GEOTECHNICAL SPECIAL PUBLICATION NO. 254

PAVEMENT PERFORMANCE MONITORING, MODELING, AND MANAGEMENT

SELECTED PAPERS FROM THE PROCEEDINGS OF THE GEO-HUBEI 2014 INTERNATIONAL CONFERENCE ON SUSTAINABLE INFRASTRUCTURE

July 20-22, 2014
Yichang, Hubei, China

SPONSORED BY
The Geo-Institute of the American Society of Civil Engineers

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Published by the American Society of Civil Engineers

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/bookstore | ascelibrary.org

Errata: Errata, if any, can be found at http://dx.doi.org/10.1061/9780784478547

ISBN 978-0-7844-1359-3 (CD)
ISBN 978-0-7844-7854-7 (E-book PDF)
Manufactured in the United States of America.

Preface

This Geotechnical Special Publication contains 14 papers that were accepted and presented at the GeoHubei 2014 International Conference on Sustainable Civil Infrastructures: Innovative Technologies and Materials, held in Yichang, Hubei, China, July 20 to 22, 2014. The 5 major topics covered are:

- Ground Improvement, and Chemical / Mechanical Stabilization for Pavement and Geotechnical Applications;
- Performance Evaluation and Pavement Management;
- Construction and Rehabilitation of Jointed Concrete Pavement, Reinforced Concrete Pavement, and Continuously reinforced Concrete Pavement;
- Performance Evaluation, Performance Modeling, and Pavement Management, and
- Bridge Deck Pavements.

The overall theme of the GSP is road pavement and material characterization, modeling and maintenance, and all papers cover various aspects of this theme. The information contained in the papers is well-balanced between theoretical analyses and practical applications. It would thus be well-worth to pavement engineers, researchers and practitioners to take note of the information as it should assist them in providing improved road pavement infrastructure to their stakeholders.

The editors would like to acknowledge the effort of the authors in preparing high-quality papers for these sessions, as well as the effort of the reviewers who conducted thorough reviews of each paper.

The following reviewers assisted ably in the review process for the papers in this GSP and their contribution is acknowledged:

Jinyoung Kim
Jiong Hu
Jongwon Jung
Joseph Anochie-Boateng
Julius Komba
Majid Ghayoomi
Malay Ghose Hajra
Martin Mgangira
Seongcheol Choi
Soonkie Nam
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Improvement of Low Plasticity Clayey Soils Using Polypropylene Fibers

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ABSTRACT: Since highways are the most common and the most advanced means of transport compared to other transportation systems in Turkey, alternative techniques and materials are constantly being investigated in order to develop innovative solutions for the construction of highway embankments and other types of earth structures. It is obvious that in highway projects, excavation, loading and transportation costs of the material are the most important factors for the total cost and improvement in subgrade soils would have significant economical side effects. In this research, an extensive laboratory experiments has been performed in order to investigate the use of Polypropylene fibers with the scope of two different low plasticity clay soils obtained from Sile (Istanbul city region) and Kitre (Bayburt city region) district of Turkey. Various soils, Polypropylene fiber mixtures were prepared in the laboratory and the engineering properties of these mixtures were observed. The compaction characteristics and the unconfined compressive strength of samples were investigated. This paper illustrates the findings from the laboratory study with particular emphasis on the use of mentioned additive that provide economic benefits as well as reduced environmental impact.

INTRODUCTION

Increasing population and changing demands require advanced approaches to the construction of transportation infrastructure. With respect to the fact that using existing soil is the most economical way, it is inevitable to stabilize and improve the engineering properties of the soil in order to satisfy the necessary criteria for highway constructions. In the conventional way of approach, the soft soil is removed and replaced by gravel or crushed rock fill layer (Senol et al., 2003).

A significant number of researches have been conducted to develop several treatment methods to stabilize soft soils. These treatment methods contain stabilization with chemical additives, prewetting, and replacement of expansive soils with nonexpansive soils, controlling compaction, moisture control, reinforcing the soil using geosynthetics, surcharge loading, and thermal methods (Sridharan et al., 2004). All these methods may have the problematic conditions of being not efficient and expensive. Hence, new methods are still being investigated to increase the strength properties and to reduce the swell behaviors of expansive soils (Puppala et al., 2002).

In recent years, randomly oriented natural and synthetic discrete fiber materials have been added and mixed into problematic soils to improve the strength behavior of soils. A lot of experimental investigations have been performed on the reinforcement of soils with fiber materials (Viswanadham et al. 2008). Previous researches present that strength characteristics of fiber-reinforced soils consisting of randomly oriented discrete fibers are a function of fiber content and fiber-surface friction along with the soil and fiber strength properties. Ziegler et al. (1998) improved that adding fiber to the plain soil result in increasing the tensile strength. Reinforcement of soft soils with fibers submits an alternative method to chemical stabilization methods and other methods for improvement. However, the reports on the use of randomly oriented natural and synthetic discrete fiber materials in order to improve of soft soils have not been seen yet. So, in this research, the efficiency of the use of fiber reinforcement in unconfined compression strength behavior of soft soils is performed.

This paper presents the results of an experimental study on the treatment of two different low plasticity clays for highway embankment construction. In this research, we investigated the use of polypropylene fibers to improve the engineering properties of mentioned clayey soils. The results from this study may lead to significant implications of making the use of marginal on-site materials possible and lowering construction costs.

INDEX AND ENGINEERING PROPERTIES OF MATERIALS

During this research two clay soils with different plasticity, grain size distribution and compactibility are used as plain soils. Improvement of these soil samples with fiber materials was discussed.

Index properties of soils (Soil-I and Soil-II)

The consistency tests show that Soil-I which obtained from Sile district has higher plasticity than Soil-II which obtained from Kitre district. Wet sieve analysis illustrates limited coarse grain size on both of the soil samples and hydrometer analysis shows that clay content of Soil-I is higher than Soil-II. The compaction tests performed on Soil-II gives higher dry unit weight and less optimum water content than Soil-I. All test results are listed in Table 1. From all data obtained during mentioned experiments and with respect to Unified Soil Classification System (ASTM D2487) both Soil-I and Soil-II will be named as CL type soil.

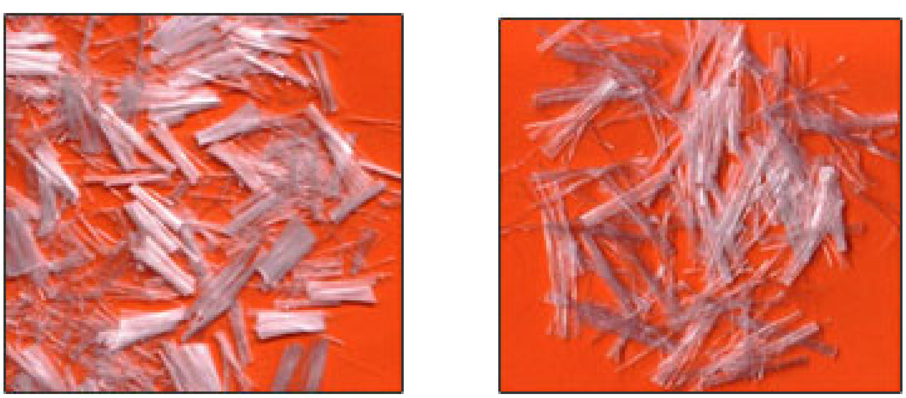
Physical properties of the polypropylene fiber

Polyfiber that made of polypropylene fiber is an engineering product. It is a production for structural materials that were explored by the test results of engineering researches in the USA in 1960s. Polypropylene fiber is the most common synthetic

material used to reinforce concrete and soil. With respect to ASTM C-1116 "Standard Specification for fiber reinforced concrete and shotcrete" polypropylene (PP) shown in Figure 1 is used in concrete applications in order to inhibit concrete cracking caused by plastic and settlement shrinkage that occurs prior to initial set. Polypropylene fiber consists of twisted and monofilament fibrillating network fiber, yielding a high-performance concrete reinforcement system. In terms of the structure of the polypropylene, the gray colored monofilament fibers demonstrates much higher tensile strength than the white colored fibrillated fibers. This extra heavy-duty fiber offers maximum long-term durability, structural enhancements, and effective secondary / temperature crack control by incorporating a truly unique synergistic fiber system of long length design.
Table 2 summarizes the physical properties of polypropylene fibers used in this research.

Table 1. Engineering properties of soil samples

Properties of soil	Soil-I	Soil-II
LL (%)	41	35
PL (%)	23	18
PI (%)	18	17
Gravel (%)	0	0.4
Sand (%)	3	33.1
Silt (%)	27	18.7
Clay (%)	70	47.7
w_{opt} (%)	22	20.3
$\gamma_{dry\ max}$ (kN/m^3)	15.2	15.7
USCS	CL	CL



(M) (F)

FIG. 1. Multifilament fiber (M) and fibrillated polypropylene (F).

Table 2. Physical properties of polypropylene

Properties of material	**Polypropylene**	
Color	White	Gray
Form	Fibrillated fiber	Monofilament fiber
Acid/Alkali resistance	Excellent	Excellent
Specific gravity	0.91	0.91
Absorption	Nil	Nil
Tensile strength (MPa)	570	758
Length (mm)	6,19	6,19
Softening point	150 ^{oC}	150 ^{oC}
Melting point	160 ^{oC}	160 ^{oC}
Compliance	ASTM C-116	ASTM C-116

TESTING PROCEDURE

During this research, the effects of polypropylene adding at different contents into two CL type of plain soils on the compaction characteristics and unconfined compression strength were evaluated. Twelve different soil and propylene mixtures are prepared using standard compaction effort (ASTM 2000, D698a). Standard proctor tests were conducted in specially designed Harvard miniature compaction equipment (Figure 2).

The compaction mold has an inner diameter of 42 mm and a height of 96 mm. As the equipment is calibrated for standard compaction energy; compaction is applied in three layers with 27 hammer blows each. The compaction tests' results for the aformentioned mixture using two different low plasticity clays are shown in Tables 3 and 4, respectively (Senol et al. 2011).

The unconfined compressive strength (ASTM D2166) test is applied in order to estimate the optimum mix design of the stabilized soil. In order to have precise results, at least five cylindrical samples with different water content from each original compacted soil-alternative material mixture are directly subjected to unconfined compression test. Variations in unconfined compressive strength versus molding water content of the prepared samples are plotted in Figures 3 and 4.

FIG. 2. Modified Harvard compaction equipment.

Table 3. Results of compaction experiments executed with Soil-I and polypropylene

Sample #	Description	w_{opt} (%)	γ_{dmax} (kN/m^3)
1	99.75% CL+0.25% PP	20	15.1
2	99. 5% CL+0.5% PP	23	15.3
3	99.25% CL+0.75% PP	18	15.4
4	99% CL+1% PP	21	15.3
5	98.75% CL+1.25% PP	20	15.2