TECHNICAL NOTE

MODULUS CHARACTERISTICS OF GEOSYNTHETICS USED IN ROADWAY CONSTRUCTION

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TenCate Geosynthetics North America offers an extensive line of geosynthetic products for the construction of roadway structures. This technical note will compare the modulus (stress versus strain) characteristics of TenCate Geosynthetics North America geosynthetics with other geosynthetics commonly used in roadway applications.

Unpaved Roadways

Geosynthetics are frequently used in construction of unpaved roadways over soft soils. In this application, the geosynthetic is placed over the soft subgrade and beneath the aggregate base-course in order to increase the load bearing capacity of the roadway system.

As shown in Figure 1, tensile forces are mobilized in the geosynthetic through deformation of the subgrade. As these tensile forces are developed, the amount of deformation of the geosynthetic and therefore the subgrade, are dependent on the modulus characteristics of the geosynthetic.

In order to minimize the depth of rutting within the aggregate, the use of a geosynthetic that achieves high tensile strengths at low strains is imperative.

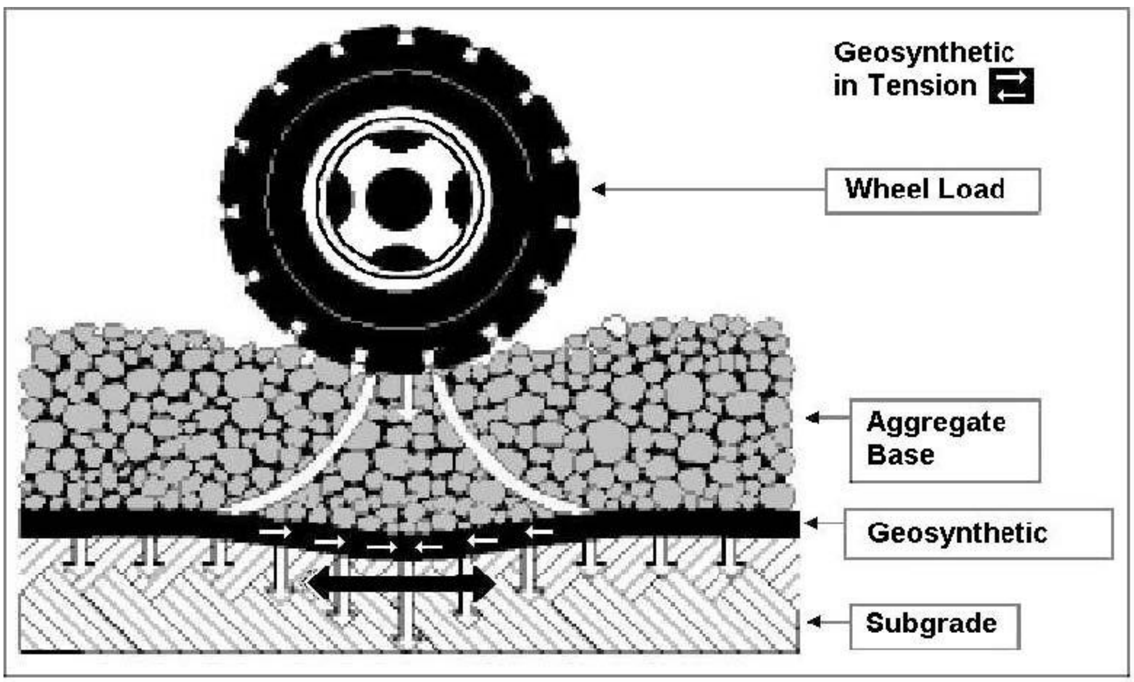

Figure 1: Unpaved Roadway Cross Section

Design Procedure

The design procedures determined in the Fabric Tension Model (FTM) developed by the University of Illinois (Barenberg, Ernest J., *Design Procedures for Soil-Fabric-Aggregate Systems with Mirafi 500X*, University of Illinois Transportation Engineering Series No. 30, UILU-ENG-80-2019, October, 1980[2]) demonstrate the inherent advantages of high modulus

geosynthetics. This model quantifies the effects of fabric modulus, or deformation resistance, on the performance of the soil/fabric/aggregate (SFA) system and defines the mechanism of performance. The FTM was developed from fundamental engineering principles and verified by full-scale tests on road sections containing a high-modulus woven geotextile, a low-modulus non-woven geotextile, and no geotextile. It was also developed from subsequent tests relating the modulus of TenCate Geosynthetics North America geotextiles to the performance of SFA systems. [2]

This research clearly demonstrated that when a load is applied to high-deformation systems constructed with fabric over a low-strength subgrade, the normal stress transmitted to the subgrade initially exceeds the allowable load and a slight rut begins to develop. As the rut deepens, however, the geotextile elongates and takes on a permanent tension. A portion of the load is then carried by the geotextile. As the rutting increases, the geotextile tension increases until the normal stress transmitted to the subgrade is equal to the permissible subgrade stress. At this point, the system becomes stable; no further rutting should occur. This increase in geotextile tension through rutting also effectively confines the aggregate, giving it greater stability, and maintains the load distribution characteristics.

The design procedures for TenCate Geosynthetics North America stabilization geotextiles limits the normal stress on the subgrade and accounts for that portion of the load carried by the geotextile by including in the design calculations the effects of geotextile modulus and rut geometry, i.e. depth and width.

TenCate Geosynthetics North America's HP-Series products combine high modulus with excellent puncture and tear resistance to provide separation, load distribution, confinement, and reinforcement to the unpaved road structure. The advantage of these products is the reduction in aggregate due to the inclusion of the HP-Series product based on the Fabric Tension Model.

Products and Testing

The most widely accepted and accurate methods of measuring the modulus, or load versus deformation, characteristics of a geosynthetic is to perform the American Society for Testing and Materials (ASTM) Test Method D 4595, "*Tensile Properties of Geotextiles by the Wide-Width Strip Method*". [5]

In an effort to quantify the relationship of stress versus strain, random samples were taken of the commonly used geosynthetics shown in Table 1.

Table 1: Geosynthetic Products Tested

Product	Type	Construction
Propex Geotex 2x2HF	Woven Geotextile	Monofilament/Slit Film
Propex Geotex 4x4	Woven Geotextile	Slit Film
Tensar BX1100	Geogrid	Extruded Polypropylene
Tensar BX1200	Geogrid	Extruded Polypropylene
Mirafi HP370	Woven Geotextile	Monofilament/Slit Film
Mirafi HP570	Woven Geotextile	Monofilament/Silt Film
Mirafi 500X	Woven Geotextile	Slit Film
Mirafi 600X	Woven Geotextile	Slit Film

Product samples were analyzed in TenCate Geosynthetics North America's GRI-GAI [6] accredited laboratory using test method ASTM D 4595 [5]. All specimens were tested using the following parameters:

Clamps – Wedge Type
Specimen Width – 8" (geogrids widths varied from 7.60" to 8.15")
Pre-load – 2.5 lbs/in (stress-strain values were measured after application of pre-load)
Strain Rate – 10% per minute

Results

The entire stress/strain curves for each product are shown in the figures shown in Appendix A. In unpaved roadway applications, geosynthetic strain levels of greater than 6% tend to produce unacceptable rut depths. Therefore, a close examination of the initial portion of the stress-strain curve is necessary to define the relative performance of a given product.

The figures shown in Appendix B isolate the stress-strain curves from 0% to 6% strain.

Conclusions

In the critical strain levels approaching 6%, geosynthetics manufactured from high modulus polypropylene yarns, such as **Mirafi® HP370** and **Mirafi® HP570**, yield tensile strengths 50% to 250% higher than lightweight woven slit-film geotextiles.

Mirafi® HP370 and **Mirafi® HP570** also demonstrate an excellent balance of high tensile strength at low strains in **both** principle directions. In contrast, Propex Geotex 2x2HF and Propex Geotex 4x4 have excellent stress strain characteristics in the cross direction, but performed poorly in the machine direction. These results can be attributed to the lack of high modulus yarns in the machine direction as well as the nature of the weave used to construct these products.

Tensar BX1100 and **Tensar BX1200** extruded polypropylene geogrids exhibited modulus characteristics similar to the lightweight slit-film products. These results may be attributed to the lack of orientation given to the polymer during manufacturing. This lack of orientation would allow the polymer yield when strained at the rates specified by ASTM D 4595.

References

American Association of State Highway and Transportation Officials, "Standard Specification for Geotextile Specification for Highway Applications, AASHTO DESIGNATION: M 28896", 1998.

Barenberg, Ernest J., "Design Procedures for Soil-Fabric-Aggregate Systems with Mirafi 500X", University of Illinois Transportation Engineering Series No. 30, UILU-ENG-802019, October, 1980.

Koerner, Robert M., Designing with Geosynthetics, 4th edition (1998).

Geosynthetic Materials Association, "Geosynthetic Reinforcement of the Aggregate Base/Subbase Courses of Pavement Structures – GMA White Paper II", January 7, 2000.

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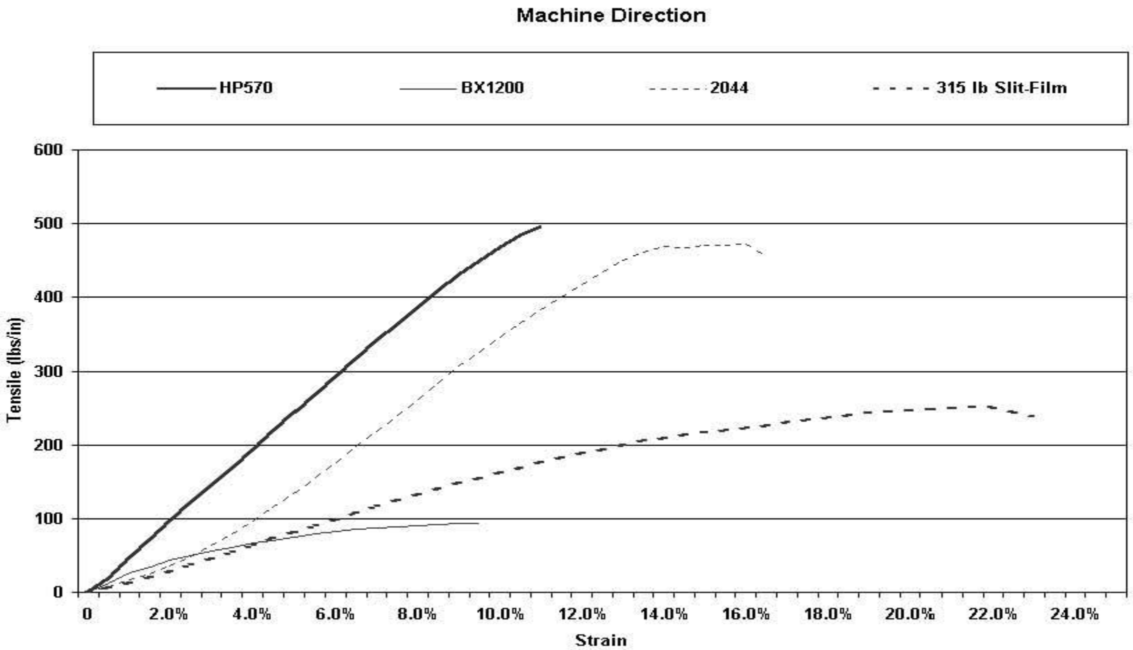
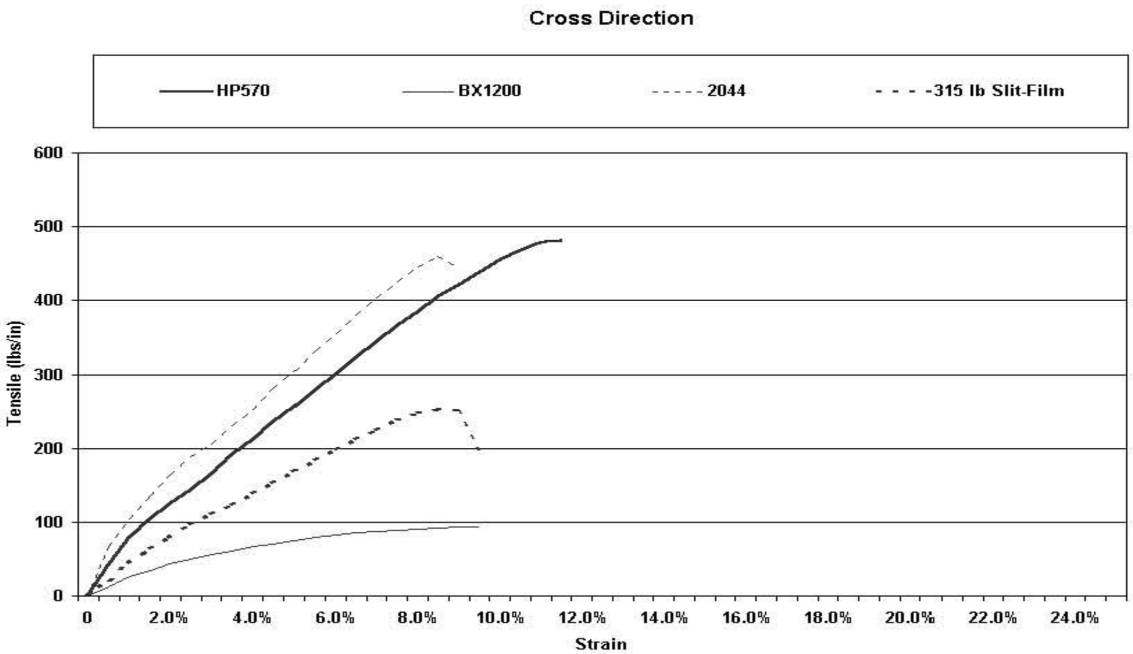
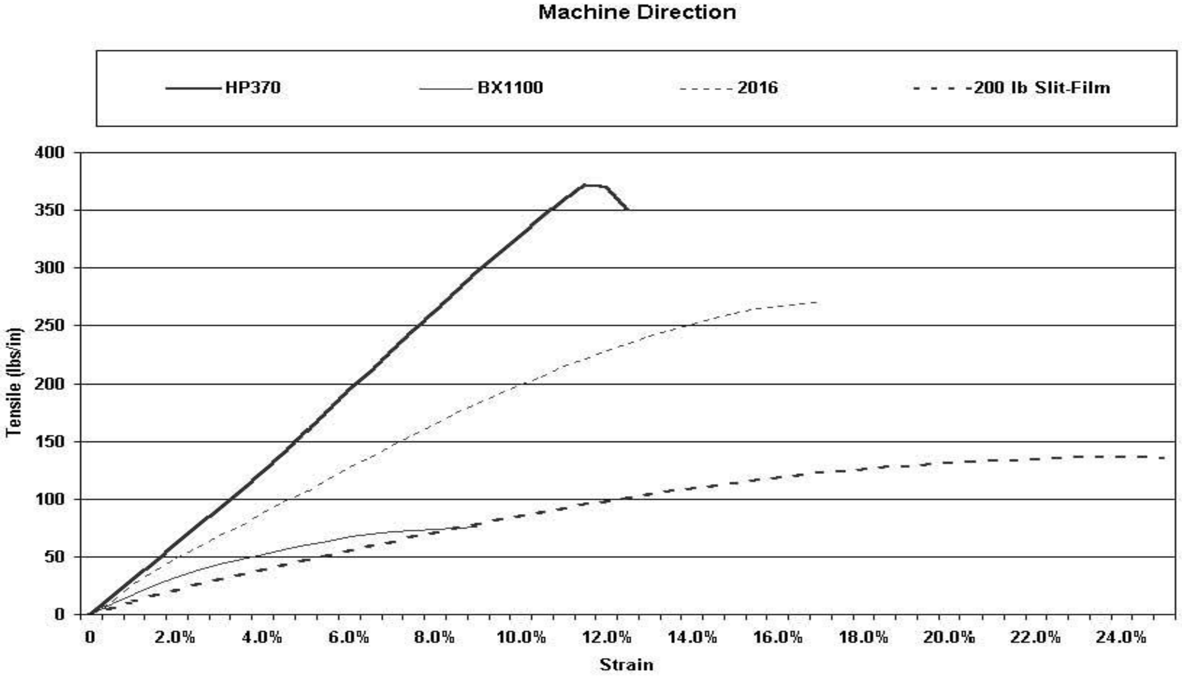
APPENDIX A

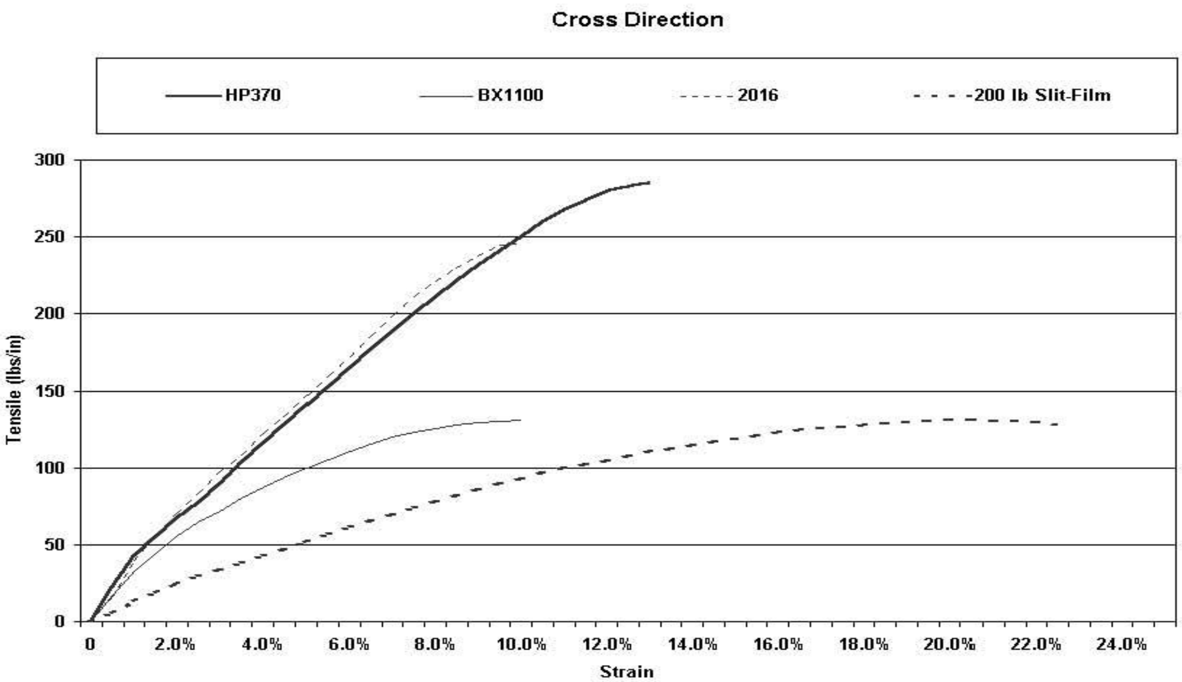
Complete Stress-Strain Curves





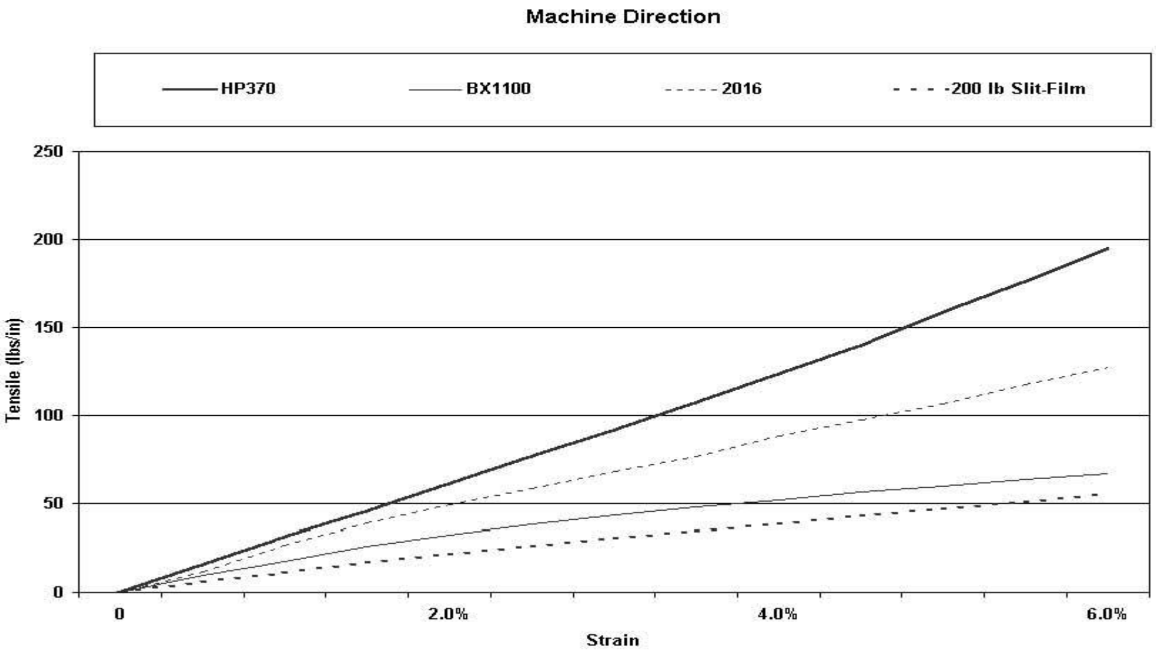
Entire Stress-Strain Curves

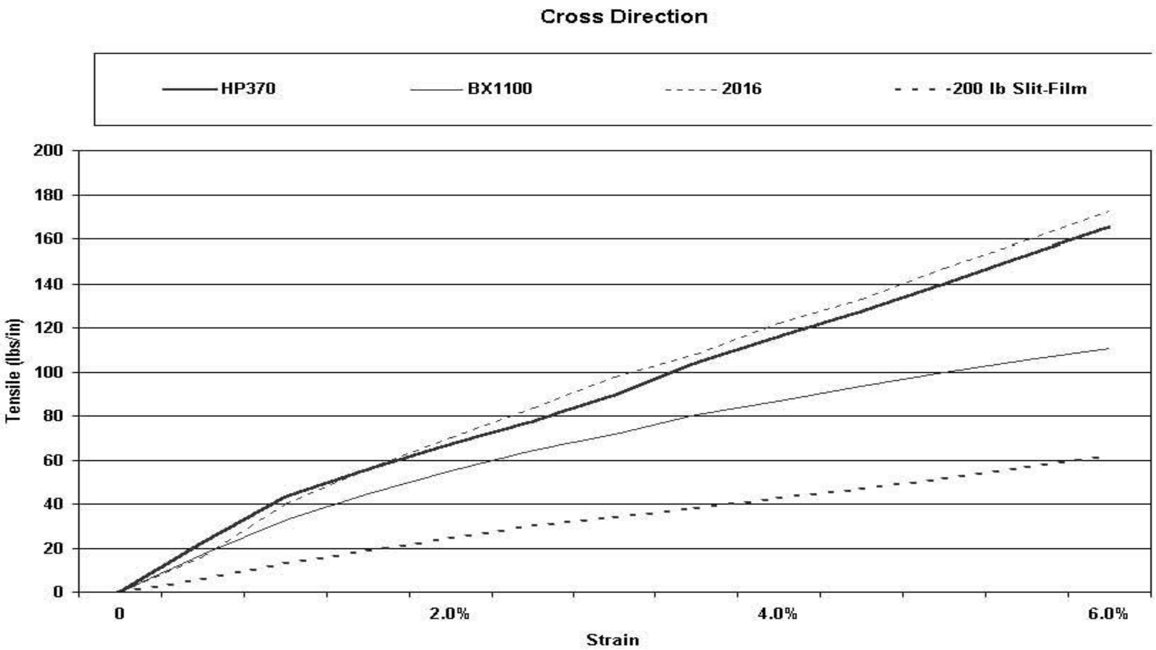




APPENDIX B

Stress-Strain Curves from 0% to 6% Elongation





Stress-Strain Curves (0% to 6% Strain) Stress-Strain Curves (0% to 6% Strain)