiffness and the product tensile strength, interpolation to other products in the product line not tested to determine creep stiffness values for those products is acceptable.

Table 7-2. Summary of creep stiffness test results.

Miragrid XT Series Style	Average Creep Stiffness @ 1000 hours for 5% UTS Ramp & Hold (lb/ft)	Average Creep Stiffness @ 1000 hours for 10% UTS Ramp & Hold (lb/ft)	Average Creep Stiffness @ 1000 hours for 20% UTS Ramp & Hold (lb/ft)	Average Creep Stiffness for 2% strain @ 1000 hrs (lb/ft)
2XT	22,193	18,272	14,875	**16,951**
8XT	46,030	45,708	43,576	**44,977**
24XT	297960	185,768	109,909	**169,525**

(Conversion: 1 lb/ft = 0.0146 kN/m)

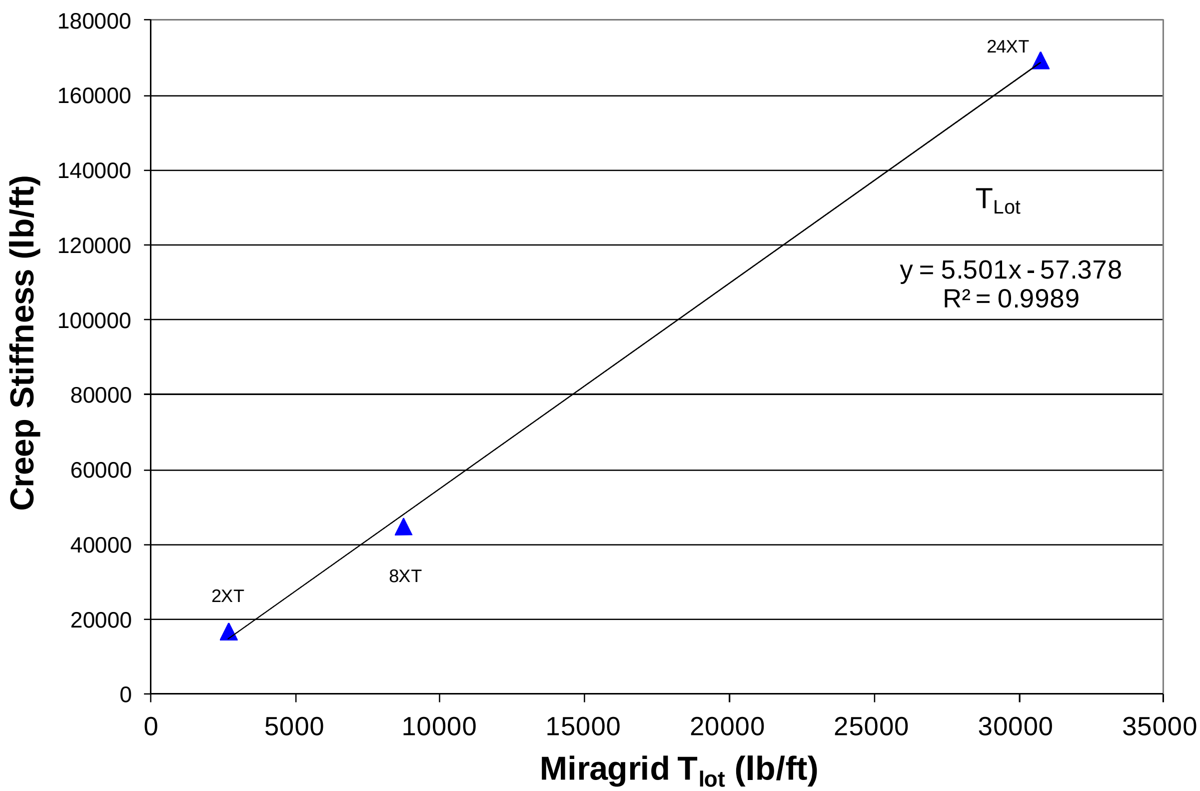

Figure 7-1. Miragrid XT creep stiffness for 2 % strain @ 1000 hours.

To obtain the minimum likely stiffness value for each product in consideration of the MARV tensile strength, multiply the stiffness value from the plot by the ratio of T_{MARV}/T_{lot}. T_{MARV} is the minimum tensile strength, as provided by the manufacturer, for each product in the product line. T_{lot} is the actual roll specific tensile strength for the sample used in the creep stiffness testing.

APPENDICES

Appendix A: NTPEP Oversight Committee

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Appendix B: Product Geometric and Production Details

B.1 Product Geometric Information

Table B-1. Typical and measured MD geogrid geometry for the Miragrid XT product line.

Machine Direction (MD) Ribs								
Style	Width (in)		Spacing (in)		Aperture Size (in)		Rib Thickness (in)	
	Typical Values	As Measured*	Typical Values	As Measured*	Typical Values	As Measured *	Typical Values	As Measured*
2XT	N/A	0.095	N/A	1.118	0.875	0.830	N/A	0.057
3XT	N/A	0.144	N/A	1.113	1.0	1.260	N/A	0.060
5XT	N/A	0.196	N/A	1.127	1.2	1.245	N/A	0.059
7XT	N/A	0.223	N/A	1.121	1.3	1.214	N/A	0.057
8XT	N/A	0.285	N/A	1.237	1.3	1.148	N/A	0.057
10XT	N/A	0.297	N/A	1.096	1.3	1.315	N/A	0.072
20XT	N/A	0.373	N/A	1.001	1.5	5.806	N/A	0.084
22XT	N/A	0.471	N/A	1.003	1.4	5.796	N/A	0.101
24XT	N/A	0.519	N/A	1.006	1.4	5.740	N/A	0.094

(Conversions: 1 in = 25.4 mm)

*Average of 5 readings obtained during NTPEP testing. Full test results in tables B-5 through B-13.

Table B-2. Typical and measured XD geogrid geometry for the Miragrid XT product line.

Cross-Machine Direction (XD) Ribs								
Style	Width (in)		Spacing (in)		Aperture Size (in)		Rib Thickness (in)	
	Typical Values	As Measured*	Typical Values	As Measured*	Typical Values	As Measured*	Typical Values	As Measured*
2XT	N/A	0.114	N/A	0.944	1.0	1.023	N/A	0.061
3XT	N/A	0.126	N/A	1.385	1.0	0.969	N/A	0.061
5XT	N/A	0.108	N/A	1.354	1.0	0.931	N/A	0.053
7XT	N/A	0.115	N/A	1.330	0.9	0.898	N/A	0.062
8XT	N/A	0.117	N/A	1.354	0.9	0.863	N/A	0.058
10XT	N/A	0.116	N/A	1.431	0.8	0.799	N/A	0.062
20XT	N/A	0.265	N/A	6.071	0.6	0.628	N/A	0.059
22XT	N/A	0.256	N/A	6.053	0.6	0.532	N/A	0.073
24XT	N/A	0.258	N/A	5.998	0.5	0.487	N/A	0.067

(Conversions: 1 in = 25.4 mm)

*Average of 5 readings obtained during NTPEP testing. Full test results in tables B-5 through B-13.

Table B-3. Typical and measured geogrid junction thickness for the Miragrid XT product line.

Style	Junction Thickness (in)	
	Typical Values	As Measured*
2XT	Not tested	0.058
3XT	Not tested	0.066
5XT	Not tested	0.060
7XT	Not tested	0.065
8XT	Not tested	0.069
10XT	Not tested	0.078
20XT	Not tested	0.101
22XT	Not tested	0.115
24XT	Not tested	0.119

(Conversions: 1 in = 25.4 mm)

*Average of 5 readings obtained during NTPEP testing. Full test results in tables B-5 through B-13.

Table B-4. Typical and measured geogrid unit weight for the Miragrid XT product line.

Geogrid Style/Type	Typical Weight (oz/yd^2)	Measured Weight*, per ASTM D5261 (oz/yd^2)
2XT	7.50	7.21
3XT	8.17	7.98
5XT	9.00	8.85
7XT	10.21	9.09
8XT	11.42	11.23
10XT	14.31	13.26
20XT	22.12	18.45
22XT	30.50	24.79
24XT	38.02	30.27

(Conversion: 1 oz/yd^2 = 33.9 g/m^2)

*Average of 5 readings obtained during NTPEP testing. Full test results in tables B-5 through B-13.

Table B-5. Geogrid geometric measurements for 2XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 9							
Specimen Length (in) 8.9							
Mass(g)	12.44	12.94	12.57	12.66	12.60		
Mass/unit area (oz/sq.yd)	7.09	7.38	7.17	7.22	7.18	**7.21**	0.11
Mass/unit area (g/sq.meter)	240	250	243	245	244	**244**	4
Aperature Size (Calipers)							
MD - Aperature Size (in)	0.837	0.829	0.832	0.767	0.885	**0.830**	0.042
MD - Aperature Size (mm)	21.3	21.1	21.1	19.5	22.5	**21.1**	1.1
TD - Aperature Size (in)	1.028	1.020	1.021	1.025	1.021	**1.023**	0.003
TD - Aperature Size (mm)	26.1	25.9	25.9	26.0	25.9	**26.0**	0.1
Rib Width (Calipers)							
MD - Width (in)	0.093	0.099	0.095	0.097	0.092	**0.095**	0.003
MD - Width (mm)	2.36	2.51	2.41	2.46	2.34	**2.42**	0.07
TD - Width (in)	0.116	0.110	0.111	0.124	0.110	**0.114**	0.006
TD - Width (mm)	2.95	2.79	2.82	3.15	2.79	**2.90**	0.15
Rib Thickness (Calipers)							
MD - Thickness (in)	0.055	0.066	0.056	0.053	0.057	**0.057**	0.005
MD - Thickness (mm)	1.40	1.68	1.42	1.35	1.45	**1.46**	0.13
TD - Thickness (in)	0.063	0.068	0.052	0.065	0.055	**0.061**	0.007
TD - Thickness (mm)	1.60	1.73	1.32	1.65	1.40	**1.54**	0.17
Node/Junction Thickness (Calipers)							
Thickness (in)	0.06	0.059	0.056	0.055	0.06	**0.058**	0.002
Thickness (mm)	1.52	1.50	1.42	1.40	1.52	**1.47**	0.06

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-6. Geogrid geometric measurements for 3XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 9.5							
Specimen Length (in) 8.9							
Mass(g)	15.00	14.65	14.67	14.44	15.06		
Mass/unit area (oz/sq.yd)	8.10	7.91	7.92	7.80	8.14	**7.98**	0.14
Mass/unit area (g/sq.meter)	275	268	269	264	276	**270**	5
Aperature Size (Calipers)							
MD - Aperature Size (in)	1.245	1.332	1.319	1.228	1.174	**1.260**	0.066
MD - Aperature Size (mm)	31.6	33.8	33.5	31.2	29.8	**32.0**	1.7
TD - Aperature Size (in)	0.936	0.987	0.984	0.975	0.964	**0.969**	0.021
TD - Aperature Size (mm)	23.8	25.1	25.0	24.8	24.5	**24.6**	0.5
Rib Width (Calipers)							
MD - Width (in)	0.155	0.130	0.145	0.151	0.137	**0.144**	0.010
MD - Width (mm)	3.94	3.30	3.68	3.84	3.48	**3.65**	0.26
TD - Width (in)	0.137	0.133	0.113	0.114	0.131	**0.126**	0.011
TD - Width (mm)	3.48	3.38	2.87	2.90	3.33	**3.19**	0.29
Rib Thickness (Calipers)							
MD - Thickness (in)	0.057	0.061	0.063	0.063	0.056	**0.060**	0.003
MD - Thickness (mm)	1.45	1.55	1.60	1.60	1.42	**1.52**	0.08
TD - Thickness (in)	0.061	0.064	0.052	0.066	0.063	**0.061**	0.005
TD - Thickness (mm)	1.55	1.63	1.32	1.68	1.60	**1.55**	0.14
Node/Junction Thickness (Calipers)							
Thickness (in)	0.062	0.072	0.066	0.065	0.067	**0.066**	0.004
Thickness (mm)	1.57	1.83	1.68	1.65	1.70	**1.69**	0.09

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-7. Geogrid geometric measurements for 5XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER						MEAN	STD. DEV.
		1	2	3	4	5		
Mass/Unit Area (ASTM D 5261)								
Specimen Width (in)	9.4							
Specimen Length (in)	9							
Mass(g)		16.15	16.50	16.19	16.46	16.63		
Mass/unit area (oz/sq.yd)		8.72	8.91	8.74	8.89	8.98	**8.85**	0.11
Mass/unit area (g/sq.meter)		296	302	296	301	304	**300**	4
Aperature Size (Calipers)								
MD - Aperature Size (in)		1.360	1.197	1.292	1.165	1.213	**1.245**	0.079
MD - Aperature Size (mm)		34.5	30.4	32.8	29.6	30.8	**31.6**	2.0
TD - Aperature Size (in)		0.940	0.928	0.929	0.911	0.947	**0.931**	0.014
TD - Aperature Size (mm)		23.9	23.6	23.6	23.1	24.1	**23.6**	0.3
Rib Width (Calipers)								
MD - Width (in)		0.214	0.198	0.180	0.213	0.174	**0.196**	0.018
MD - Width (mm)		5.44	5.03	4.57	5.41	4.42	**4.97**	0.47
TD - Width (in)		0.106	0.108	0.109	0.108	0.111	**0.108**	0.002
TD - Width (mm)		2.69	2.74	2.77	2.74	2.82	**2.75**	0.05
Rib Thickness (Calipers)								
MD - Thickness (in)		0.058	0.063	0.055	0.058	0.062	**0.059**	0.003
MD - Thickness (mm)		1.47	1.60	1.40	1.47	1.57	**1.50**	0.08
TD - Thickness (in)		0.063	0.052	0.051	0.045	0.056	**0.053**	0.007
TD - Thickness (mm)		1.60	1.32	1.30	1.14	1.42	**1.36**	0.17
Node/Junction Thickness (Calipers)								
Thickness (in)		0.061	0.061	0.058	0.059	0.063	**0.060**	0.002
Thickness (mm)		1.55	1.55	1.47	1.50	1.60	**1.53**	0.05

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-8. Geogrid geometric measurements for 7XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 9.6							
Specimen Length (in) 8.9							
Mass(g)	17.06	16.95	17.22	16.83	16.92		
Mass/unit area (oz/sq.yd)	9.12	9.06	9.21	9.00	9.04	**9.09**	0.08
Mass/unit area (g/sq.meter)	309	307	312	305	307	**308**	3
Aperature Size (Calipers)							
MD - Aperature Size (in)	1.190	1.138	1.245	1.281	1.218	**1.214**	0.054
MD - Aperature Size (mm)	30.2	28.9	31.6	32.5	30.9	**30.8**	1.4
TD - Aperature Size (in)	0.894	0.875	0.889	0.912	0.922	**0.898**	0.019
TD - Aperature Size (mm)	22.7	22.2	22.6	23.2	23.4	**22.8**	0.5
Rib Width (Calipers)							
MD - Width (in)	0.224	0.229	0.219	0.218	0.223	**0.223**	0.004
MD - Width (mm)	5.69	5.82	5.56	5.54	5.66	**5.65**	0.11
TD - Width (in)	0.121	0.115	0.108	0.117	0.116	**0.115**	0.005
TD - Width (mm)	3.07	2.92	2.74	2.97	2.95	**2.93**	0.12
Rib Thickness (Calipers)							
MD - Thickness (in)	0.055	0.054	0.062	0.057	0.056	**0.057**	0.003
MD - Thickness (mm)	1.40	1.37	1.57	1.45	1.42	**1.44**	0.08
TD - Thickness (in)	0.064	0.064	0.065	0.058	0.059	**0.062**	0.003
TD - Thickness (mm)	1.63	1.63	1.65	1.47	1.50	**1.57**	0.08
Node/Junction Thickness (Calipers)							
Thickness (in)	0.061	0.059	0.070	0.063	0.074	**0.065**	0.006
Thickness (mm)	1.55	1.50	1.78	1.60	1.88	**1.66**	0.16

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-9. Geogrid geometric measurements for 8XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 9.6							
Specimen Length (in) 8.85							
Mass(g)	20.55	21.29	20.95	21.05	20.58		
Mass/unit area (oz/sq.yd)	11.05	11.45	11.26	11.32	11.06	**11.23**	0.17
Mass/unit area (g/sq.meter)	375	388	382	384	375	**381**	6
Aperature Size (Calipers)							
MD - Aperature Size (in)	1.210	1.271	1.173	1.239	1.292	**1.237**	0.047
MD - Aperature Size (mm)	30.7	32.3	29.8	31.5	32.8	**31.4**	1.2
TD - Aperature Size (in)	0.855	0.866	0.858	0.864	0.870	**0.863**	0.006
TD - Aperature Size (mm)	21.7	22.0	21.8	21.9	22.1	**21.9**	0.2
Rib Width (Calipers)							
MD - Width (in)	0.275	0.292	0.287	0.289	0.284	**0.285**	0.007
MD - Width (mm)	6.99	7.42	7.29	7.34	7.21	**7.25**	0.17
TD - Width (in)	0.136	0.104	0.117	0.110	0.120	**0.117**	0.012
TD - Width (mm)	3.45	2.64	2.97	2.79	3.05	**2.98**	0.31
Rib Thickness (Calipers)							
MD - Thickness (in)	0.063	0.054	0.058	0.058	0.053	**0.057**	0.004
MD - Thickness (mm)	1.60	1.37	1.47	1.47	1.35	**1.45**	0.10
TD - Thickness (in)	0.053	0.051	0.060	0.067	0.060	**0.058**	0.006
TD - Thickness (mm)	1.35	1.30	1.52	1.70	1.52	**1.48**	0.16
Node/Junction Thickness (Calipers)							
Thickness (in)	0.072	0.068	0.069	0.066	0.069	**0.069**	0.002
Thickness (mm)	1.83	1.73	1.75	1.68	1.75	**1.75**	0.06

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-10. Geogrid geometric measurements for 10XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 9.5							
Specimen Length (in) 8.8							
Mass(g)	24.44	24.24	24.30	24.17	24.22		
Mass/unit area (oz/sq.yd)	13.35	13.24	13.28	13.21	13.23	**13.26**	0.06
Mass/unit area (g/sq.meter)	453	449	450	448	449	**450**	2
Aperature Size (Calipers)							
MD - Aperature Size (in)	1.310	1.311	1.310	1.332	1.310	**1.315**	0.010
MD - Aperature Size (mm)	33.3	33.3	33.3	33.8	33.3	**33.4**	0.2
TD - Aperature Size (in)	0.786	0.823	0.801	0.798	0.785	**0.799**	0.015
TD - Aperature Size (mm)	20.0	20.9	20.3	20.3	19.9	**20.3**	0.4
Rib Width (Calipers)							
MD - Width (in)	0.296	0.307	0.296	0.301	0.285	**0.297**	0.008
MD - Width (mm)	7.52	7.80	7.52	7.65	7.24	**7.54**	0.21
TD - Width (in)	0.115	0.117	0.107	0.113	0.128	**0.116**	0.008
TD - Width (mm)	2.92	2.97	2.72	2.87	3.25	**2.95**	0.20
Rib Thickness (Calipers)							
MD - Thickness (in)	0.075	0.071	0.073	0.073	0.067	**0.072**	0.003
MD - Thickness (mm)	1.91	1.80	1.85	1.85	1.70	**1.82**	0.08
TD - Thickness (in)	0.063	0.054	0.067	0.063	0.063	**0.062**	0.005
TD - Thickness (mm)	1.60	1.37	1.70	1.60	1.60	**1.57**	0.12
Node/Junction Thickness (Calipers)							
Thickness (in)	0.075	0.077	0.077	0.086	0.077	**0.078**	0.004
Thickness (mm)	1.91	1.96	1.96	2.18	1.96	**1.99**	0.11

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-11. Geogrid geometric measurements for 20XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 12.2							
Specimen Length (in) 8.9							
Mass(g)	43.60	44.17	44.44	43.67	43.38		
Mass/unit area (oz/sq.yd)	18.34	18.58	18.69	18.37	18.25	**18.45**	0.18
Mass/unit area (g/sq.meter)	622	630	634	623	619	**625**	6
Aperature Size (Calipers)							
MD - Aperature Size (in)	5.824	5.788	5.820	5.799	5.800	**5.806**	0.015
MD - Aperature Size (mm)	147.9	147.0	147.8	147.3	147.3	**147.5**	0.4
TD - Aperature Size (in)	0.631	0.632	0.660	0.630	0.586	**0.628**	0.027
TD - Aperature Size (mm)	16.0	16.1	16.8	16.0	14.9	**15.9**	0.7
Rib Width (Calipers)							
MD - Width (in)	0.402	0.369	0.354	0.365	0.374	**0.373**	0.018
MD - Width (mm)	10.21	9.37	8.99	9.27	9.50	**9.47**	0.45
TD - Width (in)	0.258	0.264	0.274	0.270	0.260	**0.265**	0.007
TD - Width (mm)	6.55	6.71	6.96	6.86	6.60	**6.74**	0.17
Rib Thickness (Calipers)							
MD - Thickness (in)	0.078	0.089	0.083	0.083	0.086	**0.084**	0.004
MD - Thickness (mm)	1.98	2.26	2.11	2.11	2.18	**2.13**	0.10
TD - Thickness (in)	0.061	0.064	0.053	0.053	0.064	**0.059**	0.006
TD - Thickness (mm)	1.55	1.63	1.35	1.35	1.63	**1.50**	0.14
Node/Junction Thickness (Calipers)							
Thickness (in)	0.101	0.100	0.098	0.105	0.099	**0.101**	0.003
Thickness (mm)	2.57	2.54	2.49	2.67	2.51	**2.56**	0.07

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-12. Geogrid geometric measurements for 22XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.
	1	2	3	4	5		
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 12.1							
Specimen Length (in) 8.9							
Mass(g)	57.86	59.95	58.12	58.30	58.02		
Mass/unit area (oz/sq.yd)	24.54	25.43	24.65	24.73	24.61	**24.79**	0.36
Mass/unit area (g/sq.meter)	832	862	836	838	834	**840**	12
Aperature Size (Calipers)							
MD - Aperature Size (in)	5.776	5.780	5.810	5.773	5.842	**5.796**	0.030
MD - Aperature Size (mm)	146.7	146.8	147.6	146.6	148.4	**147.2**	0.8
TD - Aperature Size (in)	0.462	0.560	0.558	0.528	0.554	**0.532**	0.041
TD - Aperature Size (mm)	11.7	14.2	14.2	13.4	14.1	**13.5**	1.1
Rib Width (Calipers)							
MD - Width (in)	0.456	0.469	0.488	0.487	0.455	**0.471**	0.016
MD - Width (mm)	11.58	11.91	12.40	12.37	11.56	**11.96**	0.41
TD - Width (in)	0.243	0.262	0.264	0.254	0.259	**0.256**	0.008
TD - Width (mm)	6.17	6.65	6.71	6.45	6.58	**6.51**	0.21
Rib Thickness (Calipers)							
MD - Thickness (in)	0.100	0.094	0.097	0.107	0.108	**0.101**	0.006
MD - Thickness (mm)	2.54	2.39	2.46	2.72	2.74	**2.57**	0.16
TD - Thickness (in)	0.073	0.075	0.073	0.074	0.072	**0.073**	0.001
TD - Thickness (mm)	1.85	1.91	1.85	1.88	1.83	**1.86**	0.03
Node/Junction Thickness (Calipers)							
Thickness (in)	0.113	0.115	0.118	0.114	0.115	**0.115**	0.002
Thickness (mm)	2.87	2.92	3.00	2.90	2.92	**2.92**	0.05

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table B-13. Geogrid geometric measurements for 24XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.
	1	2	3	4	5		
Mass/Unit Area (ASTM D 5261)							
Specimen Width (in) 12.2							
Specimen Length (in) 8.85							
Mass(g)	72.47	71.15	71.38	71.83	70.91		
Mass/unit area (oz/sq.yd)	30.66	30.10	30.20	30.39	30.00	**30.27**	0.26
Mass/unit area (g/sq.meter)	1039	1020	1024	1030	1017	**1026**	9
Aperature Size (Calipers)							
MD - Aperature Size (in)	5.640	5.808	5.768	5.672	5.813	**5.740**	0.080
MD - Aperature Size (mm)	143.3	147.5	146.5	144.1	147.7	**145.8**	2.0
TD - Aperature Size (in)	0.493	0.510	0.485	0.476	0.473	**0.487**	0.015
TD - Aperature Size (mm)	12.5	13.0	12.3	12.1	12.0	**12.4**	0.4
Rib Width (Calipers)							
MD - Width (in)	0.528	0.499	0.516	0.539	0.513	**0.519**	0.015
MD - Width (mm)	13.41	12.67	13.11	13.69	13.03	**13.18**	0.39
TD - Width (in)	0.253	0.262	0.266	0.253	0.255	**0.258**	0.006
TD - Width (mm)	6.43	6.65	6.76	6.43	6.48	**6.55**	0.15
Rib Thickness (Calipers)							
MD - Thickness (in)	0.097	0.082	0.097	0.094	0.098	**0.094**	0.007
MD - Thickness (mm)	2.46	2.08	2.46	2.39	2.49	**2.38**	0.17
TD - Thickness (in)	0.076	0.065	0.067	0.066	0.061	**0.067**	0.006
TD - Thickness (mm)	1.93	1.65	1.70	1.68	1.55	**1.70**	0.14
Node/Junction Thickness (Calipers)							
Thickness (in)	0.117	0.119	0.119	0.120	0.121	**0.119**	0.001
Thickness (mm)	2.97	3.02	3.02	3.05	3.07	**3.03**	0.04

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

B.2 Product Production Information

Table B-14. Typical geogrid roll dimensions for the Miragrid XT product line.

Style/Type	Width (ft)	Length (ft)	Area (yd^2)	Roll Diameter (ft)	Gross weight (lbs)
2XT	12	150	200	12.0	121
3XT	6 / 12	150	100 / 200	12.3 / 11.7	152 / 295
5XT	6 / 12	150	100 / 200	11.8	168 / 333
7XT	12	200	266	13.2	437
8XT	6 / 12	150 / 200	100 / 266	13.6 / 13.2	196 / 494
10XT	12	200	266	14.1	589
20XT	12	200	266	14.7	675
22XT	12	200	266	15.5	913
24XT	12	200	266	16.5	966

(Conversions: 1 ft = 0.3048 m; 1 yd^2 = 0.836 m^2)

B.3 Product Manufacturing Quality Control Program

Testing/sampling is done per the Miragrid Quality Control Plan Document. A summary of the program is provided in Table B-15.

Table B-15. Typical summary of quality control testing conducted by the manufacturer for the Miragrid XT product line.

Test Method	Property	Testing Frequency
ASTM D 5261	Mass / Unit Area	Per LOT (every 10,000 SY to 15,000 SY)
ASTM D6637	Single Rib Tensile	Per LOT (every 10,000 SY to 15,000 SY)
ASTM D6637	Multi-Rib Tensile	Per LOT (every 10,000 SY to 15,000 SY)
Hand measure	Aperture Size	Bi-Annually
Hand measure	Width	Per LOT
GRI-GG2	Junction Strength	Bi-Annually or change in product knit construction
GRI-GG7	CEG	Bi-Annually or change in PET fiber LOT/Merge
GRI-GG8	MW	Bi-Annually or change in PET fiber LOT/Merge

Table B-16. Typical production lot size for the Miragrid XT product line.

Style/Type	Lot Size (yd^2)	# of rolls per Lot
2XT	14,040	70
3XT	14,040	70
5XT	14,040	70
7XT	14,040	70
8XT	14,040	70
10XT	14,040	70
20XT	14,040	70
22XT	14,040	70
24XT	14,040	70

Appendix C: Tensile Strength Detailed Test Results

Table C-1. Geogrid single rib tensile test results for 2XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	MARV
	1	2	3	4	5			
Single Rib Tensile Properties (ASTM D 6637, Method A)								
MD - Number of Ribs per foot:	10.84							
MD Maximum Strength (lbs)	245.1	248.1	243.3	250.5	248.3	**247.1**	2.8	
MD Maximum Strength (lbs/ft)	2657	2689	2637	2715	2691	**2678**	31	2,000
MD Maximum Strength (kN/m)	38.8	39.3	38.5	39.6	39.3	**39.1**	0.5	
MD Break Elongation (%)	10.7	10.9	10.8	10.7	11.0	**10.8**	0.1	

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table C-2. Geogrid single rib tensile test results for 8XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	MARV
	1	**2**	**3**	**4**	**5**			
Single Rib Tensile Properties (ASTM D 6637, Method A)								
MD - Number of Ribs per foot:	10.84							
MD Maximum Strength (lbs)	763.9	802.6	819.2	813.0	821.0	**803.9**	23.5	
MD Maximum Strength (lbs/ft)	8280	8699	8879	8812	8899	**8714**	255	7,400
MD Maximum Strength (kN/m)	120.9	127.0	129.6	128.7	129.9	**127.2**	3.7	
MD Break Elongation (%)	11.6	12.9	13.2	12.8	13.3	**12.8**	0.7	

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table C-3. Geogrid single rib tensile test results for 24XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.	MARV
Single Rib Tensile Properties (ASTM D 6637, Method A)								
MD - Number of Ribs per foot:	12.25							
MD Maximum Strength (lbs)	2510	2484	2507	2540	2495	**2507**	21	
MD Maximum Strength (lbs/ft)	30752	30432	30705	31113	30567	**30714**	256	27,415
MD Maximum Strength (kN/m)	449.0	444.3	448.3	454.3	446.3	**448.4**	3.7	
MD Break Elongation (%)	14.6	14.8	14.3	15.6	14.9	**14.8**	0.5	

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table C-4. Geogrid wide width tensile test results for 2XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.	MARV
Wide Width Tensile Properties (ASTM D 6637, Method B)								
MD Number of Ribs per Specimen:	5							
MD Number of Ribs per foot:	10.84							
MD Ultimate Strength (lbs)	1225	1236	1251	1249	1246	**1241**	11	
MD Ultimate Strength (lbs/ft)	2656	2680	2712	2707	2701	**2691**	23	2,000
MD Ultimate Strength (kN/m)	38.8	39.1	39.6	39.5	39.4	**39.3**	0.3	
MD Strength @ 2% Strain (lbs)	280	292	300	282	270	**285**	11	
MD Strength @ 2% Strain (lbs/ft)	608	632	651	612	586	**618**	25	
MD Strength @ 2% Strain (kN/m)	8.9	9.2	9.5	8.9	8.6	**9.0**	0.4	
MD Strength @ 5% Strain (lbs)	570	593	607	567	584	**584**	16	
MD Strength @ 5% Strain (lbs/ft)	1236	1285	1315	1230	1265	**1266**	35	
MD Strength @ 5% Strain (kN/m)	18.0	18.8	19.2	18.0	18.5	**18.5**	0.5	
MD Strength @ 10% Strain (lbs)	1209	1213	1250	1208	1229	**1222**	18	
MD Strength @ 10% Strain (lbs/ft)	2622	2629	2710	2619	2664	**2649**	39	
MD Strength @ 10% Strain (kN/m)	38.3	38.4	39.6	38.2	38.9	**38.7**	0.6	
MD Break Elongation (%)	10.3	10.3	10.0	10.6	10.2	**10.3**	0.2	

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table C-5. Geogrid wide width tensile test results for 8XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	MARV
	1	**2**	**3**	**4**	**5**			
Wide Width Tensile Properties (ASTM D 6637, Method B)								
MD Number of Ribs per Specimen:	5							
MD Number of Ribs per foot:	10.84							
MD Ultimate Strength (lbs)	3985	3902	3887	3856	3889	**3904**	48	
MD Ultimate Strength (lbs/ft)	8639	8459	8427	8359	8431	**8463**	105	7,400
MD Ultimate Strength (kN/m)	126.1	123.5	123.0	122.0	123.1	**123.6**	1.5	
MD Strength @ 2% Strain (lbs)	870	850	831	786	847	**837**	32	
MD Strength @ 2% Strain (lbs/ft)	1885	1843	1802	1703	1837	**1814**	69	
MD Strength @ 2% Strain (kN/m)	27.5	26.9	26.3	24.9	26.8	**26.5**	1.0	
MD Strength @ 5% Strain (lbs)	1614	1553	1566	1499	1531	**1553**	43	
MD Strength @ 5% Strain (lbs/ft)	3499	3368	3394	3249	3320	**3366**	92	
MD Strength @ 5% Strain (kN/m)	51.1	49.2	49.5	47.4	48.5	**49.1**	1.4	
MD Strength @ 10% Strain (lbs)	3653	3572	3603	3481	3574	**3577**	62	
MD Strength @ 10% Strain (lbs/ft)	7918	7742	7809	7547	7749	**7753**	135	
MD Strength @ 10% Strain (kN/m)	115.6	113.0	114.0	110.2	113.1	**113.2**	2.0	
MD Break Elongation (%)	11.6	11.7	11.6	11.8	11.6	**11.7**	0.1	

MD - Machine Direction TD - Transverse/Cross Machine Direction NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table C-6. Geogrid wide width tensile test results for 24XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.	MARV
Wide Width Tensile Properties (ASTM D 6637, Method B)								
MD Number of Ribs per Specimen:	5							
MD Number of Ribs per foot:	12.25							
MD Ultimate Strength (lbs)	12257	12369	11980	12136	12092	**12167**	150	
MD Ultimate Strength (lbs/ft)	30030	30305	29352	29733	29626	**29809**	368	27,415
MD Ultimate Strength (kN/m)	438.4	442.4	428.5	434.1	432.5	**435.2**	5.4	
MD Strength @ 2% Strain (lbs)	2386	2273	2241	2151	2301	**2270**	86	
MD Strength @ 2% Strain (lbs/ft)	5846	5569	5491	5269	5638	**5563**	210	
MD Strength @ 2% Strain (kN/m)	85.3	81.3	80.2	76.9	82.3	**81.2**	3.1	
MD Strength @ 5% Strain (lbs)	3743	3725	3476	3548	3780	**3654**	134	
MD Strength @ 5% Strain (lbs/ft)	9170	9127	8515	8692	9262	**8953**	329	
MD Strength @ 5% Strain (kN/m)	133.9	133.3	124.3	126.9	135.2	**130.7**	4.8	
MD Strength @ 10% Strain (lbs)	9829	9470	9459	9533	9489	**9556**	155	
MD Strength @ 10% Strain (lbs/ft)	24080	23202	23175	23356	23247	**23412**	380	
MD Strength @ 10% Strain (kN/m)	351.6	338.8	338.3	341.0	339.4	**341.8**	5.5	
MD Break Elongation (%)	13.3	13.7	12.8	13.8	12.9	**13.3**	0.4	

MD - Machine Direction   TD - Transverse/Cross Machine Direction   NP - Not Provided

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

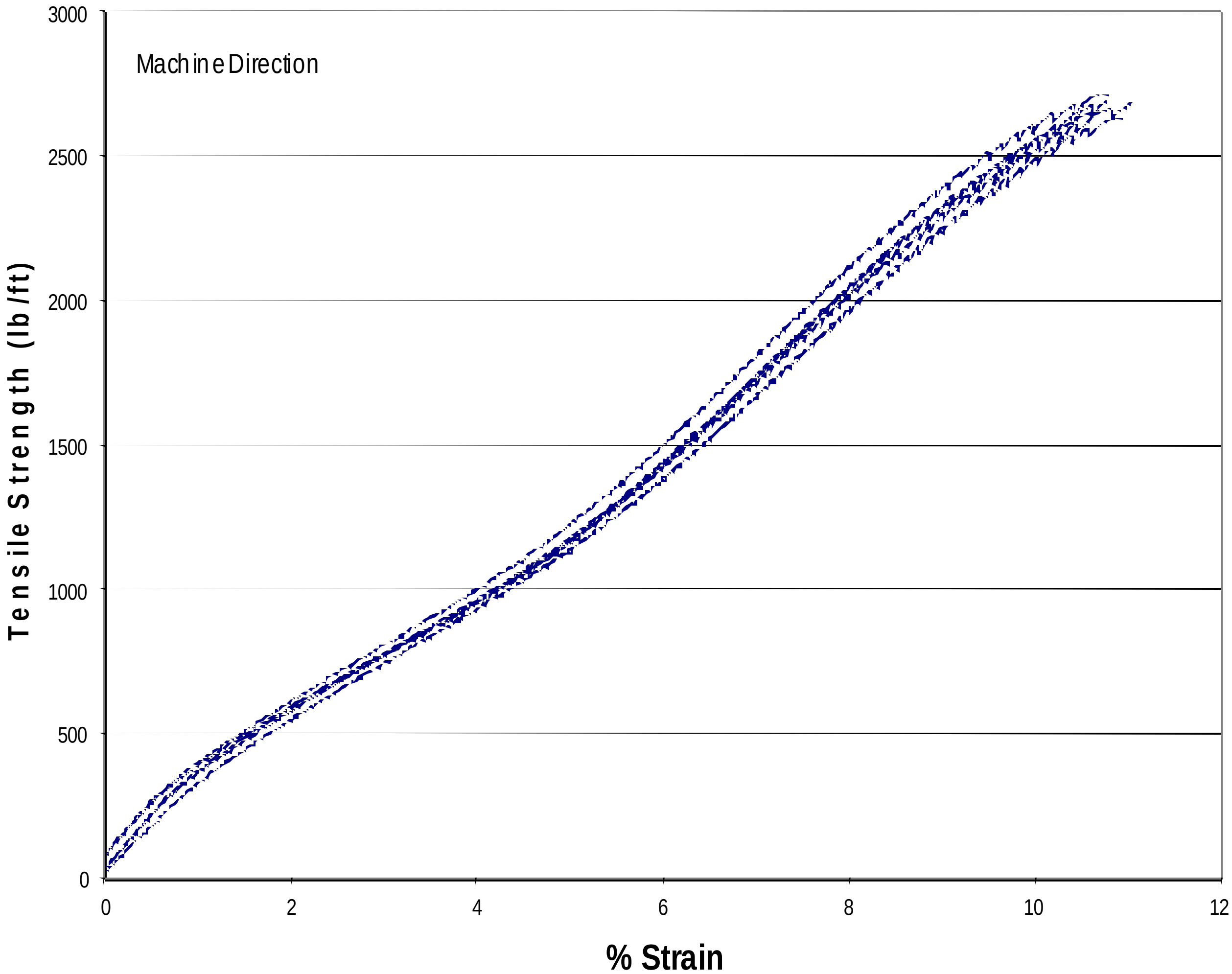

Figure C-1. Geogrid tensile test load-strain curve for 2XT

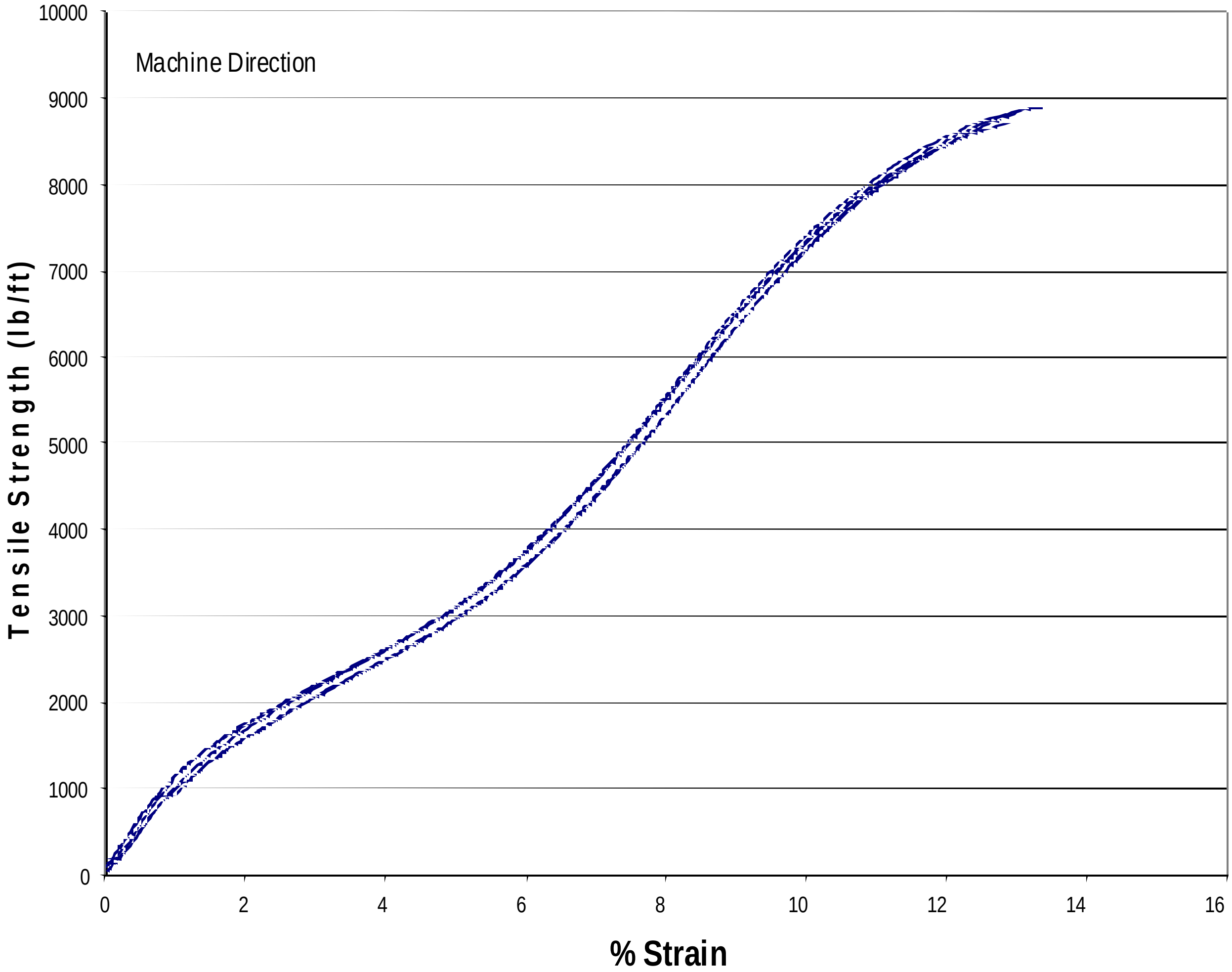

Figure C-2. Geogrid tensile test load-strain curve for 8XT

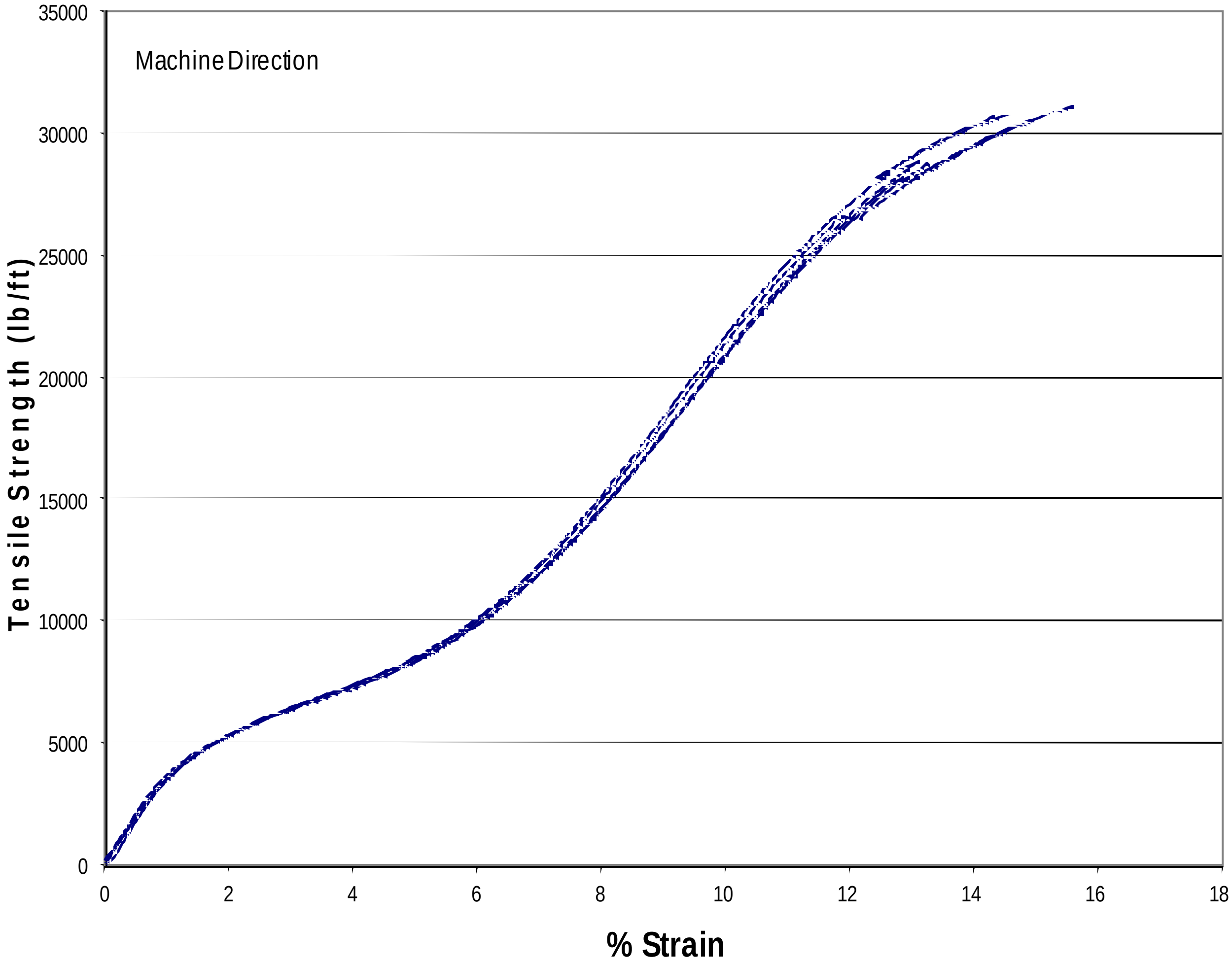

Figure C-3. Geogrid tensile test load-strain curve for 24XT

Appendix D: Installation Damage Detailed Test Results

Table D-1. Installation damage wide width tensile test results for 2XT geogrid, soil gradation 1.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT Baseline	1	10.84	5	1225	2656	38.8	10.3	280	608	8.87	570	1236	18.0	1209	2622	38.3
	2	10.84	5	1236	2680	39.1	10.3	292	632	9.23	593	1285	18.8	1213	2629	38.4
	3	10.84	5	1251	2712	39.6	10.0	300	651	9.51	607	1315	19.2	1250	2710	39.6
	4	10.84	5	1249	2707	39.5	10.6	282	612	8.93	567	1230	18.0	1208	2619	38.2
	5	10.84	5	1246	2701	39.4	10.2	270	586	8.56	584	1265	18.5	1229	2664	38.9
Average				1241	2691	39.3	10.3	285	618	9.02	584	1266	18.5	1222	2649	38.7
Standard Deviation				10.7	23.2	0.34	0.23	11.5	24.8	0.36	16.4	35.4	0.52	17.8	39	0.56
% COV				0.86	0.86	0.86	2.19	4.02	4.02	4.02	2.80	2.80	2.80	1.46	1.46	1.46

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT installed in Gradation 1 (Coarse Gravel)	1	10.84	5	861	1867	27.3	7.6	256	554	8.09	521	1130	16.5			
	2	10.84	5	784	1700	24.8	6.6	273	591	8.63	576	1249	18.2			
	3	10.84	5	849	1840	26.9	6.9	283	613	8.95	581	1259	18.4			
	4	10.84	5	881	1910	27.9	7.9	265	574	8.39	509	1103	16.1			
	5	10.84	5	809	1754	25.6	6.8	282	611	8.92	577	1250	18.3			
	6	10.84	5	764	1657	24.2	7.8	275	596	8.70	556	1205	17.6			
	7	10.84	5	611	1324	19.3	5.5	269	582	8.50	548	1187	17.3			
	8	10.84	5	909	1971	28.8	6.4	374	811	11.84	783	1696	24.8			
	9	10.84	5	442	957	14.0	6.3	204	443	6.46	332	720	10.5			
	10	10.84	5	798	1731	25.3	6.5	284	615	8.99	594	1287	18.8			
Average				771	1671	24.4	6.8	276	599	8.75	558	1209	17.6			
Standard Deviation				142.2	308	4.50	0.76	41.52	90.00	1.31	109.4	237.2	3.46			
% COV				18.44	18.44	18.44	11.13	15.02	15.02	15.02	19.62	19.62	19.62			

Percent Retained				62.1	62.1	62.1	66.5	97.0	97.0	97.0	95.5	95.5	95.5			
RFid				**1.61**	**1.61**	**1.61**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-2. Installation damage wide width tensile test results for 2XT geogrid, soil gradation 2.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT Baseline	1	10.84	5	1225	2656	38.8	10.3	280	608	8.87	570	1236	18.0	1209	2622	38.3
	2	10.84	5	1236	2680	39.1	10.3	292	632	9.23	593	1285	18.8	1213	2629	38.4
	3	10.84	5	1251	2712	39.6	10.0	300	651	9.51	607	1315	19.2	1250	2710	39.6
	4	10.84	5	1249	2707	39.5	10.6	282	612	8.93	567	1230	18.0	1208	2619	38.2
	5	10.84	5	1246	2701	39.4	10.2	270	586	8.56	584	1265	18.5	1229	2664	38.9
Average				1241	2691	39.3	10.3	285	618	9.02	584	1266	18.5	1222	2649	38.7
Standard Deviation				10.7	23.2	0.34	0.23	11.5	24.8	0.36	16.4	35.4	0.52	17.8	39	0.56
% COV				0.86	0.86	0.86	2.19	4.02	4.02	4.02	2.80	2.80	2.80	1.46	1.46	1.46

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT installed in Gradation 2 (Sandy Gravel)	1	10.84	5	1200	2600	38.0	9.63	295	640	9.35	608	1317	19.2			
	2	10.84	5	1198	2596	37.9	9.54	285	618	9.02	597	1293	18.9			
	3	10.84	5	1197	2595	37.9	9.69	292	634	9.26	589	1277	18.6			
	4	10.84	5	1167	2530	36.9	9.53	293	636	9.28	593	1286	18.8			
	5	10.84	5	1165	2526	36.9	9.66	292	632	9.23	578	1253	18.3			
	6	10.84	5	1238	2683	39.2	10.1	293	636	9.28	603	1308	19.1	1229	2665	38.9
	7	10.84	5	1153	2499	36.5	9.23	276	599	8.75	577	1250	18.3			
	8	10.84	5	1176	2549	37.2	9.70	269	584	8.52	561	1215	17.7			
	9	10.84	5	1218	2640	38.5	9.96	282	611	8.93	583	1263	18.4			
	10	10.84	5	1209	2622	38.3	9.64	270	586	8.55	566	1227	17.9			
Average				1192	2584	37.7	9.7	285	618	9.02	585	1269	18.5	1229	2665	38.9
Standard Deviation				26.5	57	0.84	0.23	9.96	21.59	0.32	15.4	33.4	0.49			
% COV				2.22	2.22	2.22	2.40	3.50	3.50	3.50	2.63	2.63	2.63			

Percent Retained			96.0	96.0	96.0	94.0	100.0	100.0	100.0	100.2	100.2	100.2	100.6	100.6	100.6
RFid			**1.04**	**1.04**	**1.04**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-3. Installation damage wide width tensile test results for 2XT geogrid, soil gradation 3.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT Baseline	1	10.84	5	1225	2656	38.8	10.3	280	608	8.87	570	1236	18.0	1209	2622	38.3
	2	10.84	5	1236	2680	39.1	10.3	292	632	9.23	593	1285	18.8	1213	2629	38.4
	3	10.84	5	1251	2712	39.6	10.0	300	651	9.51	607	1315	19.2	1250	2710	39.6
	4	10.84	5	1249	2707	39.5	10.6	282	612	8.93	567	1230	18.0	1208	2619	38.2
	5	10.84	5	1246	2701	39.4	10.2	270	586	8.56	584	1265	18.5	1229	2664	38.9
Average				1241	2691	39.3	10.3	285	618	9.02	584	1266	18.5	1222	2649	38.7
Standard Deviation				10.7	23.2	0.34	0.23	11.5	24.8	0.36	16.4	35.4	0.52	17.8	39	0.56
% COV				0.86	0.86	0.86	2.19	4.02	4.02	4.02	2.80	2.80	2.80	1.46	1.46	1.46

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
2XT installed in Gradation 3 (Sand)	1	10.84	5	1187	2573	37.6	9.9	278	602	8.80	566	1227	17.9			
	2	10.84	5	1209	2621	38.3	10.0	281	610	8.91	564	1222	17.8	1209	2620	38.3
	3	10.84	5	1191	2582	37.7	9.8	299	647	9.45	600	1300	19.0			
	4	10.84	5	1199	2599	37.9	9.8	296	642	9.37	574	1243	18.2			
	5	10.84	5	1234	2674	39.0	10.7	290	628	9.18	573	1243	18.1	1204	2609	38.1
	6	10.84	5	1247	2702	39.5	10.3	285	617	9.01	591	1282	18.7	1232	2671	39.0
	7	10.84	5	940	2038	29.8	9.6	271	587	8.57	562	1218	17.8			
	8	10.84	5	1195	2591	37.8	9.6	285	618	9.02	587	1272	18.6			
	9	10.84	5	1200	2601	38.0	9.8	282	612	8.94	583	1265	18.5			
	10	10.84	5	1238	2685	39.2	10.1	276	599	8.75	580	1257	18.4	1228	2662	38.9
Average				1184	2567	37.5	9.9	284	616	9.00	578	1253	18.3	1218	2641	38.6
Standard Deviation				88.2	191	2.79	0.34	8.63	18.71	0.27	12.5	27.0	0.39	14.0	30.3	0.44
% COV				7.45	7.45	7.45	3.42	3.04	3.04	3.04	2.16	2.16	2.16	1.15	1.15	1.15

Percent Retained			95.4	95.4	95.4	96.7	99.8	99.8	99.8	99.0	99.0	99.0	99.7	99.7	99.7
RFid			**1.05**	**1.05**	**1.05**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-4. Installation damage wide width tensile test results for 8XT geogrid, soil gradation 1.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT Baseline	1	10.84	5	3985	8639	126.1	11.6	870	1885	27.53	1614	3499	51.1	3653	7918	115.6
	2	10.84	5	3902	8459	123.5	11.7	850	1843	26.91	1553	3368	49.2	3572	7742	113.0
	3	10.84	5	3887	8427	123.0	11.6	831	1802	26.30	1566	3394	49.5	3603	7809	114.0
	4	10.84	5	3856	8359	122.0	11.8	786	1703	24.86	1499	3249	47.4	3481	7547	110.2
	5	10.84	5	3889	8431	123.1	11.6	847	1837	26.82	1531	3320	48.5	3574	7749	113.1
Average				3904	8463	123.6	11.7	837	1814	26.48	1553	3366	49.1	3577	7753	113.2
Standard Deviation				48.5	105.1	1.53	0.08	31.7	68.8	1.00	42.7	92.5	1.35	62.4	135	1.98
% COV				1.24	1.24	1.24	0.72	3.79	3.79	3.79	2.75	2.75	2.75	1.74	1.74	1.74

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT installed in Gradation 1 (Coarse Gravel)	1	10.84	5	2284	4952	72.3	6.7	824	1786	26.08	1570	3404	49.7			
	2	10.84	5	2018	4374	63.9	6.8	785	1701	24.83	1489	3228	47.1			
	3	10.84	5	2502	5423	79.2	8.5	793	1718	25.09	1454	3151	46.0			
	4	10.84	5	2652	5748	83.9	8.0	806	1746	25.50	1541	3341	48.8			
	5	10.84	5	2523	5470	79.9	7.7	807	1749	25.54	1583	3433	50.1			
	6	10.84	5	2404	5212	76.1	9.2	788	1708	24.93	1522	3300	48.2			
	7	10.84	5	2720	5895	86.1	8.2	816	1769	25.83	1553	3366	49.1			
	8	10.84	5	2605	5647	82.4	7.4	807	1749	25.53	1535	3327	48.6			
	9	10.84	5	2563	5556	81.1	7.5	808	1751	25.56	1506	3265	47.7			
	10	10.84	5	2221	4815	70.3	6.8	792	1717	25.07	1495	3241	47.3			
Average				2449	5309	77.5	7.7	802	1739	25.40	1525	3306	48.3			
Standard Deviation				217.8	472	6.89	0.80	12.74	27.61	0.40	39.8	86.2	1.26			
% COV				8.89	8.89	8.89	10.40	1.59	1.59	1.59	2.61	2.61	2.61			

Percent Retained			62.7	62.7	62.7	65.8	95.9	95.9	95.9	98.2	98.2	98.2			
RFid			**1.59**	**1.59**	**1.59**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-5. Installation damage wide width tensile test results for 8XT geogrid, soil gradation 2.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT Baseline	1	10.84	5	3985	8639	126.1	11.6	870	1885	27.53	1614	3499	51.1	3653	7918	115.6
	2	10.84	5	3902	8459	123.5	11.7	850	1843	26.91	1553	3368	49.2	3572	7742	113.0
	3	10.84	5	3887	8427	123.0	11.6	831	1802	26.30	1566	3394	49.5	3603	7809	114.0
	4	10.84	5	3856	8359	122.0	11.8	786	1703	24.86	1499	3249	47.4	3481	7547	110.2
	5	10.84	5	3889	8431	123.1	11.6	847	1837	26.82	1531	3320	48.5	3574	7749	113.1
Average				3904	8463	123.6	11.7	837	1814	26.48	1553	3366	49.1	3577	7753	113.2
Standard Deviation				48.5	105.1	1.53	0.08	31.7	68.8	1.00	42.7	92.5	1.35	62.4	135	1.98
% COV				1.24	1.24	1.24	0.72	3.79	3.79	3.79	2.75	2.75	2.75	1.74	1.74	1.74

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT installed in Gradation 2 (Sandy Gravel)	1	10.84	5	3433	7442	108.7	9.2	843	1828	26.69	1605	3479	50.8			
	2	10.84	5	3302	7158	104.5	8.8	825	1787	26.10	1581	3427	50.0			
	3	10.84	5	3563	7724	112.8	9.4	864	1872	27.33	1625	3522	51.4			
	4	10.84	5	3392	7353	107.4	9.0	848	1838	26.83	1570	3404	49.7			
	5	10.84	5	3501	7590	110.8	9.4	819	1776	25.93	1585	3437	50.2			
	6	10.84	5	3417	7406	108.1	9.1	834	1807	26.38	1606	3482	50.8			
	7	10.84	5	3327	7212	105.3	9.1	838	1816	26.51	1566	3395	49.6			
	8	10.84	5	3214	6966	101.7	8.7	792	1717	25.07	1523	3301	48.2			
	9	10.84	5	3534	7660	111.8	9.3	846	1833	26.77	1646	3569	52.1			
	10	10.84	5	3378	7323	106.9	9.2	852	1848	26.98	1560	3381	49.4			
Average				3406	7383	107.8	9.1	836	1812	26.46	1587	3440	50.2			
Standard Deviation				108.5	235	3.43	0.24	20.15	43.68	0.64	35.3	76.6	1.12			
% COV				3.19	3.19	3.19	2.62	2.41	2.41	2.41	2.23	2.23	2.23			

Percent Retained			87.2	87.2	87.2	78.3	99.9	99.9	99.9	102.2	102.2	102.2			
RFid			**1.15**	**1.15**	**1.15**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-6. Installation damage wide width tensile test results for 8XT geogrid, soil gradation 3.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT Baseline	1	10.84	5	3985	8639	126.1	11.6	870	1885	27.53	1614	3499	51.1	3653	7918	115.6
	2	10.84	5	3902	8459	123.5	11.7	850	1843	26.91	1553	3368	49.2	3572	7742	113.0
	3	10.84	5	3887	8427	123.0	11.6	831	1802	26.30	1566	3394	49.5	3603	7809	114.0
	4	10.84	5	3856	8359	122.0	11.8	786	1703	24.86	1499	3249	47.4	3481	7547	110.2
	5	10.84	5	3889	8431	123.1	11.6	847	1837	26.82	1531	3320	48.5	3574	7749	113.1
Average				3904	8463	123.6	11.7	837	1814	26.48	1553	3366	49.1	3577	7753	113.2
Standard Deviation				48.5	105.1	1.53	0.08	31.7	68.8	1.00	42.7	92.5	1.35	62.4	135	1.98
% COV				1.24	1.24	1.24	0.72	3.79	3.79	3.79	2.75	2.75	2.75	1.74	1.74	1.74

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
8XT installed in Gradation 3 (Sand)	1	10.84	5	3552	7699	112.4	9.8	841	1822	26.61	1519	3293	48.1			
	2	10.84	5	3560	7717	112.7	9.8	809	1755	25.62	1544	3348	48.9			
	3	10.84	5	3502	7591	110.8	9.7	786	1704	24.88	1446	3135	45.8			
	4	10.84	5	3379	7325	106.9	9.4	816	1769	25.83	1477	3201	46.7			
	5	10.84	5	3547	7689	112.3	9.6	805	1744	25.46	1512	3277	47.8			
	6	10.84	5	3189	6914	100.9	9.1	791	1715	25.04	1437	3114	45.5			
	7	10.84	5	3389	7346	107.3	9.6	786	1704	24.89	1490	3230	47.2			
	8	10.84	5	3553	7701	112.4	10.0	817	1770	25.85	1453	3150	46.0	3546	7686	112.2
	9	10.84	5	3571	7742	113.0	10.1	783	1697	24.77	1462	3168	46.3	3522	7635	111.5
	10	10.84	5	3434	7444	108.7	9.7	789	1711	24.98	1473	3193	46.6			
Average				3468	7517	109.7	9.7	802	1739	25.39	1481	3211	46.9	3534	7661	111.8
Standard Deviation				121.9	264	3.86	0.30	18.61	40.34	0.59	34.8	75.5	1.10	16.6	36.0	0.53
% COV				3.52	3.52	3.52	3.13	2.32	2.32	2.32	2.35	2.35	2.35	0.47	0.47	0.47

Percent Retained				88.8	88.8	88.8	83.0	95.9	95.9	95.9	95.4	95.4	95.4	98.8	98.8	98.8
RFid				**1.13**	**1.13**	**1.13**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-7. Installation damage wide width tensile test results for 24XT geogrid, soil gradation 1.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT Baseline	1	12.25	5	12257	30030	438.4	13.3	2386	5846	85.35	3743	9170	133.9	9829	24080	351.6
	2	12.25	5	12369	30305	442.4	13.7	2273	5569	81.30	3725	9127	133.3	9470	23202	338.8
	3	12.25	5	11980	29352	428.5	12.8	2241	5491	80.17	3476	8515	124.3	9459	23175	338.3
	4	12.25	5	12136	29733	434.1	13.8	2151	5269	76.93	3548	8692	126.9	9533	23356	341.0
	5	12.25	5	12092	29626	432.5	12.9	2301	5638	82.32	3780	9262	135.2	9489	23247	339.4
Average				12167	29809	435.2	13.3	2270	5563	81.21	3654	8953	130.7	9556	23412	341.8
Standard Deviation				150.3	368.3	5.38	0.44	85.9	210.4	3.07	134.2	328.7	4.80	155.1	380	5.55
% COV				1.24	1.24	1.24	3.28	3.78	3.78	3.78	3.67	3.67	3.67	1.62	1.62	1.62

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT installed in Gradation 1 (Coarse Gravel)	1	12.25	5	9718	23809	347.6	9.7	2476	6065	88.56	4023	9856	143.9			
	2	12.25	5	9234	22623	330.3	10.4	2209	5412	79.02	3743	9170	133.9	8855	21694	316.7
	3	12.25	5	9534	23359	341.0	10.3	2082	5102	74.48	3468	8495	124.0	9287	22754	332.2
	4	12.25	5	8549	20945	305.8	10.0	2087	5113	74.65	3715	9101	132.9	8499	20823	304.0
	5	12.25	5	8973	21985	321.0	9.6	2276	5577	81.42	3749	9186	134.1			
	6	12.25	5	8544	20932	305.6	9.2	2146	5258	76.77	3672	8996	131.3			
	7	12.25	5	9188	22510	328.6	9.9	2353	5764	84.15	3959	9699	141.6			
	8	12.25	5	8834	21643	316.0	9.8	2247	5505	80.37	3705	9078	132.5			
	9	12.25	5	8811	21586	315.2	10.0	2103	5153	75.24	3585	8784	128.3	8709	21338	311.5
	10	12.25	5	8938	21897	319.7	9.6	2170	5315	77.61	3587	8788	128.3			
Average				9032	22129	323.1	9.9	2215	5426	79.23	3721	9115	133.1	8838	21652	316.1
Standard Deviation				388.7	952	13.90	0.35	126.95	311.03	4.54	167.4	410.2	5.99	333.4	816.9	11.93
% COV				4.30	4.30	4.30	3.52	5.73	5.73	5.73	4.50	4.50	4.50	3.77	3.77	3.77

Percent Retained			74.2	74.2	74.2	74.2	97.6	97.6	97.6	101.8	101.8	101.8	92.5	92.5	92.5
RFid			**1.35**	**1.35**	**1.35**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

**Table D-8. Installation damage wide width tensile test results for 24XT geogrid, soil gradation 2.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).**

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT Baseline	1	12.25	5	12257	30030	438.4	13.3	2386	5846	85.35	3743	9170	133.9	9829	24080	351.6
	2	12.25	5	12369	30305	442.4	13.7	2273	5569	81.30	3725	9127	133.3	9470	23202	338.8
	3	12.25	5	11980	29352	428.5	12.8	2241	5491	80.17	3476	8515	124.3	9459	23175	338.3
	4	12.25	5	12136	29733	434.1	13.8	2151	5269	76.93	3548	8692	126.9	9533	23356	341.0
	5	12.25	5	12092	29626	432.5	12.9	2301	5638	82.32	3780	9262	135.2	9489	23247	339.4
Average				12167	29809	435.2	13.3	2270	5563	81.21	3654	8953	130.7	9556	23412	341.8
Standard Deviation				150.3	368.3	5.38	0.44	85.9	210.4	3.07	134.2	328.7	4.80	155.1	380	5.55
% COV				1.24	1.24	1.24	3.28	3.78	3.78	3.78	3.67	3.67	3.67	1.62	1.62	1.62

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT installed in Gradation 2 (Sandy Gravel)	1	12.25	5	11305	27697	404.4	12.1	2150	5268	76.91	3813	9342	136.4	9658	23663	345.5
	2	12.25	5	11195	27428	400.4	11.2	2291	5613	81.94	3879	9503	138.7	9846	24122	352.2
	3	12.25	5	11516	28213	411.9	11.6	2192	5370	78.41	3794	9295	135.7	9750	23887	348.8
	4	12.25	5	11350	27808	406.0	11.3	2273	5568	81.30	3935	9641	140.8	10083	24704	360.7
	5	12.25	5	11302	27691	404.3	11.2	2159	5290	77.23	3946	9668	141.2	9875	24194	353.2
	6	12.25	5	11233	27521	401.8	11.5	2257	5529	80.72	3787	9279	135.5	9925	24316	355.0
	7	12.25	5	11459	28075	409.9	12.0	2050	5022	73.32	3493	8559	125.0	9808	24031	350.8
	8	12.25	5	10911	26733	390.3	10.6	2173	5323	77.72	3584	8780	128.2	9843	24116	352.1
	9	12.25	5	11176	27380	399.8	11.7	2172	5321	77.68	3871	9485	138.5	9457	23170	338.3
	10	12.25	5	11110	27219	397.4	11.6	2035	4985	72.79	3532	8653	126.3	9255	22676	331.1
Average				11256	27576	402.6	11.5	2175	5329	77.80	3764	9221	134.6	9750	23888	348.8
Standard Deviation				174.2	427	6.23	0.44	85.72	210.02	3.07	166.9	408.9	5.97	239.8	587.4	8.58
% COV				1.55	1.55	1.55	3.83	3.94	3.94	3.94	4.43	4.43	4.43	2.46	2.46	2.46

Percent Retained			92.5	92.5	92.5	86.4	95.8	95.8	95.8	103.0	103.0	103.0	102.0	102.0	102.0
RFid			**1.08**	**1.08**	**1.08**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table D-9. Installation damage wide width tensile test results for 24XT geogrid, soil gradation 3.
Installation damage testing (ASTM D 5818, as modified in WSDOT T925).
Wide wide tensile testing (ASTM D 6637, Method B).

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT Baseline	1	12.25	5	12257	30030	438.4	13.3	2386	5846	85.35	3743	9170	133.9	9829	24080	351.6
	2	12.25	5	12369	30305	442.4	13.7	2273	5569	81.30	3725	9127	133.3	9470	23202	338.8
	3	12.25	5	11980	29352	428.5	12.8	2241	5491	80.17	3476	8515	124.3	9459	23175	338.3
	4	12.25	5	12136	29733	434.1	13.8	2151	5269	76.93	3548	8692	126.9	9533	23356	341.0
	5	12.25	5	12092	29626	432.5	12.9	2301	5638	82.32	3780	9262	135.2	9489	23247	339.4
Average				12167	29809	435.2	13.3	2270	5563	81.21	3654	8953	130.7	9556	23412	341.8
Standard Deviation				150.3	368.3	5.38	0.44	85.9	210.4	3.07	134.2	328.7	4.80	155.1	380	5.55
% COV				1.24	1.24	1.24	3.28	3.78	3.78	3.78	3.67	3.67	3.67	1.62	1.62	1.62

Machine Direction

Sample Identification	Specimen Number	Ribs per Foot Width	Number of Ribs Tested	Maximum Load (lbs)	Maximum Load (lbs/ft)	Maximum Load (kN/m)	Elongation @ Break (%)	Load @ 2% lbs	Load @ 2% (lbs/ft)	Load @ 2% (kN/m)	Load @ 5% lbs	Load @ 5% (lbs/ft)	Load @ 5% (kN/m)	Load @ 10% lbs	Load @ 10% (lbs/ft)	Load @ 10% (kN/m)
24XT installed in Gradation 3 (Sand)	1	12.25	5	10938	26798	391.2	11.1	2159	5290	77.24	3832	9389	137.1	9666	23682	345.8
	2	12.25	5	11020	26999	394.2	11.6	2094	5130	74.89	3501	8578	125.2	9845	24120	352.1
	3	12.25	5	11546	28287	413.0	11.6	2318	5680	82.93	3895	9542	139.3	10087	24713	360.8
	4	12.25	5	10942	26808	391.4	11.6	2189	5363	78.30	3621	8870	129.5	9610	23546	343.8
	5	12.25	5	11367	27849	406.6	11.2	2117	5187	75.74	3631	8896	129.9	10082	24700	360.6
	6	12.25	5	11698	28661	418.5	11.8	2284	5595	81.69	3633	8900	129.9	9917	24297	354.7
	7	12.25	5	11237	27530	401.9	11.8	2382	5837	85.22	3945	9666	141.1	9858	24152	352.6
	8	12.25	5	10888	26677	389.5	11.4	2215	5427	79.23	3579	8769	128.0	9650	23643	345.2
	9	12.25	5	10641	26071	380.6	10.8	2212	5420	79.13	3581	8773	128.1	9576	23461	342.5
	10	12.25	5	11023	27007	394.3	11.0	2040	4999	72.98	3509	8597	125.5	9427	23096	337.2
Average				11130	27269	398.1	11.4	2201	5393	78.73	3673	8998	131.4	9772	23941	349.5
Standard Deviation				326.0	799	11.66	0.34	105.46	258.37	3.77	159.3	390.4	5.70	220.8	540.9	7.90
% COV				2.93	2.93	2.93	2.97	4.79	4.79	4.79	4.34	4.34	4.34	2.26	2.26	2.26

Percent Retained			91.5	91.5	91.5	85.6	96.9	96.9	96.9	100.5	100.5	100.5	102.3	102.3	102.3
RFid			**1.09**	**1.09**	**1.09**										

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

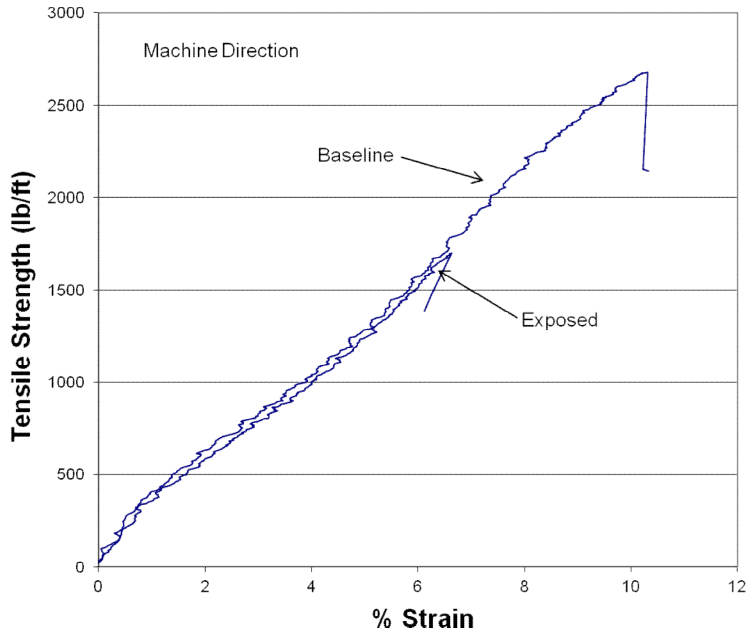

Figure D-1. Example baseline and exposed wide width tensile test load-strain curves for 2XT geogrid installed in soil gradation 1.

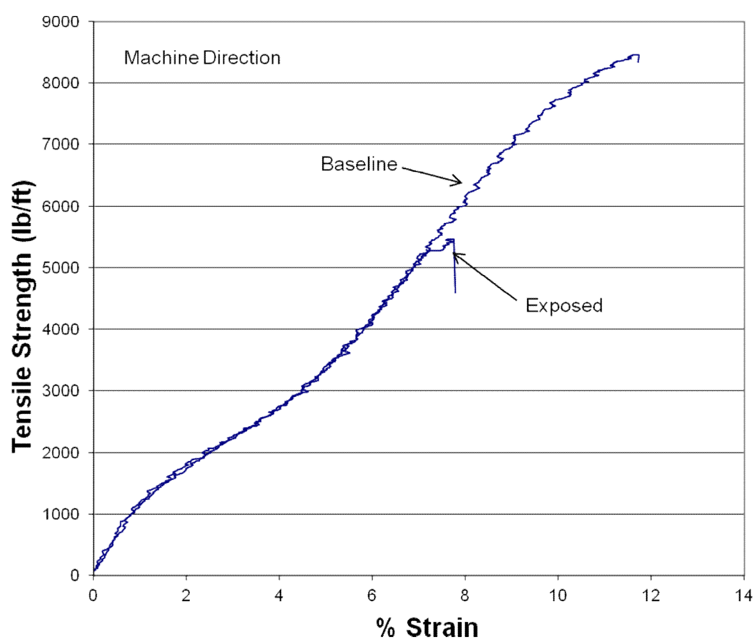

Figure D-2. Example baseline and exposed wide width tensile test load-strain curves for 8XT geogrid installed in soil gradation 1.

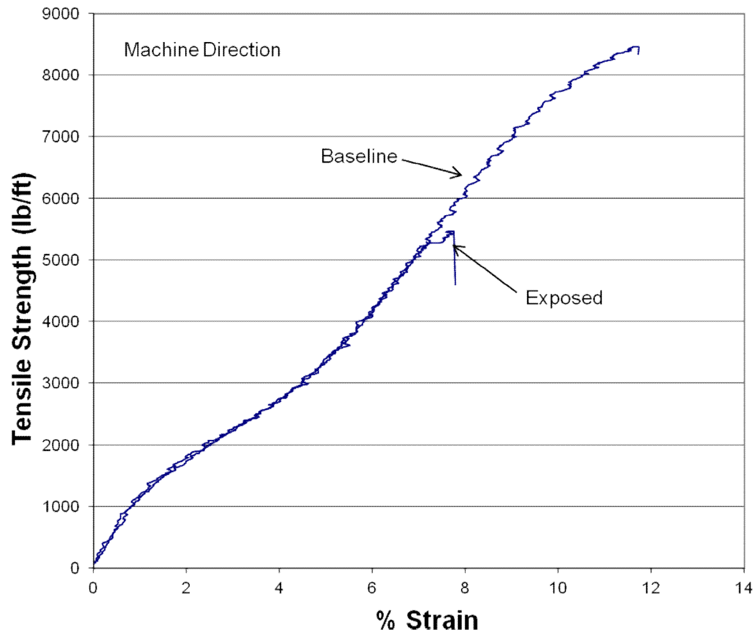

Figure D-3. Example baseline and exposed wide width tensile test load-strain curves for 24XT geogrid installed in soil gradation 1.

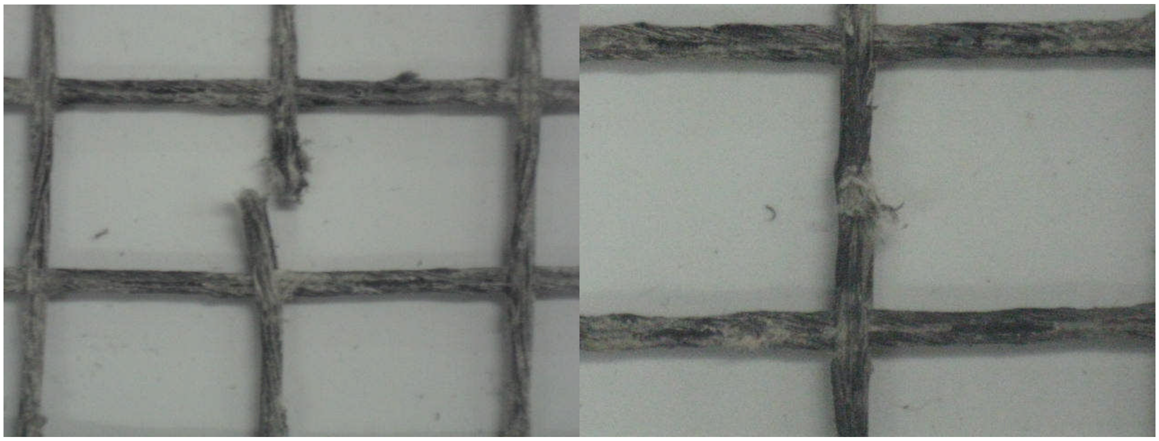

Figure D-4. Photos of typical visual damage of 2XT installed in soil gradation 1.

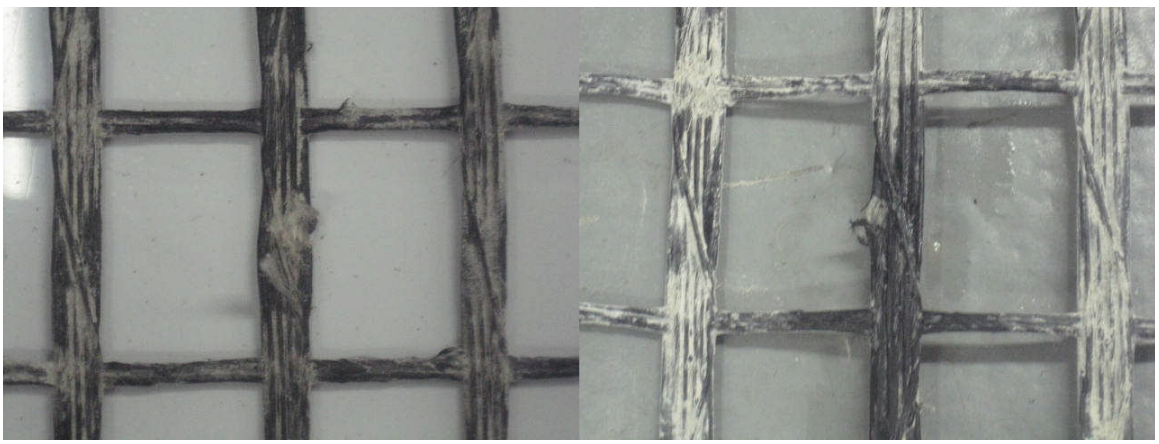

Figure D-5. Photos of typical visual damage of 8XT installed in soil gradation 1.

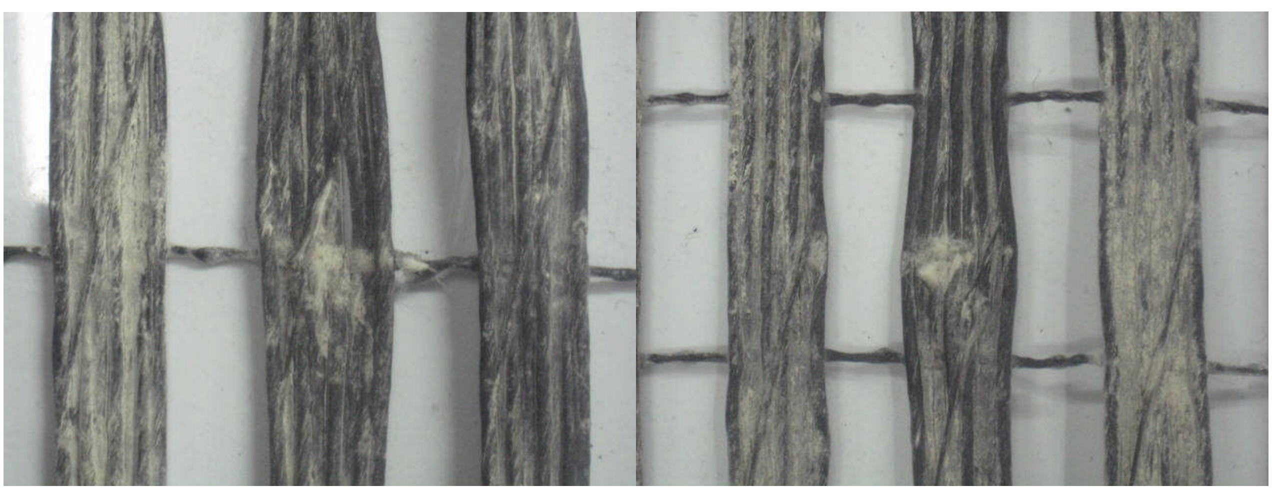

Figure D-6. Photos of typical visual damage of 24XT installed in soil gradation 1.

Table D-10. Standard test soil gradations (% passing).

Standard Installation Damage Soils Used for Field Exposures				
US Sieve No.	Sieve Size (mm)	Percent Passing by Weight		
		Type 1 (Coarse Gravel)	Type2 (Sandy Gravel)	Type 3 (Silty Sand)
6 - in	150	100.0	100.0	100.0
3 - in.	75	100.0	100.0	100.0
2 - in.	50	100.0	100.0	100.0
1.5 - in.	38		100.0	100.0
1 - in.	25	65.8	100.0	100.0
3/4 - in.	19	25.4	100.0	100.0
1/2 - in.	12.5			100.0
3/8 - in.	9.5	1.3	98.7	100.0
No. 4	4.75	1.0	33.8	99.8
No. 10	1.7	0.9	0.0	79.5
No. 20	0.85	0.8	0.0	42.1
No. 40	0.425	0.0	0.0	28.7
No. 60	0.25	0.0	0.0	23.8
No. 100	0.15	0.0	0.0	21.2
No. 200	0.075	0.0	0.0	18.4
D50, mm		22.6	5.9	1.1
LA Abrasion Small Drum Method B 500 Cycles		20.2% loss	12.6% loss	
Liquid Limit, %		-	-	-
Plasticity Index, %		-	-	-
Angularity (ASTM D 2488)		Angular to Subangular	Angular	Angular to Subangular
Soil Classification		GP	GP	SM
		Poorly Graded Gravel	Poorly Graded Gravel with Sand	Well Graded Silty Sand

Figure D-7. Lifting Plates positioned between ties and covered with first lift of compacted soil/aggregate.

Figure D-8. Grid positioned over compacted base and covered. Cover soil/aggregate is uniformly spread and compacted using field-scale equipment and procedures.

Figure D-9. The density of the compacted soil is measured with a nuclear density gauge.

Figure D-10. The steel plates are tilted to facilitate exhumation.

Appendix E: ISO/EN Laboratory Installation Damage Detailed Test Results

E.1 ISO/EN Laboratory Installation Damage Test Program

Testing is done per the EN/ISO 10722. Five wide width tensile specimens are exposed to 200 cycles producing between 209 lb/ft^2 (10 kPa) minimum and 10,443 lb/ft^2 (500 kPa) maximum stress at a frequency of 1 Hz. The aggregate used is a sintered aluminum oxide with a grain size such that 100% shall pass a 10 mm sieve and 0% shall pass a 5 mm sieve. The exposed specimens and five baseline specimens are tested according to ISO/EN 10319.

Representative photos of test apparatus and aggregate are provided in Figures E-1 and E-2. Detailed test results are provided in Tables E-1 through E-9.

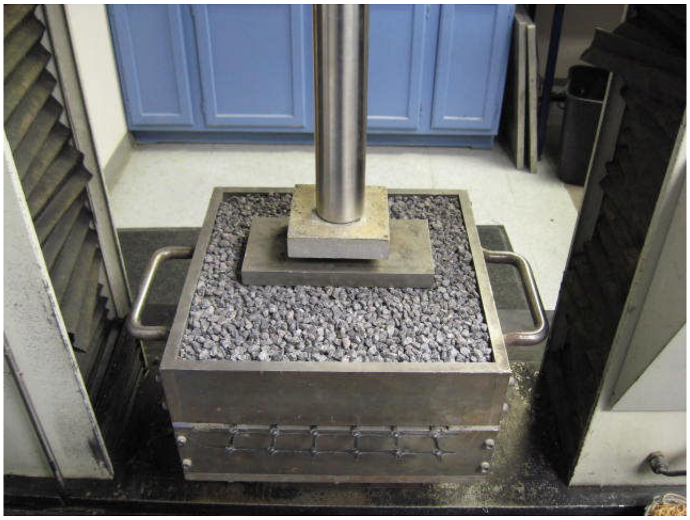

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Figure E-1. ISO/EN 10722, laboratory installation damage test apparatus.

Figure E-2. ISO/EN 10722, laboratory installation damage aggregate.

Table E-1. Laboratory installation damage (ISO/EN 10722) tensile test results for 2XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via w ide w idth tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	10.84								
MD - Tensile Strength (lbs) - B	2029	2038	2020	2044	1993	**2025**	20	1	
MD Tensile Strength (lbs/ft) - B	2750	2762	2737	2769	2701	**2744**	27	1	
MD Tensile Strength (kN/m) - B	40.1	40.3	40.0	40.4	39.4	**40.1**	0.4	1.0	
MD - Tensile Strength (lbs) - E	1622	1875	1960	1963	1998	**1884**	153	8	
MD Tensile Strength (lbs/ft) - E	2198	2541	2655	2660	2707	**2552**	207	8	**93**
MD Tensile Strength (kN/m) - E	32.1	37.1	38.8	38.8	39.5	**37.3**	3.0	8.1	
MD - Elong. @ Max. Load (%) - B	10.7	10.7	10.6	10.6	10.2	**10.5**	0.2	2.2	
MD - Elong. @ Max. Load (%) - E	8.5	9.6	10.0	9.8	10.1	**9.6**	0.6	6.7	**91**
B - Baseline Unexposed									
E - Exposed									

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as w ell as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-2. Laboratory installation damage (ISO/EN 10722) tensile test results for 3XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	11.20								
MD - Tensile Strength (lbs) - B	2884	2970	2929	2922	2899	**2921**	33	1	
MD Tensile Strength (lbs/ft) - B	4038	4158	4100	4091	4059	**4089**	46	1	
MD Tensile Strength (kN/m) - B	58.9	60.7	59.9	59.7	59.3	**59.7**	0.7	1.1	
MD - Tensile Strength (lbs) - E	2898	2874	2787	2921	2806	**2857**	58	2	
MD Tensile Strength (lbs/ft) - E	4057	4024	3902	4089	3928	**4000**	81	2	**98**
MD Tensile Strength (kN/m) - E	59.2	58.7	57.0	59.7	57.4	**58.4**	1.2	2.0	
MD - Elong. @ Max. Load (%) - B	10.1	10.6	10.4	10.3	10.0	**10.3**	0.2	2.3	
MD - Elong. @ Max. Load (%) - E	10.1	10.2	9.4	10.5	9.5	**9.9**	0.5	4.6	**97**
B - Baseline Unexposed									
E - Exposed									

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-3. Laboratory installation damage (ISO/EN 10722) tensile test results for 5XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER 1	2	3	4	5	MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	10.91								
MD - Tensile Strength (lbs) - B	3825	3843	3885	3788	3776	**3823**	44	1	
MD Tensile Strength (lbs/ft) - B	5216	5241	5298	5165	5149	**5214**	60	1	
MD Tensile Strength (kN/m) - B	76.2	76.5	77.3	75.4	75.2	**76.1**	0.9	1.1	
MD - Tensile Strength (lbs) - E	3566	3592	3747	3727	3692	**3665**	81	2	
MD Tensile Strength (lbs/ft) - E	4862	4899	5110	5083	5035	**4998**	111	2	**96**
MD Tensile Strength (kN/m) - E	71.0	71.5	74.6	74.2	73.5	**73.0**	1.6	2.2	
MD - Elong. @ Max. Load (%) - B	10.9	11.7	11.7	11.6	11.3	**11.4**	0.4	3.1	
MD - Elong. @ Max. Load (%) - E	10.2	11.1	10.6	11.5	11.2	**10.9**	0.5	4.7	**95**

B - Baseline Unexposed
E - Exposed

MD - Machine Direction   TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-4. Laboratory installation damage (ISO/EN 10722) tensile test results for 7XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via w ide w idth tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	10.79								
MD - Tensile Strength (lbs) - B	4808	4850	4632	4694	4713	**4740**	88	2	
MD Tensile Strength (lbs/ft) - B	6485	6542	6248	6331	6357	**6393**	119	2	
MD Tensile Strength (kN/m) - B	94.7	95.5	91.2	92.4	92.8	**93.3**	1.7	1.9	
MD - Tensile Strength (lbs) - E	4182	4511	4531	4242	3981	**4289**	232	5	
MD Tensile Strength (lbs/ft) - E	5641	6084	6111	5721	5370	**5785**	313	5	**91**
MD Tensile Strength (kN/m) - E	82.4	88.8	89.2	83.5	78.4	**84.5**	4.6	5.4	
MD - Elong. @ Max. Load (%) - B	11.1	10.8	10.2	10.9	10.8	**10.8**	0.4	3.4	
MD - Elong. @ Max. Load (%) - E	9.2	9.4	9.4	8.9	8.1	**9.0**	0.5	5.9	**84**

B - Baseline Unexposed
E - Exposed

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as w ell as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-5. Laboratory installation damage (ISO/EN 10722) tensile test results for 8XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	10.84								
MD - Tensile Strength (lbs) - B	6018	6248	6192	6305	6333	**6219**	125	2	
MD Tensile Strength (lbs/ft) - B	8154	8465	8390	8542	8580	**8426**	169	2	
MD Tensile Strength (kN/m) - B	119	124	122	125	125	**123**	2	2	
MD - Tensile Strength (lbs) - E	5867	5372	5482	5816	6011	**5709**	271	5	
MD Tensile Strength (lbs/ft) - E	7948	7278	7427	7879	8145	**7735**	367	5	**92**
MD Tensile Strength (kN/m) - E	116	106	108	115	119	**113**	5	5	
MD - Elong. @ Max. Load (%) - B	10.6	11.7	11.4	11.8	15.0	**12.1**	1.7	14.0	
MD - Elong. @ Max. Load (%) - E	10.7	9.7	9.8	10.7	10.5	**10.3**	0.5	4.8	**85**

B - Baseline Unexposed
E - Exposed

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-6. Laboratory installation damage (ISO/EN 10722) tensile test results for 10XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	10.79								
MD - Tensile Strength (lbs) - B	8011	8052	8031	7880	7408	**7876**	270	3	
MD Tensile Strength (lbs/ft) - B	10804	10860	10832	10628	9992	**10623**	364	3	
MD Tensile Strength (kN/m) - B	158	159	158	155	146	**155**	5	3	
MD - Tensile Strength (lbs) - E	7467	7147	7245	7163	6968	**7198**	181	3	
MD Tensile Strength (lbs/ft) - E	10071	9640	9772	9662	9397	**9708**	245	3	**91**
MD Tensile Strength (kN/m) - E	147	141	143	141	137	**142**	4	3	
MD - Elong. @ Max. Load (%) - B	11.5	11.9	12.2	11.7	10.9	**11.6**	0.5	4.3	
MD - Elong. @ Max. Load (%) - E	10.3	9.8	10.4	10.1	9.7	**10.0**	0.3	2.9	**86**

B - Baseline Unexposed
E - Exposed

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-7. Laboratory installation damage (ISO/EN 10722) tensile test results for 20XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via w ide w idth tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	9								
MD Number of Ribs per foot:	12.15								
MD - Tensile Strength (lbs) - B	12343	12308	12401	12083	11956	**12218**	190	2	
MD Tensile Strength (lbs/ft) - B	16850	16802	16929	16495	16322	**16680**	259	2	
MD Tensile Strength (kN/m) - B	246	245	247	241	238	**244**	4	2	
MD - Tensile Strength (lbs) - E	11244	11914	11747	11407	11519	**11566**	267	2	
MD Tensile Strength (lbs/ft) - E	15350	16265	16037	15572	15726	**15790**	365	2	**95**
MD Tensile Strength (kN/m) - E	224	237	234	227	230	**231**	5	2	
MD - Elong. @ Max. Load (%) - B	11.6	11.5	12.5	11.6	11.1	**11.7**	0.5	4.3	
MD - Elong. @ Max. Load (%) - E	9.6	10.7	10.4	9.7	10.4	**10.2**	0.5	4.4	**87**
B - Baseline Unexposed									
E - Exposed									

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as w ell as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-8. Laboratory installation damage (ISO/EN 10722) tensile test results for 22XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	9								
MD Number of Ribs per foot:	12.41								
MD - Tensile Strength (lbs) - B	15712	16510	16915	17280	16986	**16680**	607	4	
MD Tensile Strength (lbs/ft) - B	22412	23551	24128	24649	24229	**23794**	866	4	
MD Tensile Strength (kN/m) - B	327	344	352	360	354	**347**	13	4	
MD - Tensile Strength (lbs) - E	15814	15087	15581	15451	15272	**15441**	279	2	
MD Tensile Strength (lbs/ft) - E	22557	21521	22225	22040	21784	**22026**	399	2	**93**
MD Tensile Strength (kN/m) - E	329	314	324	322	318	**322**	6	2	
MD - Elong. @ Max. Load (%) - B	11.1	11.3	12.0	12.2	12.1	**11.7**	0.5	4.5	
MD - Elong. @ Max. Load (%) - E	10.7	10.6	10.8	10.7	10.6	**10.7**	0.1	1.0	**91**
B - Baseline Unexposed									
E - Exposed									

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table E-9. Laboratory installation damage (ISO/EN 10722) tensile test results for 24XT

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	COEF. VARI.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**				
Laboratory Installation Damage (ISO/EN 10722)									
Strength Retained measured via wide width tensile (ISO/EN 10319)									
MD Number of Ribs per Specimen:	8								
MD Number of Ribs per foot:	12.25								
MD - Tensile Strength (lbs) - B	19647	19330	18984	19095	17806	**18972**	700	4	
MD Tensile Strength (lbs/ft) - B	30856	30358	29814	29988	27964	**29796**	1099	4	
MD Tensile Strength (kN/m) - B	450	443	435	438	408	**435**	16	4	
MD - Tensile Strength (lbs) - E	16962	16983	16858	16517	17110	**16886**	225	1	
MD Tensile Strength (lbs/ft) - E	26639	26672	26476	25940	26871	**26520**	353	1	**89**
MD Tensile Strength (kN/m) - E	389	389	387	379	392	**387**	5	1	
MD - Elong. @ Max. Load (%) - B	13.1	13.8	14.1	14.9	13.0	**13.8**	0.8	5.8	
MD - Elong. @ Max. Load (%) - E	11.5	12.2	11.8	11.1	11.7	**11.6**	0.4	3.5	**85**
B - Baseline Unexposed									
E - Exposed									

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Appendix F: Creep Rupture Detailed Test Results

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m2xt7013l11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
2XT

Specimen:	568n2m2xtsim70	Test Date:	13-Jul-11	Method:	SIM (10^4s, 14C),single rib, machine dir.		
Average Creep Stress:	1874.6	lb/ft				%UTS:	70.00
Ultimate Tensile Strength:	2678.0	lb/ft				Rupture:	YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	21.01	-
2	9400	10020	620	0.09	1.2074	34.82	0.0875
3	19500	20010	510	0.09	1.3172	48.61	0.0955
4	29500	30000	500	0.1	1.3213	62.52	0.0950
5	39500	39990	490	0.08	1.3296	76.69	0.0938
6							

Summary	Initial	Final	Units	@20C refT
lab time	41.0	46800	sec	-
$logA_T(t-t')$	1.6128	9.0388	log hours	5.5711
$A_T(t-t')$	-	34.65	years	42.49
Strain	6.247	11.213	%	-
Modulus	23924.0	16746.4	lb/ft	-

AVG 0.0929

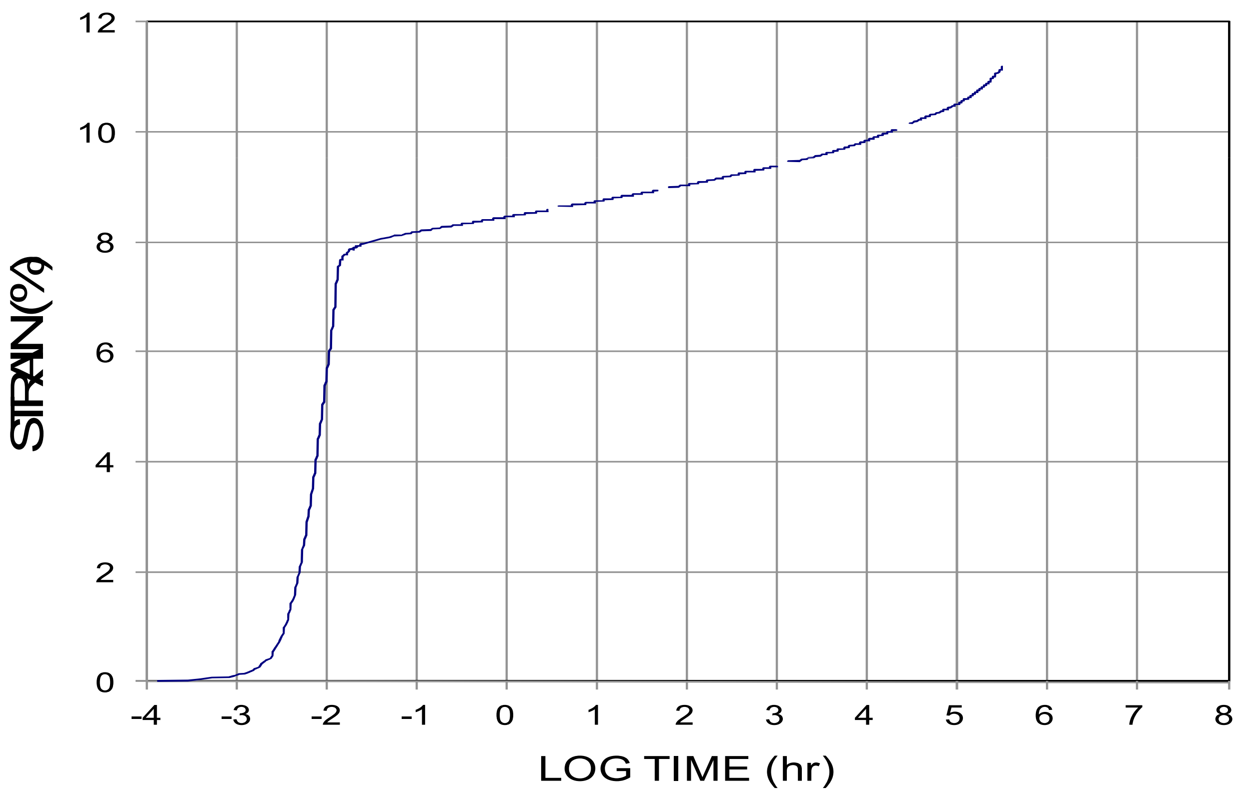


Figure F-1. SIM/Creep data/curve for 2XT at load level of 70.00% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m2xt7426l11.xls   SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
2XT

Specimen: 568n2m2xtsim74   Test Date: 26-Jul-11   Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 1981.6 lb/ft   %UTS: 73.99
Ultimate Tensile Strength: 2678.0 lb/ft   Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.81	-
2	9400	10020	620	0.08	1.2073	34.50	0.0882
3	19400	20010	610	0.09	1.2393	48.24	0.0902
4	29400	30000	600	0.09	1.2461	62.02	0.0905
5							
6							

Summary	Initial	Final	Units	@20C refT
lab time	56.0	33240	sec	-
$logA_T(t-t')$	1.7481	7.2770	log hours	3.7918
$A_T(t-t')$	-	0.60	years	0.71
Strain	7.623	10.439	%	-
Modulus	25996.3	18985.4	lb/ft	-

AVG 0.0896

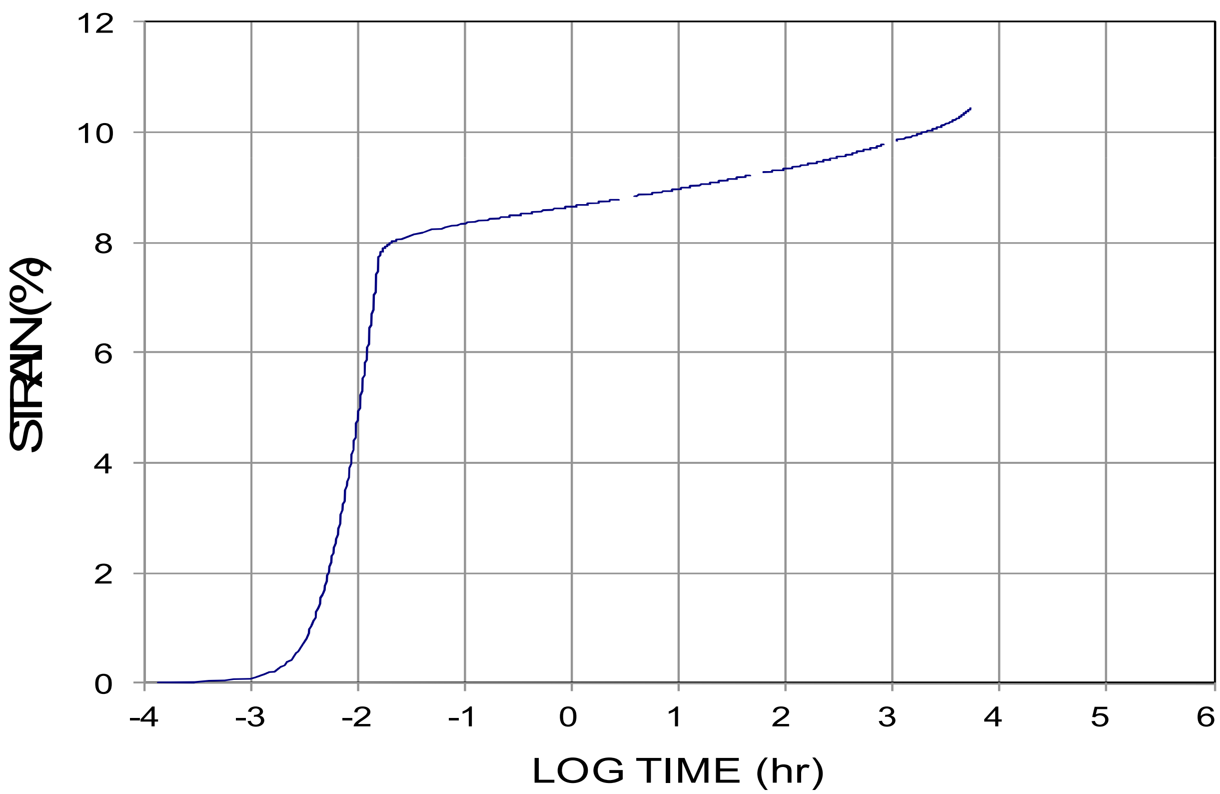


Figure F-2. SIM/Creep data/curve for 2XT at load level of 73.99% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m2xt7725l11.xls SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
2XT

Specimen: 568n2m2xtsim77 Test Date: 25-Jul-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 2061.8 lb/ft %UTS: 76.99

Ultimate Tensile Strength: 2678.0 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.77	-
2	9400	10020	620	0.09	1.2074	34.57	0.0875
3	19500	20010	510	0.09	1.3172	48.31	0.0958
4							
5							
6							
						AVG	0.0917

Summary	Initial	Final	Units	@20C refT
lab time	53.5	24390	sec	-
$logA_T(t-t')$	1.7281	6.2138	log hours	2.7248
$A_T(t-t')$	-	0.05	years	0.06
Strain	7.904	10.571	%	-
Modulus	26085.2	19502.4	lb/ft	-

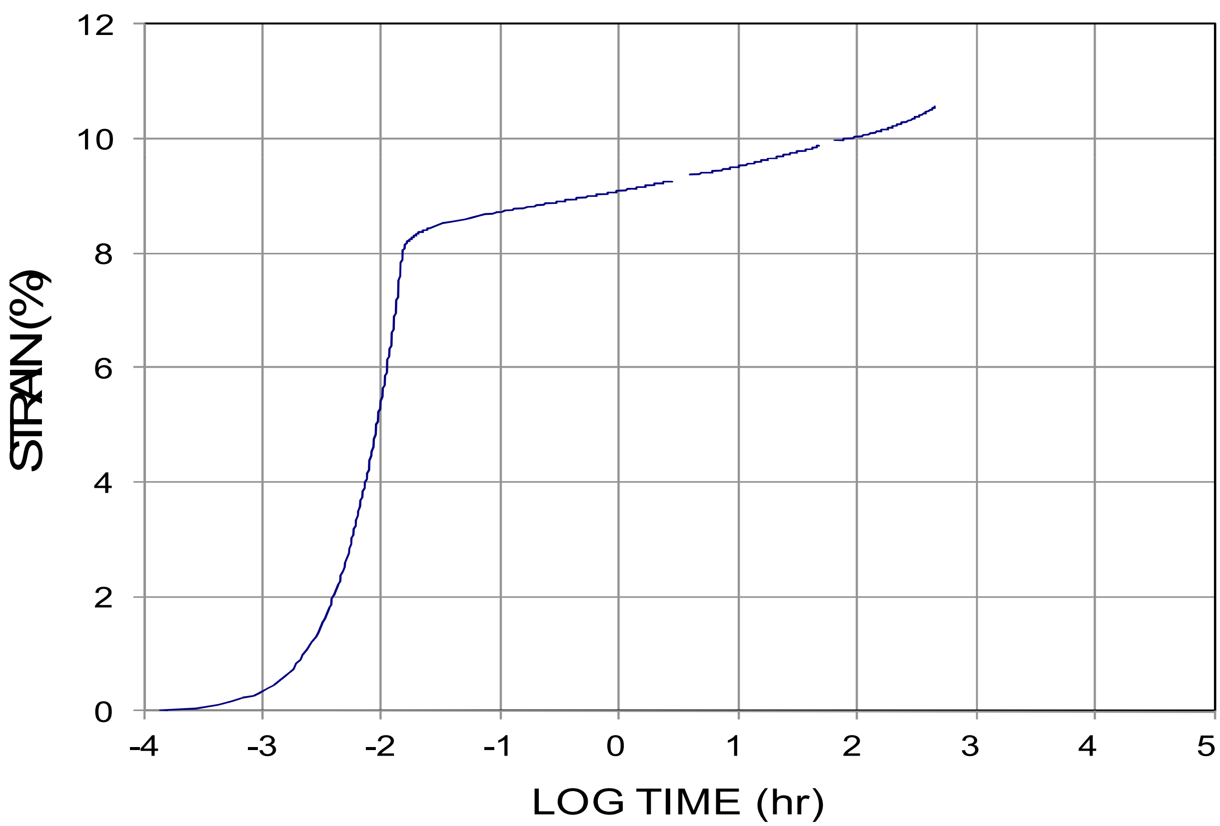


Figure F-3. SIM/Creep data/curve for 2XT at load level of 76.99% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m2xt8015l11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products 2XT

Specimen: 568n2m2xtsim80 Test Date: 15-Jul-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 2142.4 lb/ft %UTS: 80.00

Ultimate Tensile Strength: 2678.0 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$\log A_T$	Temp	$\log A_T/T$
1	0	0.5	0.5	-	-	21.50	-
2	9500	10019	519	0.05	1.2840	35.42	0.0923
3	19500	20009	509	0.05	1.3133	52.52	0.0768
4							
5							
6							

Summary	Initial	Final	Units	@20C refT
lab time	49.2	20129	sec	-
$\log A_T(t-t')$	1.6921	5.3962	log hours	1.9786
$A_T(t-t')$	-	0.01	years	0.01
Strain	8.343	11.125	%	-
Modulus	25681.4	19251.3	lb/ft	-

AVG 0.0837

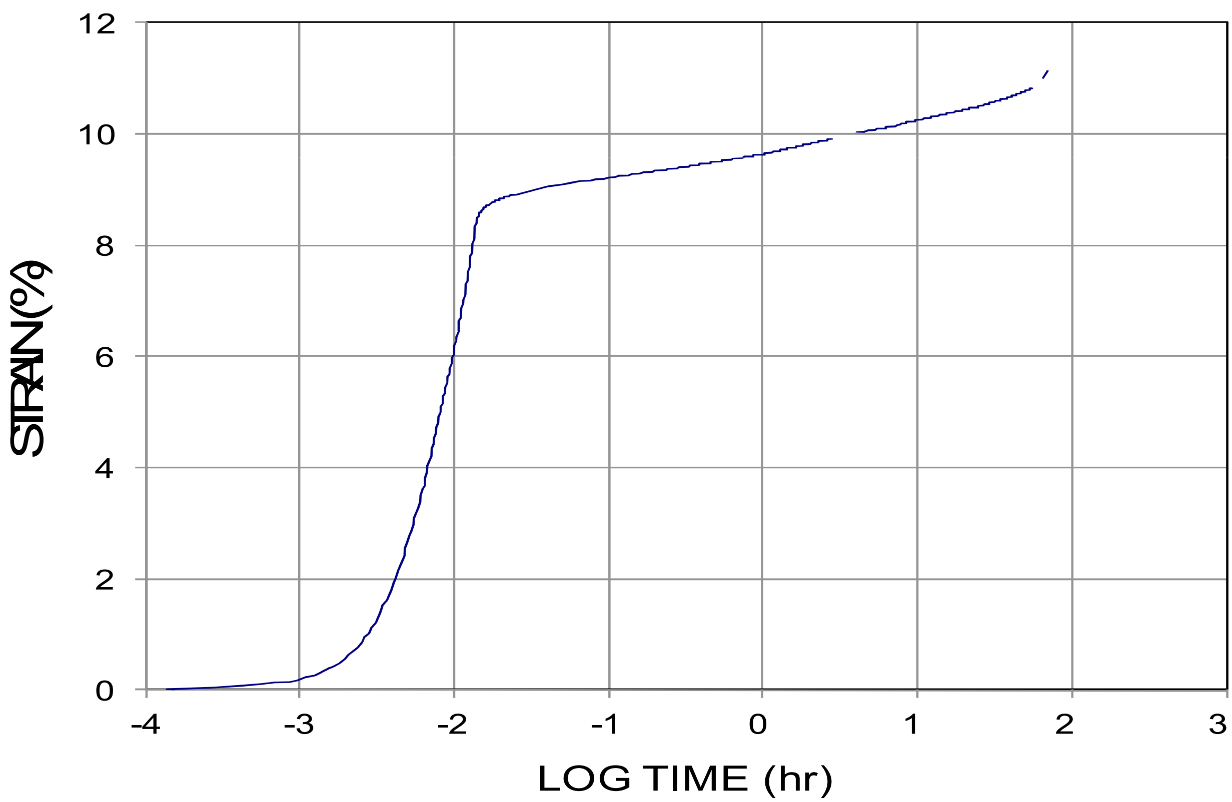


Figure F-4. SIM/Creep data/curve for 2XT at load level of 80.00% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt6519l11.xls SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
8XT

Specimen: 568n2m8xtsim65 Test Date: 19-Jul-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 5607.6 lb/ft %UTS: 64.35

Ultimate Tensile Strength: 8714.4 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.94	-
2	9500	10019	519	0.09	1.2840	34.81	0.0926
3	19500	20009	509	0.09	1.3132	48.70	0.0945
4	29800	29999	199	0.09	1.7201	62.72	0.1227
5	39500	39989	489	0.1	1.3172	76.73	0.0940
6	49500	49979	479	0.12	1.3384	90.87	0.0947
						AVG	0.0997

Summary	Initial	Final	Units	@20C refT
lab time	47.5	51539	sec	-
$logA_T(t-t')$	1.6767	10.2824	log hours	6.8129
$A_T(t-t')$	-	607.09	years	741.52
Strain	7.036	11.875	%	-
Modulus	69329.8	47223.1	lb/ft	-

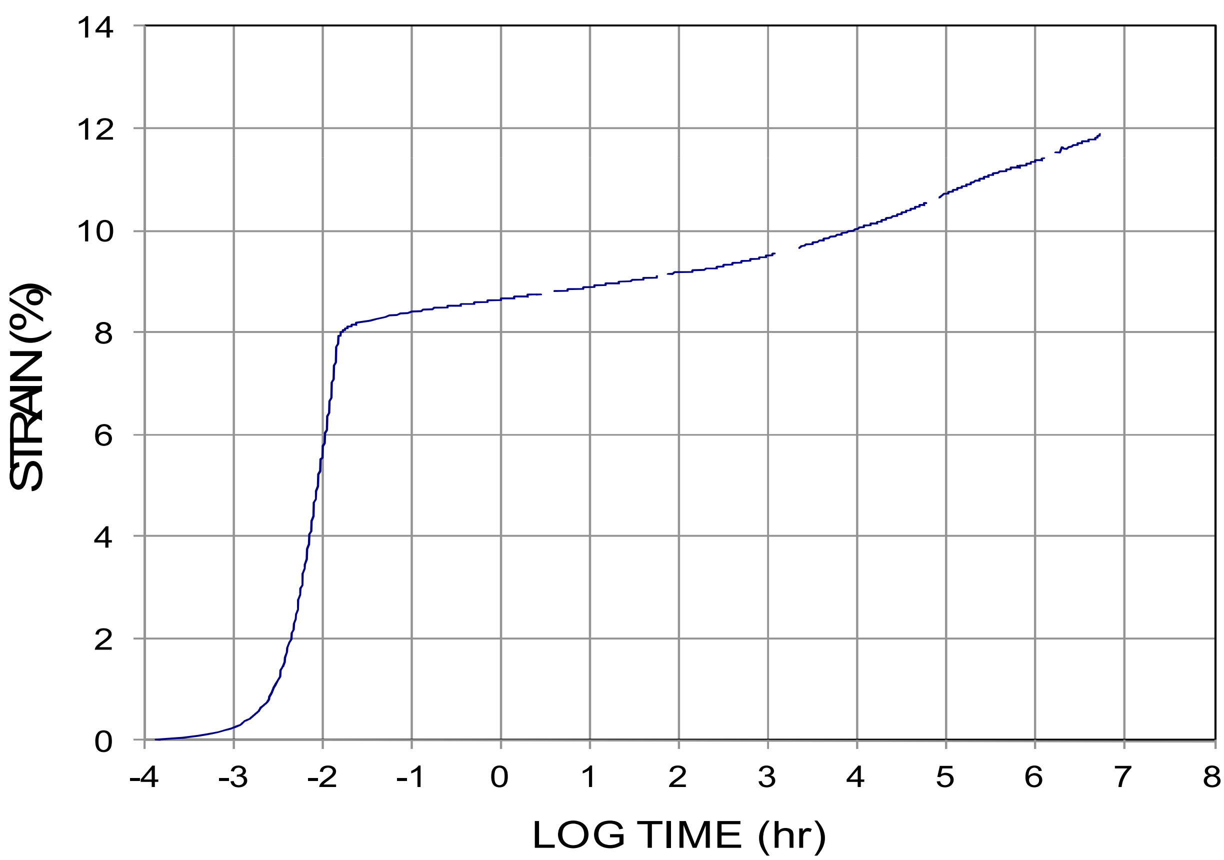


Figure F-5. SIM/Creep data/curve for 8XT at load level of 64.35% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt7029u11.xls SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products

8XT

Specimen: 568n2m8xtsim70 Test Date: 29-Jun-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 6039.0 lb/ft %UTS: 69.30

Ultimate Tensile Strength: 8714.4 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$\log A_T$	Temp	$\log A_T/T$
1	0	0.5	0.5	-	-	21.54	-
2	9400	10020	620	0.07	1.2074	35.41	0.0870
3	19600	20010	410	0.07	1.4121	49.30	0.1017
4	29200	30000	800	0.1	1.1129	63.24	0.0798
5	39300	39990	690	0.1	1.1932	77.23	0.0853
6	49400	49980	580	0.12	1.2642	91.32	0.0897
						AVG	0.0887

Summary	Initial	Final	Units	@20C refT
lab time	47.5	50670	sec	-
$\log A_T(t-t')$	1.6767	9.2935	log hours	5.8708
$A_T(t-t')$	-	62.28	years	84.73
Strain	6.995	11.988	%	-
Modulus	68358.9	50376.9	lb/ft	-

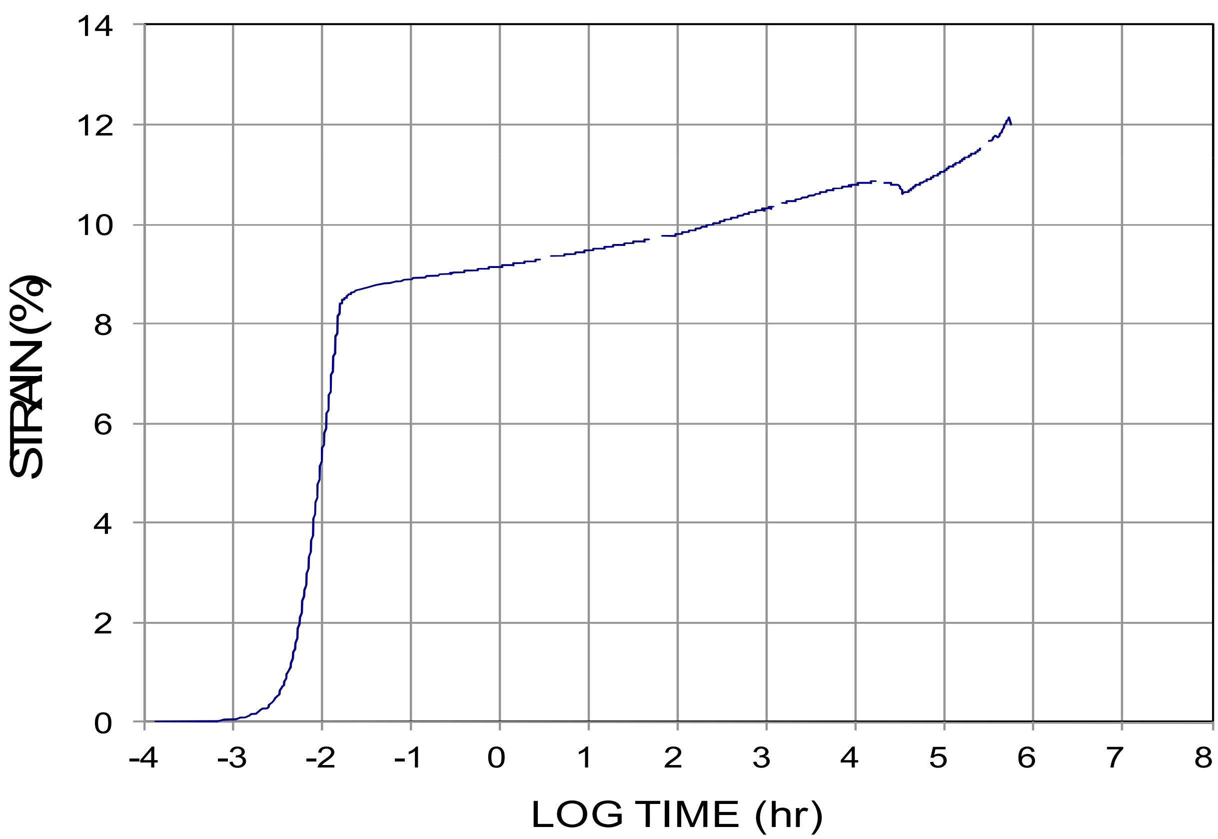


Figure F-6. SIM/Creep data/curve for 8XT at load level of 69.30% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt7201l11.xls   SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
8XT

Specimen: 568n2m8xtsim72.5   Test Date: 01-Jul-11   Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 6254.7 lb/ft   %UTS: 71.77

Ultimate Tensile Strength: 8714.4 lb/ft   Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.68	-
2	9500	10019	519	0.12	1.2840	34.85	0.0906
3	19600	20009	409	0.14	1.4082	48.82	0.1008
4	29600	29999	399	0.16	1.4143	62.77	0.1014
5							
6							
						AVG	0.0976

Summary	Initial	Final	Units	@20C refT
lab time	48.5	39959	sec	-
$logA_T(t-t')$	1.6860	8.1219	log hours	4.6272
$A_T(t-t')$	-	4.20	years	4.83
Strain	8.397	11.553	%	-
Modulus	74487.1	54138.2	lb/ft	-

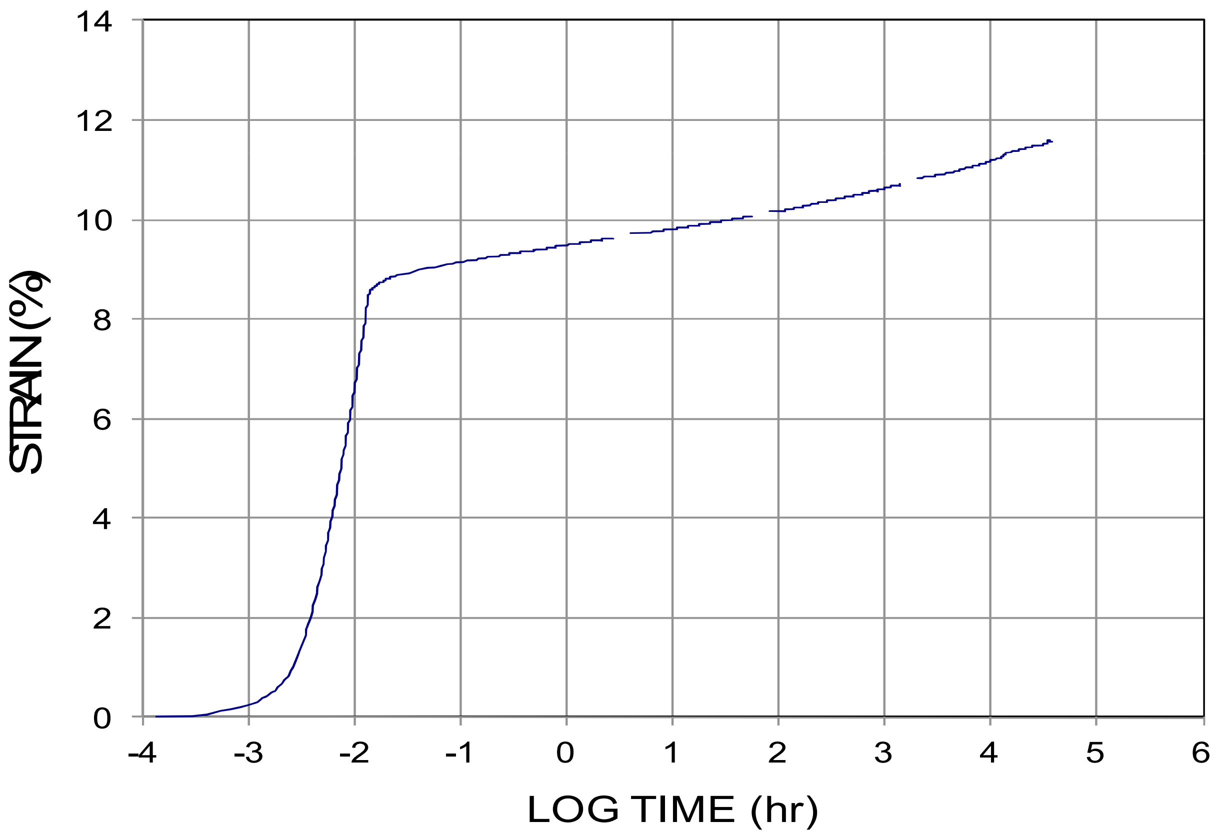


Figure F-7. SIM/Creep data/curve for 8XT at load level of 71.77% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt7520l11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
8XT

Specimen: 568n2m8xtsim75 Test Date: 20-Jul-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 6470.4 lb/ft %UTS: 74.25

Ultimate Tensile Strength: 8714.4 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.85	-
2	9350	10020	670	0.03	1.1737	34.69	0.0848
3	19500	20010	510	0.02	1.3192	48.55	0.0952
4	29400	30000	600	0.09	1.2420	62.42	0.0896
5							
6							

AVG 0.0899

Summary	Initial	Final	Units	@20C refT
lab time	58.0	34320	sec	-
$logA_T(t-t')$	1.7634	7.4268	log hours	3.9427
$A_T(t-t')$	-	0.85	years	1.00
Strain	8.418	12.875	%	-
Modulus	69937.0	50254.1	lb/ft	-

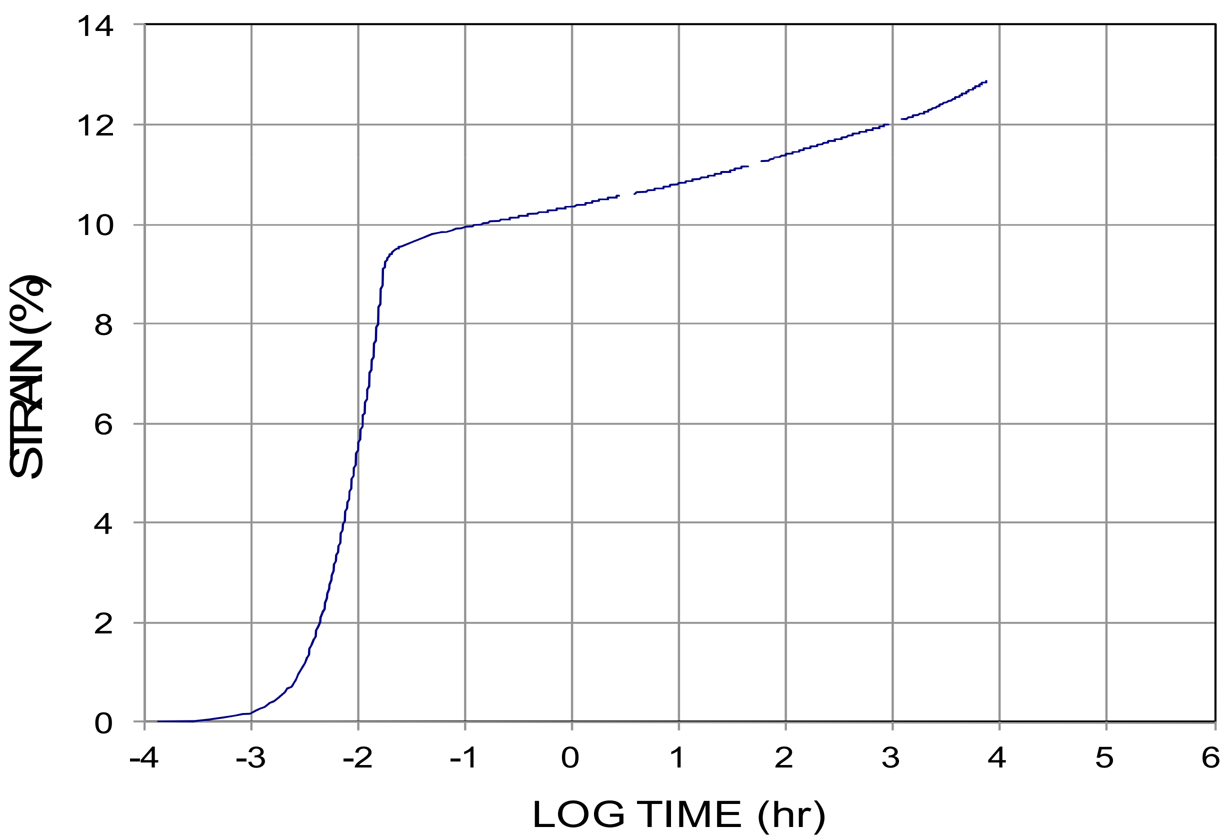


Figure F-8. SIM/Creep data/curve for 8XT at load level of 74.25% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt7722l11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products 8XT

Specimen:	568n2m8xtsim77.5	Test Date:	22-Jul-11	Method:	SIM (10^4s, 14C),single rib, machine dir.		
Average Creep Stress:	6686.2	lb/ft				%UTS:	76.73
Ultimate Tensile Strength:	8714.4	lb/ft				Rupture:	YES

Dwell Seq	t'	t	$(t\text{-}t')_i$	Vshift(%)	$\log A_T$	Temp	$\log A_T/T$
1	0	0.5	0.5	-	-	20.73	-
2	9400	10020	620	0.05	1.2075	34.58	0.0872
3	19400	20010	610	0.06	1.2395	48.36	0.0899
4	29400	30000	600	0.06	1.2463	62.20	0.0900
5							
6							
						AVG	0.0890

Summary	Initial	Final	Units	@20C refT
lab time	66.0	37440	sec	-
$\log A_T(t\text{-}t')$	1.8195	7.5985	log hours	4.1056
$A_T(t\text{-}t')$	-	1.26	years	1.45
Strain	9.388	14.207	%	-
Modulus	71034.8	47061.2	lb/ft	-

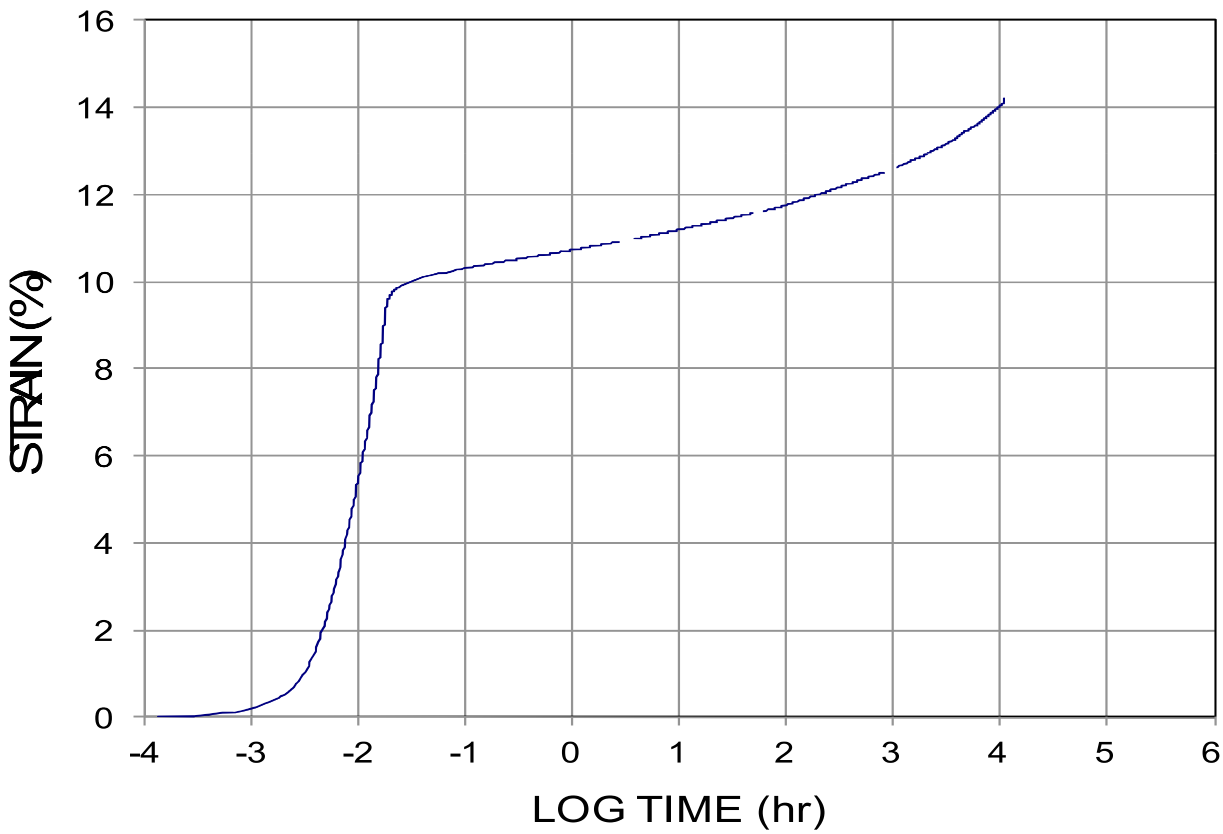


Figure F-9. SIM/Creep data/curve for 8XT at load level of 76.73% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m8xt8021l11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products

8XT

Specimen: 568n2m8xtsim80 Test Date: 21-Jul-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 6901.9 lb/ft %UTS: 79.20

Ultimate Tensile Strength: 8714.4 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.67	-
2	9400	10020	620	0.04	1.2075	34.63	0.0865
3	19500	20010	510	0.03	1.3173	48.74	0.0934
4							
5							
6							
						AVG	0.0899

Summary	Initial	Final	Units	@20C refT
lab time	68.6	22470	sec	-
$logA_T(t-t')$	1.8365	5.9974	log hours	2.4988
$A_T(t-t')$	-	0.03	years	0.04
Strain	9.898	13.166	%	-
Modulus	69734.4	52420.6	lb/ft	-

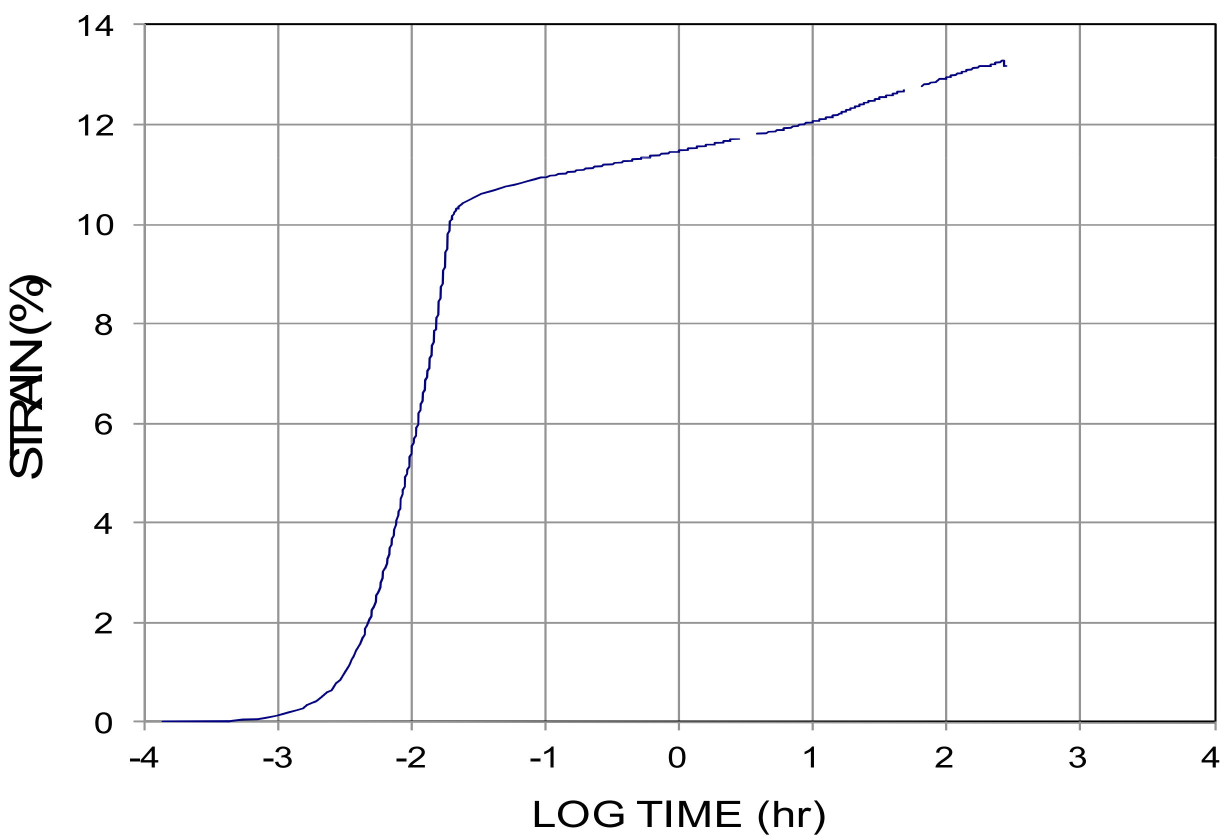
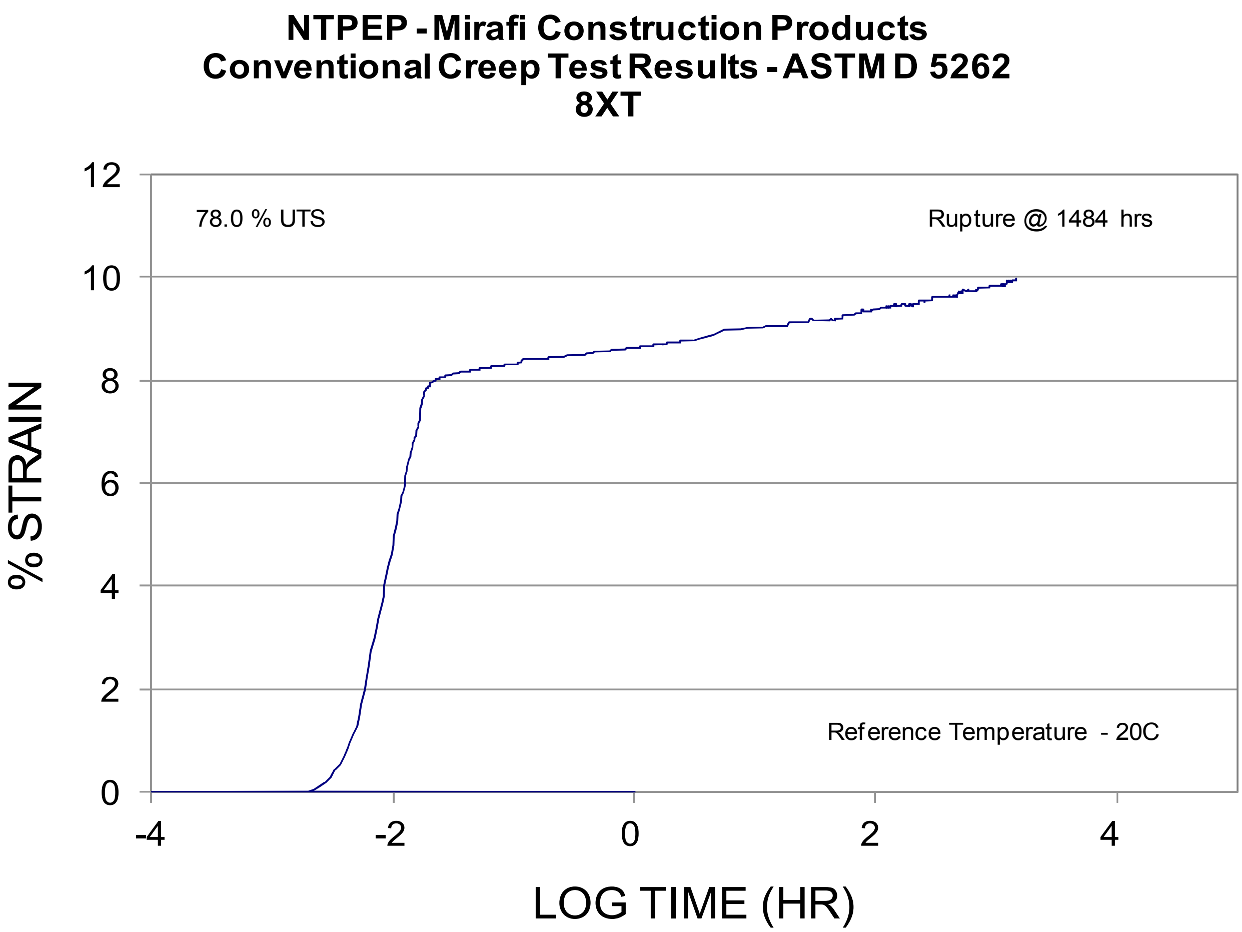
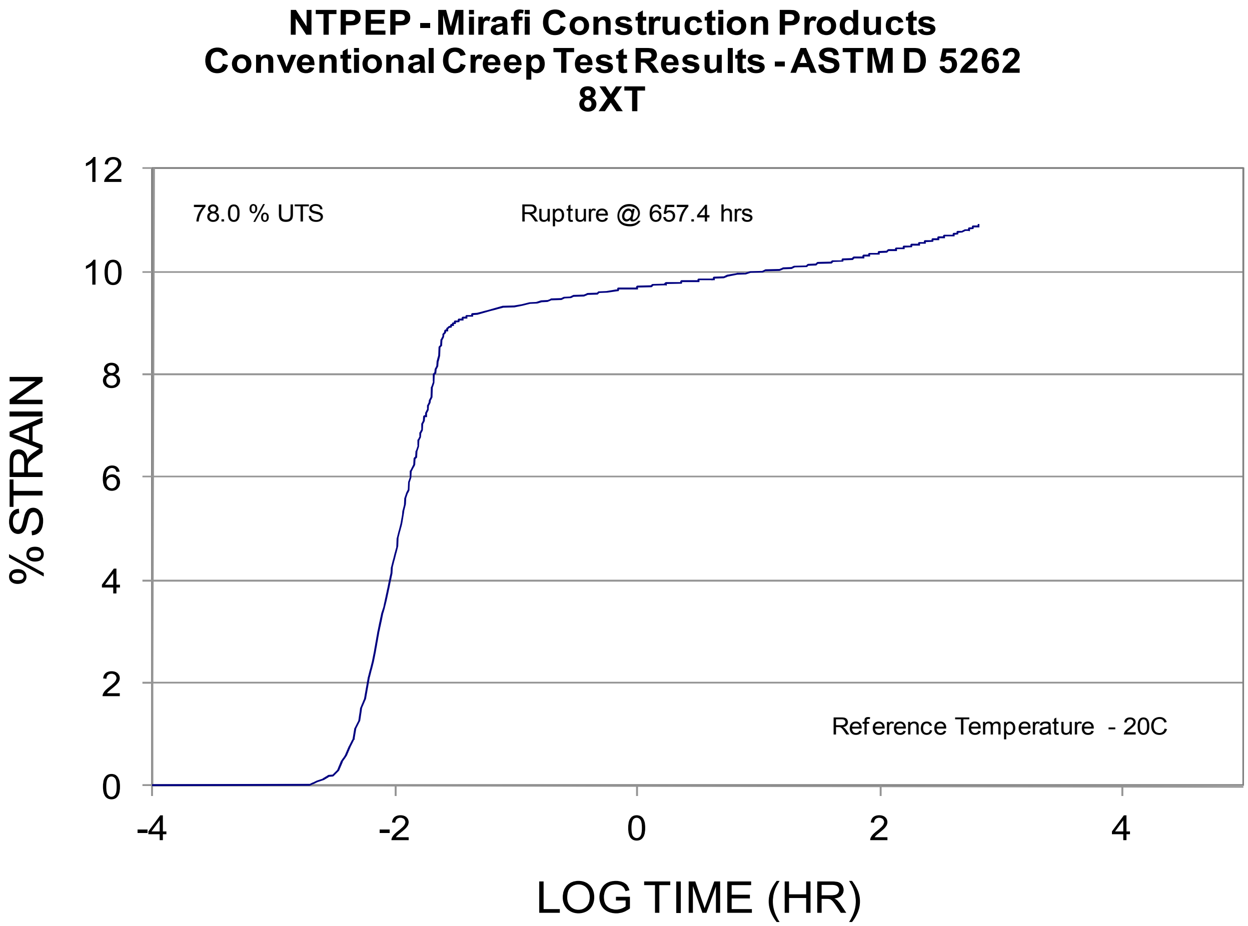


Figure F-10. SIM/Creep data/curve for 8XT at load level of 79.20% UTS.



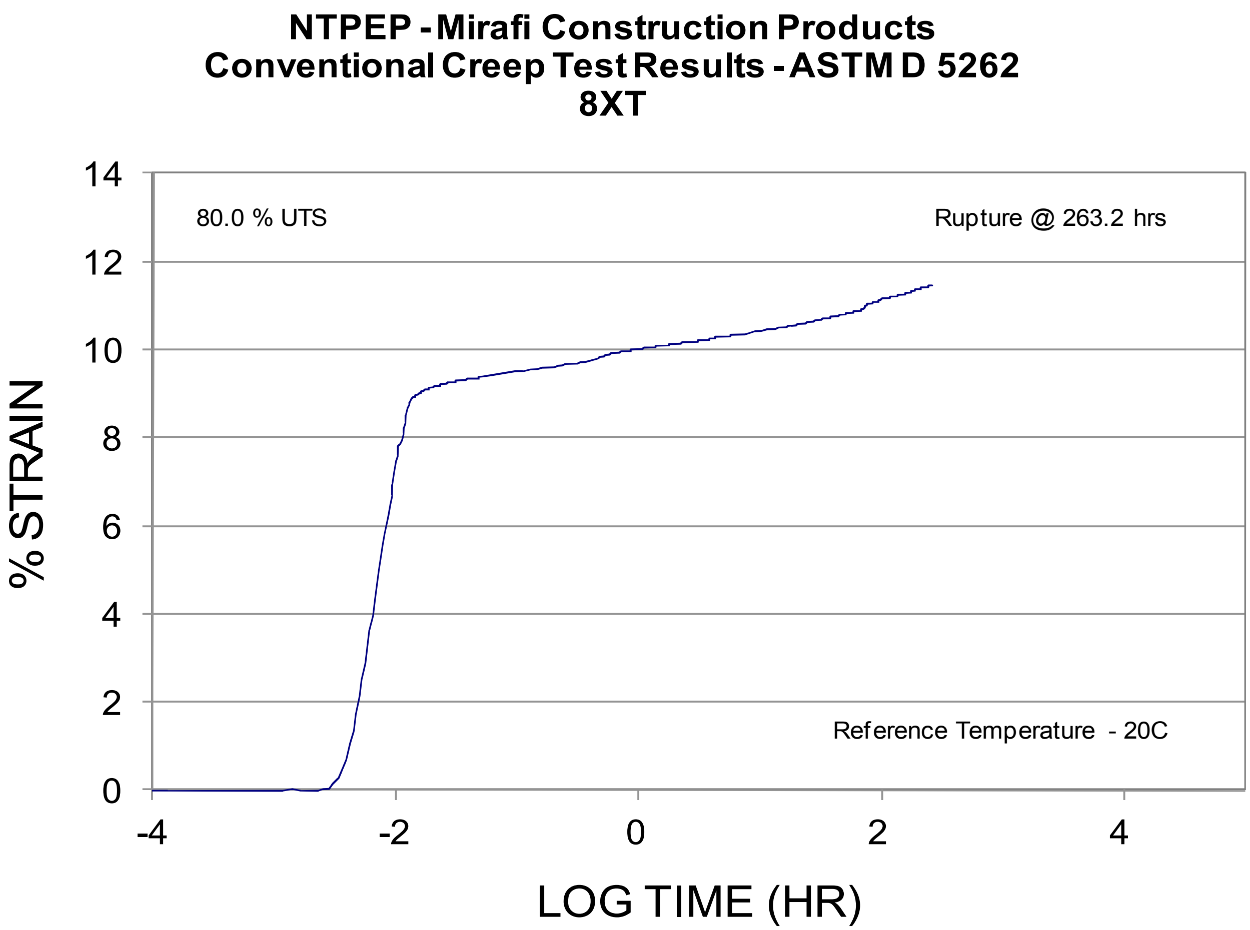
TRI Log # E2280-56-08

Figure F-11. Creep data/curve per ASTM D5262 for 8XT at a load level of 78.0% UTS and 68°F(20°C)



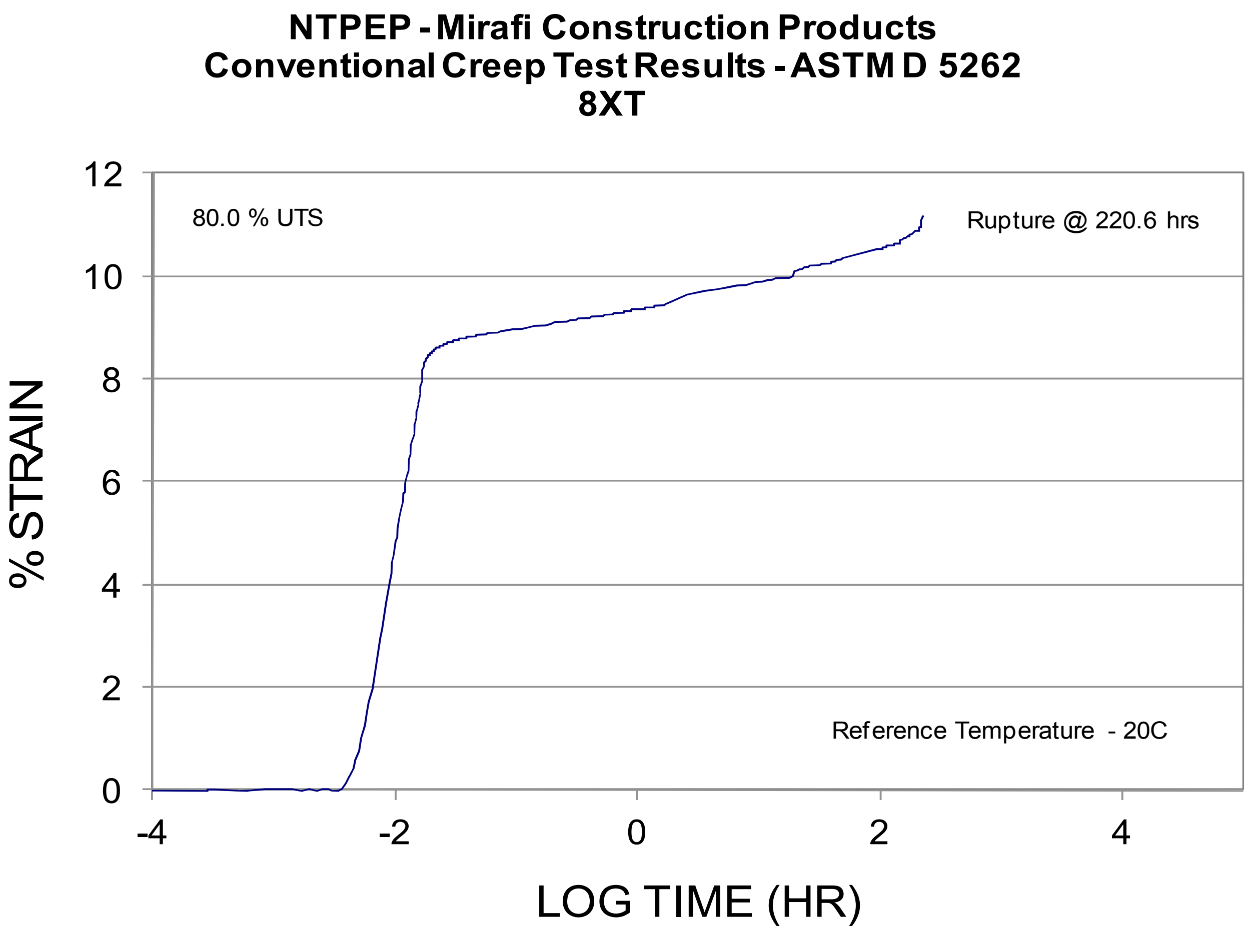
TRI Log # E2280-56-08

Figure F-12. Creep data/curve per ASTM D5262 for 8XT at a load level of 78.0% UTS and 68°F(20°C)



TRI Log # E2280-56-08

Figure F-13. Creep data/curve per ASTM D5262 for 8XT at a load level of 80.0% UTS and 68°F(20°C)



TRI Log # E2280-56-08

Figure F-14. Creep data/curve per ASTM D5262 for 8XT at a load level of 80.0% UTS and 68°F(20°C)

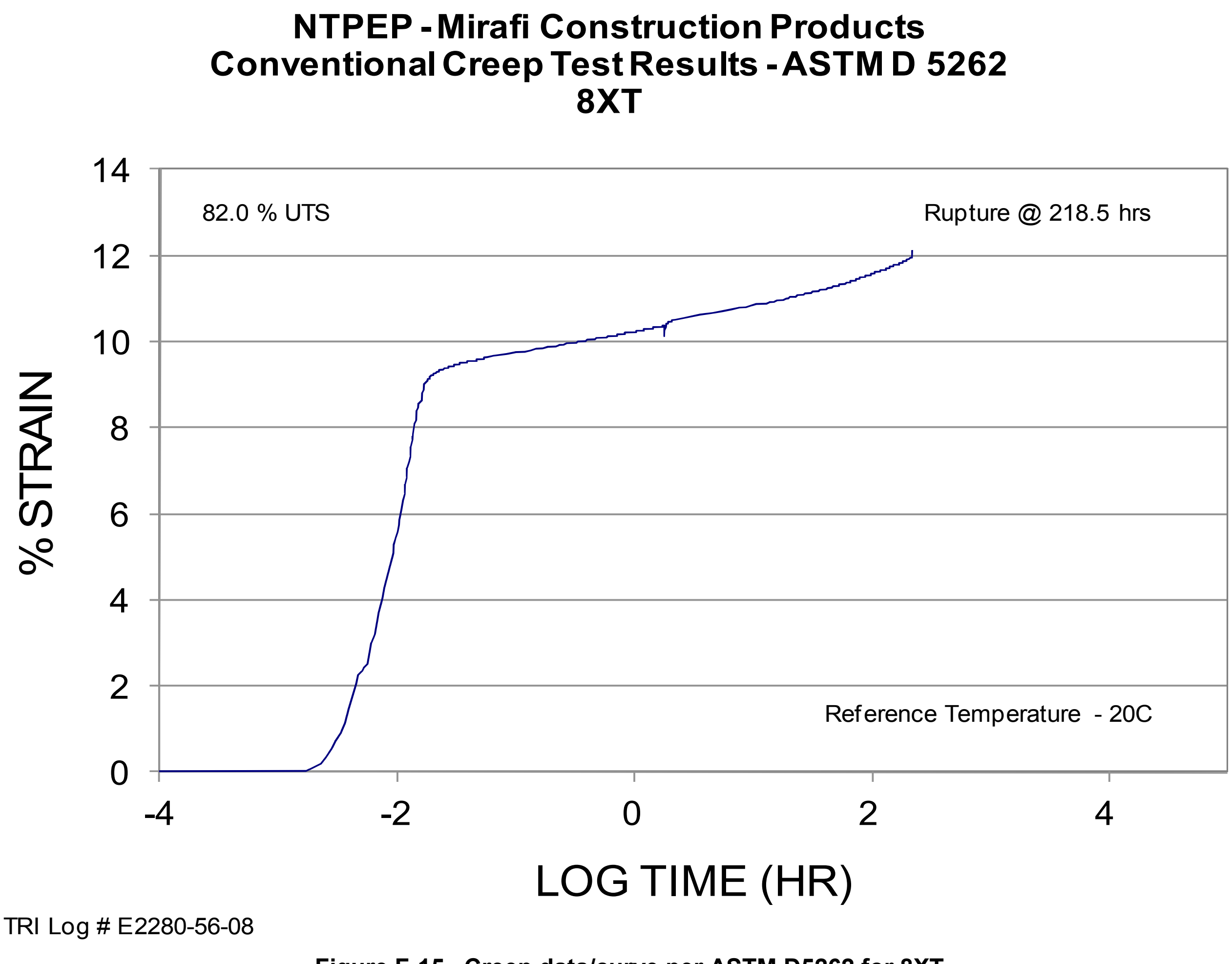
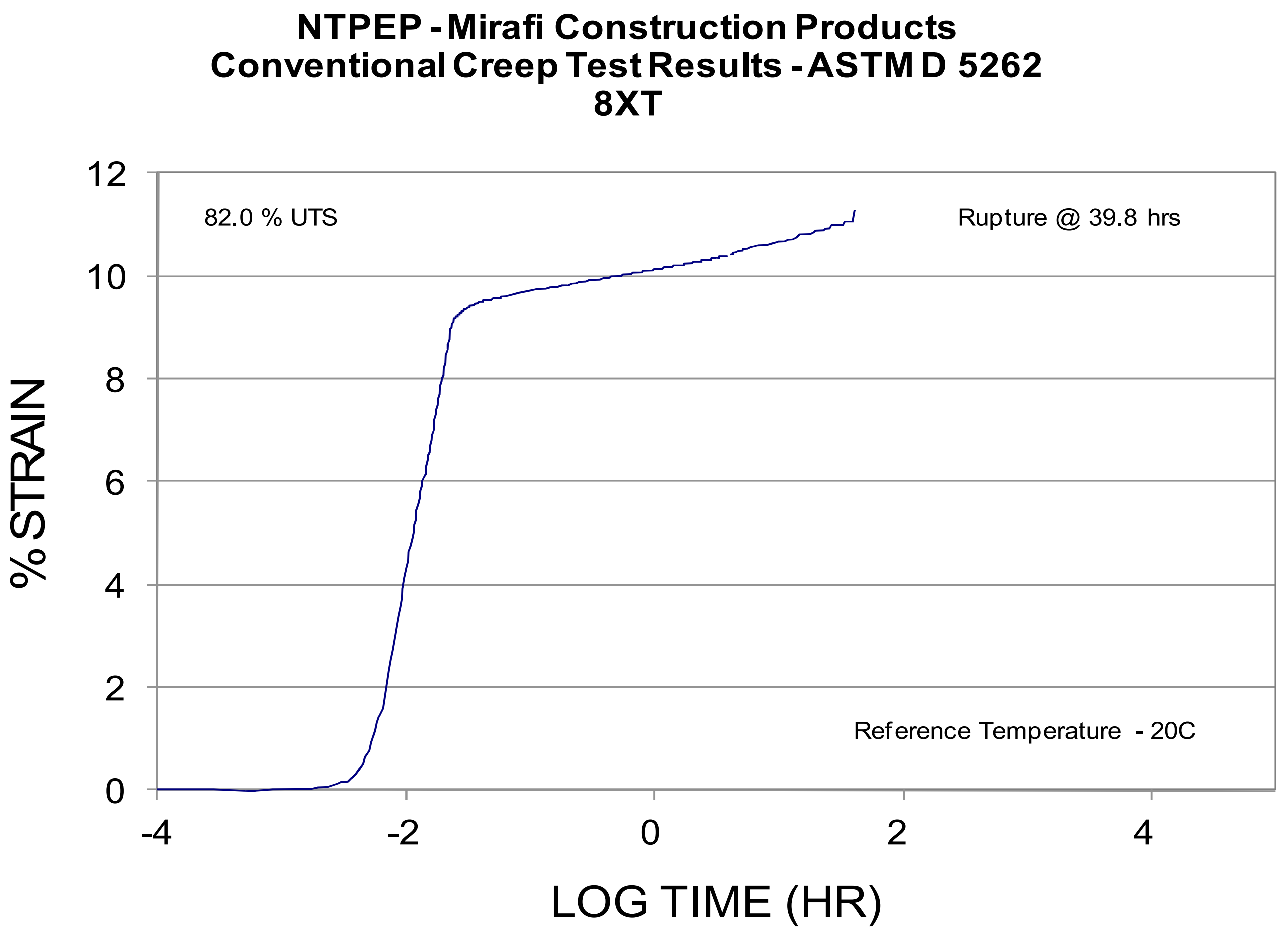


Figure F-15. Creep data/curve per ASTM D5262 for 8XT at a load level of 82.0% UTS and 68°F(20°C)



TRI Log # E2280-56-08

Figure F-16. Creep data/curve per ASTM D5262 for 8XT at a load level of 82.0% UTS and 68°F(20°C)

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m24xt6802g11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
24XT

Specimen: 568n2m24xtsim68 Test Date: 02-Aug-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 20885 lb/ft %UTS: 68.00

Ultimate Tensile Strength: 30714 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t\text{-}t')_i$	Vshift(%)	$\log A_T$	Temp	$\log A_T/T$
1	0	0.5	0.5	-	-	20.78	-
2	9500	10020	520	0.1	1.2834	34.56	0.0931
3	19500	20010	510	0.11	1.3126	48.36	0.0951
4	29500	30000	500	0.12	1.3208	62.31	0.0947
5	39400	39990	590	0.12	1.2485	76.31	0.0892
6	49400	49980	580	0.12	1.2597	90.27	0.0902

Summary	Initial	Final	Units	@20C refT
lab time	80.0	52230	sec	-
$\log A_T(t\text{-}t')$	1.9031	9.8768	log hours	6.3928
$A_T(t\text{-}t')$	-	238.61	years	281.83
Strain	9.909	15.893	%	-
Modulus	210787.2	131413.5	lb/ft	-

AVG 0.0925

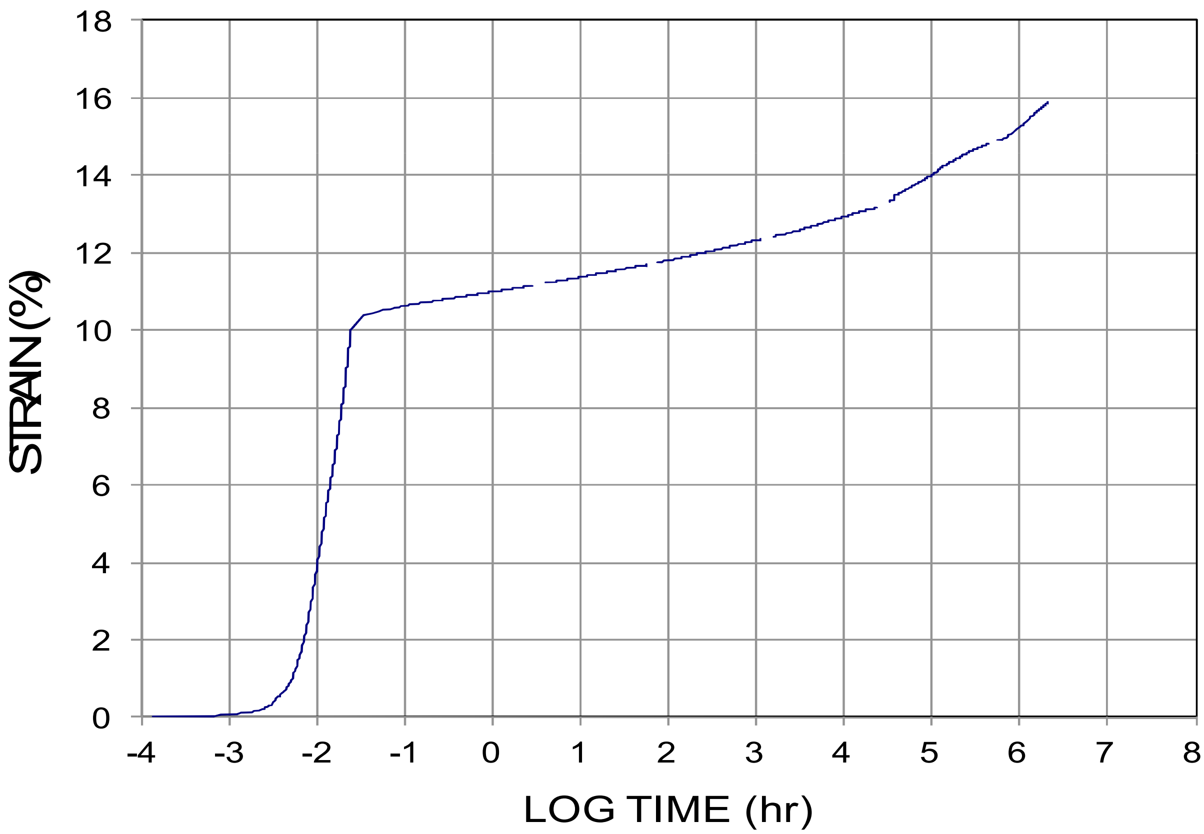


Figure F-17. SIM/Creep data/curve for 24XT at load level of 68.00% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m24xt7127l11.xls — SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products 24XT

Specimen: 568n2m24xtsim68 — Test Date: 02-Aug-11 — Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 21807 lb/ft — %UTS: 71.00

Ultimate Tensile Strength: 30714 lb/ft — Rupture: YES

Dwell Seq	t'	t	$(t\text{-}t')_i$	Vshift(%)	$\log A_T$	Temp	$\log A_T/T$
1	0	0.5	0.5	-	-	20.73	-
2	9500	10020	520	0.09	1.2837	34.41	0.0938
3	19500	20010	510	0.15	1.3129	48.20	0.0952
4	29500	30000	500	0.11	1.3211	62.15	0.0947
5	39400	39990	590	0.12	1.2488	76.19	0.0889
6							
						AVG	0.0931

Summary	Initial	Final	Units	@20C refT
lab time	79.7	45600	sec	-
$\log A_T(t\text{-}t')$	1.9015	8.9589	log hours	5.4707
$A_T(t\text{-}t')$	-	28.83	years	33.72
Strain	10.081	14.394	%	-
Modulus	189030.2	151498.4	lb/ft	-

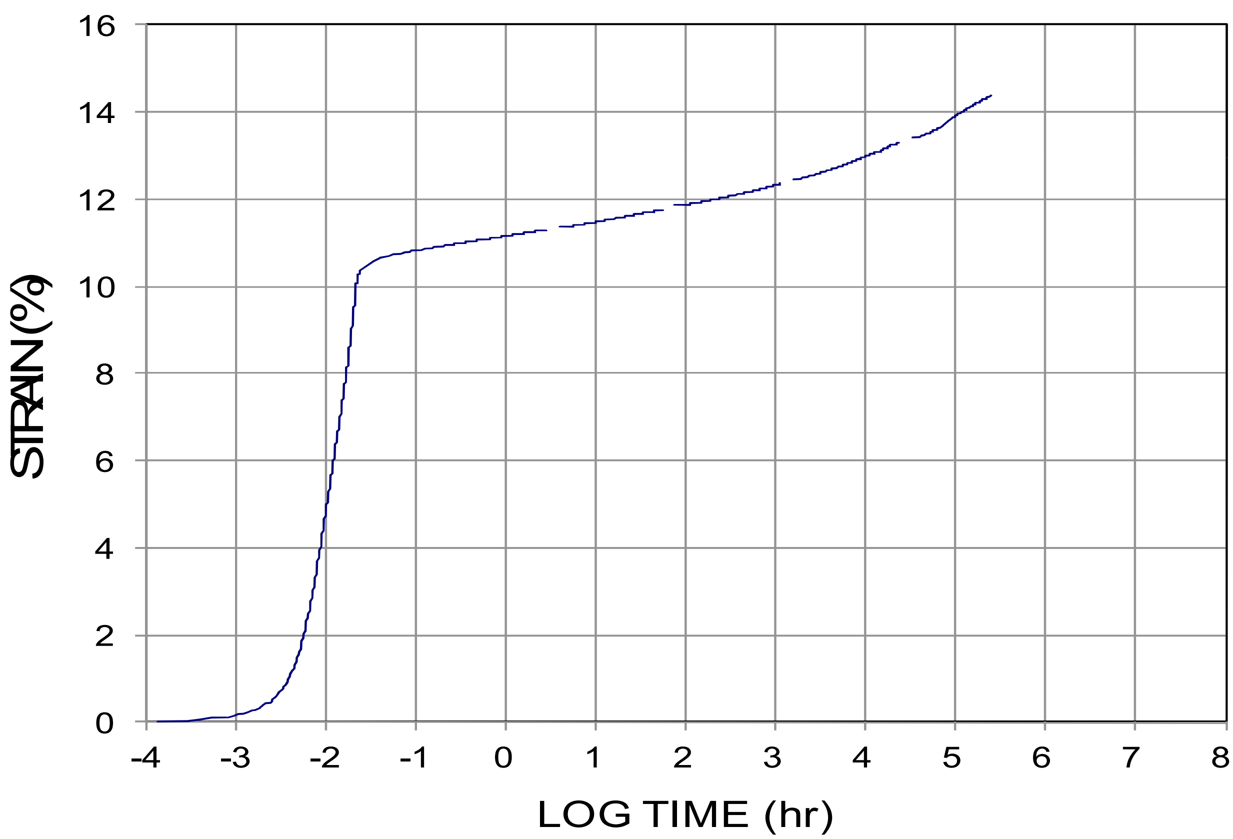


Figure F-18. SIM/Creep data/curve for 24XT at load level of 71.00% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m24xt7529l11.xls   SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products
24XT

Specimen:	568n2m24xtsim75	Test Date:	29-Jul-11	Method:	SIM (10^4s, 14C),single rib, machine dir.		
Average Creep Stress:	23036	lb/ft				%UTS:	75.00
Ultimate Tensile Strength:	30714	lb/ft				Rupture:	YES

Dwell Seq	t'	t	$(t-t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.82	-
2	9500	10020	520	0.11	1.2837	34.54	0.0935
3	19500	20010	510	0.13	1.3129	48.43	0.0946
4	29400	30000	600	0.13	1.2419	62.41	0.0888
5							
6							
						AVG	0.0923

Summary	Initial	Final	Units	@20C refT
lab time	80.0	37740	sec	-
$logA_T(t-t')$	1.9031	7.7597	log hours	4.2798
$A_T(t-t')$	-	1.82	years	2.17
Strain	10.465	15.717	%	-
Modulus	193139.5	146568.8	lb/ft	-

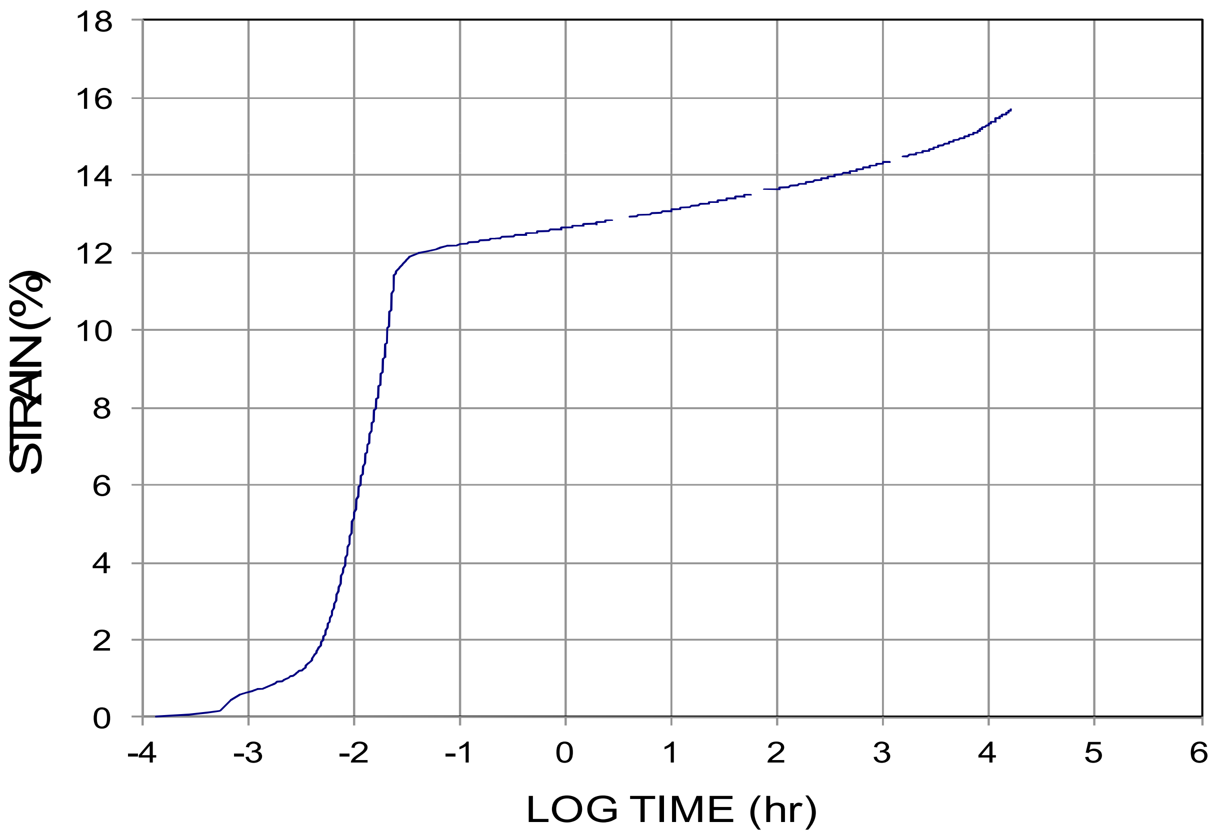


Figure F-19. SIM/Creep data/curve for 24XT at load level of 75.00% UTS.

Accelerated Creep Rupture via SIM - ASTM D 6992

568n2m24xt7901g11.xls

SUMMARY CREEP PARAMETERS: NTPEP - Mirafi Construction Products 24XT

Specimen: 568n2m24xtsim79 Test Date: 01-Aug-11 Method: SIM (10^4s, 14C),single rib, machine dir.

Average Creep Stress: 24264 lb/ft %UTS: 79.00

Ultimate Tensile Strength: 30714 lb/ft Rupture: YES

Dwell Seq	t'	t	$(t\text{-}t')_i$	Vshift(%)	$logA_T$	Temp	$logA_T/T$
1	0	0.5	0.5	-	-	20.70	-
2	9500	10021	521	0.11	1.2827	34.61	0.0922
3	19400	20011	611	0.12	1.2343	48.47	0.0891
4							
5							
6							

AVG 0.0906

Summary	Initial	Final	Units	@20C refT
lab time	90.0	25981	sec	-
$logA_T(t\text{-}t')$	1.9542	6.3354	log hours	2.8434
$A_T(t\text{-}t')$	-	0.07	years	0.08
Strain	11.090	15.497	%	-
Modulus	206745.0	156575.5	lb/ft	-

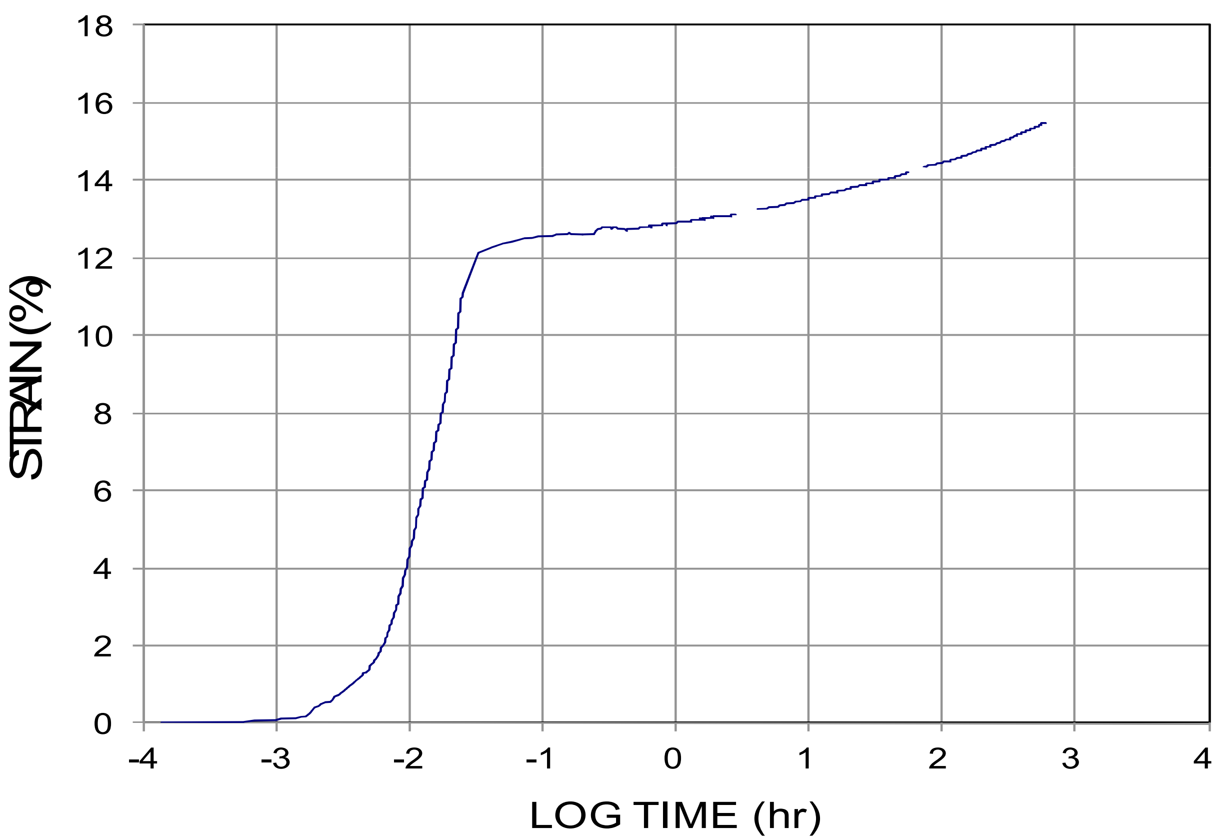


Figure F-20. SIM/Creep data/curve for 24XT at load level of 79.00% UTS.

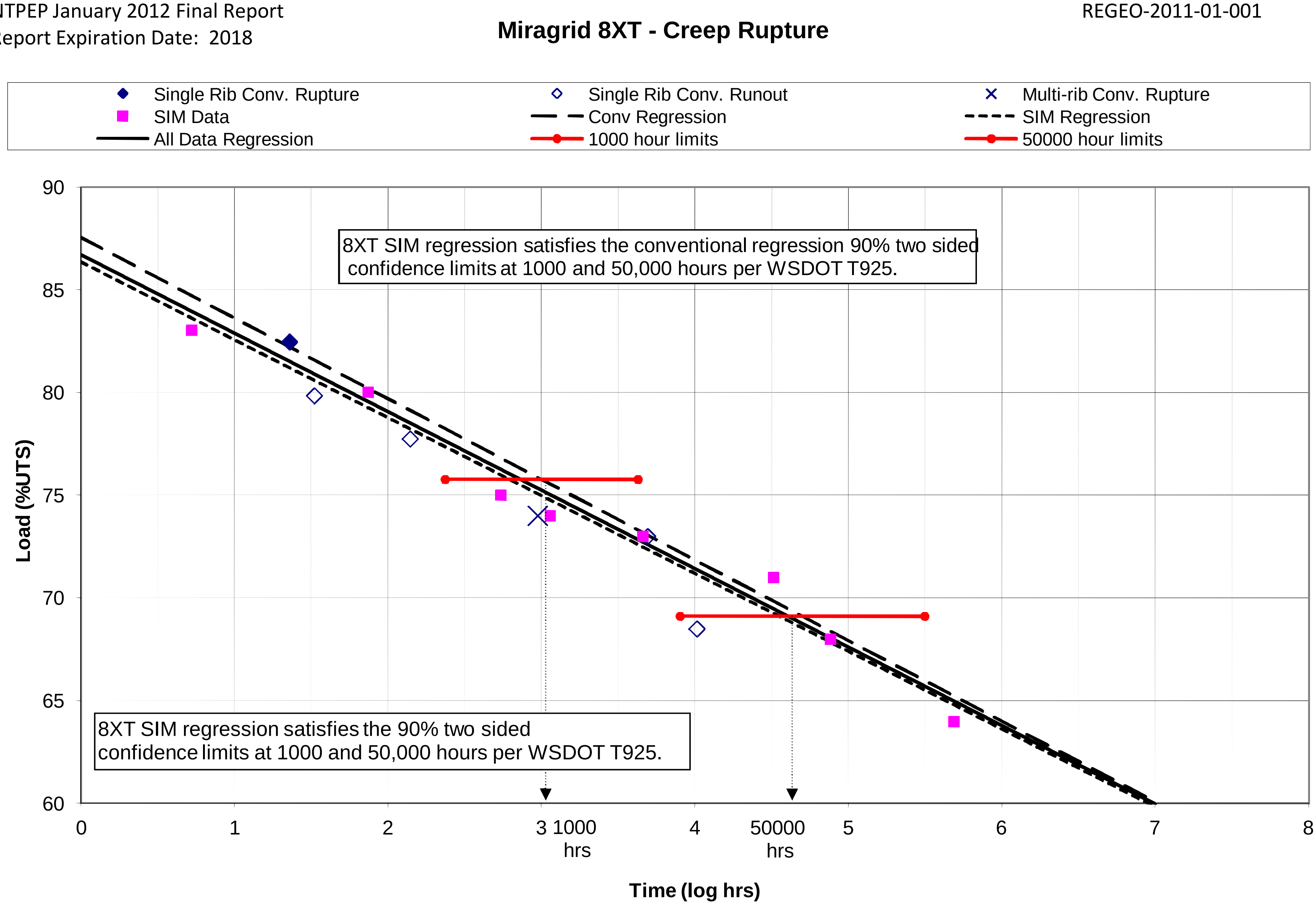


Figure F-21. Statistical evaluation results for determining validity of using SIM to extend Miragrid XT geogrid conventional creep rupture data, and to compare single-rib to multi-rib data (from NTPEP 2008, Report 8505.3).

Miragrid 8XT- Creep Rupture

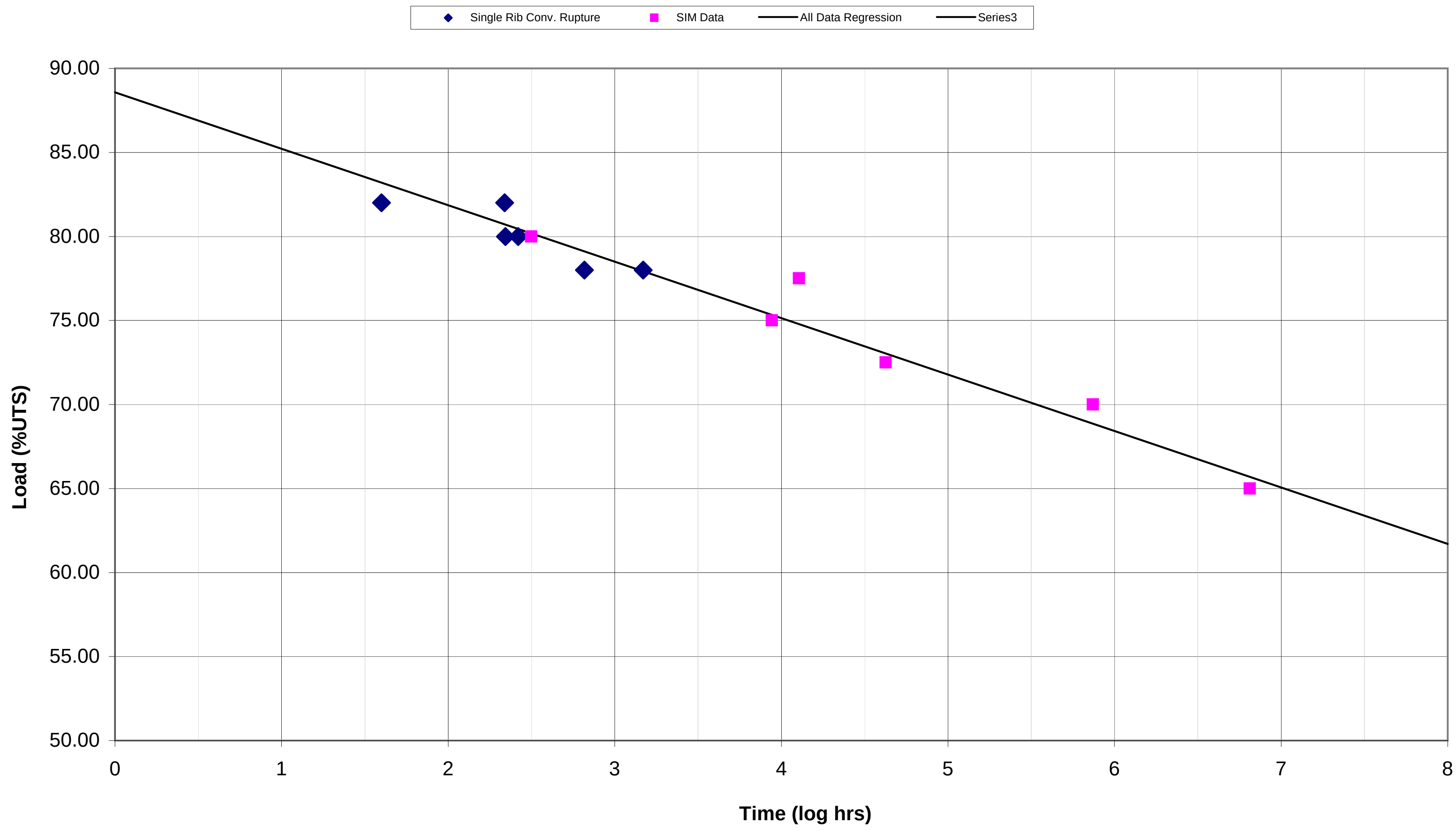


Figure F-22. Visual evaluation for verifying validity of using SIM to extend Macgrid XT geogrid conventional creep rupture data.

Miragrid 8XT - 2XT - 24XT - Creep Rupture

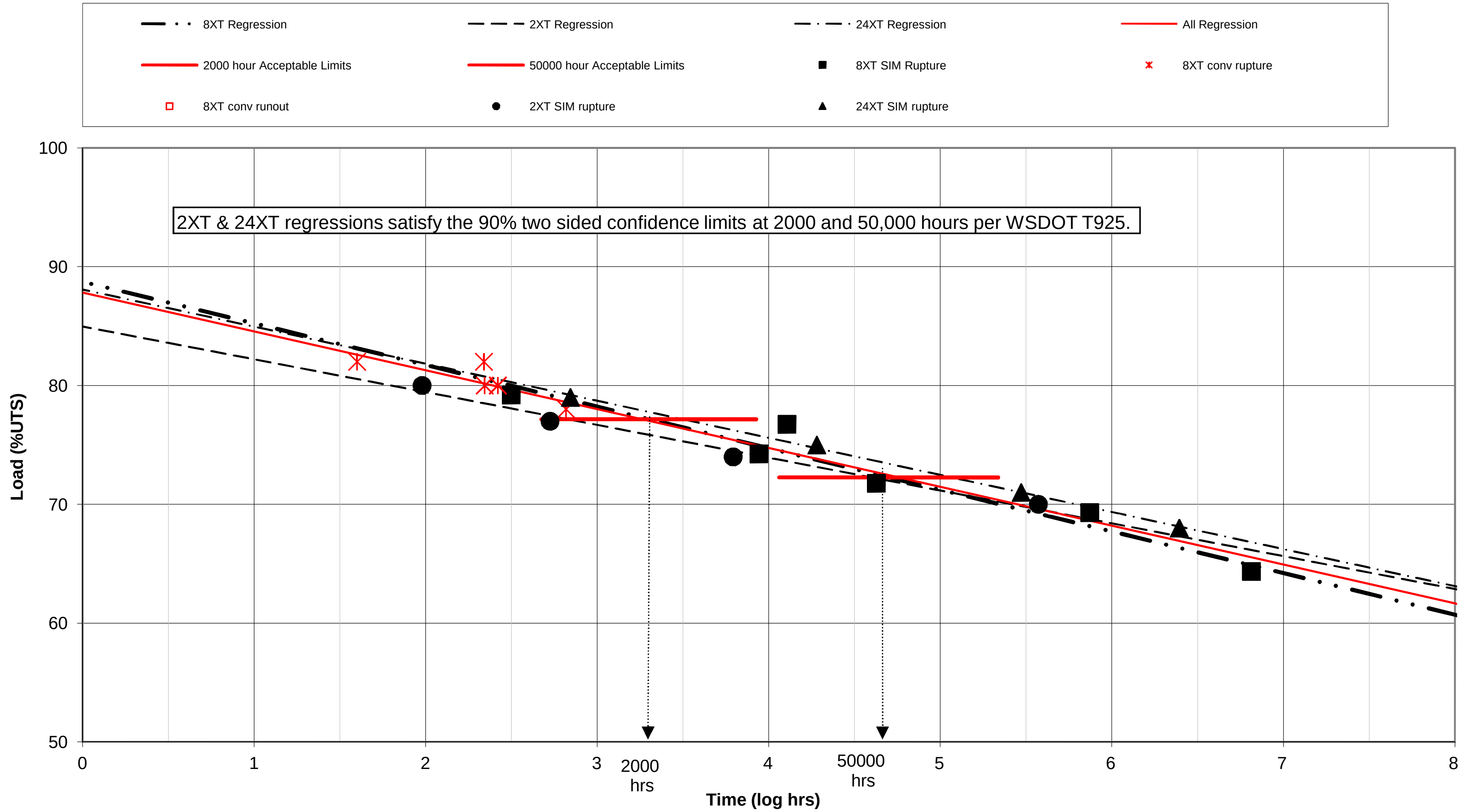


Figure F-23. Statistical evaluation results for determining validity of creating composite creep rupture envelope for the Miragrid XT geogrid product line.

Table F-2. Computation table to determine statistical validity of creating composite creep rupture envelope for the Miragrid XT geogrid product line - 2XT and 8XT comparision.

Miragrid 2XT Creep Data Evaluation

SIM Tests on 2XT

Test Report	Product	Expected time, log hrs	%UTS	Rupture
	2XT	5.5711	70.00	70.00
	2XT	3.7918	73.99	73.99
	2XT	2.7248	76.99	76.99
	2XT	1.9786	80.00	80.00

student's t =	1.812	(90% 2-sided prediction limit)	
n-2XT =	4		
n-8XT =	12	d-o-f	10
treg =	3.3010		
treg =	4.6990		
P2000 =	77.1577		
P50000 =	72.2606		
sigma squared =	0.1099		
sigma =	0.3315		

90% 2-sided conf. limit	
df	student's t
2	2.92
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.86
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761

SIM & Conventional Tests on 8XT

Test Report	Product	time, log hrs	%UTS	Rupture	Runout	logti-logtbar	(logti-logtbar)2	Pi - Pbar	(Pi-Pbar)2	K * L	
	8XT	6.8129	64.35	64.35		3.23	10.4522	-11.80	139.1327	-38.1345	SIM
	8XT	5.8708	69.30	69.30		2.29	5.2481	-6.85	46.86025	-15.6821	SIM
	8XT	4.6272	71.77	71.77		1.05	1.0968	-4.38	19.1446	-4.58234	SIM
	8XT	3.9427	74.25	74.25		0.36	0.1316	-1.90	3.592748	-0.68764	SIM
	8XT	4.1056	76.73	76.73		0.53	0.2763	0.58	0.341693	0.307286	SIM
	8XT	2.4988	79.20	79.20		-1.08	1.1688	3.05	9.330248	-3.30232	SIM
	8XT										SIM
	8XT										SIM
	8XT	1.5999	82.00	82.00		-1.98	3.9205	5.85	34.2757	-11.5922	Conv
	8XT	2.3395	82.00	82.00		-1.24	1.5386	5.85	34.2757	-7.26207	Conv
	8XT	2.3436	80.00	80.00		-1.24	1.5285	3.85	14.85752	-4.76544	Conv
	8XT	2.4203	80.00	80.00		-1.16	1.3447	3.85	14.85752	-4.46979	Conv
	8XT	2.8178	78.00	78.00		-0.76	0.5808	1.85	3.439339	-1.41338	Conv
	8XT	3.1714	78.00	78.00		-0.41	0.1669	1.85	3.439339	-0.75761	Conv
	8XT										Conv
	8XT										Conv
	8XT										Conv
	8XT										Conv
	Sum	39.3791	837.60		Sum	-0.41	27.4540	1.85	323.5474	-92.3422	
	Mean	3.5799	76.15								

* runout plotting below the regression line is not included in the regression

8XT - 2000 hrs (log 3.301)			8XT - 50000 hrs (log 4.699)		
log tL - lower =	2.67	77.1577	log tL - lower =	4.06	72.2606
log tL - upper =	3.93	77.1577	log tL - upper =	5.34	72.2606
2XT - logtL @ Load =	2.82 **OK**		**2XT - logtL @ Load =**	4.60 **OK**	

2XT - All Points
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.362004	-2.7624
intercept	30.75553	84.9592
R squared	0.984141	0.984141
	-2	90.48401
	10	57.33516
	3.3010	75.84042 = 2000 hr intercept
	4.6990	71.97875 = 50000 hr intercept

8XT - All Points
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.285463	-3.50308
intercept	25.32671	88.72148
R squared	0.959993	0.959993
	-2	95.72763
	10	53.69068
	3.3010	77.15771 = 2000 hr intercept
	4.6990	72.26061 = 50000 hr intercept

All Creep Data 8XT & 2XT (conv & SIM)
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.293708	-3.40475
intercept	25.87097	88.08412
R squared	0.947144	0.947144
	-2	94.89361
	10	54.03664
	5.8176	68.27666 = 75-yr intercept
	5.9425	67.8514 = 100-yr intercept

Table F-3. Computation table to determine statistical validity of creating composite creep rupture envelope for the Miragrid XT geogrid product line - 24XT and 8XT comparision.

Miragrid 24XT Creep Data Evaluation

SIM Tests on 24XT

Test Report	Product	Expected time, log hrs	%UTS	Rupture
	24XT	6.3928	68.00	68.00
	24XT	5.4707	71.00	71.00
	24XT	4.2798	75.00	75.00
	24XT	2.8434	79.00	79.00

student's t = 1.812 (90% 2-sided prediction limit)
n-24XT = 4
n-8XT = 12 d-o-f 10
treg = 3.3010
treg = 4.6990
P2000 = 77.1577
P50000 = 72.2606
sigma squared = 0.1099
sigma = 0.3315

90% 2-sided conf. limit	
df	student's t
2	2.92
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.86
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761

SIM & Conventional Tests on 8XT

Test Report	Product	time, log hrs	%UTS	Rupture	Runout	logti-logtbar	(logti-logtbar)2	Pi - Pbar	(Pi-Pbar)2	K * L	
	8XT	6.8129	64.35	64.35		3.23	10.4522	-11.80	139.1327	-38.1345	SIM
	8XT	5.8708	69.30	69.30		2.29	5.2481	-6.85	46.86025	-15.6821	SIM
	8XT	4.6272	71.77	71.77		1.05	1.0968	-4.38	19.1446	-4.58234	SIM
	8XT	3.9427	74.25	74.25		0.36	0.1316	-1.90	3.592748	-0.68764	SIM
	8XT	4.1056	76.73	76.73		0.53	0.2763	0.58	0.341693	0.307286	SIM
	8XT	2.4988	79.20	79.20		-1.08	1.1688	3.05	9.330248	-3.30232	SIM
	8XT										SIM
	8XT										SIM
	8XT	1.5999	82.00	82.00		-1.98	3.9205	5.85	34.2757	-11.5922	Conv
	8XT	2.3395	82.00	82.00		-1.24	1.5386	5.85	34.2757	-7.26207	Conv
	8XT	2.3436	80.00	80.00		-1.24	1.5285	3.85	14.85752	-4.76544	Conv
	8XT	2.4203	80.00	80.00		-1.16	1.3447	3.85	14.85752	-4.46979	Conv
	8XT	2.8178	78.00	78.00		-0.76	0.5808	1.85	3.439339	-1.41338	Conv
	8XT	3.1714	78.00	78.00		-0.41	0.1669	1.85	3.439339	-0.75761	Conv
	8XT										Conv
	8XT										Conv
	8XT										Conv
	8XT										Conv
	Sum	39.3791	837.60		Sum	-0.41	27.4540	1.85	323.5474	-92.3422	
	Mean	3.5799	76.15								

* runout plotting below the regression line is not included in the regression

8XT - 2000 hrs (log 3.301)			8XT - 50000 hrs (log 4.699)		
log tL - lower =	2.67	77.1577	log tL - lower =	4.06	72.2606
log tL - upper =	3.93	77.1577	log tL - upper =	5.34	72.2606

24XT - logtL @ Load = 3.49 **OK** **24XT - logtL @ Load =** 5.06 **OK**

24XT - All Points
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.320467	-3.12045
intercept	28.22085	88.06176
R squared	0.998046	0.998046
	-2	94.30267
	10	56.85726
3.3010	77.76106 = 2000 hr intercept	
4.6990	73.39886 = 50000 hr intercept	

8XT - All Points
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.285463	-3.50308
intercept	25.32671	88.72148
R squared	0.959993	0.959993
	-2	95.72763
	10	53.69068
3.3010	77.15771 = 2000 hr intercept	
4.6990	72.26061 = 50000 hr intercept	

All Creep Data 8XT & 24XT (conv & SIM)
time is dependent variable:

	if time were the y axis	but time is the x axis
slope	-0.298388	-3.35134
intercept	26.38553	88.42702
R squared	0.962598	0.962598
	-2	95.12971
	10	54.91357
5.8176	68.93024 = 75-yr intercept	
5.9425	68.51165 = 100-yr intercept	

Table F-4. Computation table for composite creep rupture envelope for the Miragrid XT geogrid product line (in support of Figure 5-1).

Stress, % of UTS

product:	data for regression calculation	loghrs	all	2XT	24XT	8XT	sim rupture	rlt rupture	conv''l rupture	sim runout*	conv'l runout*
	2XT	5.5711	70.00	70.00			70.00				
	2XT	3.7918	73.99	73.99			73.99				
	2XT	2.7248	76.99	76.99			76.99				
	2XT	1.9786	80.00	80.00			80.00				
	24XT	6.3928	68.00		68.00		68.00				
	24XT	5.4707	71.00		71.00		71.00				
	24XT	4.2798	75.00		75.00		75.00				
SIM	24XT	2.8434	79.00		79.00		79.00				
DATA:											
	8XT	6.8129	64.35			64.35	64.35				
	8XT	5.8708	69.30			69.30	69.30				
	8XT	4.6272	71.77			71.77	71.77				
	8XT	3.9427	74.25			74.25	74.25				
	8XT	4.1056	76.73			76.73	76.73				
	8XT	2.4988	79.20			79.20	79.20				
CONV											
DATA:	8XT	1.5999	82.00			82.00			82.00		
	8XT	2.3395	82.00			82.00			82.00		
	8XT	2.3436	80.00			80.00			80.00		
	8XT	2.4203	80.00			80.00			80.00		
	8XT	2.8178	78.00			78.00			78.00		
	8XT	3.1714	78.00			78.00			78.00		

NOTE: Don't include runouts in the regression calculation unless the points lie above the line

SIM & Conventional - 2XT
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.362004	-2.7624	
intercept	30.75553	84.9592	
R squared	0.984141	0.98414	
	-2	90.484	
	10	57.3352	
	6	68.38478	= 114 Year intercept
	5.817863	68.88791	= 75 Year intercept

SIM & Conventional - 24XT
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.320467	-3.1205	
intercept	28.22085	88.0618	
R squared	0.998046	0.99805	
	-2	94.3027	
	10	56.8573	
	6	69.33906	= 114 Year intercept
	5.817863	69.90741	= 75 Year intercept

SIM Only - 8XT
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.27603	-3.6228	
intercept	24.68277	89.4206	
R squared	0.939709	0.93971	
	-2	96.6662	
	10	53.1927	
	5.999706	67.68493	= 114 Year intercept
	5.817863	68.34371	= 75 Year intercept

SIM & Conventional - 8XT
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.286105	-3.4952	
intercept	25.36552	88.658	
R squared	0.960264	0.96026	
	-2	95.6485	
	10	53.7059	
	5.999706	67.68776	= 114 Year intercept
	5.817863	68.32334	= 75 Year intercept

SIM Only - All
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.3140648	-3.1840561	
intercept	27.4475609	87.3945745	
R squared	0.93666255	0.93666255	
	-2	93.7626867	
	10	55.5540132	
	5.99970632	68.2911728	= 114 Year intercept
	5.81786273	68.870173	= 75 Year intercept

SIM & Conventional - All
time is dependent variable:

	if time were the y axis	but time is the x axis	
slope	-0.3058047	-3.2700614	
intercept	26.8534688	87.8124921	
R squared	0.95013202	0.95013202	
	-2	94.3526149	
	10	55.111878	
	5.99970632	68.193084	= 114 Year intercept
	5.81786273	68.7877237	= 75 Year intercept

The regression for the all creep tests on the primary product (8XT) produced log 3.3010 hr (2,000 hrs) and log 4.6990 hr (50,000 hrs) intercepts at 77.16% and 72.26% UTS, respectively. The regression for the creep tests on 2XT & 24XT produced log time intercepts for the same %UTS within the 90% confidence limits of log 2.67 to log 3.93 and log 4.06 to log 5.34 associated with those %UTS. This evaluation is summarized in Table F-5. Thus, the primary, 8XT, and secondary products, 2XT & 24XT, data may be used together to construct the characteristic creep rupture curve of the family of products. Confidence limits satisfied per T925.

Table F-5. Summary of statistical comparison between rupture envelopes for all tested XT geogrid products, to test validity of composite creep rupture envelope for product line.

Product	Intercept at log 3.3010 & 4.6990 hrs, %UTS	Intercept at same % UTS, log hrs	90% Confidence Limits @ Higher %UTS, log hrs	90% Confidence Limits @ Lower %UTS, log hrs
8XT	77.16 & 72.26	3.3010 & 4.6990	-	-
2XT		2.82 & 4.60	2.67 to 3.93	4.06 to 5.34
24XT	-	3.49 & 5.06	2.67 to 3.93	4.06 to 5.34

Appendix G: Durability Detailed Test Results

Table G-1. Yarn test results to evaluate susceptibility to hydrolysis

Material: Polyester Yarn
Product Identification: Uncoated 3XT
TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER			MEAN	STD. DEV.
	1	**2**	**3**		
Carboxyl End Group (CEG) Count (Test Method: GRI GG7)					
mmol/Kg	15.0	15.4	15.2	**15.2**	0.2
Molecular Weight (Test Method: GRI GG8)					
Mn (Number average molecular weight)	34,765	34,760	35,040	**34,855**	160

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table G-2. UV resistance test results of 2XT geogrid.

TRI Log #: E2280-56-08

PARAMETER	TEST REPLICATE NUMBER					MEAN	STD. DEV.	PERCENT RETAINED
	1	**2**	**3**	**4**	**5**			
UV Resistance (ASTM D 4355)								
Strength Retained measured via single strip tensile (ASTM D 6637, Method A, mod.)								
MD - Number of Ribs per foot:	10.84							
MD - Tensile Strength (lbs) - B	245.1	248.1	243.3	250.5	248.3	**247**	3	
MD - Tensile Strength (lb/ft) - B	2657	2689	2637	2715	2691	**2678**	31	
MD - Tensile Strength (kN/m) - B	38.8	39.3	38.5	39.6	39.3	**39.1**	0.5	
MD - Tensile Strength (lbs) - E	208.2	214.3	210.0	207.5	211.9	**210**	3	
MD - Tensile Strength (lb/ft) - E	2257	2323	2276	2249	2297	**2280**	30	**85**
MD - Tensile Strength (kN/m) - E	32.9	33.9	33.2	32.8	33.5	**33.3**	0.4	
MD - Elong. @ Max. Load (%) - B	10.7	10.9	10.8	10.7	11.0	**10.8**	0.1	
MD - Elong. @ Max. Load (%) - E	10.1	10.8	10.1	10.4	10.1	**10.3**	0.3	**95**

B - Baseline Unexposed
E - Exposed for 500 hours of ASTM D 4355 Cycle

MD - Machine Direction TD - Transverse/Cross Machine Direction

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested.

Table G-3. Summary of UV resistance test results for Miragrid 2XT geogrid.

Miragrid XT Series Style	Mean Baseline Tensile Strength (lb/ft)	Standard Deviation (lb/ft)	Mean Exposed Tensile Strength (lb/ft)	Standard Deviation (lb/ft)	% Strength Retained
2XT	2,678	31	2,280	30	85

(Conversion: 1 lb/ft = 0.0146 kN/m)

Appendix H: Creep Stiffness Detailed Test Results

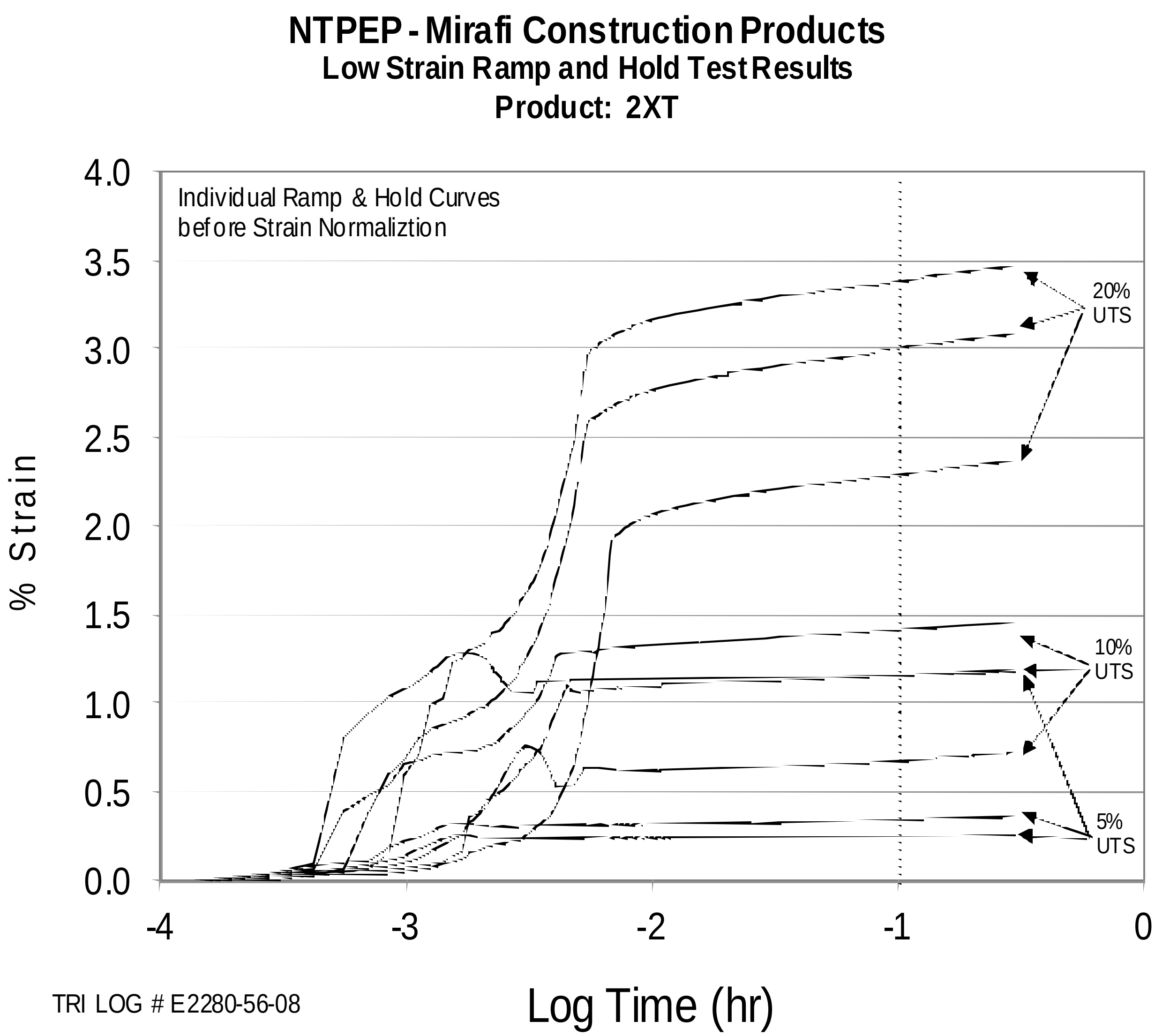


Figure H-1. Low strain ramp and hold tests for 2XT, before strain normalization.

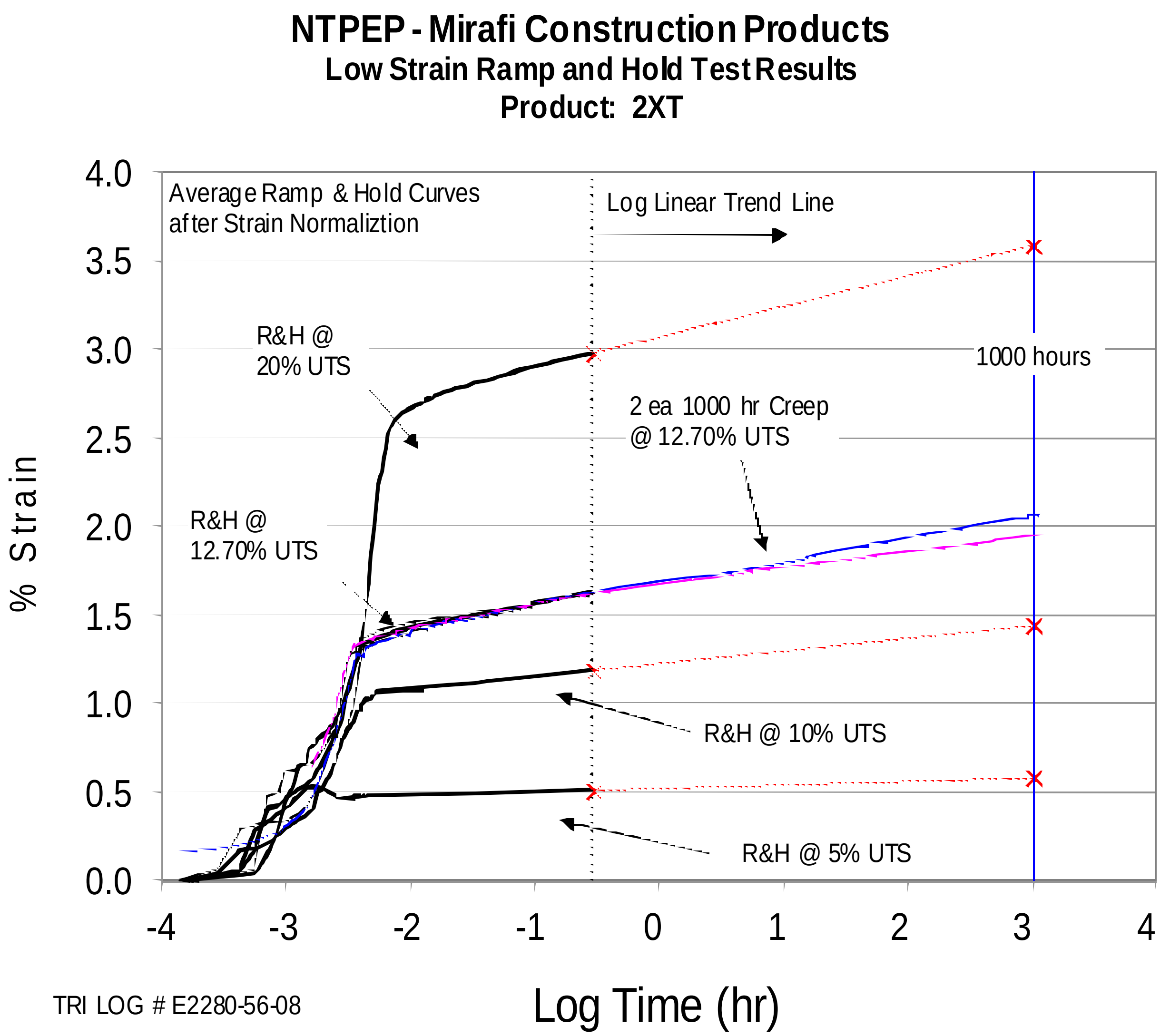


Figure H-2. Low strain ramp and hold tests for 2XT, after strain normalization, with 1000 hour low strain creep tests.

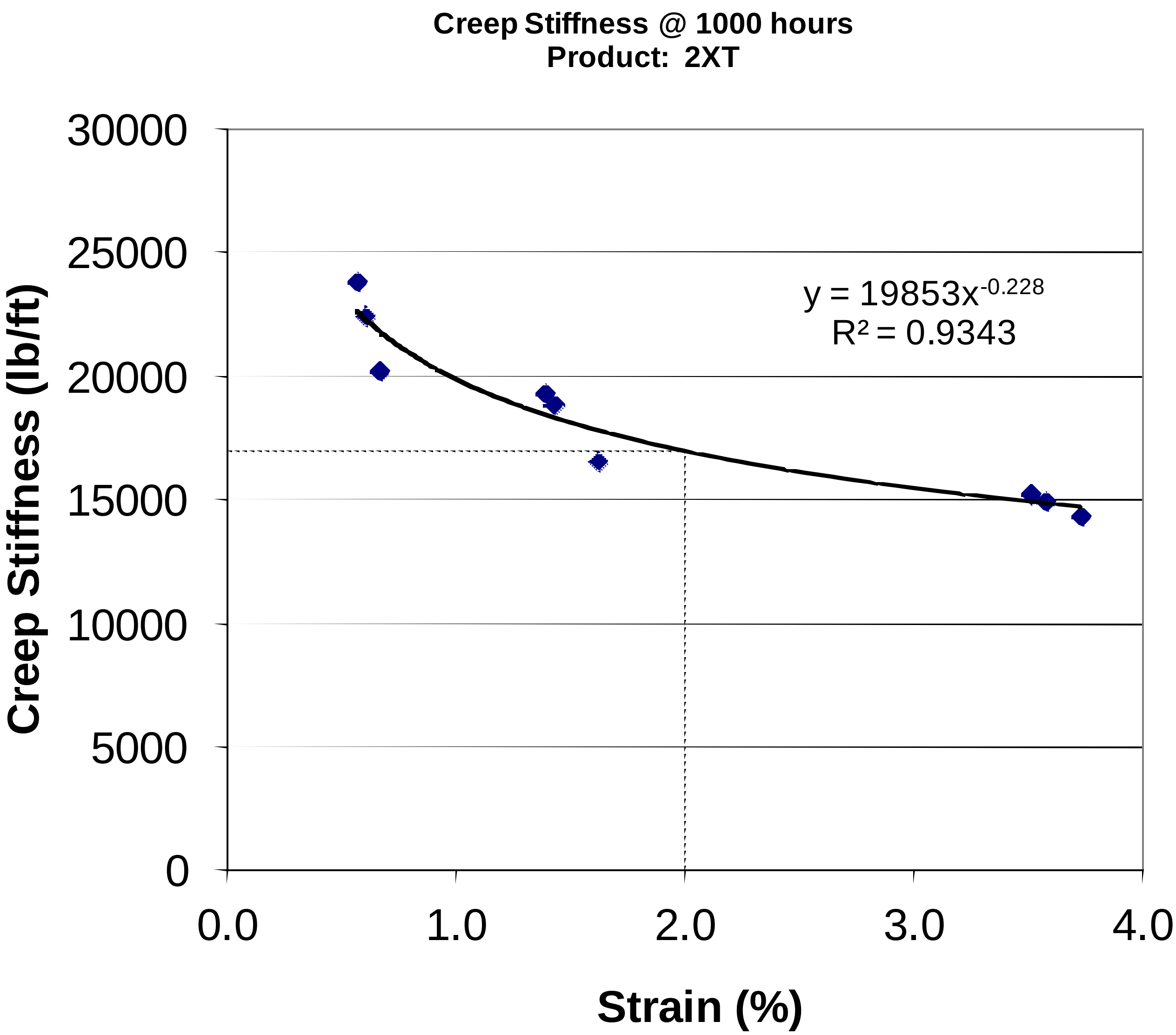


Figure H-3. Creep stiffness versus strain at 1,000 hours for 2XT.

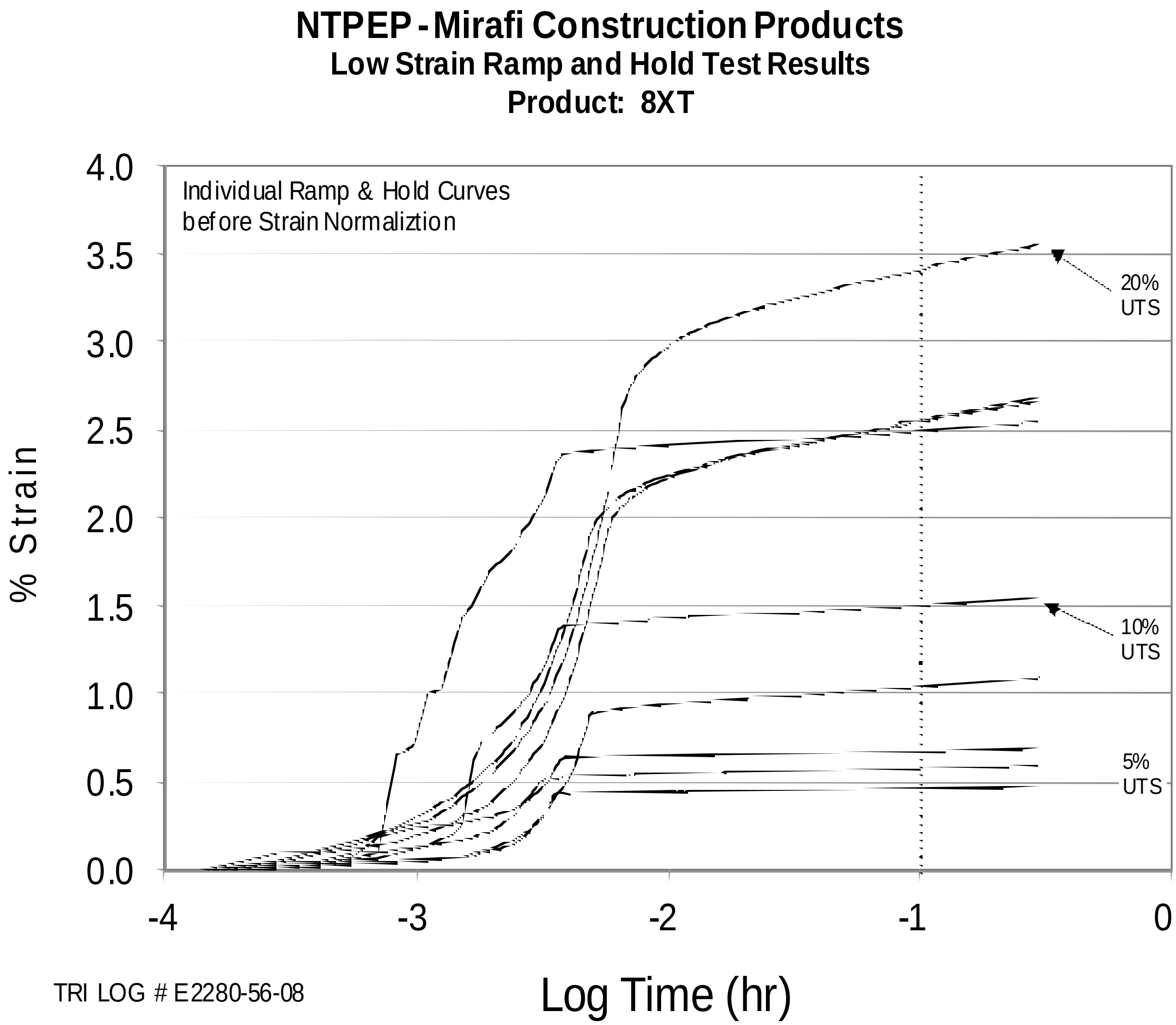


Figure H-4. Low strain ramp and hold tests for 8XT, before strain normalization.

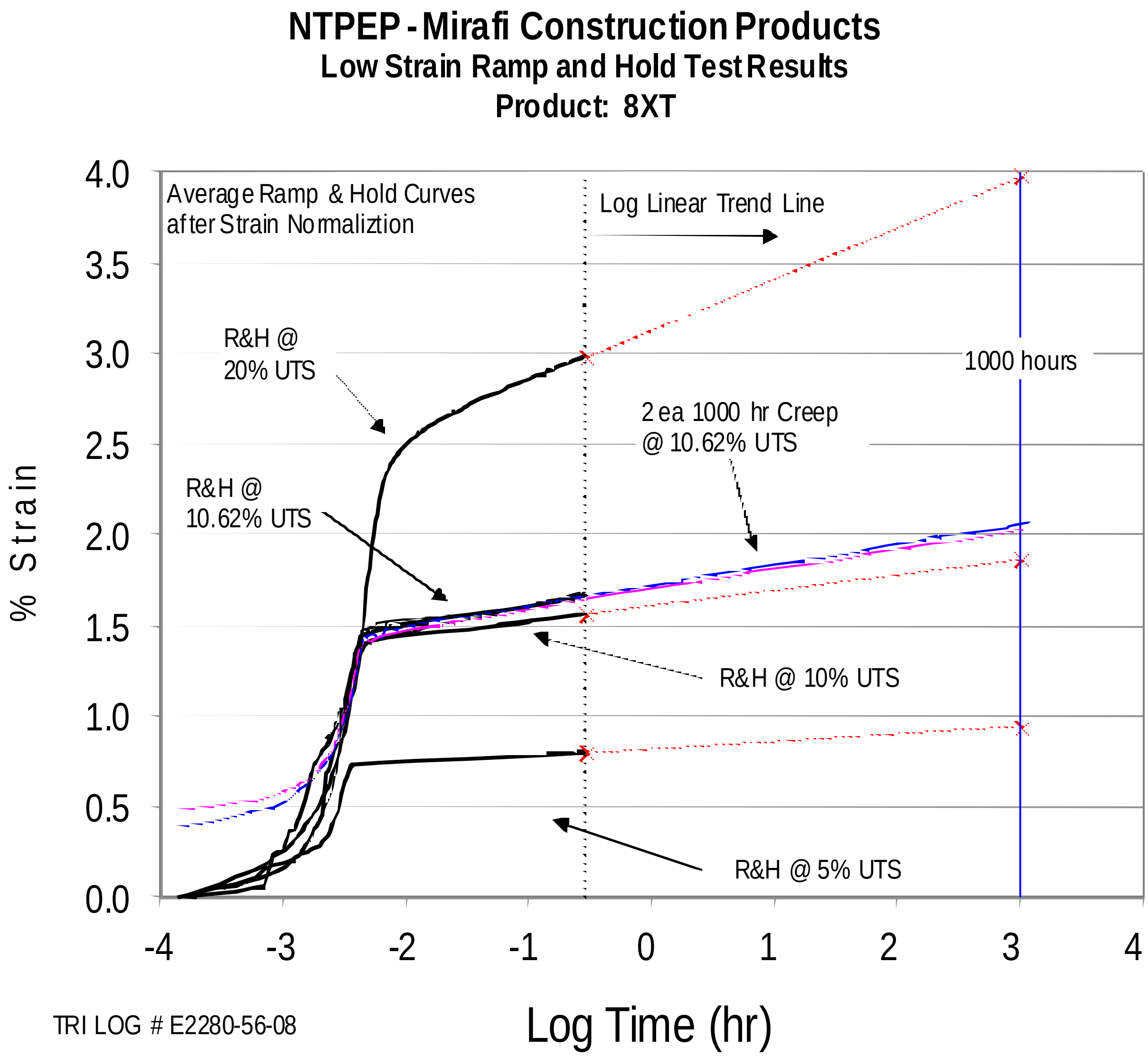


Figure H-5. Low strain ramp and hold tests for 8XT, after strain normalization, with 1000 hour low strain creep tests.

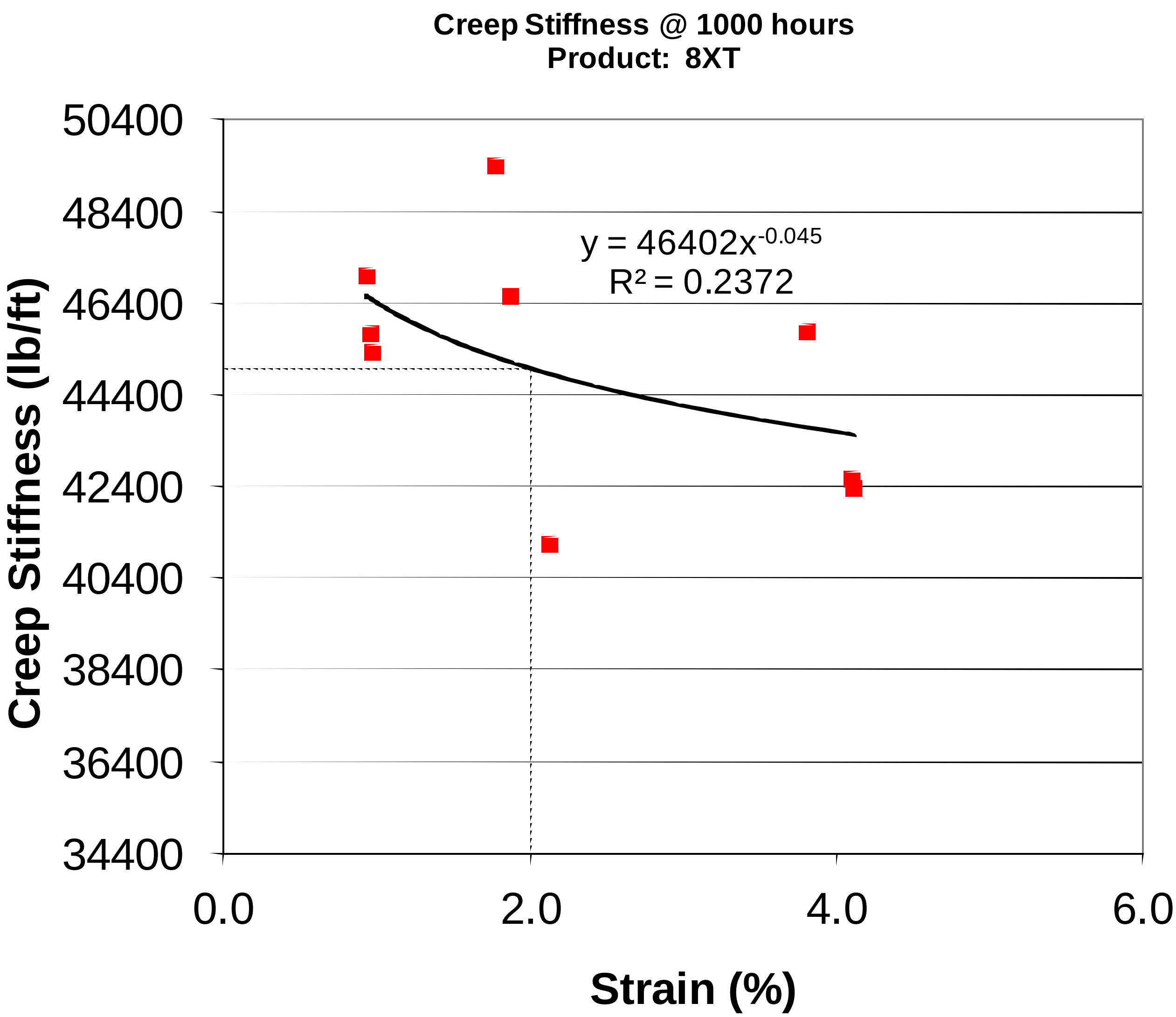


Figure H-6. Creep stiffness versus strain at 1,000 hours for 8XT.

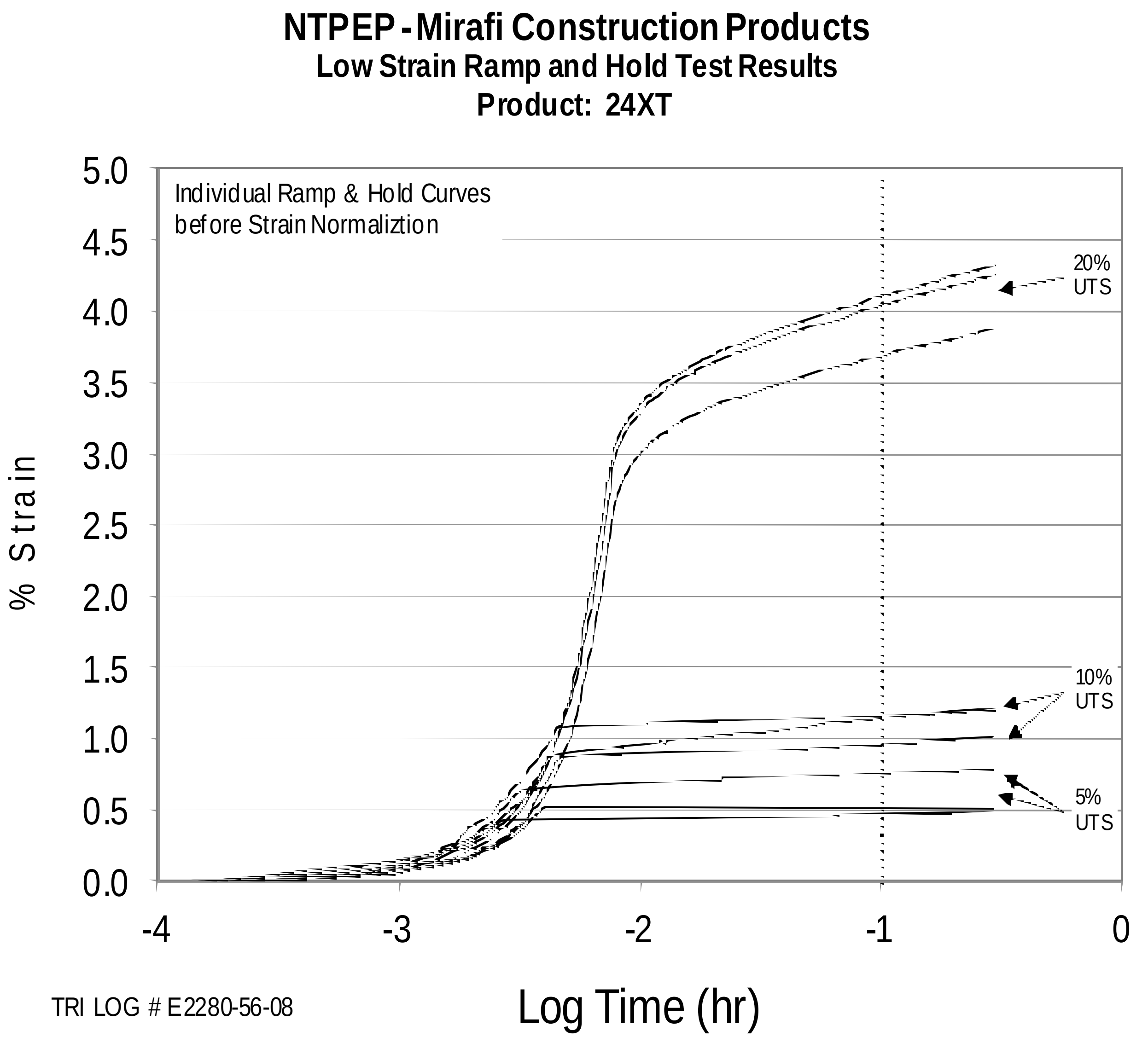


Figure H-7. Low strain ramp and hold tests for 24XT, before strain normalization.

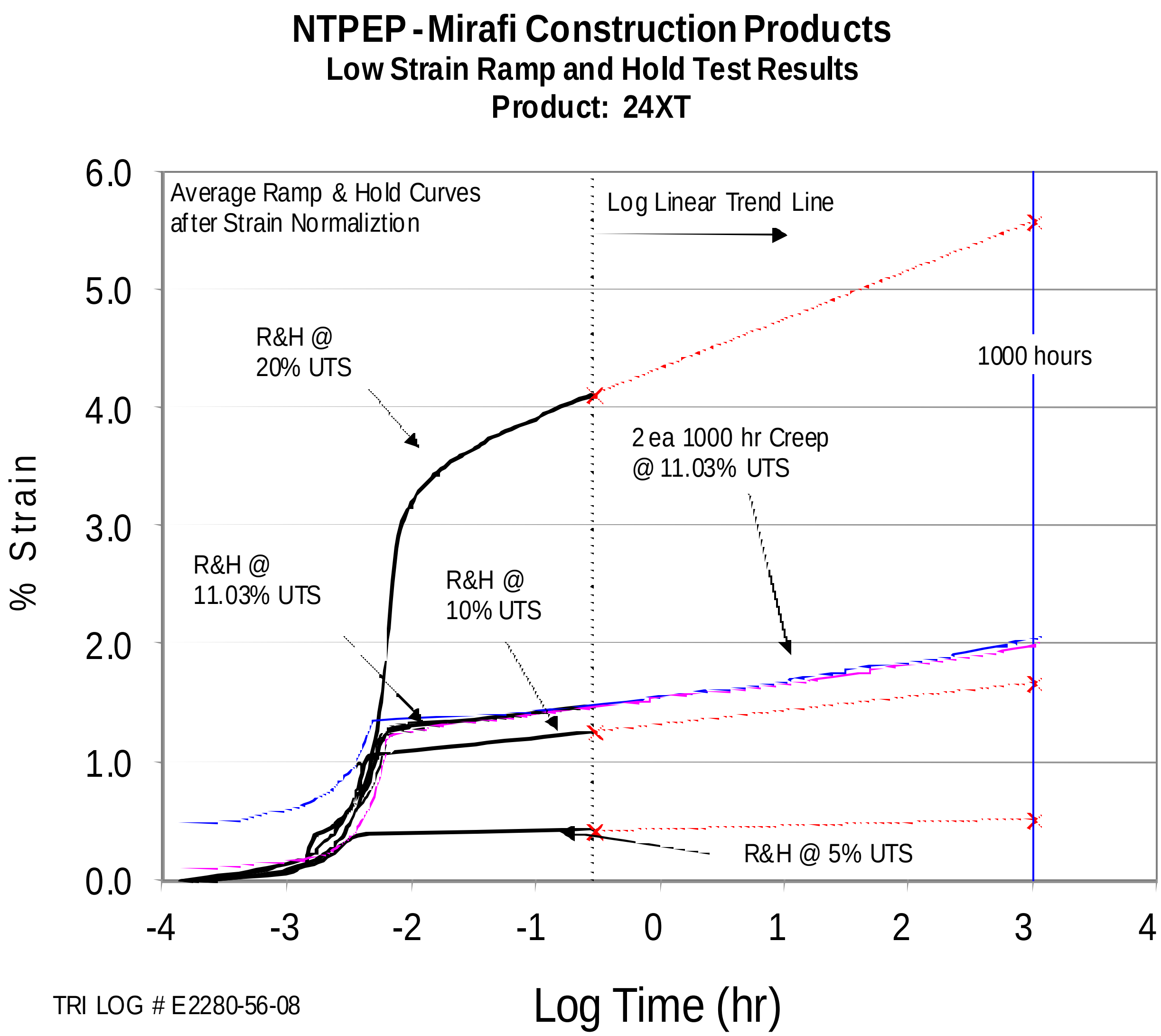


Figure H-8. Low strain ramp and hold tests for 24XT, after strain normalization, with 1000 hour low strain creep tests.

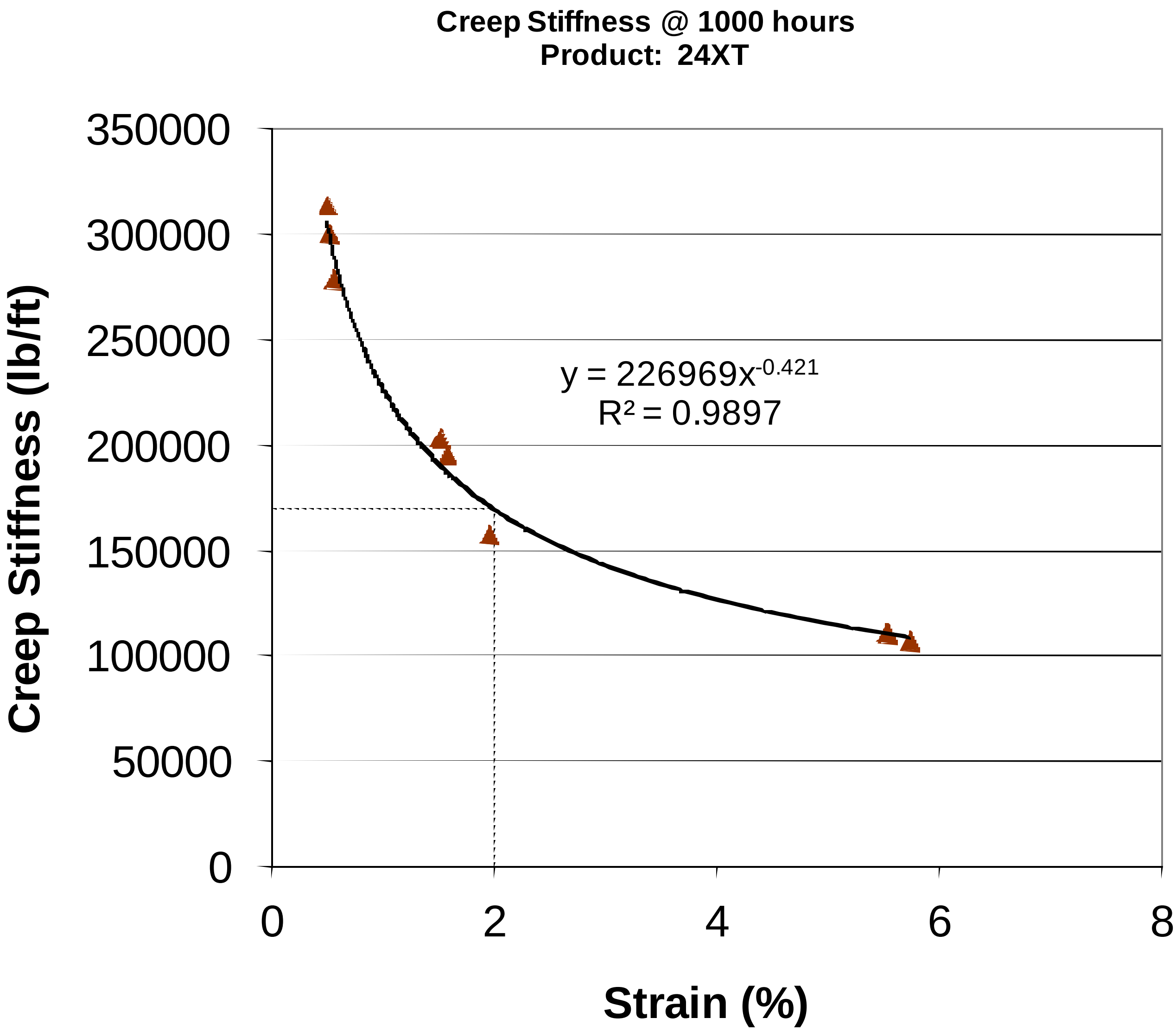


Figure H-9. Creep stiffness versus strain at 1,000 hours for 24XT.

"The National Transportation Product Evaluation Program (NTPEP) was established by the American Association of State Highway and Transportation Officials (AASHTO) in early 1994. The program pools the professional and physical resources of the AASHTO member departments in order to test materials, products and devices of common interest. The primary goals of the program are to provide cost-effective evaluations for the states by eliminating duplication of routine testing by the states; and to reduce duplication of effort by the manufacturers who produce and market commonly used proprietary, engineered products." **NTPEP**

-- Rick Smutzer (IN), former NTPEP Chairman

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