# GRIPS, CLAMPS, CLAMPING TECHNIQUES, AND STRAIN MEASUREMENT FOR

# Testing of Geosynthetics

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# *Grips, Clamps, Clamping Techniques, and Strain Measurement for Testing of Geosynthetics*

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# Foreword

This publication, *Grips, Clamps, Clamping Techniques, and Strain Measurement for Testing of Geosynthetics,* contains papers presented at the symposium of the same name held in Memphis, Tennessee, on 28 January 1999. The symposium was sponsored by ASTM Committee D35 on Geosynthetics. The symposium chairman was Peter E. Stevenson, Stevenson and Associates and the co-chairman was Sam R. Allen, TRI/Environmental.

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# Overview

For me, the work reported in this publication began with confusing test results. The first purpose of the research reported here is to provide the reader with the tools to understand the problems and techniques in testing and reporting data for strong reinforcement products. The second purpose of the work is to point the way to a repeatable and reproducible test methodology for those strong products. The tests in question were performed on the first edition of prototype high-strength geotextiles and the results were quite different than those expected. The lab was highly skilled, managed by the mechanical engineering department of a local university, routinely employed by the aerospace industry, and comfortable with high-strength, high-modulus materials. The problem was elongation. Test results of 20 to 30% extension for products with strengths of 100 to 1000 kN/m were two to three times expectation.

The mystery was soon resolved through consultation with an experienced geosynthetic lab. Comparison of results, test methods, and testing technique revealed that the mechanical engineering lab had adopted the test protocol described in ASTM D 4595, literally. The geosynthetic lab pointed out that reinforcements were typically tested by an amended protocol familiar to many in the geosynthetics industry, but not evident in the language of the test procedure. This experience initiated a research project on tensile testing methodology. The objective of the research was, and is, the development of a repeatable and reproducible test protocol for strong and very strong geosynthetics. The product range addressed in the research in this publication spans grids and fabrics from 35 to 1200 kN/m.

The research presented in the following articles identifies several problems with ASTM D 4595 and its ISO counterpart ISO 10319. The investigation into the causes of the incorrect results previously discussed led to a review of 183 papers on testing, all written before 1995. Selected papers are listed in the bibliography to this overview. These selected papers identified eleven concerns with testing protocols for strong and reinforcing products and cast doubt on the reliability of the data generated by these test methods. Kelkar enumerates the eleven issues. Most important, in a 1998 paper published by GRI, the test lab accreditation agency, GAI LAP of GRI, ranks D 4595 as the least consistent test protocol in the geosynthetic inventory. Reproducibility and repeatability are the core problems. The influence of pre-stressing or pre-loads makes accuracy an additional problem. Also, in 1998 the ISO subcommittee on mechanical properties, TC38/SC21/WG3, resolved that a separate test protocol should be developed for the testing of strong reinforcements. The tensile test task group of the ASTM D-35 committee on Geosynthetics proposes to include protocols for high-strength materials within the D 4595 umbrella.

One might expect that, after fifteen years, the D-35 committee on Geosynthetics would have developed consistent test methodologies for reinforcements, but this is not true, and our European counterparts have not progressed farther than we. How can this be? The answer lies in the evolution of the test protocols, geosynthetic products, and the industry. My personal recollection of the test method history begins with Alan Haliburton and his proposal to D-18 that a wide strip test for geosynthetics would be palatable to civil engineers and perhaps could serve to generate design information. Work began immediately in North America and Europe, resulting in the early editions of D 4595 and ISO 10319. Along the way there were some noteworthy events. First, nonwovens held a huge influence on the industry with upwards of a 70% market share that continued into the late 1980s. Today's reinforcing products were largely unknown. Specimen size and shape, particularly width, were developed to accommodate nonwoven geotextiles. The 200-mm width was developed to minimize the

Poisson's effect or necking influences in nonwoven specimens. A small gage of 100 mm was selected as an effective tool for the labs with minimal negative effects on nonwoven fabrics and weak woven products, such as those produced from olefin-based slit tapes. Second, the general efficacy of the test for a majority of geotextiles was proven in a series of round robins. Interesting, D 4595 and ISO 10319 are not the normal nonwoven testing reference as the industry approaches the year 2000. Much, if not most, nonwoven product data are published citing the Grab test. A Grab test, ASTM D 4632, is easier to perform and is often used in internal quality control as well as in published data.

During the period that ASTM D 4595 and ISO 10319 were adapted for a broad spectrum of geosynthetics, work was performed on strong and new products to be used as reinforcements. In 1986 Myles published research on wide-width testing of high-strength geotextiles and presented an article on the reporting of test data. GRI developed and published test methods GRI, GG1, and GG2 to facilitate testing of geogrids and grid junction strength. These precursors of the work published in this volume clearly identified problems in testing and reporting data for reinforcements. Peggs, Skochdopole, and Kelkar, among others in this volume, revisit the arguments, and Peggs and Skochdopole present solutions to the dilemma of trying to develop a practical test method while reporting information in consistent, clear, and meaningful terms.

During the 1980–1995 period, the geosynthetics industry experienced significant growth. Products evolved, and applications, such as walls, requiring strong products came to the forefront and stronger fabrics and grid structures were introduced. These products immediately experienced difficulties with the test protocols in D 4595 and ISO 10319, most notably gripping problems. Many innovations were tried and innovative solutions to the problems and influences of grips on test results continue in this volume. Grips, problems with grips, and solutions to gripping problems are the primary focus issues for the papers by Koerner, Elvidge, Jones, Müller-Rochholz, Thornton, Skochdopole, Kelkar, and Farrag. One of the early solutions to gripping problems was the introduction of capstan or roller clamps and rollers. These work quite well in producing ultimate strength data. However, rollers require very long specimens, which creates havoc with the twin concerns of grip separation and specimen gage. When testing a nonwoven, the gage is 100 mm. In this instance, 100 mm stands for the separation of clamps as well as the area to be observed for extension. When roller clamps and very long specimens are introduced, grip separation becomes much different. Thornton and Kelkar discuss gage length and the influence of varying specimen lengths on reported test results. Sample size and its influence on results is also discussed by Müller-Rochholz, Skochdopole, and Chang. Further, the concepts of gage become complex with long specimens. ASTM has five distinct definitions of gage length. Originally, for the nonwoven tests, gage length and jaw separation were the same. With the introduction of long specimens a different definition was applied to gage length: the original length of that portion of the specimen over which strain or change of length is determined. This means the adoption of the convention in which one observes extension over only a portion of the specimen. Does similar convention exclude consideration of Kelkar's first and second modulus, despite the reasonableness of his argument? Peggs discusses other confusions over terms. The concern over true gage length and effective gage length might seem unnecessary, except that gage governs test speed and measures extension. Small changes in gage have a significant effect on results. Further, gage must be observed at the same point from specimen to specimen, as variability in the locus of observation will also influence results. Repeatability is a formidable task when using roller specimens that are 200-mm wide and 1800-mm long with grip separations that vary between 250 to 500 mm. Jones, Skochdopole, and Kelkar report that optical devices solve the problem of repeatable gage. According to the test protocols, for geosynthetics the observed gage length remains 100 mm.

In the abstract, extension can be accurately measured by many techniques, including cross head movement, LVDTs, and optical devices. Chew argues that LVDTs can influence test results if care is not exercised. Nonetheless, in the realm of strong product tensile testing, LVDTs are most serviceable in horizontal applications as discussed by Chew, Farrag, and Chang. Jones discusses the unsuitability of LVDTs for vertical tensile test applications. It seems that mounting LVDTs to geosynthetics requires a two-stage test. The first stage is to sufficiently stress the material to permit the mounting of the device for measuring extension. The second stage measures extension with the mounted device. Accuracy seems likely to suffer and Skochdopole and Kelkar present data to support Jones to that effect. Jones, Skochdopole, and Kelkar offer viable extension measurement techniques that are not dependent upon prestressing, and Skochdopole offers two ways to present nonprestressed data in a format that permits comparison to historical records of data acquired with prestressing. As discussed by Peggs, Müller-Rochholz, Thornton, Skochdopole, Kelkar, and Greenwood, the problem is the need for accuracy at low strains. Low strain data represent the potential for deformation in a reinforced, earthen structure and also defines the initial loading phase of the creep curves to determine long-term properties.

In conclusion, there may be more work necessary to demonstrate the problems with the test protocols when applied to strong materials: but in my opinion, a great deal of such work is unnecessary. The problems and the solutions are presented in this publication and the references it cites. What is necessary is for the few who are not interested in better and more accurate testing to restrain their objections, or at least offer data that are based on work of their own that will contribute to and direct the resolution of the problems. I thank the authors of papers for the ASTM Symposium on Grips, Clamps, Clamping Techniques, and Strain Measurement for Testing of Geosynthetics for the hard work and great effort they exerted to make this publication meaningful.

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