SOUTHERN PLAINS TRANSPORTATION CENTER

SPTC Brief

Highlighting Developments at Southern Plains Transportation Center
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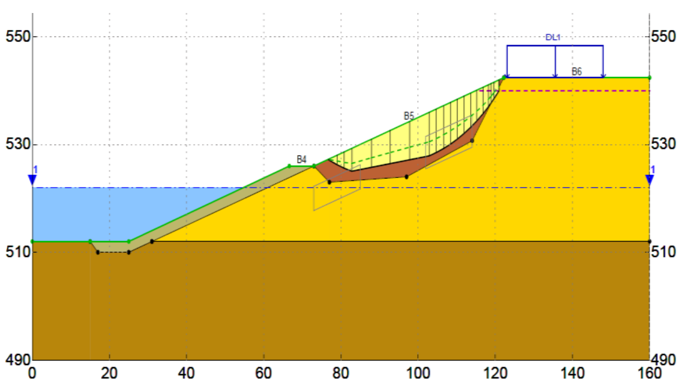
GUIDELINES FOR THE USE OF FIBER REINFORCED SOIL (FRS)

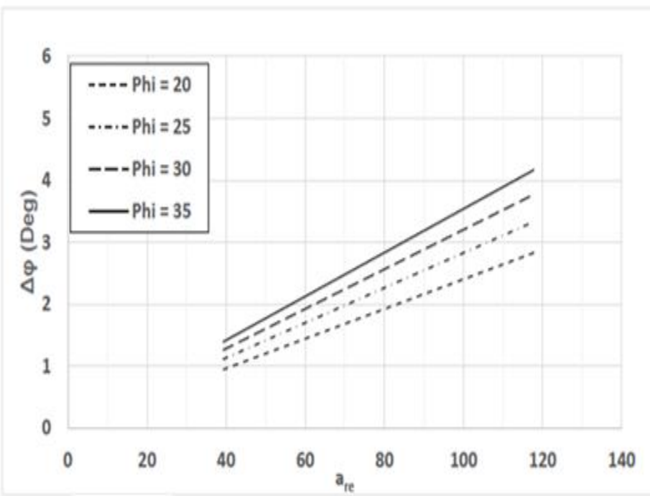
OVERVIEW Fiber Reinforced Soil (FRS) is essentially polypropylene fibers mixed with soil to reinforce the soil mass against shear or tensile failure. This concept has been in use in traditional construction throughout history, such as in clay bricks and mud roofs reinforced with straw. FRS is also applicable to a wide range of current transportation projects, such as those relating to retaining walls, slopes, foundations, and pavement subgrades. However, despite its proven record, long history of use, affordability and ease of construction, this technology has been underutilized in transportation applications. This is primarily due to the requirements for extensive laboratory testing and lack of practical guidance. This project focuses on FRS guidance for application in repairing shallow slope failures (shown in the figure).



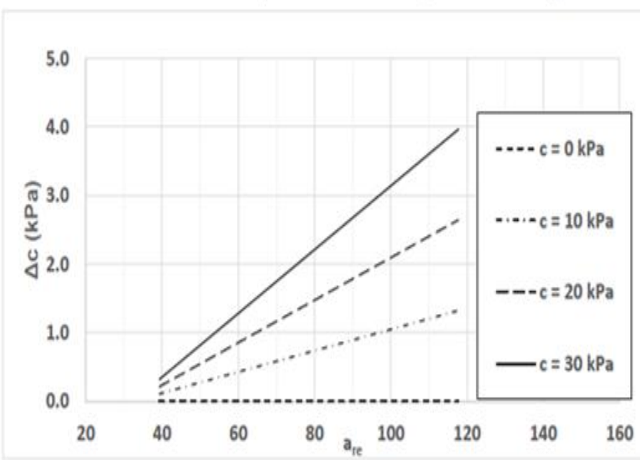
CURRENT RESEARCH With significant developments in theoretical models, laboratory testing, field application and verification in recent years, soil and fiber properties can be used as input values in mathematical models to predict the magnitude of increase in shear strength of the FRS relative to the unreinforced (i.e. raw) soil. The resulting data can be used in stability analysis programs to obtain the desired factors of safety in the earthwork project at hand. When the engineer is satisfied with a potential fiber type and application rate, targeted verification tests can be performed as necessary to improve confidence in design.

This project provides a brief review of different slope stabilization techniques beyond soil reinforcement, followed by descriptions of major discrete models developed for FRS, sample preparation and testing procedures in the laboratory, important concepts, and field implementation. Two case studies are also provided together with detailed slope stability calculations, which illustrate alternative methods of using commonly available slope stability analysis programs in combination with FRS data from spreadsheet calculations versus special programs which can accept fiber properties and application rate as input values in their algorithms. The case study projects evaluated in the project constitute the largest applications of FRS in the United States.

The recently developed discrete models can aid in the design of FRS slopes and slope repairs and other geotechnical projects by allowing the engineer to easily predict FRS strength without extensive testing. These models, given the unreinforced soil properties and fiber properties, allow the engineer to predict increases in cohesion and friction angle within reasonable and practical accuracy and thus calculate the improved shear strength without the need for extensive testing. A series of design charts can be developed to assist engineers in determining a starting point/application rate for fibers (lb/yd3) for use in slope stability analysis and design of an FRS slope. For example, a failed slope may need to be repaired back to its original dimensions due to right-of-way acquisition costs. After analyzing the previous slope's failure mechanisms and determining necessary information such as slip plane, one may back calculate a necessary friction angle and/or cohesion required for a desired factor of safety. Knowing the types of FRS fiber products that are available on the market, the engineer can use design charts to easily determine candidate products that can provide the required increase in friction and/or cohesion for a desired level of stability. This is a powerful tool, which affords an engineer the ability to quickly determine if a certain fiber is more advantageous or efficient than another, or if FRS is a viable option for any specific site. Example design charts are shown below.



Effective Aspect Ratio vs. Change in Friction Angle



Change in Cohesion vs. Effective Aspect Ratio

To conduct slope stability analysis, commonly available slope stability programs can be used in conjunction with separate spreadsheet calculations of FRS properties. Alternatively, computer programs are available that have built-in FRS models, which can be used to determine the required fiber content and other FRS properties required to obtain a desired factor of safety value more directly and in reduced time.

The two case studies conducted for this project demonstrate the use of FRS and corresponding slope stability analyses in both repair and preventive applications in highway projects. The FRS slopes have performed well to date.

The project also provides detailed laboratory procedures and testing guidelines for FRS samples, as well as field application insight. A major benefit of the use and application of FRS at a project site is that the practices associated with its application are similar to those of adding any chemical additive (such as lime, cement, CKD, Fly Ash) to soil.

IMPACT Benefits of using FRS in slope stabilization stem from having an option that is cost-effective and can be designed and built with confidence about its performance. This project provides agencies with practical guidance for using and implementing FRS technology.

About the Researchers

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