Proceedings of the 3rd International Conference on

Geotechnical Engineering for Disaster Mitigation and Rehabilitation 2011

combined with the 5th International Conference on

Geotechnical and Highway Engineering – Practical Applications, Challenges and Opportunities

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Geotechnical and Highway Engineering – Practical Applications, Challenges and Opportunities

Semarang, Central Java, Indonesia, 18 to 20 May 2011

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Diponegoro University, Indonesia

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Preface

The Third International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation (3ICGEDMAR 2011) together with the Fifth International Conference on Geotechnical and Highway Engineering — Practical Applications, Challenges and Opportunities (5ICGHE) are held at the Gumaya Tower Hotel in Semarang, Indonesia, from 18 to 20 May 2011. This is the third conference in the GEDMAR conference series. The first was held in Singapore from 12 to 13 December 2005 and the second in Nanjing, China, from 30 May to 2 June 2008.

The conference is jointly organized by The Joint Working Group on Geotechnical Engineering for Disaster Mitigation and Rehabilitation (JWG-DMR), Diponegoro University, Indonesia, Ministry of Public Works of the Republic of Indonesia and Indonesian Road Development Association. This has been the fifth time for Semarang to host an international conference on geotechnical engineering since 2002. The conference is held under the auspices of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) Technical Committee TC-303: Coastal and River Disaster Mitigation and Rehabilitation, TC-203: Earthquake Geotechnical Engineering and Associated Problems, TC-302: Forensic Geotechnical Engineering, TC-304: Engineering Practice of Risk Assessment and Management, TC-213: Geotechnics of Soil Erosion, TC-202: Transportation Geotechnics, TC-211: Ground Improvement, Southeast Asian Geotechnical Society (SEAGS), Association of Geotechnical Societies in Southeast Asia (AGSSEA), and Road Engineering Association of Asia & Australasia (REAAA). The conference is also supported by other national and international organizations and universities.

The response for the call for abstracts for the 3ICGEDMAR & 5ICGHE was overwhelming. More than 150 abstracts were received. After a rigorous review process of both the abstracts and full papers, eventually over 89 papers from 25 countries and regions are accepted for publication in this proceedings. These papers have been categorized into sub themes as follows:

1. Case Studies on Recent Disasters
2. Soil Behaviours and Mechanisms for Hazard Analysis
3. Disaster Mitigation and Rehabilitation Techniques
4. Risk Analysis and Geohazard Assessment
5. Innovation Foundations for Rail, Highway, and Embankments
6. Slope Failures and Remedial Measures

The proceeding also includes 14 Keynote Lectures & 17 invited lectures written by internationally renowned experts. It is hope that this proceedings will be a useful source of reference to researchers and practitioners in the field of geotechnical and highway engineering, and other disaster related fields.

Editors
S. P. R. Wardani,
J. Chu,
S. C. Robert Lo,
S. Iai,
K. K. Phoon

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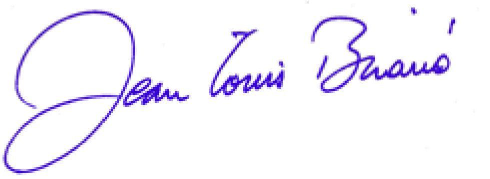
Message from
President of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)

On behalf of the International Society for Soil Mechanics and Geotechnical Engineering, I welcome you the 3rd International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation (GEDMAR2011) combined with the 5th International Conference on Geotechnical and Highway Engineering, here in Semarang, Indonesia. The first topic, Disaster Mitigation and Rehabilitation, has been clearly a source of great concern worldwide in the last couple of years with major disasters in Haiti, Chile, New Zealand, and now Japan. It is critical that all geotechnical engineers keep doing their part to help mitigate such dramatic events and rehabilitate the infrastructure after the fact. The second topic, Geotechnical and Highway Engineering, is also very important. Indeed as populations grow, the traffic congestions become more and more of a problem. Geotechnical engineering has a critical role to play in the development of smart highway engineering infrastructure because any roadway, any bridge, any tunnel is built on or in soil or rock.

Two important ISSMGE technical committees (TC) have a strong connection with these two very important topics in our field. The first one is the TC on Coastal and River Disaster Mitigation and Rehabilitation chaired by Professor Susumu Iai in Japan (iai@geotech.dpri.kyoto-u.ac.jp) and the TC on Transportation Geotechnics chaired by Professor Antonio Correia in Portugal (AGC@civil.uminho.pt). Several other committees are related to those topics and I would encourage you to check the list of ISSMGE technical committees on the ISSMGE web site and join these TCs if you are not already participating.

Consistent with some of the goals of ISSMGE, this conference intends to focus on the interaction between academicians and practitioners for the development of improved solutions. Professor Wardani was the one who started this conference in Semarang in 2002 and has continued to host it since then. The conference has grown and is a tribute to her leadership. Professor Wardani has been actively working to bridge the gap between geotechnical engineering research and practice. Within as short time, she has also managed to establish academic links with a number of countries in Southeast Asia. I would like to recognize and thank Professor Wardani for her vision and dedication to our profession.

I would also like to convey my deepest gratitute to the organizing committee for their hard work to ensure the success of the conference. I wish all the participants a fruitfull and successful conference and a pleasant stay in Semarang.



Prof. Jean-Louis Briaud
President of ISSMGE
Semarang, Indonesia
18 May 2011

Message from
Chair of the Organizing Committee
3ICGEDMAR, 5ICGHE & Int'l Symposium

It gives me great pleasure to extend a very warm welcome to all participants of the 3rd International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation (3ICGEDMAR) combined with the 5th International Conference on Geotechnical and Highway Engineering (5ICGHE). I am also very pleased and felt deeply honored that various experts in their fields of research, academicians and practisioners from national and international organizations and universities are attending to give their big support for the success of the conference. Their knowledge and experience will certainly be useful for the participants and students to understand the sacrifice needed in quest of scientific and technology progress. This conference has indeed grown from strength to strength as evident from the significant increase of international participants. This will not only provide a venue to showcase current research among Indonesian and their International peers but it will also extend a platform for them to share their research findings, exchange of ideas, increase networking as well as explore opportunities for future International collaborations. Thus the thrust of this conference which is to enhance innovation via their research activities is timely and significant.

On behalf of the organizing committee, I would like to express my appreciation to all sponsors for their generous support, and to all speakers for coming here to share their ideas in this international conference. I would like to convey my deepest gratitude to the national and international conference committee members for all the toiling and sweating. For their selfless dedication, I am totally confident that this conference will be a great success. Finally, I hope you will enjoy a great time here.

Prof. Sri Prabandiyani Retno Wardani
Chair of the Organizing Committee
3ICGEDMAR, 5ICGHE & International Symposium
Semarang, Indonesia
18 May 2011

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Case Studies on Recent Disasters

Soil Behaviours and Mechanisms for Hazard Analysis

LABORATORY MODEL TEST ON OF IMPROVED SOIL USING LIME-COLUMN

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ABSTRACT

This lime-column technique has been applied successfully in recent years to improve the physical and mechanical properties of the soils. This technique would increase soil bearing capacity and reduces soil settlement owing to improving of soil strength and stiffness. This paper presents the preliminary results of the small laboratory model test of lime-column technique on soft clay soil to investigate load-settlement characteristic in laboratory. The lime-column was designed as single column with 50 mm in diameter (D), and the depth was 100 mm. The laboratory tests carried out was one dimensional consolidation and small plate loading test. The test results show that before installation of the lime-column, based on the load-settlement curve, the mode of failure was likely defined as general shear failure. The bearing capacity of the soft soil increased from 0.23 kN to 5.2 kN, it was about more than 20 times increasing, after the lime-column was installed. Whole results indicated that lime-column technique is a valuable method to enhance soil bearing capacity and reduce soil settlement.

Keywords: lime-column, deformation, soft soil, bearing capacity

INTRODUCTION

Lime and cement treatment has been extensively used in the field of highways, railroads and airports construction purposes resulting in increased bearing capacity of soft subgrade, enabling an improvement the mechanical properties of the bearing layers. The use of lime or cement stabilization has been extended to greater depth in which lime or cement columns act as a type of soil reinforcement. The layers of lime or cement stabilized soils can also function as rigid crust which is useful in spreading the applied loads to the subsoil. The lime or cement column is variant of deep mixing method. The Deep Mixing Method (DMM) is common technique for an in situ soil treatment technology whereby the soil is blended with cementitious and/or other materials. These materials are widely referred to as "binders" and can be introduced in dry or slurry form. They are injected through hollow, rotated mixing shafts tipped with some type of cutting tool (Terashi, 1997). The lime-column method was formed by injecting the dry or wet lime under preferable pressure into soil in-situ. The dry mixing is commonly applied for clays, and wet mixing is suitable for sands layers (Rogers and Glendinning, 1997). The lime-column technique has been applied successfully in recent years to improve the physical and mechanical properties of the soils. This technique would increase soil bearing capacity and reduces soil settlement owing to improving of soil strength and stiffness. Hence, this technique was preferable for soft soil improvement (Broms and Boman, 1975). A study carried by Baker (2000) on full-scale model showed that the stiffness of the improved soil using lime-column increased more significantly than that of lime-cement column. Several researchers (e.g. Shen et al., 2003; Tonoz et al., 2003; Budi, 2003) studied separately the strength of the soil surrounding the lime-column. They reported that the soil strength increased near the column to a distance up to 2 to 3 times of the column diameter in radial direction. Muntohar and Liao (2006) found that the strength of clay beneath the lime-column increased multiply. The influencing layer was up to 4 to 6 times of the column diameter from the bottom of column. This paper aim is at examining the load and deformation of the lime-column model in laboratory scale.

DESIGN OF EXPERIMENTS

Materials

The soil was taken from the area in Kasihan, Bantul where is located at southern nearby Universitas Muhammadiyah Yogyakarta campus. The specific gravity of the soil was about 2.64. The particle size distribution of the soil sample is shown in Figure 1a. The soil was consisted of about 10% coarse particles and 90% fines particles. The fines particle was predominantly silt size fraction that is 60% and the rest was 30% clay size particles. The liquid limit and plasticity index of the soil were 73% and 36% respectively. According to the Unified Soil Classification System by ASTM D2487, the soil used is classified as clayey soil which is symbolized with ML/OH (Figure 1b). The unconfined compressive strength of the soil at its liqud limit state was examined about 5.8 kPa. Hydrated lime was used as stabilizing agent in this research. To reduce the carbonation effect due to humidity, the lime was kept in an airtight plastic container.

Specimens Preparation and Testing Procedures

Lime columns of 50 mm in diameter and 100 mm in length were installed in the container of 100 x 25 x 20 cm in dimension of length, height, and width respectively (Figure 2). The clay prepared in the tank was saturated by controlling the water level at the ground surface for 1 – 2 months. It results in a degree of saturation about 90%-98%. Consolidation test for the soil sample indicated that the soil undergoes a higher stresses before compared with the current stress and can be considered as OC clay since the overconslidated ratio (OCR) was 1.85. The compressibility coefficient (C_c) and swelling index (C_s) are about 0.5 to 0.6 and 0.07 to 0.085 respectively. Loading test was performed in this study to investigate settlement characteristic. A steel plate with 25 mm thickness and 150 mm in diameter was placed on the soil surface. This foundation was then loaded until failure was reached. The loading rate was arranged about 1 mm/minute. The settlement and load was recorded from the dial gauge upon on the foundation and in proving ring respectively (Figure 2).

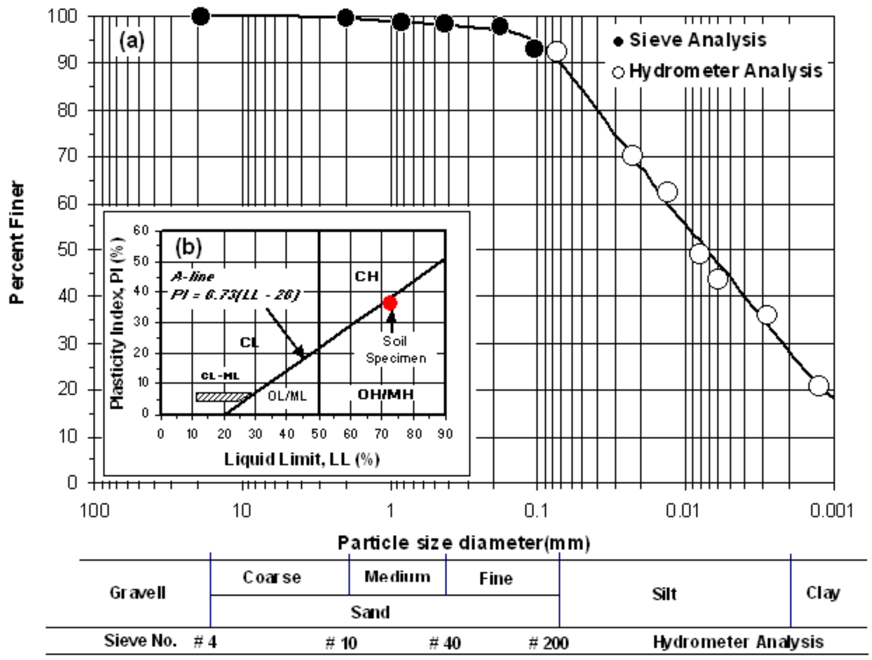

Figure 1: Particle size distribution of the soil used

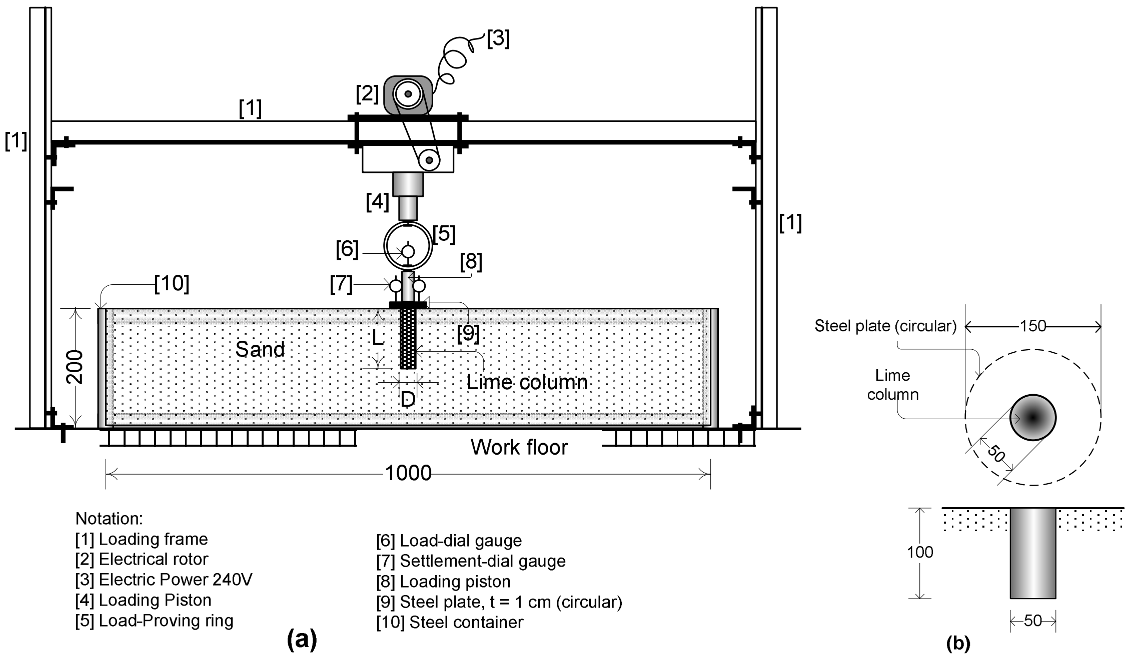

Figure 2 Arrangement of loading test (a) schematic diagram of the load frame, (b) details size of lime-column and steel plate

RESULTS AND DISCUSSION

Figure 3 shows the load–settlement curves for the constant rate loading test carried out using 15 cm circular plates directly on soft soil surface. Diameter of the plate represents the effective influence zone (Figure 2). The area replacement ratio (α_c) of the soil-lime column was 0.33 that is a ratio between diameter of lime-column (5 cm) and effective influence zone (15 cm).

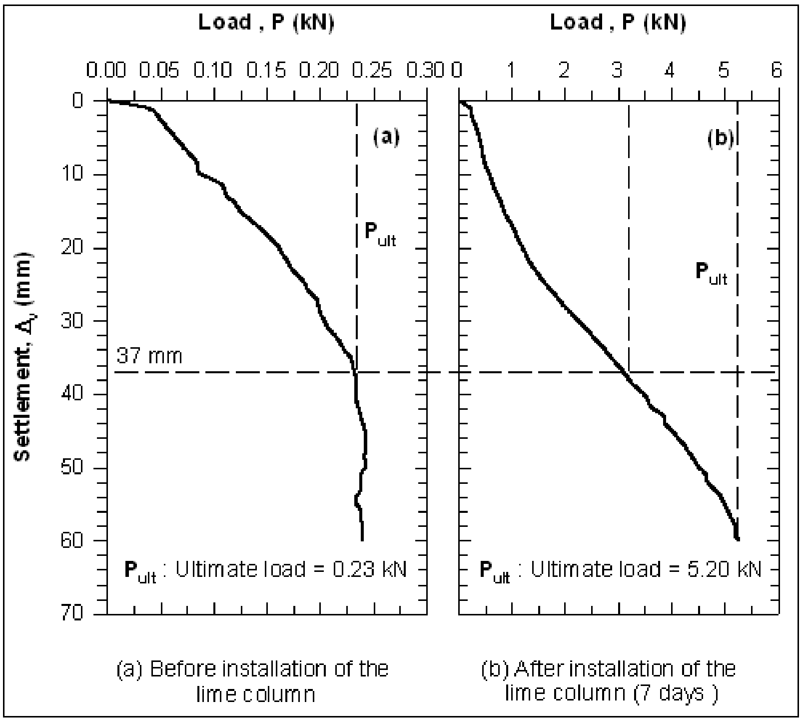

Figure 3 Load – settlement curve for constant rate loading test.

Comparing the load–settlement curves, it was clearly observed that installation of the lime-column improved the bearing capacity of the soft soil. This behavior is consistent with the UCS test and CPT results as discussed by Muntohar and Liao (2006). Before installation of the lime-column, based on the load-settlement curve, the mode of failure was likely defined as general shear failure (Craig, 2004). The soil experienced failure at 0.23 kN loading. Coincidently, the plate undergoes larger settlement up to 37 mm (Figure 3a). On contrary for the lime-column improved soft soil, the strength of improved soft soil increased continuously even at large deformations (Figure 3b). Failure would be attained after reaching 60 mm vertical deformation. The ultimate load was approaching 5.2 kN. It means that the bearing capacity increased 23 times approximately after the lime-column was installed. But, if the load was measured at 37 mm vertical deformation, the bearing capacity lead to increase 13 times from 0.23 kN to 3 kN.

Kempfert (2003) mentioned that the effect of a soil improvement is usually expressed by an improvement factor β:

$$\beta = \frac{\text{Settlement of the unimproved soil}}{\text{Settlement of the improved soil}} \quad (1)$$

Larger improvement factor indicates larger reduction in soil settlement. Comparing the settlement at P_{ult} = 0.23 kN, the settlement of the unimproved soil is about 37 mm while settlement of the improved soil is about 2 mm. Hence, the improvement factor β is 18.5.

CONCLUDING REMARKS

The laboratory experiment has been successfully carried out to study load and deformation of the improved soft soil by using lime-column installation. Remarks form test result is that the lime-column improved the bearing capacity of the soft soil. The bearing capacity of the soft soil increased 23 times from 0.23 kN to 5.2 kN after the lime-column was installed. The improvement factor β, for are replacement ratio α_c = 0.33, was about 18.5. Since the test is a small laboratory model, experiments on large scale and numerical simulation should be extended to cover more impressive conclusion.

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Sincerely Yours,
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SHEAR STRENGTH CHARACTERISTICS OF THE WASTE FIBERS REINFORCED LIME-RICE HUSK ASH STABILIZED CLAY

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ABSTRACT

In order to reduce the brittleness of soil stabilized by lime only, a recent study of a newly proposed mixture of fiber wastes and lime – rice hush ash mixtures for ground improvement is described and reported in the paper. The research was conducted to investigate the influence of the mixture of wastes fibers on the mechanical properties of the stabilized clay soil with lime-rice husk mixtures. The amount of lime and rice husk ash was prepared 12% by dry weight of soil specimen. The fiber content and length are 0.4% (by weight of the parent soil) and 2 mm respectively. The treated specimens were subjected to triaxial tests under unconsolidated – undrained condition (UU) condition which is tested after 3, 7, 14 and 21 days of curing. It was found that addition of fibers contributed significant influence on the shear strength behavior of the treated soil. The shear strength increased with increasing of curing. Stress and strain relationship shows the post peak strength which indicating ductility behavior of the treated soil.

Keywords: shear strength, fibers, lime, rice husk ash, clay, triaxial

INTRODUCTION

A main concern with clayey soils is their generally low strength which typically varies with loading and drainage conditions. Soil modification and stabilization by using some pozzolanic materials is the common method to enhance the strength of clay. Addition of rice husk ash (RHA) in lime or cement stabilized soils enhanced the compressive strength significantly (Balasubramniam et al, 1999, Muntohar and Hashim, 2002). However, the higher strength was obtained at small strain (Basha et al, 2005). This characteristic can be improved by means inclusion of discrete element such as fibers in the stabilized soil. Stabilized and reinforced soils are, in general, composite materials that result from combination and optimization of the properties of individual constituent materials. A known approach in this area is the use of fiber waste materials in the composite (Consoli et al., 2002). Plastic-waste materials are produced plentifully such as polyethylene terephthalate (PET) plastic bottles, polypropylene (PP) of plastic sack, and polypropylene (PP) of carpet. But such materials have been used little for engineering purposes, and the overwhelming majority of them have been placed in storage or disposal sites.

Utilization of the waste materials for geotechnical materials was to explore the conversion of the waste-fibers into a value-added product for soil reinforcement. Many researches on soil-fiber reinforcement have demonstrated that the inclusion of fibers significantly improves the engineering response of soils under a variety of stress paths (e.g., Maher and Gray 1990; Consoli et al., 2002; Zornberg, 2002; Michalowski and Cermák, 2003; and Kumar et al., 2006). Some of factors such as the content, length, thickness, modulus, tensile strength, and failure strain of fibers and the soil properties such as grain size distribution, type and shape, influence the behavior of the soil–fiber composite. More work is necessary to comprehend the influence of fiber inclusion on the mechanical behavior of cemented a soils. This paper aims at examining the influence of plastic-waste fiber on the undrained shear strength characteristics of treated clay with lime – rice husk ash mixtures.

METHOD OF EXPERIMENTS

Materials

The disturbed and undisturbed soil was obtained from the quarry of double-track railway project in Sentolo, Yogyakarta, Indonesia. Particle size test ASTM D422 for soil samples indicated that the soil was comprised of 35% clay-size fraction, 43% silt-size fraction, and 23% sand fraction as shown in the particle size distribution in Figure 1. The liquid limit and plastic limit test (ASTM D 4318) resulted that the liquid limit and plasticity index of the soil were 59% and 29% respectively. The soil was classified as high-plasticity clay (CH) according to Unified Soil Classification System (ASTM D2487). The maximum dry density (MDD) and optimum water content (OMC) of the clay are 10.32 kN/m^3 and 35% respectively according to ASTM D698. Lime and rice husk ash was used in powder form. Hydrated lime was used as stabilizing agent in this research. To reduce the carbonation effect due to humidity, the lime was kept in an airtight plastic container. The grey-colored RHA were collected from the rice husk combustion. Before used, the rice husk ash was sieved to separate other useless material. To obtain fines ashes, the RHA were grounded in machine. The grinding process produces suitable fineness and proper surface area of RHA respectively about 12.4% and 25 mm^2/g. Plastic fibers used in the present investigation were cut to the designed length from locally available plastic-bag wastes. The plastic-bag was consisted of woven polypropylene fibers. The width of single fiber was approximately 2 mm – 2.5 mm. Tensile strength of the plastic fiber specimens were 63 kN/m^2 and the strain at rupture was 15 % in average. For this research, the plastic-bag was cut to the length of 20 mm to yield a discrete fiber.

Specimens Preparation and Testing Procedures

The treated and reinforced soil specimens were compacted at their respective MDD and OMC. For treated specimens, predetermine amount of lime and rice husk ash was prepared first in dry mixture, and followed with addition of water. For reinforced specimens, fibers were then gradually dispersed and added into the mix, followed by the addition of water and further mixing. All the fibers were mixed thoroughly to achieve a fairly uniform mixture. Soil specimens were compacted to a diameter of 38 mm and a height of 72 mm. The mass of specimen was determined immediately after preparation and then kept in a plastic bag for 3, 7, 14, and 21 days of curing. All specimens were then placed into the triaxial chamber under unconsolidated-undrained conditions (UU). The cell pressures were applied at 98.1 kPa, 196.2 kPa, and 294.3 kPa. The testing procedure of triaxial UU refers to ASTM D2850. triaxial tests at the shear rate of 0.8 mm/min.

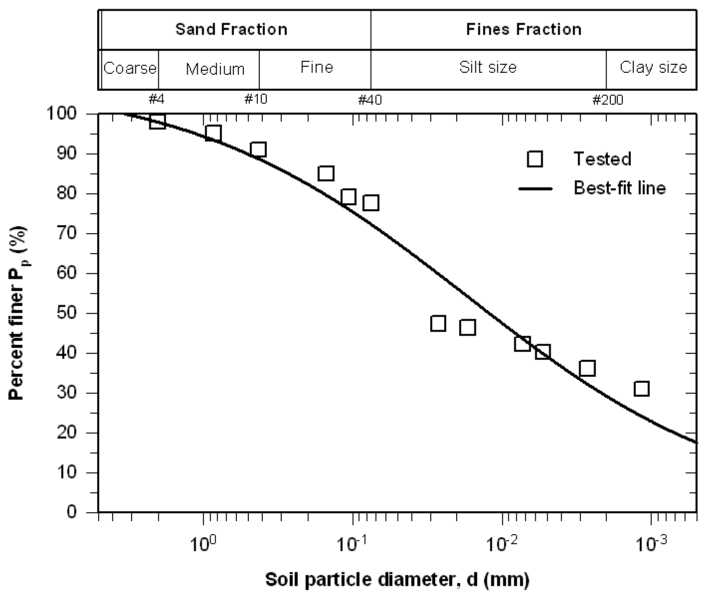

Figure 1: Particle size distribution of the soil used

RESULTS AND DISCUSSION

Figures 2 illustrates the stress difference ($\Delta\sigma_d$) and strain (ε_v) relationships of untreated and treated clay mixed with the fibers at different cell pressures respectively 98.1 kPa, 196.2 kPa, and 294.3 kPa after seven days of moist-curing. The figure depicts that the treated clay with lime-RHA show higher stress response comparing with undisturbed soil. The mixed clay with lime-RHA shows brittle behavior among the tested specimens. Inclusion of fibers in the mixed-clay can reduce the brittleness. The change in the ductility of the soil specimens can be defined using a brittleness factor (Consoli et al. 2002, Li 2005), which quantifies the differences in the stress-strain curves of the soil. The brittleness factor is defined as the ratio of the peak principal stress ratio to the residual principal stress ratio minus unity as given in Equation (1) as following:

$$I_B = \frac{(\Delta\sigma_d)_{peak}}{(\Delta\sigma_d)_{residual}} - 1 \qquad (1)$$

The value of I_B ranges from 1 to 0, where 0 represents perfectly ductile behavior. The brittleness factor for unreinforced clay specimens ranged from 0.02 to 0.09, while the factor ranged from 0.52 to 0.67 and 0.13 to 0.35 respectively for treated and reinforced soil specimens. The range of factors is much influenced by the confining pressure within the specimens. This research indicates that inclusion of plastic waste fibers enhance ductility of the clay and lime-RHA mixtures. In this research, the brittleness factors also increase with increasing of curing age of the treated specimens. The brittleness factor increases to 0.36 – 0.38 and 0.58 – 0.61 respectively after 14 and 21 days of curing.

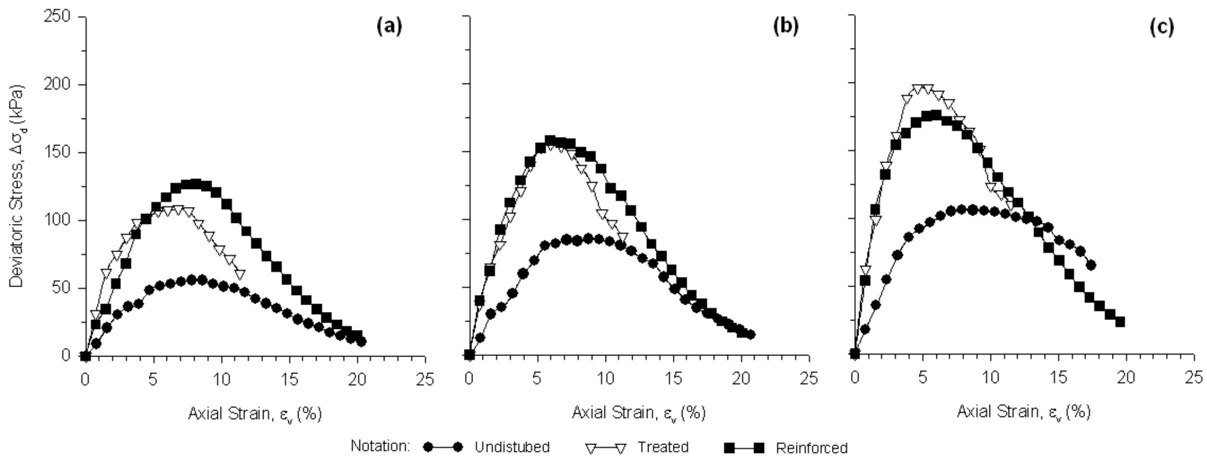

Figure 2: Typical deviatoric stress and strain relationship at cell pressure, σ_3 = 98.1 kPa (a), σ_3 = 196.2 kPa (b), and σ_3 = 294.3 kPa (c).

Table 1 Shear strength parameters of the specimens tested

Specimens	Curing Age (days)	Cohesion, c (kPa)	Friction Angle, ϕ (degree)
Undisturbed soil	--	14.3	6.5
Treated	7	27.3	10.5
Reinforced	3	27.6	7.8
	7	41.0	12.8
	14	46.7	12.35
	21	58.3	12.18

Effect of curing age on the shear strength parameter is presented in Table 1. The table clearly depicts that curing age affected significantly the cohesion of specimens. But, the effect on internal friction angle seems to be neglected after seven days of curing. This result implies that increasing shear strength of soil-fibers composite is much controlled by cohesion. From the data it can be seen that the values of cohesion of fiber-reinforced treated soil, like those of cemented soil, increase with increasing the curing time. Tang et al. (2007) observed that the increase in strength of combined fiber and cement inclusions is much more than the sum of the increases caused by them individually.

CONCLUSIONS

A series of tests were performed to study the effects of randomly distributed short plastic waste-fiber reinforcement on the shear strength behavior of treated soil with lime-RHA mixture. The effects of fiber inclusions and curing age on shear strength parameters and ductility of soil specimens were determined. The following are the conclusions from these tests. Inclusion of plastic waste fibers enhanced ductility of the stabilized clay. However, the brittleness factors also increase with increasing of curing age of the treated specimens. It could be concluded from this study that the combination of discrete plastic waste fiber and lime–RHA has the virtues clay soil, and therefore the addition of fiber–lime–RHA to soil can be considered as an efficient method for ground improvement.

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