Analysis of effect of polypropylene fibre and lime admixture on engineeringproperties of clayey soil

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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 polypropylene fibre and lime for ground improvement is described and reported in the paper. To investigate and understand the influence of the mixture of polypropylene fibre and lime on the engineering properties of a clayey soil, nine groups of treated soil specimens were prepared and tested at three different percentages of fibre content (i.e. 0.05%, 0.15%, 0.25% by weight of the parent soil) and three different percentages of lime (i.e. 2%, 5%, 8% by weight of the parent soil). These treated specimens were subjected to unconfined compression, direct shear, swelling and shrinkage tests. Through scanning electron microscopy (SEM) analysis of the specimens after shearing, the improving mechanisms of polypropylene fibre and lime in the soil were discussed and the observed test results were explained. It was found that fibre content, lime content and curing duration had significant influence on the engineering properties of the fibre–lime treated soil. An increase in lime content resulted in an initial increase followed by a slight decrease in unconfined compressive strength, cohesion and angle of internal friction of the clayey soil. On the other hand, an increase in lime content led to a reduction of swelling and shrinkage potential. However, an increase in fibre content caused an increase in strength and shrinkage potential but brought on the reduction of swelling potential. An increase in curing duration improved the unconfined compressive strength and shear strength parameters of the stabilized soil significantly. Based on the SEM analysis, it was found that the presence of fibre contributed to physical interaction between fibre and soil whereas the use of lime produced chemical reaction between lime and soil and changed soil fabric significantly.

Keywords: Soil; Polypropylene fibre; Lime; Ground improvement; SEM analysis

1. Introduction

With the reduction of available land resources, more and more construction of civil engineering structures is carried out over weak or soft soil, which leads to the establishment and development of various ground improvement techniques such as soil stabilization and reinforcement.

Lime stabilization has been extensively applied in practice of civil engineering such as foundations, roadbeds, embankments and piles (Ye and Ye, 1999; Jiang, 2002). When lime is added to soils, it reacts with soil particles, which leads to the improvement in many engineering properties of soils. Some investigators

Table 1
Engineering properties of the clayey soil used

Serial number	Engineering properties	Values
1	Specific gravity	2.73
2	Grain size analysis	
	Gravel	0.0%
	Sand	13.2%
	Silt	61.8%
	Clay	25.0%
3	Consistency limit	
	Liquid limit	34.5%
	Plastic Limit	16.9%
	Plasticity index	17.6
4	IS Classification	CL
5	Compaction study	
	Optimum moisture content	15.8%
	Maximum dry density	1.70 g/cm^3
6	Shear strength parameters	
	Cohesion	90.0 kPa
	Angle of internal friction	19.1°

found that the strength behavior of soils was greatly improved after lime treatment (Balasubramaniam et al., 1989; Locat et al., 1990, 1996; Narasimha Rao and Rajasekaran, 1996). The work of Bell (1996) indicated that soils treated with lime experienced notable increases in optimum moisture content while undergoing a decrease in maximum dry density. Rajasekaran and Narasimha Rao (1996, 2002) reported that the strong cementation bonds between soil particles, brought by lime–soil reactions, could resist the forces applied effectively, which resulted in the reduction of compressibility of marine soils. Du et al. (1999) and Al-Rawas et al. (2005) carried out tests on the expansive soils and found that both swell percentage and swell pressure reduced to zero with a given amount of lime admixed to expansive soils. While the use of lime improves the above engineering properties, it brings unfavorable changes of other properties. The test results of Clare and Cruchley (1957) indicated that there was a decrease in plasticity of soils after lime stabilization. Some researchers found that lime treatment contributed to the brittle failure characteristics of soils that led to a rapid and great loss in strength when failure occurs (Sabry et al., 1996; Cai et al., 2005).

In recent years, discrete fibres have been added and mixed into soils to improve the strength behavior of soils (Mandal and Murti, 1989; Prabakar and Sridhar, 2002). Li et al. (1995) reported that there were notable increases in shear strength, toughness and plasticity of a cohesive soil after reinforcement with discrete polypropylene fibre. The results of Cai et al. (2005) indicated that fibre-reinforced soils took on the strain-hardening ductile failure characteristics. In addition, some investigators (Péra and Ambrois, 1998; Savastano et al., 2003; Kaufmann et al., 2004) found that the use of discrete fibre increased significantly the toughness and led to further improvement of the strength behavior of cement. However, the reports on the use of discrete fibre for improving the toughness and strength of lime-stabilized soils have not been seen yet. Thus, an attempt to admix polypropylene fibre and lime to soils for ground improvement was presented in this paper.

In order to understand the effect of polypropylene fibre content, lime content and curing time on the strength behavior of a clayey soil investigated, a great number of untreated and treated soil specimens were subjected to unconfined compressive tests and direct shear tests. Moreover, other important engineering properties such as swell percent, shrinkage parameters and failure characteristics were studied. Besides these tests, some specimens after shearing were taken for scanning electronic microscopy (SEM) analysis. On the basis of SEM analysis, the improving mechanisms of polypropylene fibre and lime were discussed and the observations from tests were explained. The primary objective of this paper described herein is to assess the usefulness of admixture of polypropylene fibre and lime as soil treatment material for improving the pertinent engineering properties of a clayey soil, e.g. strength, swelling–shrinkage potential and failure characteristics.

2. Materials and experimental programme

Materials

The soil used herein was Xiashu soil, a typical clayey soil extensively distributed in Nanjing region, China. Owing to high initial moisture content, the soil was air-dried at first and then broken into pieces in the laboratory. Engineering properties of the collected soil are presented in Table 1. Polypropylene fibre used in this investigation was provided by Nanjing Fibre Company.

Table 2
Physical and chemical properties of fibre used

Serial number	Physical and chemical properties	Values
1	Fibre type	Single fibre
2	Unit weight	0.91 g/cm^3
3	Average diameter	0.034 mm
4	Average length	12 mm
5	Breaking tensile strength	350 MPa
6	Modulus of elasticity	3500 MPa
7	Fusion point	165 °C
8	Burning point	590 °C
9	Acid and alkali resistance	Very good
10	Dispersibility	Excellent

Table 3
Preparation of specimens for different tests

Test	Size		Moisture content (%)	Dry density (g/cm^3)
	Diameter (mm)	Height (mm)		
Unconfined compression[a]	39.1	80	16.5	1.6
Direct shear	61.8	20	16.5	1.6
Swelling	61.8	20	16.5	1.6
Shrinkage	61.8	20	30	1.5

[a] Four-layered compaction was adopted to keep the uniformity of specimens.

The behavior parameters of the fibre are given in the Table 2. In addition, the content percentages of CaO and MgO in lime are, respectively, 71.27% and 3.64%, which ensures the effectiveness of lime stabilization.

Preparation of specimens

According to some pertinent studies on lime soils (Bell, 1996; Han and Wang, 2001) and fibre reinforced soils (Li et al., 1995), three different percentages of lime content (i.e. 2%, 5% and 8% by weight of the parent soil) and three different percentages of polypropylene fibre content (i.e. 0.05%, 0.15% and 0.25% by weight of the parent soil), were chosen in this investigation, which formed nine groups of fibre–lime treated soil. In order to fully understand the improvement of fibre–lime treated soil, the specimens of the untreated soil, 0.25% fibre-reinforced soil and 8% lime-stabilized soil were prepared as reference specimens. All specimens were prepared with static compaction method specified in GB/T 50123-1999, i.e. a national criterion for geotechnical tests in China. Owing to different test requirements, there are differences in preparation of specimens for different tests. Table 3 shows the preparation of specimens for each test carried out in this investigation. After completion of compaction, all specimens, except for the untreated specimens and pure fibre ones (made only by fibre), were wrapped with thin plastic film and stored in the curing box (20 ± 1 °C, 96 ± 2% RH) until tested at 7, 14 and 28 days.

Testing programme

As a prerequisite of this investigation, the engineering properties of the clayey soil used, e.g. specific gravity, consistency limit, IS classification, shear strength parameters, were determined in the laboratory according to the pertinent tests specified in GB/T 50123-1999. In order to assess the influence of random inclusion of lime and fibre on engineering properties of the clayey soil, twelve groups of soil specimens including one untreated, one fibre-reinforced, one lime-stabilized and nine fibre–lime treated specimens were subjected to four different tests, i.e. unconfined compressive test, direct shear test, swelling and shrinkage tests. To the specimens for the unconfined compressive test, they were taken from the plastic film and soaked in the water for 1 day before testing. Because of collapses of untreated and fibre-reinforced specimens in the water, these two specimens were directly tested without one-day immersion in the water. This test was performed on specimens at the strain rate of 2.4 mm/min until specimens failed. The direct shear test was carried out at the strain rate of 0.8 mm/min under the normal pressures (σ_1) of 50, 100, 200 and 300 kPa. Owing to the Xiaoshu soil of weak swelling–

Table 4
Unconfined compressive strength and swelling–shrinkage potentials of specimens

Serial number	Fibre content (%)	Lime content (%)	Unconfined compressive strength (MPa)			Swell Percentage (%)	Shrinkage percentage (%)	Shrinkage coefficient
			7 days	14 days	28 days			
1	0.05	2	0.24	0.28	0.35	0.37	1.60	0.072
2	0.05	5	0.43	0.49	0.84	0.19	1.27	0.054
3	0.05	8	0.41	0.47	0.74	0.13	1.24	0.051
4	0.15	2	0.27	0.30	0.36	0.35	1.69	0.084
5	0.15	5	0.46	0.51	0.87	0.16	1.30	0.063
6	0.15	8	0.44	0.50	0.76	0.09	1.25	0.054
7	0.25	2	0.28	0.34	0.39	0.21	1.80	0.102
8	0.25	5	0.53	0.58	0.88	0.10	1.40	0.068
9	0.25	8	0.50	0.56	0.79	0.06	1.37	0.056
10	0	8	0.31	0.38	0.66	0.07	1.15	0.042
11	0	0	-[a]/0.09[b]			11.48	2.12	0.159
12	0.25	0	-[a]/0.12[b]			8.41	2.15	0.161

[a] The specimen collapsed after soaking in water and hence no value could be obtained.
[b] The value was gained without the specimen's immersion in water and curing before testing.

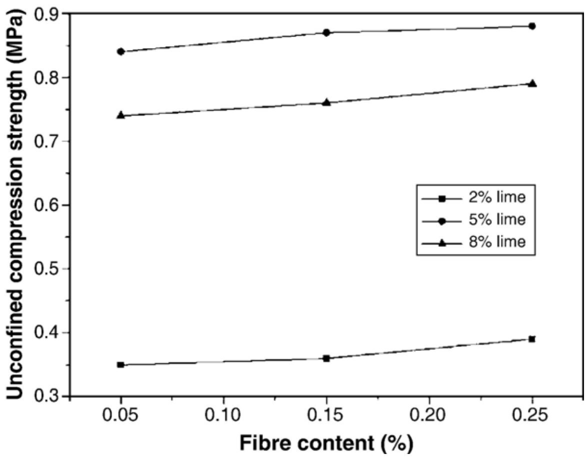

Fig. 1. Effect of the fibre content on unconfined compressive strength of fibre–lime treated soil specimens after 28-day curing.

shrinkage potential, the unloaded swell method was employed and only 7-day curing was concerned for both swelling and shrinkage tests in this investigation.

3. Results and analysis

Variation of unconfined compressive strength

The values of unconfined compressive strength of specimens are presented in Table 4. It is observed that the strength of each fibre–lime specimen, like that of lime-stabilized one, increases while increasing the length of curing. For the specimens of the same curing duration, the differences in both fibre and lime content result in the variation of the strength. Fig. 1 presents the variation of the strength after 28-day curing. It is indicated that, for any particular lime content, an increase in fibre content from 0.05% to 0.25% induces a gradual improvement in strength. However, for any fibre content studied, the strength increases at first and then decreases a little while lime amount increases from 2% to 8%. The maximum value of the strength as 0.88 MPa, is observed at 0.25% fibre + 5% lime content, which is 9.8 times that of the untreated specimen, 7.3 times that of the pure fibre one and 1.3 times that of the pure lime one with 28-day curing. The lowest value, recorded as 0.35 MPa in the case of 0.05% fibre+ 2% lime content, is 3.9 times that of the untreated specimen and 2.9 times that of the pure fibre one. Due to the incomplete reactions between lime and soil, the strength variation trend of 7-day cured specimens with lime content is different from those of specimens after curing of 14 and 28 days.

Variation of shear strength parameters

The values of cohesion and internal friction angle of specimens tested at 7, 14 and 28 days are given in Table 5. It is shown that by an increase in the length of curing time, both cohesion and internal friction angle of fibre–lime treated specimens increase. In addition, the addition amounts of fibre and lime have the significant influence on the development of cohesion and internal friction angle and the similar trends are found in three different curing durations studied herein. With the curing of 28 days as an example, the variations of cohesion and friction angles with fibre content are illustrated in Figs. 2 and 3, respectively. It is indicated from Fig. 2 that cohesion of fibre–lime specimens at any particular lime content increases while increasing fibre content. But in the case of the same fibre content, cohesion increases initially and then decreases slightly

Table 5
Cohesion and angle of internal friction tested at different curing duration

Serial number	Fibre content (%)	Lime content (%)	Cohesion (kPa)			Angle of internal friction (degree)		
			7 days	14 days	28 days	7 days	14 days	28 days
1	0.05	2	155.0	164.6	173.7	26.0	29.2	31.2
2	0.05	5	158.6	220.4	240.5	31.6	37.2	38.4
3	0.05	8	126.0	136.1	236.0	32.9	35.7	38.5
4	0.15	2	161.9	171.8	178.4	30.8	34.0	35.9
5	0.15	5	214.3	245.9	267.1	33.3	39.4	42.3
6	0.15	8	200.3	230.0	263.7	33.1	40.8	41.5
7	0.25	2	171.6	195.2	197.2	33.3	35.5	37.4
8	0.25	5	233.4	261.6	292.7	37.3	41.7	45.0
9	0.25	8	217.9	235.6	287.1	34.8	41.2	43.7
10	0	8	188.7	204.0	216.1	33.5	36.2	37.7
11	0	0	90.0[a]			19.1[a]		
12	0.25	0	108.6[a]			25.6[a]		

[a] The value was obtained without curing of the specimen before testing.

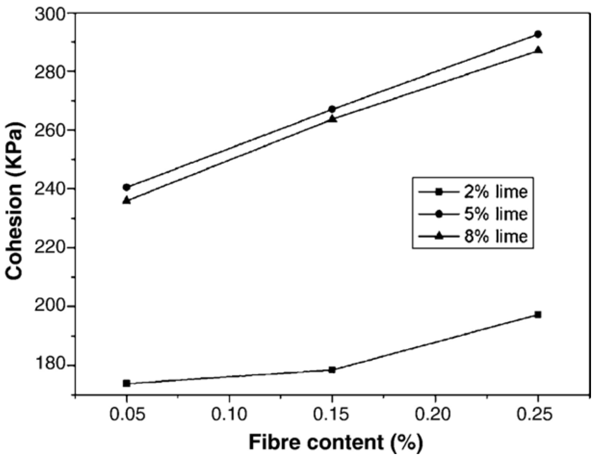

Fig. 2. Effect of the fibre content on cohesion of fibre–lime treated soil specimens after 28-day curing.

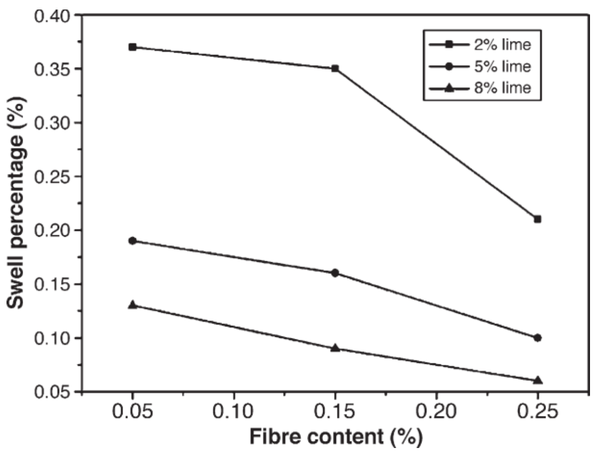

Fig. 4. Effect of the fibre content on swell percentage of fibre–lime treated soil specimens after 7-day curing.

with an increase in lime content from 2% to 8%. The maximum of cohesion is observed at 0.25% fibre+ 5% lime content as 292.7 kPa, which is 3.3 times that of the untreated specimen, 2.7 times that of the pure fibre one, 1.4 times that of the pure lime one of the same curing duration. The minimum is 173.7 kPa in the case of 0.05% fibre+ 2% lime content, which is 1.9 times that of the untreated specimen and 1.6 times that of the pure fibre one.

The variation of internal friction angle with fibre content, illustrated in Fig. 3, is similar to that of cohesion. The maximum of internal friction angle, 45.0°, is also observed at 0.25% fibre+ 5% lime content. It increases by 2.4 times that of the untreated specimen, 1.8 times that of the pure fibre one and 1.2 times that of the pure lime one cured for 28 days. The lowest value, found as 31.2° in the case of 0.05% fibre+ 2% lime content, is 1.6 times that of the untreated specimen and 1.2 times that of the pure fibre one. According to the results of unconfined compressive test and direct shear test, the optimum lime requirement for strength improvement could be determined as a certain percentage close to 5.

Variation of swelling and shrinkage potential

The values of indices of swelling–shrinkage potential, i.e. swell percentage, shrinkage percentage and shrinkage coefficient are presented in Table 4. It is shown that the swelling–shrinkage potential of fibre–lime treated specimens, approaching that of lime-stabilized one, is far smaller than that of the untreated

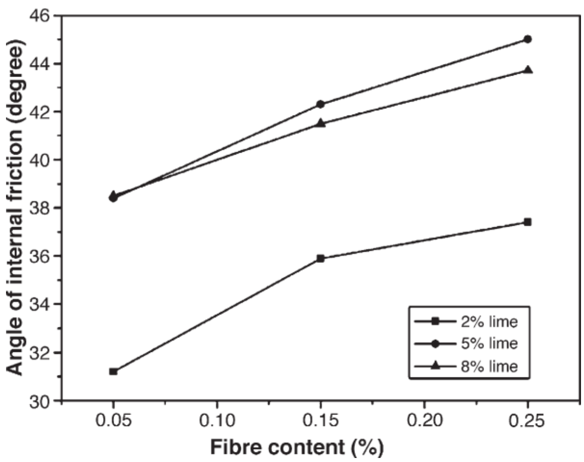

Fig. 3. Effect of the fibre content on angle of internal friction of fibre–lime treated soil specimens after 28-day curing.

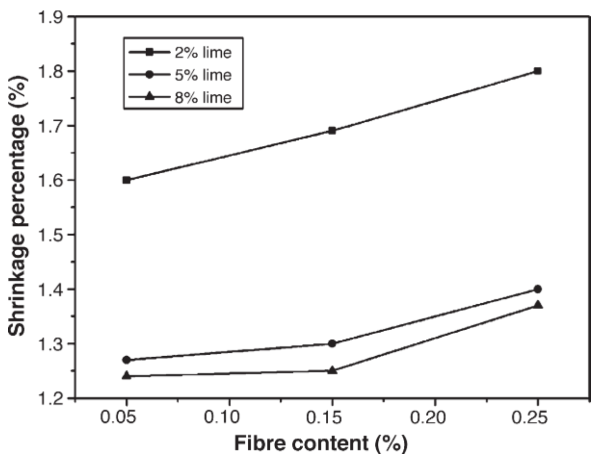

Fig. 5. Effect of the fibre content on shrinkage percentage of fibre–lime treated soil specimens after 7-day curing.

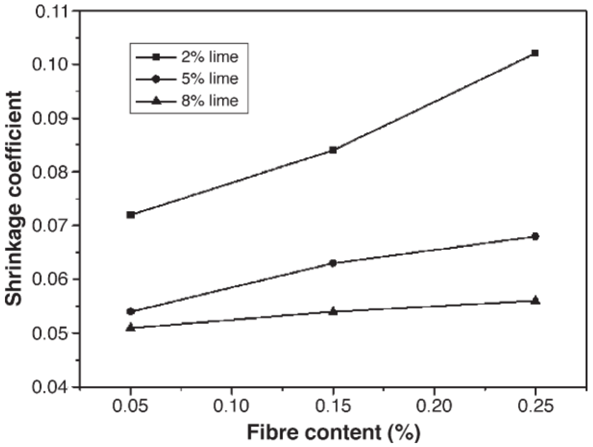

Fig. 6. Effect of the fibre content on shrinkage coefficient of fibre–lime treated soil specimens after 7-day curing.

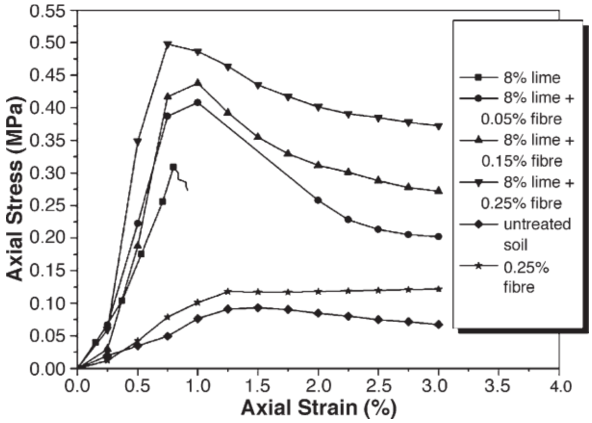

Fig. 7. Axial stress–strain curves of six specimens after 7-day curing.

one which is very close to that of fibre-reinforced one. For any particular fibre content, with an increase in amount of lime, there are notable decreases in three indices above, which is different from the variation of strength behavior with lime content.

The variations of swell percentage, shrinkage percentage and shrinkage coefficient with fibre content are plotted in Figs. 4, 5 and 6, respectively. It is observed from Fig. 4 that for any particular lime content, an increase in fibre content causes a distinct decrease in swell percentage. The minimum of swell percentage in Fig. 4 is recorded as 0.06% with addition amounts of 0.25% fibre and 8% lime.

Figs. 5 and 6 indicate that by an increase in fibre content at any lime content, the shrinkage percentage and shrinkage coefficient increase, which is opposite to the variation trend of swelling percentage. The lowest value of shrinkage percentage, observed at 0.05% fibre+ 8% lime content, is 1.24%, which represents the reduction of approximately 2 times compared with those of the untreated and pure fibre specimens. The minimum of shrinkage coefficient is found as 0.051 in the case of 0.05% fibre+ 8% lime content.

Variation of failure characteristics

The addition of fibre and lime has significant influence on the failure characteristics of specimens. From six axial stress–strain curves presented in Fig. 7, it is observed that fibre–lime specimens, like the untreated one, take on strain-softening ductile failure and the pure fibre one does strain-hardening ductile failure, whereas the pure lime one does brittle failure. As far as four specimens with inclusion of 8% lime are concerned, an increase in fibre content from 0 to 0.25% gives a rise to the residual strength of specimens varying from 0 to 0.39 MPa and also causes the variation of failure mode from complete brittleness to ductility. The difference in size of cracks in the surface of these four specimens after compression failure is observed in Fig. 8. It is clearly shown that big cracks gradually vanish and small ones appear instead of them while increasing the fibre content.

SEM studies

After shearing, four specimens including the untreated, 0.25% fibre-reinforced, 8% lime-stabilized and 0.25% fibre–8% lime ones were subjected to SEM analysis. The micrographs obtained from these four specimens are presented in Fig. 9. In order to clearly observe the soil fabric of four different specimens, there

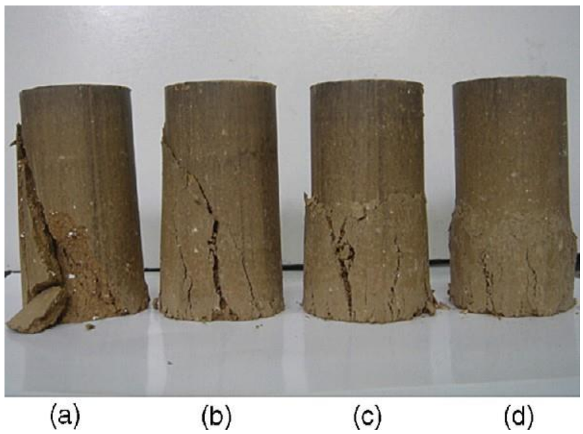

Fig. 8. Variation of the failure characteristics of stabilized soil specimens with the fibre content: (a) 8% lime stabilized soil; (b) 0.05% fibre–8% lime treated soil; (c) 0.15% fibre–8% lime treated soil; (d) 0.25% fibre–8% lime treated soil.

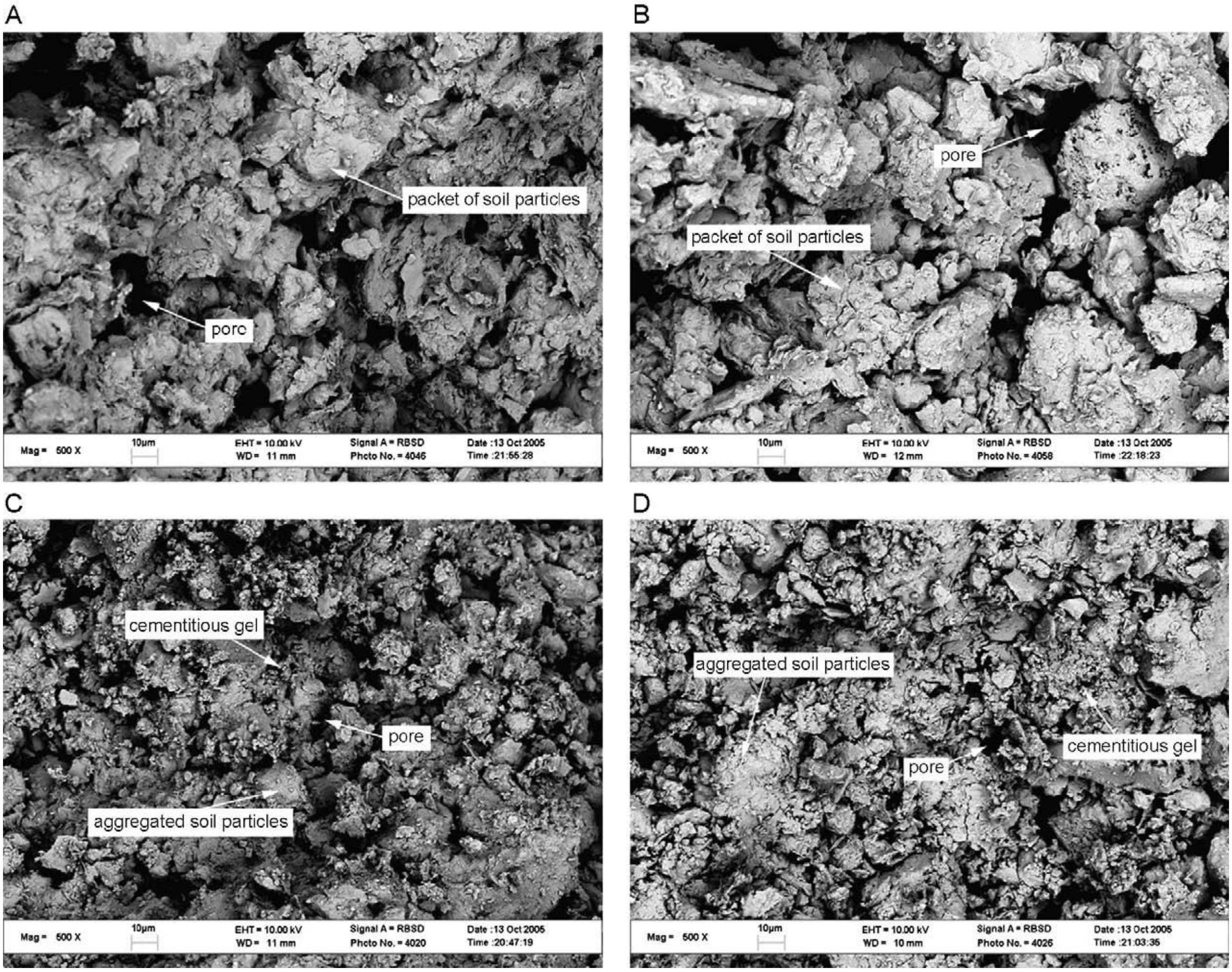

Fig. 9. Scanning electron micrographs of soil specimens: (A)the untreated soil; (B) 0.25% fibre-reinforced soil; (C) 8% lime-stabilized soil; (D) 0.25% fibre–8% lime treated soil (original magnification of 500).

is no fibre included in Fig. 9(B) and (D), because the image of fibre could cover most of a micrograph under magnification of 500. It is observed from these micrographs that both the untreated soil and the pure fibre soil have the fabric with big packets of soil particles in Fig. 9(A) and (B), whereas both the lime stabilized soil and the fibre–lime treated soil have the fabric with cementitious gel between aggregated soil particles in Fig. 9(C) and (D). It may be because that in the presence of water, clay particles adhere to each other or to fibre to form big packets and consequently, there are many big pores in the untreated and fibre-reinforced soils. However, when lime is initially admixed with dried clayey soil, lime makes the clay particles be of hydrophobic behavior. Thus, the soil particles are difficult to form big aggregation when water is added to the lime–soil admixture. Liu (2003) referred to this phenomenon as sandification. Furthermore, some pores between particles are filled with cementitious gel formed, which also results in the fabric with small pores in stabilized soil. Hence, the treatment with lime contributes to the denser soil fabric.

Besides the study on soil fabric, the improving mechanism of lime and fibre were analyzed by the means of SEM. Fig. 10 shows the micrograph of the white cementitious gel formed in reactions between lime and soils. These reaction products bind the soil particles around them together and finally strengthen the soils (Mathew and Narasimha, 1997; Nalbantoglu and Gucbilmez, 2001). The micrograph of the shear plane of a fibre–lime specimen is given in Fig. 11. From the micrograph, it is clearly seen that after shearing, some fibres were left in soil with part of length exposed to the air and on the other hand, some threadlike grooves appear in the shear plane. This is probably due to the strong resistance of fibre to tension. Part of a fibre is

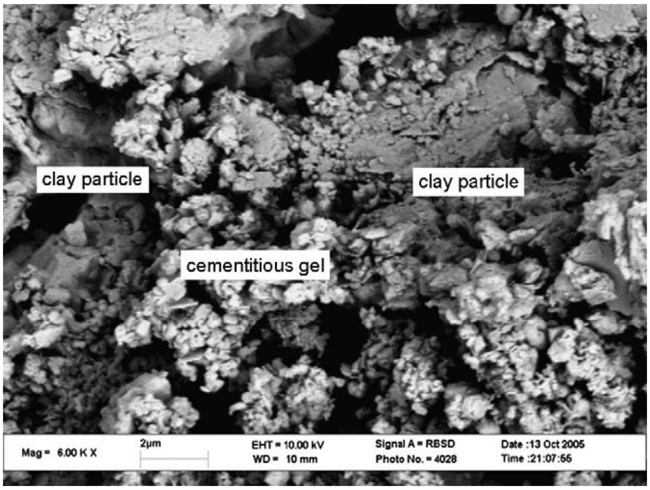

Fig. 10. Scanning electron micrograph of cementation compounds formed in lime–soil reactions (original magnification of 6000).

pulled out from the soil when shearing occurs and fibre itself is not sheared off. From the abrasion trace in fibre surface shown in Fig. 12, it is indicated that fibre strengthens the soil by the friction between fibre and soil particles.

Analysis of test results

Owing to the time-dependent pozzolanic reactions, the stabilization of lime soil is a long-term process (Narasimha Rao and Rajasekaran, 1996). Thus, the unconfined compression and shear strength of the stabilized soil increase while increasing the curing duration. In addition, the formation of the cementation compounds in lime–soil reactions leads to the increases in bonding and interlocking forces between soil particles due to the high rigidity and rough surfaces of the compounds formed and as a result, the strength, cohesion and the angle of internal friction of the clayey soil improve after lime treatment. In view of the influence of cementitious compounds on soil strength, more lime addition amount can produce more compounds and hence result in the greater strength of the soil. As a matter of fact, the additional amount of lime is related to the clay content of the soil and normally does not exceed 8% (Bell, 1996), which agrees with the optimum lime requirement obtained in this investigation.

With an increase in the fibre content, the strength of the stabilized soil increases. This maybe can be explained that the total contact area between fibres and soil particles increases while increasing the fibre content and consequently the friction between them increases,

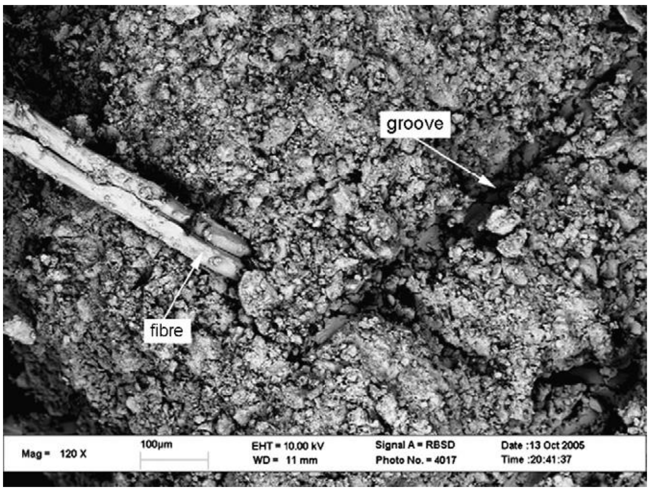

Fig. 11. Scanning electron micrograph of the shear plane of 0.25% fibre–8% lime soil specimen (original magnification of 120).

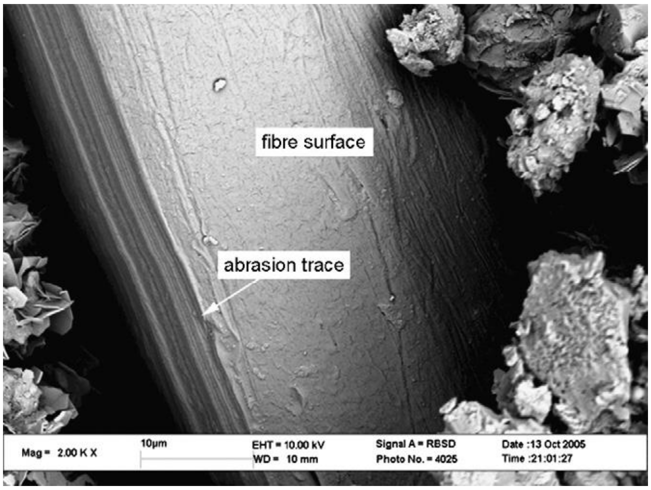

Fig. 12. Scanning electron micrograph of the fibre surface in clayey soil after shearing (original magnification of 2000).

which contributes to the increase in resistance to forces applied. Moreover, when local cracks appear in a specimen, some fibres across these cracks are responsible for the tension in the soil by fibre–soil friction, which effectively impedes the further development of cracks and improves the toughness of the stabilized soil and accordingly changes the failure mode of the stabilized specimens. Due to the smaller pores in the lime-stabilized soil than those in the untreated soil, the effective contact area of a fibre with clay particles in the fibre–lime treated soil is greater than that in the pure fibre soil in the case of the same fibre addition amount and correspondingly, the total effective friction between fibre and particles in the fibre–lime treated soil is greater, which causes more effective fibre reinforcement. However, too much fibre added could reduce the effectiveness of the improvement in the strength and toughness, inasmuch as the fibres adhere to each other to form lumps and cannot contact with soil particles fully. This agrees with the work of Prabakar and Sridhar (2002).

Aggregation of soil particles due to lime–soil reactions makes pores in the soil smaller and disconnected. It is very difficult for moisture to enter soil and react with soil particles fully to induce the swelling of the soil, and also difficult to escape from the soil to engender the shrinkage of the soil. Moreover, the cementation compounds produced contribute to the strong inter-particle bond that can offer the great resistance to swelling and shrinkage of the soil. Thus, an increase in the lime content causes the reduction of both swelling and shrinkage potential of the soil. However, the influence of fibre on the swelling potential is very different from that on shrinkage potential. When swelling of the soil occurs, the fibres in the soil are stretched and the tension in fibres resists the further swelling. Consequently, the swelling potential of the soil reduces while fibre is added, which is confirmed by Ramanatha Ayyar et al. (1989). When the soil shrinks, the fibres in the soil slack and give no resistance to shrinkage. Furthermore, as bypasses linking inside and outside of the soil, the fibres can help moisture to easily escape from the soil, which promotes the shrinkage of the soil. Therefore, the shrinkage potential of the soil increases while increasing the amount of fibre added.

4. Conclusions

The effects of both polypropylene fibre and lime on the unconfined compressive strength, shear strength parameters, swelling–shrinkage potential and failure characteristic of the clayey soil have been studied. It is shown from the test results that the addition of the mixture of polypropylene fibre and lime causes the beneficial changes in the above engineering properties of clayey soil used in this investigation.

It is observed from testing that these engineering properties of fibre–lime soil vary and depend on many factors such as fibre content, lime content and length of curing. The unconfined compressive strength, cohesion and friction angles increase while increasing the length of curing. An increase in lime content contributes to an initial increase followed by a slight decrease in unconfined compressive strength and shear strength parameters of the clayey soil. The optimum gain in strength appears to be with about 5% lime. On the other hand, the swelling–shrinkage potential and toughness of clayey soil reduce with an increase in lime content. An increase in fibre content leads to increases in strength, shrinkage potential and toughness of soil while results in the reduction of swelling potential. In brief, with the combination of lime stabilization and fibre reinforcement techniques, the fibre–lime soil exhibits more gains in strength, cohesion and internal friction angle than lime stabilized soil does. However, the swelling–shrinkage potential and failure characteristic of fibre–lime soil stand between pure fibre soil and pure lime soil.

SEM images of four soils including the untreated soil, fibre-reinforced soil, lime-stabilized soil and fibre–lime soil indicate that fibre reinforcement is a physical interaction between fibre and soil which has few influence on the soil fabric, while lime stabilization is a chemical reaction between lime and soil which greatly changes soil fabric and thereby results in the variation of some engineering properties of soil.

Trough this investigation, it is clearly indicated that the technique of fibre reinforced lime soil is a very effective method of ground improvement, which improves the strength, swelling–shrinkage potential and toughness of soil and consequently, enhance the stability and durability of infrastructures such as foundation and roadbed. However, the construction technology of the method has not been well developed yet. Some key problems probably met in future engineering practice, e.g. the mixture of discrete fibre and lime soil, are now under consideration. With the development of the construction technology, this improvement technique will have an extensive application prospect and could be employed in many fields of geotechnical engineering, such as foundation, roadbed and slope engineering.

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