Research Brief

Wisconsin Highway Research Program
Project 0092-15-07
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Correlation of Geotextile Puncture Test Methods

Research Objectives

- Correlate the CBR and pin puncture strengths for various categories of woven and non-woven, PP geotextiles
- Develop new puncture strength standards for geotextiles

Research Benefits

- Established a correlation between the CBR puncture strength and pin puncture tests for woven and nonwoven PP materials
- Recommended a transition to the new ASTM D6241 puncture test standard that does not bias the factor to woven specimens
- Confirmed that woven PP geotextiles exhibit puncture strength approximately double that of nonwoven PP materials with the same mass per unit area

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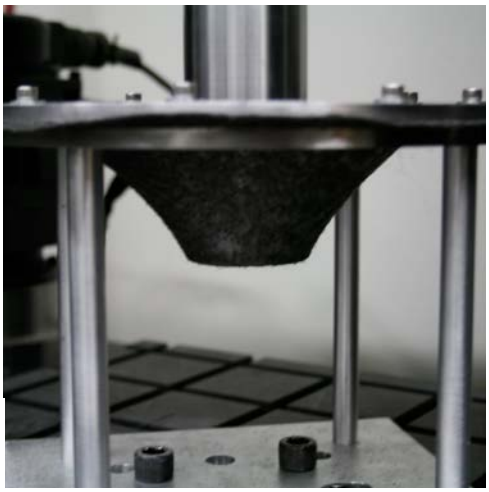
Background

Geotextiles are commonly used in pavements, earth retaining structures, landfills and other geotechnical contexts. Various tests are conducted to evaluate and classify geotextiles to determine their suitability for each of these applications. The ASTM standard recently changed from the standard pin puncture strength test, D4833, to the California bearing ratio (CBR) puncture strength test, D6241; however, transportation authorities across the country still vary in their standards. The objective of this research was to correlate the CBR and pin puncture strengths for various categories of geotextiles, regardless of weave type and mass per unit area. Deterioration of geotextiles due to freeze-thaw conditioning as well as ultraviolet (UV) light exposure were also investigated.

Methodology

Woven and non-woven geotextiles of various polypropylene (PP) materials were collected from manufacturers and WisDOT projects and evaluated according to ASTM D4833 (pin) and ASTM D6241 (CBR) procedures. Samples were cut along the material diagonal in sizes of 120mm-diameter for the ASTM D4833 standard and 240mm-diameter for the ASTM D6241 standard. Samples were taken parallel to one another and over the same material width to reduce the impact of variability in material location on the results. Each sample was affixed to the corresponding ASTM test fixture, and the puncture rod was lowered at a constant rate of extension (CRE) until it completely ruptured the sample.

To test for effects on puncture strength from UV and environmental exposure, specimens were subjected to temperatures of 140°F and UV light with typical radiation of 0.89 W/m2/nm in a specially designed chamber before puncture testing. In order to investigate the effect of climate conditions on puncture strength of geotextiles, specimens were also subjected to various cycles of freeze-thaw conditioning. Samples were fully submerged in water within an insulated drawer and run through cycles between 15°F and 45°F.



Fibers extend before rupture during a CBR puncture test.

"The geotextile industry has transitioned away from determining puncture strength by ASTM D4833 (pin) and has adopted ASTM D6241 (CBR) as the new standard. This research allows WisDOT to confidently update our specifications to reflect the current industry standards and more accurately specify what type of geotextile is needed for specific applications."
– Andy Zimmer, WisDOT

Interested in finding out more?

Final report is available at:
WisDOT Research website.

Results

For woven materials, the pin puncture load at failure ranged from 88 lbs (391 N) to 110 lbs (489 N) with an average of 99 lbs (440 N) and coefficient of variation equal to 6.6%. The CBR puncture load at failure ranged from 693 lbs (3,083 N) to 762 lbs (3,390 N) with an average of 733 lbs (3,261) and coefficient of variation equal to 2.8%.

For non-woven materials, the pin puncture load at failure ranged from 56 lbs (250 N) to 94 lbs (418 N) with an average of 73 lbs (324 N) and coefficient of variation of 13.3%. The CBR puncture load at failure ranged from 324 lbs (1,441 N) to 457 lbs (2,033 N) with an average of 362 lbs (1,611) and coefficient of variation of 11.4%.

Woven materials exhibited a CBR puncture strength approximately double that of nonwoven materials with the same mass per unit area, a finding consistent with industry standards.

The freeze-thaw conditioning showed minor levels of degradation on the puncture test; however, UV and weathering tests showed significant degradation in the puncture strength after exposure.

Recommendations for Implementation

The researchers proposed new limits based on the testing performed. The new results are not biased against woven specimens, which would achieve the highest benefit from adopting the CBR standard.

The researchers also proposed including the UV Radiation Stabilization ASTM D4355 standard of 50% retention of strength for 500 hours of exposure in the field.

This brief summarizes Project 0092-15-07,
"Correlation of ASTM D4833 and D6241 Geotextile Puncture Test Methods and Results for Use on WisDOT Projects"
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