

## TECHNICAL SUMMARY

Digital Image Analysis Techniques for Fiber and Soil Mixtures

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## INTRODUCTION

In general accordance with the Transportation Innovation and Research Exploration program (TIRE), this project explored new techniques of digital image analysis to study the nature and character of materials used by DOTD.

Image processing is used to visually enhance, quantify, and/or statistically evaluate some aspect of an image not readily apparent in its original form. Processed digital image data can be analyzed in numerous ways. In order to summarize the gathered data into helpful information, classification techniques must be employed. Most analysis techniques use image-classifying algorithms that involve aspects of mathematical morphology. Digital image analysis is a powerful method for gathering information using a computer-based system.

The use of admixtures, such as synthetic fibers, in soils is intended to increase the mechanical properties of the soil. When used in correct quantity, these synthetic fibers produce net-like configurations. In turn, these provide a means for reinforcement of the soil matrix and thus, an increase in strength. Characteristics such as void ratio, spatial variability, orientation, roughness, and the ability to identify the synthetic fiber in the sample are all essential in assessing material parameters.

This project used innovative technologies of digital image analysis for the characterization of a material currently being considered for broad use at DOTD. The material under consideration is a mixture of fiber

and soil for use in the stabilization of road sub-grades, bases, and embankment slopes. It is not apparent that the material has been released for broad use at the state level. One of the reasons for not using this material is the unique mixing requirement for proper distribution of the fibers. Digital image analysis provides a quantitative means to measure some properties that can characterize the mixture.

LTRC has two in-house projects related to the use of fibrillated polypropylene fibers or geo-fibers in conjunction with Louisiana soils (silts and clays) for stabilization of roadway embankments where both field and laboratory tests were performed by LTRC. The common goal of these projects is to evaluate the added value of the fibers, when used in conjunction with Louisiana soils and soil-cement.

In addition to the body of this report supplementary material related to the topics discussed are included in the four appendices located in this volume.

## OBJECTIVES

- Establish a working relationship with the LTRC and LA DOTD in image analysis techniques for material characterization.
- Identify image processing routines to characterize the complex structure of soil/fiber mixtures.
- Prepare a report that includes the research findings and recommend future work in this area for LTRC.

## SCOPE

- Integrate an image analysis system to capture, synthesize, manipulate, and analyze images from a specimen prepared in the laboratory or field.
- Select and develop analytical routines that can quantify the character structure and fabric (if any) of soil/fiber mixture.

## CONCLUSIONS

Image acquisition was best achieved with polarized light using linear and half-and quarter-wave retarders. The FOV was generally the size of the sample, or a bit larger, to achieve the focal length of the lenses available for this project. A close-up lens with a much smaller focal lengths will allow more flexibility with the focus and FOV of interest, which is at about five times the length of the average fiber shown in the surface. The sequence of image enhancement routines before segmenting the image was applied in the following order: polarizing light, smoothing, sharpening, mapping, and thresholding.

The count and area computation of features was accomplished with the "blob set analysis," the segmenting routine available in the Inspector software. The quality of surface preparation of the specimen is crucial to obtain good results using this function. To obtain the orientation of the individual fibers, ROI was required around each fiber. It is anticipated that another macro script can be developed for each blob set to quantify the orientation angle for each fiber. These routines could be used in conjunction with a statistical software package to eliminate the presence of outlines and calculate distributions of the exposed fiber length and area.

Intensity line profiles routines and macros proved to be an effective methods of identifying and quantifying clusters of fibers, and the degree of spatial distribution of the fibers n the examined surfaces. A macro script was developed to generate the intensity line plots. Several surfaces can be tested separately and then compiled to run statistical analysis and to summarize trend.

The ease and low-cost of the integrated system makes these technologies more available to the research engineers. The material being tested here was not found cited in previous literature. This lack of

information posed a significant challenge on achieving successful results. However, this system is a valuable tool for more traditional measurements such as fracture identification, aggregate characterization and pore size distribution of granular materials.

## RECOMMENDATIONS

A significant amount of effort was invested in the surface preparation of a specimen before image acquisition. The material is heterogeneous and in prone to fissures and slip planes if the fibers in the mix do not open or separate from their initial condition. From the surface preparation methods experimented in this study, the cryogenic freezing technique with liquid nitrogen, long freezing time, and then cutting with a power tool, was considered the most effective. More experimentation with different types of cutting devices may be required to develop a better technique than hand blade and cutting disc.

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