PSC-CUNY Research Awards (Traditional A)

Control No: TRADA-51-282
Rank: Assistant Professor
Tenured: No
College: NEW YORK COLLEGE OF TECHNOLOGY
Panel: Physics & Engineering
Discipline : Engineering
Co-PI :

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Human Subject Use: No
Animal Subject Use: No
Supplementary Materials: No
List of Supplementary Material:
Will Interviews be Conducted?: No
Department: Construction Technology

Title of Proposed Project: Use of Recycled Whole Textile Fabric for the Shear Strength Enhancement of Soil

Brief Abstract

Through centuries, humans have used soil reinforcement as an effective technique for soil stabilization. Recent efforts to use new fibers as reinforcement from manmade and natural materials has concentrated on adding thin long fibers to natural soils. The technique has been found to be effective in laboratory experiments but difficult to implement in real world. The difficulty in creating random soil masses and entanglement of fibers in production settings result in non-homogeneous mixtures which can lead to localized deformation planes, resulting in an economic deterrent to the wider adoption of the techniques. The author while studying the effects of the addition of whole (rather than fiber form) recycled textile fabrics into soil has observed that there is an increase in resistance to compaction with the use of textiles cut into small squares. This is an indicator of an increase in shear strength of the soil mass. This study attempts to quantify the improvement in soil strength parameters using this technique by conducting laboratory shear strength tests.

Relevant Publications & Scholarship

1. Guzman, I. Iskander, M., Bless, S., A Comparison of Half and Quarter Space Penetration into Granular Media. Geotechnical Testing Journal, June 2020. In Print

2. Guzman, I., Torres, S. (2019), Use of Repurposed Fibers to Decrease Hydraulic Conductivity without Compromising Load Restrictions in Urban Roof Farms. Geo-Institute of the American Society of Civil Engineers, Proceedings of the 2019 Geo-Congress. Philadelphia, Pennsylvania March 24-27, 2019.

3. Guzman, I., Iskander, M., Bless, S. (2015), Observations of Projectile Penetration into a Transparent Soil. Technical Note. Mechanics Research Communications.

4. Guzman, I., Iskander, M., Bless, S. (2014), Terminal Depth of Penetration of Spherical Projectiles in Transparent Granular Media. Journal Article. Granular Matter.
5. Guzman, I., Iskander, M., Suescun, E., Omidvar, M. (2013), A Transparent Aqueous Based Sand. Journal Article. ACTA Geotechnica.

6. Guzman, I., Iskander, M. (2013), Geotechnical Properties of Sucrose Saturated Fused Quartz for use in Physical Modeling. Technical Note. ASTM Geotechnical Testing Journal.

Education

Institution	Degree	Year(s)	Discipline
New York University	PhD	2013	Geotechnical Engineering
Kennesaw State University	MBA	2005	Business
University of Florida	Master Engineering	1998	Civil Engineering
University of Puerto Rico	BSCE	1997	Civil Engineering

Other Current & Past Funding (last 5 years)

Period	Role	Title	Amount	Funding Source

Attachments

Description	File Name	File Size	Date Attached
Project Description	PSC_Cuny_2019_Grant_-_Proposal_-_Iv	622280	12/23/2019 1:39:07 PM

Budgets

Description			Requested Amount
Research Staff	Fringe Benefit Expense MTA Payroll Tax	0.00 0.00	0.00
Clerical Staff	Fringe Benefit Expense MTA Payroll Tax	0.00 0.00	0.00
Summer Salary (Principal Investigator) Conduct Laboratory experiments	Fringe Benefit Expense	2580.00 688.86	3268.86
General Office Supplies/Xeroxing		0.00 0	0.00
Research Supplies Triaxial Membranes, Research Grade sand (Ottawa Sand, Oklahoma Sand), Misc		206.14 0	206.14
Domestic Travel		0.00 0	0.00
Foreign Travel		0.00 0	0.00
Independent Contractors		0.00 0	0.00

Subject Payments		0.000	0.00
Laboratory Fees		0.000	0.00
Equipment		0.000	0.00
Manuscript Preparation/ Publication Costs		0.000	0.00
		Total	**3,475.00**

PSC-CUNY Research Award Program Cycle 51
Grant Proposal

Use of Recycled Whole Textile Fabric for the Shear Strength Enhancement of Soil

Grantee:

Ivan L. Guzman, PhD, PE

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Abstract

Through centuries, humans have used soil reinforcement as an effective technique for soil stabilization. Recent efforts to use new fibers as reinforcement from manmade and natural materials has concentrated on adding thin long fibers to natural soils. The technique has been found to be effective in laboratory experiments but difficult to implement in real world construction applications. The difficulty in creating truly random soil masses and entanglement of fibers in production settings result in non-homogeneous mixtures which can lead to localized deformation planes, resulting in an economic deterrent to the wider adoption of the techniques. While studying the effects of the addition of whole (rather than fiber form) recycled textile fabrics into soil I have observed that there is an increase in resistance to compaction with the use of textiles cut into small squares. This is an indicator of an increase in shear strength of the soil mass. Additionally, I have found that creating uniform specimens is much less cumbersome when the textile is cut into small whole pieces rather than in fiber form. This study attempts to quantify the improvement in soil strength parameters using this technique by conducting laboratory shear strength tests.

Background and Purpose

Global yearly demand of textile fabrics exceeded 90 million tons in 2018 and is expected to increase by 30% by year 2030, Figure 1 [1]. Inevitably, the majority of this textile will end up as waste. The United States alone produces approximately 16 million tons of used textiles each year of which approximately 16% is recycled, 18% is combusted for energy and 66% ends up in landfills. However, nearly 100% of textiles are recyclable. The availability of an underused readily available commodity such as recycled textiles, offers a unique economic opportunity for environmentally conscious business savvy entrepreneurs.

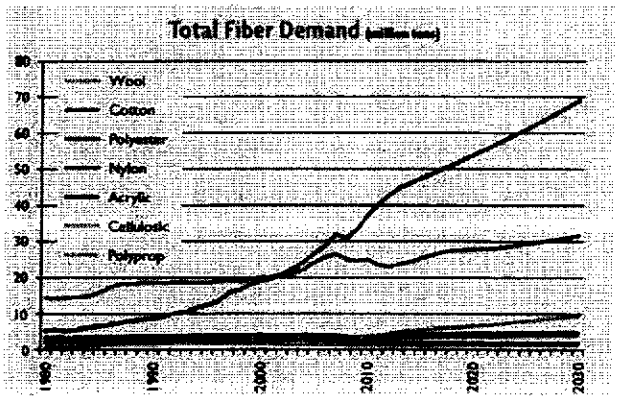

Figure 1 Forecast of Total Fiber Demand per Year. Borrowed Chart [1]

Humans have been using natural fibers to reinforce construction materials for thousands of years. This includes natural fiber reinforced adobe bricks in ancient Egypt and inclusion of tree branches for soil reinforcement in the Great Wall of China, to more recently, the construction of mechanically stabilized retaining walls and reinforced soil slopes with polymeric textiles. The former use randomly oriented fiber inclusions in soil while the latter use carefully laid out and localized inclusion of geo synthetics (geo-grids) to increase the tensile strength of soil [2].

Soil reinforcement has a vast array of applications. Taking into account that nearly all civil engineering/construction projects involve movement and compaction of soil to desired final grades the market potential is gigantic. The application of soil reinforcement techniques result in increased bearing capacity of foundation soils, which has the effect of smaller foundations and thus the reduction in material and labor costs. The techniques, if implemented successfully, can also translate into steeper engineered slopes, which would save in materials, labor, and transportation costs, which in turn is an environmentally friendly solution due to the reduction of CO2 emissions from transportation and compaction equipment. Steeper fill slopes also lead to lower real estate costs related to the smaller plan area associated with steeper slopes. Other applications include modified base and subbase materials for pavements, and the construction of temporary slopes with biodegradable reinforcement (i.e. cotton textile).

Recently there has been an increase in scientific interest in the use of randomly oriented short fibers, with research being done with natural fibers such as Coir (coconut), Sisal, Palm, Jute, Flax, and Bamboo, and synthetic fibers made out of Polypropylene, Polyethylene, glass, nylon and others. The fibers used in these studies are very thin (diameters between 0.01 to 0.5 cm) and long (10 to 50 cm). However, the shape and size of fibers lead to problems related to tangling and localization of the fibers which leads to non-homogeneous mixing and the potential for localized failure zones. This makes preparation of truly random specimens in a laboratory setting cumbersome, and extremely difficult in a mass production setting, which imposes an economic deterrent to the wider use of the technologies. Additionally, if manmade and natural fibers such as polyester and cotton are sourced from recycling the problem of how to convert whole textile fabrics (i.e. t-shirts, jeans, linen) into fiber form adds an additional manufacturing step that further would hinder the adoption of the technology.

Through my own laboratory experiments, I have observed that adding controlled amounts of whole recycled textiles (from t-shirts) cut into simple shapes (squares) to light weight engineered soils and sand has a moderate and measurable effect on hydrogeological and compaction characteristics of the host soil [3]. Of interest to this study is the acquired resistance to compaction of the modified soil, as measured by the Maximum Media Density (MMD) in standardized compaction tests (Figure 2). This is an indicator of the enhanced shear strength capability of the soil through the inclusion of whole textile fabric.

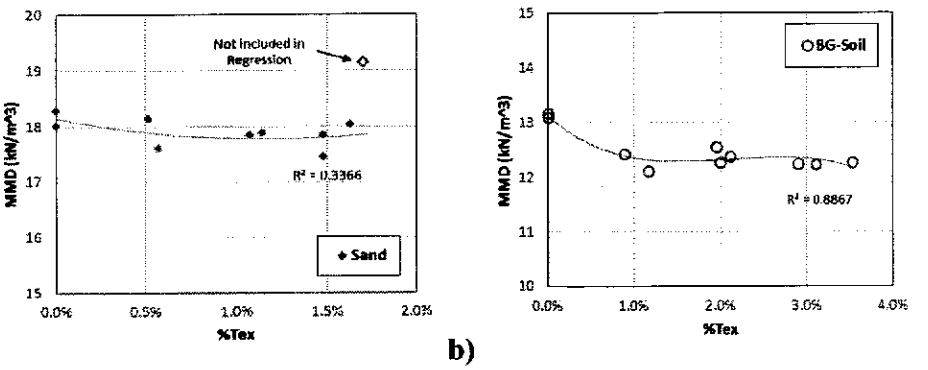

Figure 2. Maximum Media Density vs. $\%Tex$ for Sand (a) and Lightweight Soil (B-G Soil) (b)

It is my hypothesis that the addition of small amounts of whole textile fabric cut into small pieces will increase the shear strength capabilities of the host soil. My previous experience with these materials also indicate that the desired random characteristics of the specimens are much easier to achieve with this technique, which can ultimately lead to the faster adoption into real world scenarios.

Methodology

The proper characterization of soil shear strength parameters of remolded specimens is done by conducting laboratory experiments that include Direct Shear Testing (ASTM D3080) and Triaxial Shear Testing (ASTM D7181). The Construction Management and Civil Engineering Technology (CMCE) department of the New York City College of Technology has two Direct Shear testing machines that will be used during the experimental portion of this study. Triaxial Shear Tests are much more involved and require specialized equipment and training not common in academic soil mechanics laboratories. However, I have extensive experience successfully conducting Triaxial tests in a research setting as evidenced by my journal publications [4]. As a Research Associate at New York University (NYU) I have access to its soil mechanics laboratory which houses three top of the line Triaxial machines. In addition I have notified and received approval in writing from the chair of the Civil and Urban Engineering Department, Dr. Magued Iskander, to conduct the tests proposed herein.

During laboratory experiments specimens will be prepared by mixing laboratory sand with controlled amounts of recycled textiles and tested at different confinement pressures so that the drained shear strength parameters of angle of internal friction (Φ') and effective cohesion (c') can be properly assessed and quantified. Other soil characterization tests may include grain size analysis (ASTM D6913), Standard Proctor compaction (ASTM D698), and others.

Outcomes

If the results are favorable, the findings will be submitted for publication in a peer reviewed publication and/or conference proceedings. If viable the results can be the basis to request a bigger grant with a government organization such as National Science Foundation and/or the New York Department of Transportation.

References

1. Leblanc, R. *Textile and Garment Recycling Facts and Figures*. Sustainable Businesses 2019 12/5/2019]; Available from: https://www.thebalancesmb.com/textile-recycling-facts-and-figures-2878122.
2. Hejazi, S., et al., *A simple review of soil reinforcement by using natural and synthetic fibers.* Construction and Building Materials, 2012. **30**: p. 100–116.
3. Guzman Ivan, L. and M. Torres Sandra, *Use of Repurposed Fibers to Decrease Hydraulic Conductivity without Compromising Load Restrictions in Urban Roof Farms.* Geo-Congress 2019: p. 291-303.
4. Guzman, I.L., et al., *A transparent aqueous-saturated sand surrogate for use in physical modeling.* Acta Geotechnica, 2014. **9**(2): p. 187-206.