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Application Note

Geotextiles

Static Puncture Strength of Geotextile Products Using a 50mm Probe

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Geotextiles

1. Introduction

Geotextiles are permeable geosynthetic materials, typically made from polypropylene or polyester, available in woven and non-woven forms. They provide separation, filtration, drainage, and reinforcement, improving soil stability, load distribution, and the durability of infrastructure such as roads, railways, embankments, landfills, and retaining structures.

During transportation, installation, and service geotextiles can be exposed to concentrated loads and sharp objects which can reduce the effectiveness of materials therefore puncture resistance is a critical parameter for evaluating geotextile durability. The puncture resistance of geotextiles are commonly determined as per ASTM D6241[1)] and ISO 12236[2)], which measures the force required to penetrate the fabrics using a standard plunger. Overall, puncture resistance testing plays a vital role in ensuring the long-term durability and reliability of geotextiles in demanding engineering applications.

The Shimadzu AGS-X2 series Universal Testing Machine is a high-precision universal testing system designed for accurate evaluation of mechanical properties such as tensile, compression, and puncture resistance. It features advanced control technology, high data acquisition rates, and reliable load measurement, ensuring consistent and reproducible results. The system is operated using TRAPEZIUMX-V software, enabling efficient test control, data acquisition, and analysis that complies with national and international standards.

2. Test Method

The test was conducted on the non-woven geotextile using the AGS-50kNX2D UTM, shown in the Figure 1. Two different samples (1000 and 400 GSM) were procured from the market and five specimens were prepared from various areas of each sample. Table 1 shows testing apparatus and test conditions and Figure 2 shows the typical clamping and loading system.

Table 1. Test conditions and apparatus

Test conditions	
Type of sample	Non-woven geotextile 1000 GSM and 400 GSM
Numbers of samples tested	1000 GSM: 5 400 GSM: 5
Atmosphere for testing	Humidity 50 to 70 % and temperature 19 to 23 ˚C
Conditioning	Equilibrium from as received
Testing speed	50 mm/min
Apparatus	
Testing Machine	AGS-50kNX2D with TRAPEZIUMX-V
Load cell	50kN (10 to 90 % of rupture)
Plunger	Diameter 50 mm, Radius 2.5 mm, polished
Clamping device	Internal diameter 150 mm, external diameter 250 mm , surfaces coarse sandpaper bonded

Fig. 1 AGS-50kNX2D

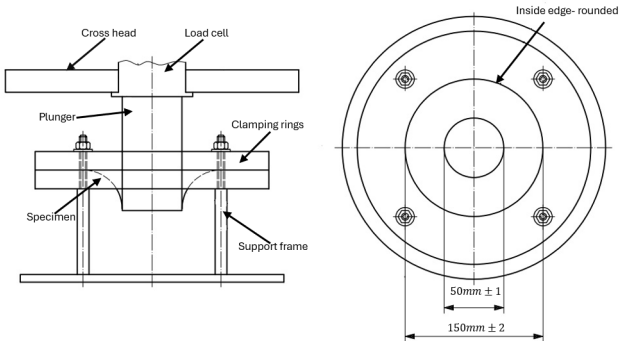


Fig. 2 Typical clamping and loading system

2.1. Sample Preparation

The specimens were brought to moisture equilibrium in the standard atmosphere for testing geotextiles (humidity 50 to 70% and temperature 19 to 23 ˚C). Equilibrium was considered to have been reached when the increase in mass of the specimen in successive weighing, made at intervals of not less than 2 hours, did not exceed 0.1% of the specimen's mass. Five specimens were taken from each sample in a randomly distributed pattern across the width, with no specimens taken nearer the selvage edge. The specimens were cut so that each edge extended at least 10 mm beyond the edge of the clamp. A representative sample is shown in Figure 3.

2.2. Test Setup

The test specimens were centered and secured between the holding rings, ensuring that each specimen extended beyond the outer edge of the clamping rings. Each specimen was marked along the inside circumference of the holding rings to monitor potential slippage during testing. In cases where slippage exceeded 5 mm, the test was discarded and a new specimen was used.

The load cell was selected within 10 to 90 % of the approximate maximum load. The mounting setup was positioned on the lower side of the machine and the plunger fixed on the upper side, ensuring it was precisely aligned at the center of the specimen. The testing method used in a compression mode and test started in a speed 50 mm/min until the plunger completely ruptured the specimen while ensuring there is no slippage obtained. Test setup and specimen during the testing are shown in Figure 4.

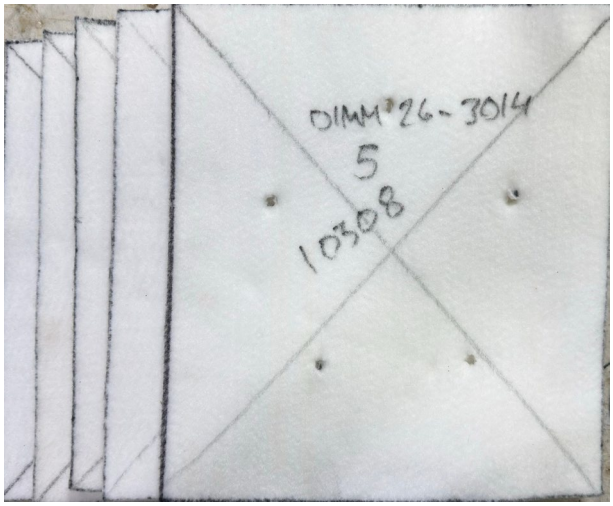


Fig. 3 Samples before clamping (after preparation).

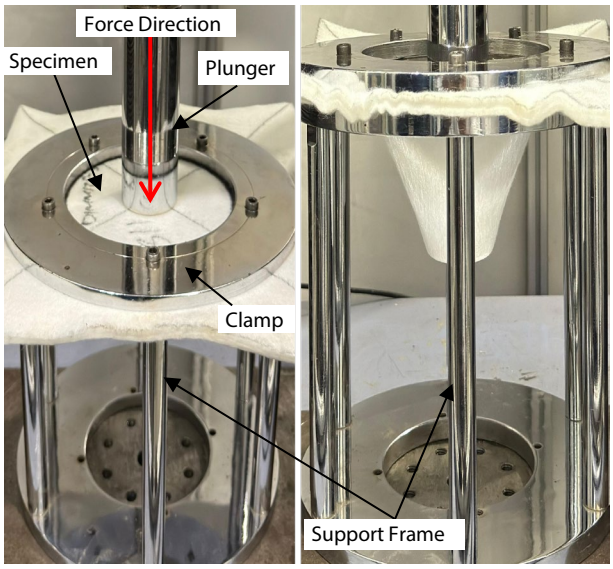


Fig. 4 Test setup and sample during test.

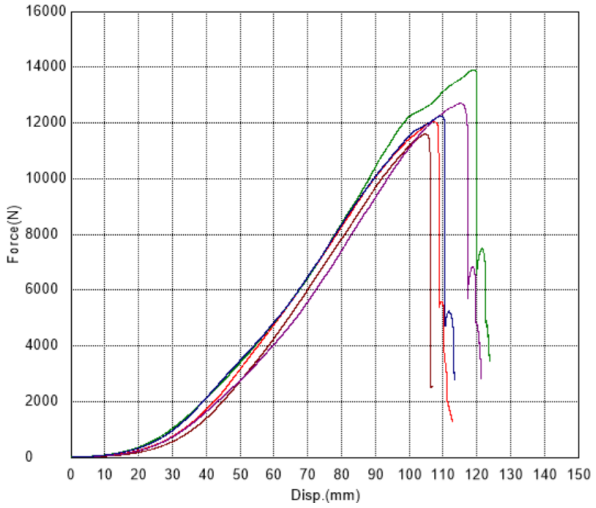
3. Results and Discussion

The maximum force obtained during the test was reported as the puncture strength in Newtons (N). Table 2 presents the five individual test results from each sample, along with the calculated average values for puncture strength and displacement at maximum force (mm). Figure 5 shows the overlay graph of load versus displacement observed during testing.

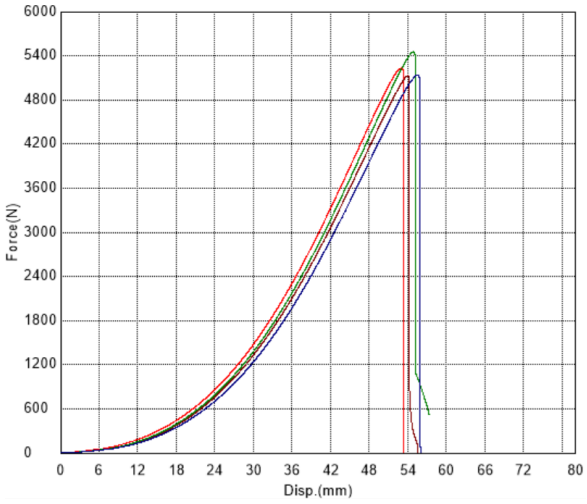
All reported values were taken from the first (initial) peak of the load–displacement curve. In cases where the material exhibited double peak behavior, the initial peak value was reported as the puncture strength, even if the second peak was higher. The results indicated the puncture resistance characteristics of the tested geotextile under static loading conditions. The load–displacement curves demonstrated the material response up to failure, including stiffness behavior prior to peak load. Reporting the initial peak ensured consistency with the standard and provided a reliable basis for comparison between different materials tested under the same conditions.

Table 2. Test results

Test results		
GSM/Sample No.	Puncture strength(Max Force), N	Displacement at Max force, mm
1000/1	12045	107.2
1000/2	11595	104.7
1000/3	12701	115.3
1000/4	13908	119.1
1000/5	12249	109.5
Average	**12500**	**111.2**
400/1	5234	53.1
400/2	5131	54.0
400/3	5372	54.0
400/4	5454	54.8
400/5	5137	55.6
Average	**5266**	**54.3**



(a) 1000 GSM



(b) 400 GSM

Fig. 5 Overlay graph of Load vs Displacement

4. Conclusion

The test results are consistent across multiple specimens and exhibit gradual deformation behavior. This indicates that the material can withstand high penetration forces without sudden failure, demonstrating its ability to effectively resist localized stresses.

Geotextiles are available in different GSM values, representing mass per unit area and directly influence their mechanical and physical performance. Lower GSM geotextiles are lighter, flexible and lower thickness making them suitable for applications involving moderate loads. In contrast higher GSM geotextiles are thicker and denser, offering significantly higher puncture resistance and making them suitable for heavy duty applications.

The Shimadzu's universal testing machine AGS-X2 series demonstrated accurate, stable, and repeatable performance for conducting puncture resistance testing in accordance with ASTM D6241 and ISO 12236. The system provided precise control of crosshead speed, reliable load measurement, and clear identification of the initial peak load as required by the standard. The high-resolution load–displacement data acquisition enabled accurate determination of puncture strength and displacement at maximum force. Overall, the Shimadzu system ensures compliance with ASTM D6241 and ISO 12236 requirements and offers a dependable solution for quality control, research, and material comparison of geotextiles.

References

1) ASTM D6241- Standard test method for measuring static puncture strength of Geotextiles and Geosynthetic-Related products using a 50mm probe.

2) ISO 12236- Geosynthetics – Static puncture test (CBR test).

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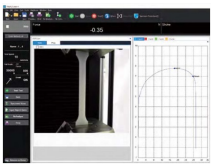

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