Pullout Testing
of
Xgrid PET PVC 40/20 IT
and
Xgrid PET PVC 80/30 IT
In Sand

February, 2006

Submitted to:

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Submitted by:
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February 1, 2006

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Subject: Pullout Tests of Xgrid PET PVC 40/20 IT and PET PVC 80/30 IT in Sand

Dear Dr. Peterle:

This letter report presents the results for large-scale pullout tests performed on Xgrid PET PVC 40/20 IT and PET PVC 80/30 IT in Sand. Included are data developed for a range of normal compressive loads. All testing work was performed in general accordance with the ASTM D 6706, *Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil*. Generated results were used to develop general pullout resistance versus normal load curves.

TRI is pleased to present this final report. The data presented herein appears to be consistent with commonly reported values. Please feel free to call if we can answer any questions or provide any additional information.

Sincerely,

C. Joel Sprague, P.E.
Senior Engineer
Geosynthetics Services Division

Cc: Sam Allen, John Allen - TRI

PULLOUT RESISTANCE REPORT

Xgrid PET PVC 40/20 IT and PET PVC 80/30 IT in Sand

TESTING EQUIPMENT AND PROCEDURES

Overview of Test and Apparatus

TRI/Environmental, Inc.'s (TRI's) large-scale pullout box is a custom-made apparatus measuring, nominally, 762mm wide x 610mm high x 1.52m long. Soil is placed beneath and above the geosynthetic layer. Horizontal force is then applied to the geosynthetic and the force required to pull the geosynthetic out of the soil is recorded. Pullout resistance is obtained by dividing the maximum load attained by the test specimen width. Graphs of pullout resistance versus deformation at various points along the geosynthetic are generated for various applied normal stresses.

Geosynthetic

The following geosynthetic material was evaluated.

Table 1. Geosynthetic Reinforcement Tested

	As-Received	Specification
Wide-width tensile strength – MD, ASTM D 6637:		
Xgrid PET PVC 40/20 IT	41.1 kN/m	40 kN/m
Xgrid PET PVC 80/30 IT	71.8 kN/m	80 kN/m

Backfill Material

Backfill soil as described in Table 2 was placed below and above the geosynthetic.

Table 2. Backfill soil material

	As-Received	Specification
Backfill	See Appendix	Sand

Preparation of the Test Specimens

After the test soil was remolded into the lower half of the pullout box, the geosynthetic test specimen was placed over the prepared soil layer. Strain extensometers were mounted onto the geosynthetic in such a way as to not disturb the material during testing. These "Tell-tails" mounted to the geosynthetic were used to monitor movement of the geosynthetic at various points along its length during the test. A layer of soil was then placed and compacted above the geosynthetic specimen. A rigid steel platen was then placed upon the soil and the load was applied using a large air bladder. All soil was compacted to 95% modified Proctor density.

Specific Test Procedure

All testing was performed using one test replicate (or run) per normal compressive load. The specimens were pulled out at a constant rate of 1 mm per minute (0.04 inches/min). The range of normal loads chosen for testing and the equivalent soil depths are shown in Table 3. During the entire test, normal load, tensile load, and geosynthetic displacement at the front of the pullout box and at points along the geosynthetic were recorded at regular time intervals. The test was continued until there was a sustained loss of tensile resistance due to either rupture of the reinforcement or reinforcement pullout. The type of pullout failure - slippage at the soil-geosynthetic interface or rupture of the geosynthetic or partial geosynthetic rupture/slippage - was identified and recorded.

TEST RESULTS

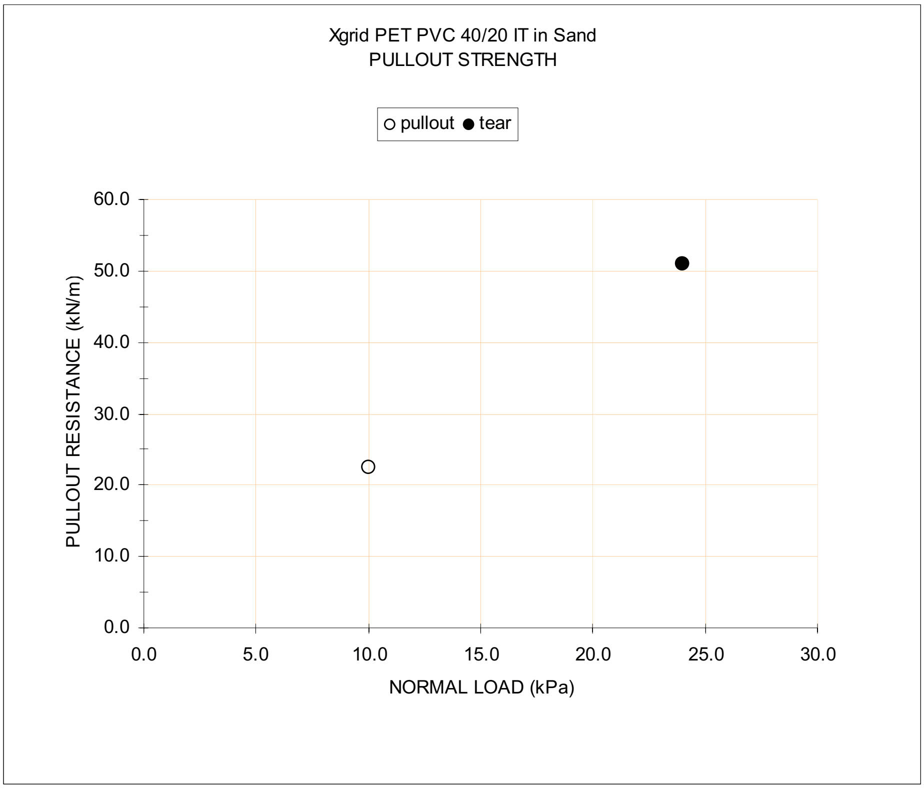
The pullout resistance of soil reinforcement is commonly defined by the maximum pullout force required to cause outward sliding of the reinforcement through the soil. Pullout resistance is obtained by dividing the maximum load attained by the test specimen width. Graphs of pullout resistance versus deformation at various points along the geosynthetic are also generated for each applied normal stresses and are shown in the appendix. Test results are summarized in Table 3.

Note: Geogrid rupture occurred rather than pullout.

Table 3. Summary of Pullout Test Results
Soil(s): Sand (φ = 43.4°)
Geosynthetic Type: Xgrid PET PVC 40/20 IT and PET PVC 80/30 IT

Test #	Width of Geogrid (m)	Embedment Length Initial (m)	Normal Load (kPa)	Approx. Soil Depth (m)	Peak Tensile Capacity (kN/m)	Mode of Failure	Pullout Interaction Coefficient*, C_i
PET PVC 40 30 IT							
1	0.6	1.2	10	0.3	22.5	Pullout	0.99
2	0.6	1.2	24	1.1	51.0	Rupture	0.94
PET PVC 80 30 IT							
1	0.6	1.2	20	2.3	42.0	Pullout	0.93
2	0.6	1.2	45	2.3	77.5	Rupture	0.76

Geosynthetic Tensile Strength (ASTM D 6637) = 40 and 80 kN/m
$C_i = P / (C \sigma'_v L_e \tan\varphi)$ Where: P = pullout resistance per unit width; C = effective unit perimeter - 2 for geosynthetics; σ'_v = effective vertical stress; L_e = embedment length
(* Note: A soil's φ angle is normal load dependent.)


Xgrid PET PVC 40/20 IT in Sand
PULLOUT STRENGTH
pullout
tear
PULLOUT RESISTANCE (kN/m)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
NORMAL LOAD (kPa)

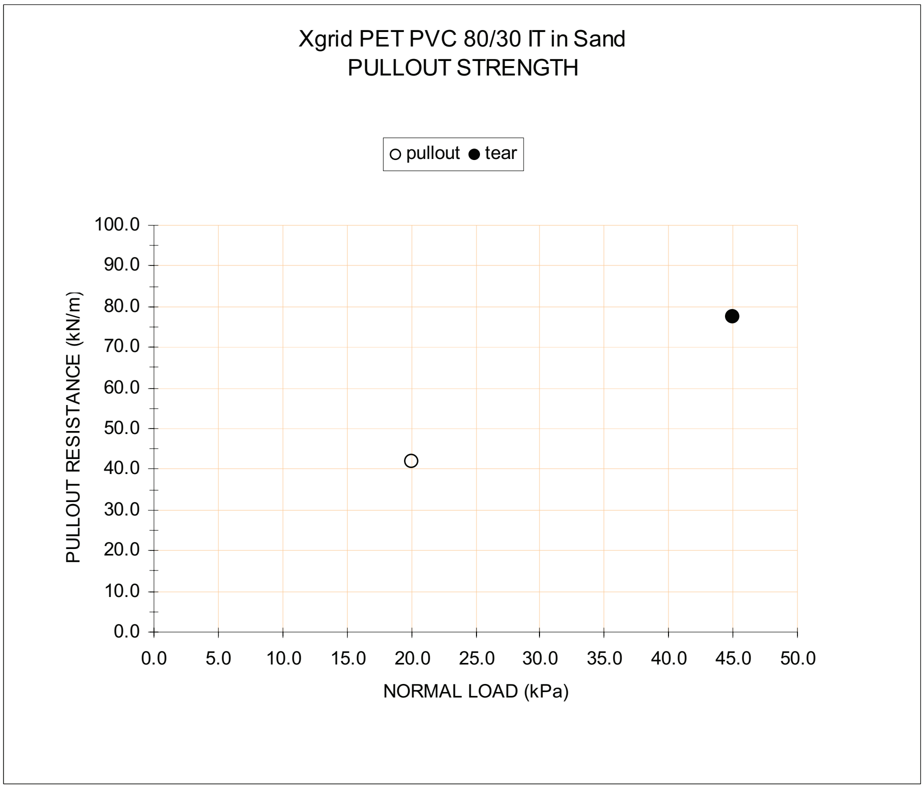
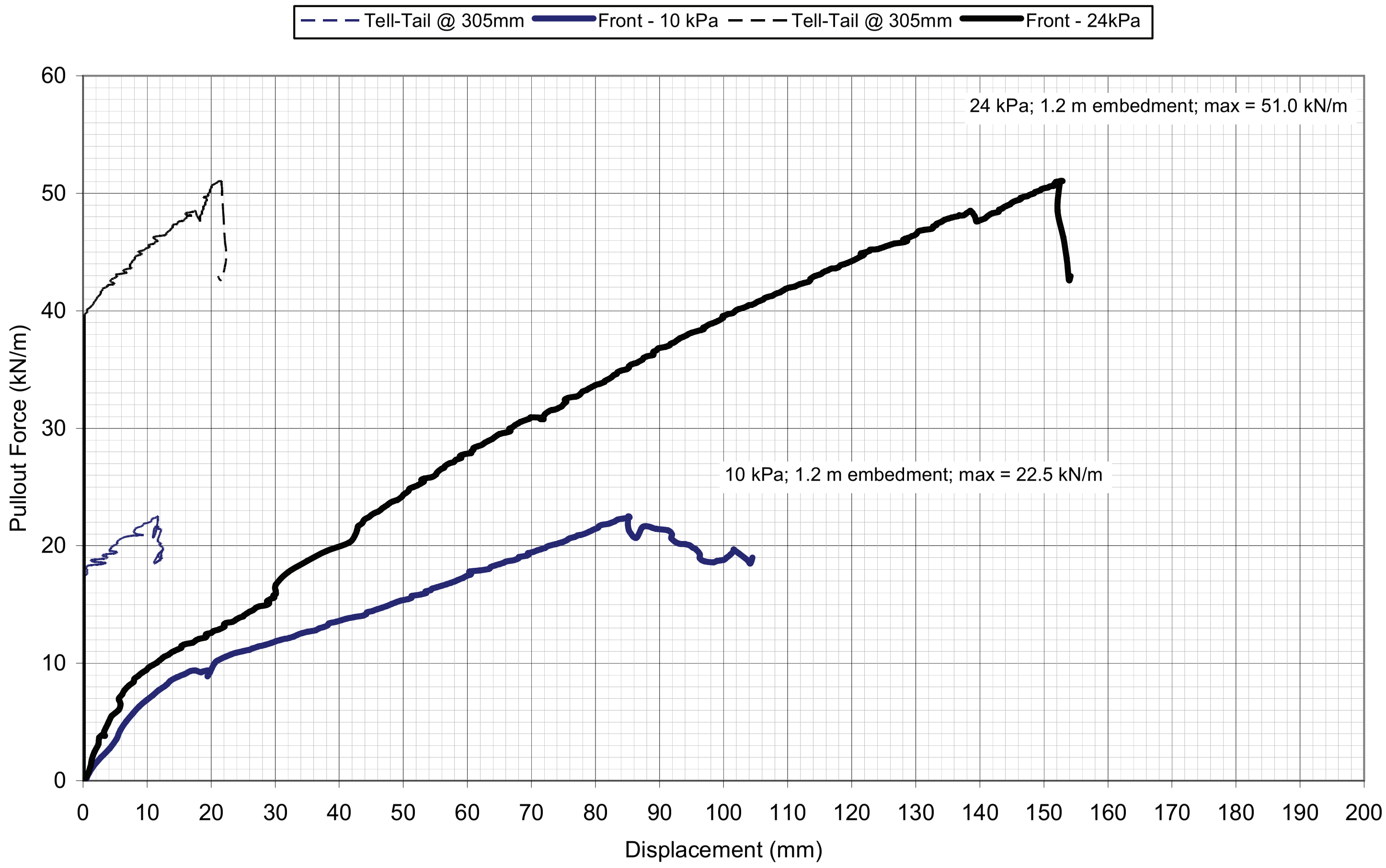

Xgrid PET PVC 80/30 IT in Sand
PULLOUT STRENGTH
pullout
tear
PULLOUT RESISTANCE (kN/m)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
NORMAL LOAD (kPa)

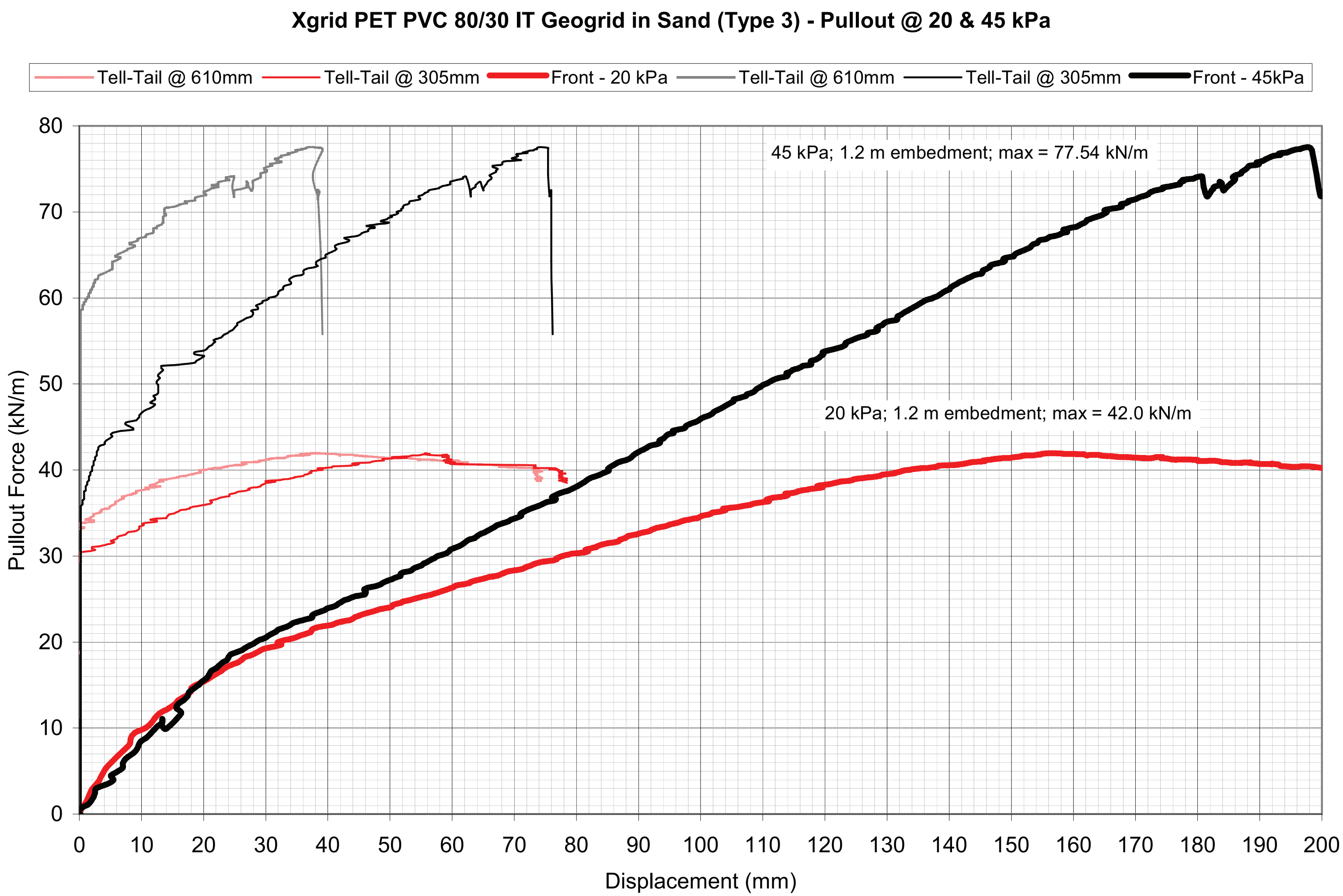
Figure 1. Pullout Box and Tell-tails in a Typical Test

APPENDIX A – RECORDED DATA

Normal Load / Pullout Force vs. Pullout Displacement Curves

Xgrid PET PVC 40/20 IT Geogrid in Sand (Type 3) - Pullout @ 10 & 24 kPa




Xgrid PET PVC 80/30 IT Geogrid in Sand (Type 3) - Pullout @ 20 & 45 kPa
Tell-Tail @ 610mm
Tell-Tail @ 305mm
Front - 20 kPa
Tell-Tail @ 610mm
Tell-Tail @ 305mm
Front - 45kPa
45 kPa; 1.2 m embedment; max = 77.54 kN/m
20 kPa; 1.2 m embedment; max = 42.0 kN/m
Pullout Force (kN/m)
Displacement (mm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

APPENDIX B – BACKFILL SOIL

The grain size distribution curves of the backfill soils used in the pullout test are shown in Figure B-1. Backfill soil was moistened and compacted in-place.

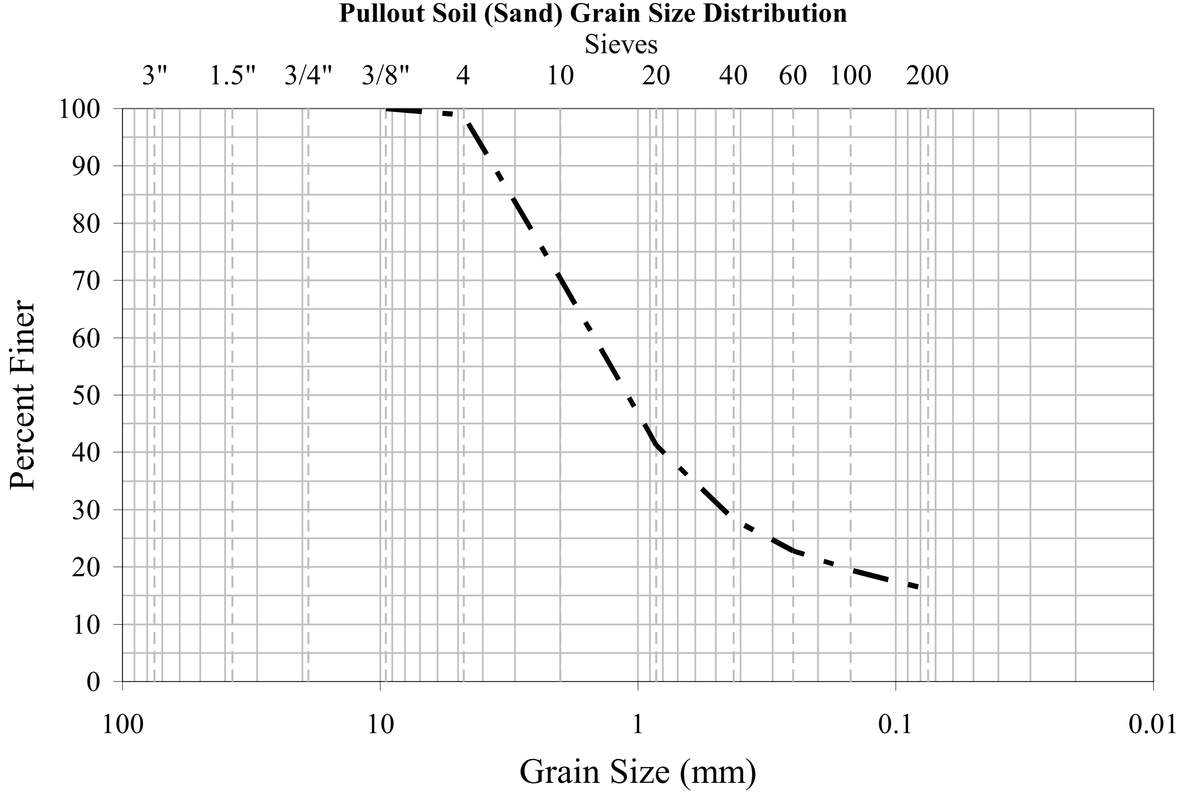


Figure B-1. Backfill soil grain size distribution curve