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DEGRADATION BEHAVIOUR OF COIR GEOTEXTILES WITHIN CLAY SOILS

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ABSTRACT: Coir is a natural product which is available in India abundantly at low costs. Many products of geotechnical interest can be manufactured from coir fibres. This paper describes some laboratory tests carried out to test the durability of coir buried within clay soils. The tests were performed by exposing the coir samples to soils mixed with various chemicals. The wide width tensile strength of samples after the exposure was used to characterise the effect of chemicals on the durability of coir samples. Some durability tests were performed after coating the coir samples with polymer to examine if its life can be improved with such treatments. Some pre-treatment techniques were also examined to enhance the effectiveness of polymer coating. The chemical test configuration was designed rationally using Box-Hunter technique. By performing regression analysis of test data, simple equations were developed to predict the tensile strength of coir samples as a function of time.

1. INTRODUCTION

The soil reinforcement technique using natural reinforcement materials made of coir or jute is ideally suited for India because of their abundant availability at much lower costs than the polymeric products. A total of 15,14,000 hectares area is under coconut cultivation in India with an annual production of coir fibre of 1,75,000 tons. The reinforcement products made of coir are more stronger and stable compared to the jute products, Rao et al. (1). The initial strength, stiffness and hydraulic properties of coir reinforcements are almost comparable to those of similar products made of more expensive polymeric materials, Ramakrishna (2). In particular when the requirement of reinforcement is for shorter durations, coir products can be the first choice for reinforcement applications. By chemical treatment and polymer coatings, the life of coir products can be improved, Datye (3).

The life of coir products in soil environment is an important aspect to be understood to use them in various geotechnical applications. These products are subjected to different degradation actions in the field such as those induced by installation damage, temperature fluctuations, chemical action, hydrolysis, biological degradation, ultra-violet degradation and other degradation processes. The degradation due to chemical, hydrolysis and biological factors are most predominant in the soil environment. This paper examines some of these aspects through laboratory tests. The effect of various parameters on the durability of coir was characterised using wide-width tensile strength of coir geotextile samples. These tests were carried out at a rate of 10 mm/minute on samples 200 mm wide and 100 mm long.

2. PHYSICAL PROPERTIES OF COIR GEOTEXTILE

A commercially available flooring mat made of coir fibres was used as coir geotextile in this investigation. The physical and other engineering properties were studied at as-received condition of the coir geotextile. The coir fibre is composed of 41-45% of lignin, 36-43% of cellulose, 0.15-0.25% of hemicellulose and 3-4% of pectin, Kulkarni, et. al. (4). The various other physical properties have been determined in the laboratory according to the relevant ASTM guidelines for geosynthetic materials. Some of these properties are listed in the following: specific gravity: 1.402, mass per unit area: 1396 g/m^2 , thickness: 7.2 mm at 2 kPa, stiffness: 300 mg-m, tensile strength: 37 kN/m, secant modulus at 10% strain: 110 kN/m, tensile toughness: 8.21 kN/m.

3. DEGRADATION DUE TO HYDROLYSIS and BIOLOGICAL ACTIONS

As the coir geotextiles are made up of organic based fibres they absorb moisture when exposed to water. The moisture content of the coir fibre greatly affects the strength and hence it is important to perform hydrolysis test. The tests were performed by performing wide-width tensile tests on samples immersed in tap water for varying periods of time. Some of these samples were dried and then tested in dry condition. In general, it was found that the strength of coir geotextiles in wet conditions is very much less. The strength in the wet conditions drops by more than 70% whereas the samples dried after wetting had almost the same strength as the virgin samples. The water content of coir had increased from 9% to 120% due to the immersion in water.

Micro-organisms use both constitutive and inducible enzymes to degrade and synthesise a wide variety of compounds for their survival and secondary metabolism. The coir exposed to soil media degrades faster than the ones exposed in air. Micro-organisms such as bacteria, actinomycetes, fungi, algae and protozoa, mushrooms, degrade the coir fibre either individually or synergistically depending upon the prevailing soil conditions. Studies were performed on coir fibres by exposing them to bacterial strains obtained from three different sources. The loss of weight of samples indicates the effect of these organisms on the coir. The bacteria did not survive in the coir medium for more than 7 days during which time the coir samples lost only 1 to 2% weight indicating that the coir is not susceptible to decay from these organisms.

4. DEGRADATION DUE TO CHEMICAL ACTION

The chemical degradation test procedures for plastics is covered by ASTM D543 under the title *Resistance of Plastics to Chemical Reagents*. This test covers a wide range of reagents under both acid and alkaline groups. But for the degradation studies of coir fibre (which is an organic material) acid reagents have been used in the past to wash away the lignin, e.g. Uma et. al. (5). In the absence of standard method of testing the coir fibre for chemical degradation, a general procedure was adopted to test the fibre for both acid and alkaline reagents. The tests were performed under the laboratory conditions at different concentrations of acid and alkaline reagents for different duration of exposures. The test conditions and the variation of wide width tensile strength of coir geotextiles under these exposure conditions are shown in **Table 1**. It is clear from these results that the strength of coir decreases more under exposure to alkaline environment than under acidic environment. Both the concentration and the number of days of exposure also influence the loss of strength.

Table 1 Results from the chemical degradation of coir geotextiles

Type of reagent	concentration %	duration (days)	tensile strength (kN/m)
Acetic Acid	5	1/7/90	24.5/20.5/16
Acetic Acid	10	1/7/90	18/14/12.5
Sodium Hydroxide	5	1/7/90	18/14.5/10.5
Sodium Hydroxide	10	1/7/90	13/11.5/8

5. DEGRADATION OF COIR FIBRE IN ORGANIC CLAYEY SOIL

Biological and chemical agencies in the presence of water are the most likely causes of the degradation of coir. The study of coir fibre degradation by single agencies like alkali, acidic reagent, or a particular type of micro-organism strain may not simulate the real conditions and also the degradation by a particular strain alone was not significant as discussed in the previous sections. Therefore, degradation of coir fibre in organic clay media by synergistic activity of chemical reagents and micro-organisms was employed in this investigation. The coir samples were exposed to this mixture for varying periods of time.

Four naturally occurring chemical compounds, Calcium Chloride ($CaCl_2$), Magnesium Sulphate ($MgSO_4$), Sodium Hydroxide (NaOH), and Potassium Carbonate (K_2CO_3), were mixed in different proportions to a specially prepared organic clay in these studies. The chemical compositions had been decided based on a second order rotatable theory proposed by Box and Hunter (6). This theory is most suitable to study the effect of various parameters. More details of this application can be found in Ramakrishna (2).

5.1 Preparation of Samples and Test Procedure

The soil used for preparing the organic clay was obtained from the Manali area North of Madras. This soil was converted to organic clay by composting technique to make it a good host environment for soil micro-organisms. The objective of composting in this study was to provide sufficient natural carbon source for good growth of all possible inhabitant micro-organisms of soil.

The organic clay was prepared in a steel tank (1000 mm × 1000 mm × 900 mm) fabricated for this purpose. Organic matter such as withered and green twigs and leaves cut to 50 mm size were introduced in layers of 100 mm thick. The clay and organic matter were spread in steel tank alternately in layers of 150 mm and 100 mm respectively. The layers were built up to a height of 800 mm. The moisture content of the clay was maintained at the liquid limit (42%) for the first one month and as the composting continued it was allowed to evaporate at room temperature. The process of composting was continued for 200 days. When the organic matter was completely decomposed the mixture was removed from the tank and thoroughly mixed on concrete floor.

The organic clay was mixed with chemical compounds and was transferred to sixty-two plastic buckets in 10 KGs each and mixed with tap water at 60% by weight of organic clay. The buckets were separated into two groups, each group containing thirty-one buckets. The first group of thirty-one buckets were used for studying the degradation of natural coir geotextiles and the other group of thirty-one buckets for studying the behaviour of polymer coated coir geotextiles which is covered in the next section. In addition to these, another four buckets with natural clay, organic clay, dry sand and tap water as a blank were used for comparing the results. The pH value, soluble salts and organic matter in the mix were measured at the time of preparation.

The coir geotextile samples were left buried in organic clay for a maximum period of 180 days. Samples were exhumed after 90 and 180 days for performing the wide-width tensile strength tests. The tensile strength of these exposed samples had been used to perform a detailed regression analysis on the effect of different chemical compounds on the coir geotextile. From these regression analyses, an equation has been developed which can be used to predict the strength of coir geotextile in different soil environments.

6. TESTS ON POLYMER COATED SAMPLES

The reinforcement products made of natural coir fibre develop their ultimate strength at very high strains because of their low modulus, **Figure 1**. Hence, their tensile capacity is not fully utilised if there is a restriction on the maximum deformations that a structure can undergo. To overcome this problem, the natural coir fibres can be given a coat of thermosetting polyester to increase their strength and stiffness, Prasad et. al. (7). The results from their studies showed that the polyester coating improves the durability, strength, stiffness and decreases the water absorption of coir fibres. The effectiveness of polymer coating was found to depend on the pre-treatment methods used before applying the polymer coating. The variation of ultimate strength and stiffness of polymer coated coir samples (with alkali, acidic and copper pre-treatment) was determined before and after exposing them to organic clay for six months.

6.1 Pre-treatment and Polyester Coating

The same coir geotextile used for earlier studies was used in these studies. General purpose thermosetting polyester, initiator Methyl Ethyl Ketone Peroxide (MEKP), accelerator Cobalt Napthanate, plasticisers diebutyl pthalate and Methyl Ethyl Ketone and vaporiser Acetone were used in this investigation. All these polymers were mixed in different proportions and workable solution was prepared for coating the coir geotextiles by dipping method. Three methods of pre treatment (alkali, acid and copper treatments) were tried out to increase the wettability of the coir for better polymer coating. The alkali pre-treatment was performed using commercially available Sodium Hydroxide and Acetic acid was used for acidic pre-treatment. The copper pre-treatment was given using Sodium Hydroxide, Hydroflouric acid of concentration 1:1, Stannous Chloride, Palladium chloride, Hydrochloric acid, Rochelle salt (Potassium sodium tartarate), Copper Sulphate, Sodium Carbonate and Formaldehyde solution 35% by weight.

7 RESULTS AND DISCUSSIONS

Degradation properties of coir geotextiles were studied under four different categories such as chemical degradation, hydrolysis degradation, biological degradation and degradation in compost media. The results from the tests in organic clay are shown in **Tables 2** and **3** which shows the average strengths from 3 tests.

7.1 Natural Coir Geotextiles

The strength of coir geotextile samples exposed to compost media in the presence of strong alkaline and acidic reagents for 180 days had decreased to 20.6 kN/m which is a reduction of about 45%. The corresponding average strength at the end of 90 days was approximately 28.9 kN/m. A second order polynomial equation of the form shown in Eq. (**1**) was used to perform the regression analysis on the tensile strengths at the end of 180 days.

$$y = b_o + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_{12} X_1 X_2 + b_{13} X_1 X_3 + b_{14} X_1 X_4 + b_{23} X_2 X_3 + b_{24} X_2 X_4 + b_{34} X_3 X_4 + b_{11} X_1^2 + b_{22} X_2^2 + b_{33} X_3^2 + b_{44} X_4^2 \quad (1)$$

in which b_1 .... b_4 are the first order terms, b_{12} ..... b_{34} and b_{11} ..... b_{44} are the second order terms. In the above b_{12},.... b_{34} are the interaction terms which represent the interaction between various chemical compounds. A computer program has been developed to perform the regression analysis and determine the various regression coefficients. These coefficients represent the influence of various chemical compounds on the degradation of the coir geotextile. The regression analysis has given the following equation which allows for the estimation of the effect of various chemical compounds on the loss of strength of coir geotextile.

$$Y_{t=180} = 21.5 - 0.19\, Z_1 - 0.009\, Z_2 - 0.027\, Z_3 - 0.014\, Z_4 - 0.018\, Z_2 Z_3 - 0.006\, Z_1^2 - 0.004\, Z_3^2 - 0.004\, Z_4^2 \quad (2)$$

in which $Y_{t=180}$ is the tensile strength of the coir geotextile at the end of 180 days exposure. In the above equation, the constant term is dependent on the synergistic micro-organism activity, hydrolysing capacity of the soil and various other factors as discussed in the previous sections. The equation shows that $CaCl_2$ (Z_1) has the maximum effect whereas $MgSO_4$ (Z_2) has the least influence on the degradation of coir. Though, NaOH (Z_3) can degrade the lignin significantly in its pure form, it has shown only a moderate influence when it is present in soil. The interaction terms that are not present in Eq. **2** have very minimal influence on the degradation of coir.

Based on the test data from samples tested at 90 and 180 days, it can be concluded that the strength decreases linearly with time. Using the above equation, a large-set of strength values at 180 days was generated for various concentrations of the four chemical compounds. The generated data and the experimental results were analysed and the following equation has been developed to estimate the strength of coir geotextile in the soil media as a function of time.

$$T(t) = T_{t=0} - 0.117\, t \quad (3)$$

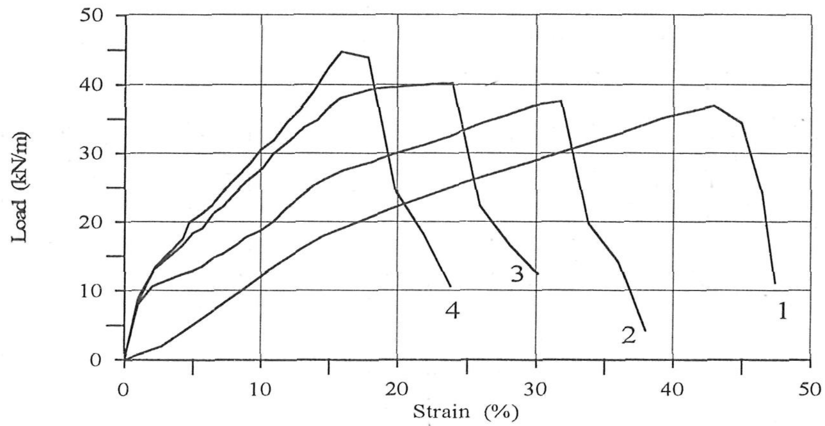
Table 2. Concentrations of chemical compounds as per Box-Hunter rotatable design

Sample No.	pH	Soluble salts (%)	Organic matter (%)	$CaCl_2$ in g/l (Z_1)	$MgSO_4$ in g/l (Z_2)	NaOH in g/l (Z_3)	K_2CO_3 in g/l (Z_4)	Strength at 180 days (y_f)
1	5.77	0.08	8.20	6	6	6	6	20.20
2	5.98	0.17	8.60	2	6	6	6	21.15
3	6.15	0.14	8.40	6	2	6	6	19.8
4	6.04	0.09	8.20	2	2	6	6	20.70
5	5.52	0.10	8.30	6	6	2	6	20
6	5.96	0.08	8.40	2	6	2	6	21.00
7	5.76	0.07	8.30	6	2	2	6	19.9
8	6.31	0.04	8.20	2	2	2	6	20.90
9	6.42	0.17	8.20	6	6	6	2	20.40
10	6.64	0.09	8.60	2	6	6	2	21.30
11	6.64	0.13	8.40	6	2	6	2	20.0
12	6.59	0.09	8.60	2	2	6	2	20.9
13	6.28	0.17	8.70	6	6	2	2	20.2
14	6.35	0.08	8.80	2	6	2	2	20.10
15	5.93	0.07	8.40	6	2	2	2	20
16	6.08	0.05	8.80	2	2	2	2	21
17	6.29	0.10	8.80	0	4	4	4	21.50
18	6.24	0.16	8.50	8	4	4	4	19.6
19	6.15	0.11	8.40	4	0	4	4	20.4
20	6.05	0.15	8..60	4	8	4	4	20.9
21	5.77	0.17	8.50	4	4	0	4	20.5
22	6.30	0.08	8.60	4	4	8	4	20.6
23	6.07	0.14	8.60	4	4	4	0	20.7
24	6.27	0.15	8.50	4	4	4	8	20.4
25	6.33	0.14	8.60	4	4	4	4	20.6
26	6.22	0.15	8.40	4	4	4	4	20.6
27	5.81	0.15	8.50	4	4	4	4	20.6
28	6.13	0.16	8.50	4	4	4	4	20.6
29	6.10	0.14	8.60	4	4	4	4	20.6
30	5.95	0.13	8.60	4	4	4	4	20.6
31	6.32	0.14	8.50	4	4	4	4	20.6
32 clay	5.70	0.04	1.10	--	--	--	Blank	22.10
33 organic clay	6.80	0.001	7.60	--	--	--	Blank	20.8
34 dry sand							Blank	32.20
water	6.9						Blank	35.2

in which T(t) is the tensile strength of coir geotextile at any time in kN/m, $T_{t=0}$ is the initial strength of geotextile (kN/m) and t is the duration of exposure in days. Using this equation, the strength of coir beyond 180 days also can be predicted. The validity of the above equation was verified with the tensile strength of samples which were buried for more than 300 days in some of the above combinations of chemical compounds. The predicted tensile strengths from the equation have compared to within 10 to 15 % of the measured strength values of the samples.

7.2 Tests on Polyester Coated Samples

A comparison of the load-strain behaviour of polyester coated samples after different pre-treatments is shown in **Figure 1**. The strength had increased by about 4% to 16%. More importantly, the stiffness had drastically increased. The strain at peak loads for polyester coated samples had reduced to a range of 15 to 32% from more than 40% for natural coir samples. The best performance was obtained with copper pre-treatment. However, this copper treatment is much more expensive than the other two methods of treatment.



curve-1: natural coir geotextile
curve-2: alkaline pre-treated polyester coated
curve-3: acid pre-treated polyester coated
curve-4: copper pre-treated polyester coated

The effect of polyester coating on durability was studied by exposing the alkaline and acid pre-treated samples to the organic clay media for 180 days. The same procedure used to study the degradation of natural coir geotextiles was followed in this study also. The copper treated samples were not considered for this study because of cost factors. The results from this study are shown in **Table 3**.

A regression analysis was performed on the data from these investigations to develop equations to predict the strength of polymer coated coir geotextiles in soil media as a function of time. The effect of various chemical compounds on the strength degradation of polymer coated coir geotextiles with alkali and acid pre-treatments were obtained from this regression analysis as shown in Equations **4** and **5**.

$$Y_{(t=180)} = 26.5 - 0.025 Z_1 - 0.0206 Z_2 - 0.006 Z_3 - 0.02 Z_4 + 0.009 Z_3 Z_4 - 0.0105 Z_2 Z_3 - 0.002 Z_1 Z_4 - 0.005 Z_2 Z_4 + 0.002 Z_1^2 + 0.003 Z_2^2 + 0.004 Z_3^2 + 0.003 Z_4^2 \quad \textbf{(4)}$$

$$Y_{(t=180)} = 20.5 - 0.0316 Z_1 + 0.019 Z_2 - 0.0207 Z_3 - 0.022 Z_4 - 0.046 Z_1 Z_2 - 0.032 Z_2 Z_3 - 0.0215 Z_1 Z_4 - 0.0343 Z_2 Z_4 + 0.0436 Z_1^2 + 0.012 Z_2^2 + 0.014 Z_3^2 + 0.025 Z_4^2 \quad \textbf{(5)}$$

in which $Y(_{t=180})$ is the tensile strength at the end of 180 days of exposure to the organic clay soil.

It can be observed that the samples with alkali pre-treatment have performed better than the samples with acid pre-treatment. In the above equation, the constant term is unrelated to any chemical compounds and is dependent on the synergistic micro-organism activity, hydrolysing capacity of the soil and various other factors as discussed in the previous chapter. From **Eq. 4**, it can be interpreted that the three chemical compounds $CaCl_2$, $MgSO_4$ and K_2CO_3 have almost equal influence on the degradation of alkali treated and polymer coated coir geotextiles. The other chemical compound NaOH and other interacting terms have lesser or very little influence. The influence of all the terms with a positive sign is to stabilise the coir geotextile (or to reduce the degradation due to other factors). All the second order terms have positive sign, which indicates that the effect of these terms is to reduce the rate of decay.

In the case of acid pre-treated coir samples, all the four chemical compounds have almost equal influence on the degradation behaviour as indicated by the value of the coefficients of linear and second-order terms. The net influence of any chemical compound on the degradation can be interpreted as negligible in this case.

Based on the data from this analysis, the following equations have been developed to predict the strength of polymer coated coir geotextiles as a function of time for alkali and acid pre-treated samples.

$$T(t) = T_{t=0} - 0.078\,t \qquad (6)$$
$$T(t) = T_{t=0} - 0.092\,t \qquad (7)$$

in which $T(t)$ is the tensile strength at time t in days and $T_{t=0}$ is the initial tensile strength.

The coefficient with the term time represents the rate of degradation of coir geotextile. The equations clearly show that the coir with alkali pre-treatment has lesser rate of degradation compared to those of the acid pre-treated samples. The corresponding term for the natural coir geotextile was found to be 0.117 which is 21 to 33% higher than the polyester coated samples. This result clearly shows the benefit of polymer coating on the durability of coir geotextiles in soil environment. The rate of degradation of polymer coated coir geotextile very much depends on the soil environment and the quality of the polymer coating. If better coating methods such as spray coating etc. were used, more improvement could have been observed in the performance of polymer coated samples. Hence, the above equation should be carefully applied when some other coating techniques are used.

8. CONCLUSIONS

This paper has studied the various factors that affect the durability of coir products buried within the soil. Four different categories of degradation, hydrolysis, biological, chemical and degradation in compost media were investigated. The strength of coir was found to decrease due to the wetting action. The biological degradation due to micro-organisms was found to be negligible. The strength of coir was found to decrease by more than 50% when exposed to alkaline and acidic reagents for 180 days. Hence, the coir products should be carefully used whenever there is a chance for them to come in direct contact with these chemicals. The effect of various chemical compounds on coir geotextile within an organic clay medium was studied extensively. The effect of these chemicals was quantified by means of a second order polynomial equation. The polymer coating was found to increase the strength and stiffness of coir geotextiles and improve its durability.

REFERENCES

1. Rao, G.V. and Balan, K. (1994) Coir Geotextiles-A Perspective, 2nd Int. Workshop on Geotextiles, New Delhi, January, 119-126.
2. Ramakrishna, S. (1996) Investigation on Applications of Coir Reinforcement in Geotechnical Engineering, M.S. Thesis, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai.
3. Datye, K.R. (1988) Natural Materials for Soil Reinforcement, Int. Symp. on Theory and Practice of Earth Reinforcement, Fukuoka, Japan, 69-74.
4. Kulkarni, A.G., Cherian, K.A., Satyanarayana, K.G. and Rohatgi, P.K. (1983). Studies on Moisture Sorption of Coir Fibres (Cocos Nucifera L). *J. Applied Polymer Sciences*, Vol. 28, 625-632.

5. Uma, L., Kalaiselvi, R. and Subramanian, G. (1994) Isolation of a lignolytic bacterium for the degradation and possible utilisation of coir waste, *J. of Biotechnology Letters*, Vol. 16, 303-308.
6. Box, G. and Hunter, J. (1957). Regression Analysis, *J. Ana. Math. Statistics*, Vol. 28, 1-15.
7. Prasad, S.V., Pavitran, C. and Rohatgi, P.K. (1983). Alkali treatment of coir fibres for coir-polyester composites. *J. of Mat. Science.* Vol. 18, 1443-1454.

Table 3. Test configurations and results for polyester coated samples for regression analysis

Sample No.	pH	soluble salts (%)	organic matter (%)	Z_1 in g/l ($CaCl_2$)	Z_2 in g/l ($MgSO_4$)	Z_3 in g/l (NaOH)	Z_4 in g/l (K_2CO_3)	Tensile strength (alkali treated)	Tensile strength (acid treated)
1	5.9	0.108	8.20	6	6	6	6	25.9	21
2	6.1	0.12	8.60	2	6	6	6	25.9	21.4
3	6.2	0.13	8.40	6	2	6	6	26.3	21.75
4	6.2	0.09	8.20	2	2	6	6	26.3	21.4
5	5.6	0.10	8.30	6	6	2	6	26.1	20
6	6.1	0.12	8.40	2	6	2	6	26.1	20.8
7	5.8	0.09	8.30	6	2	2	6	26.2	21.1
8	6.3	0.09	8.20	2	2	2	6	26.2	20.75
9	6.3	0.18	8.20	6	6	6	2	25.5	21.7
10	6.6	0.12	8.60	2	6	6	2	25.5	21.6
11	6.7	0.11	8.40	6	2	6	2	26	21.8
12	6.6	0.09	8.60	2	2	6	2	26	21.1
13	6.3	0.20	8.70	6	6	2	2	26	20.5
14	6.40	0.09	8.80	2	6	2	2	25.9	20.6
15	6.2	0.12	8.40	6	2	2	2	26	21.2
16	6.2	0.12	8.80	2	2	2	2	26	20.5
17	6.4	0.10	8.80	0	4	4	4	26	21.2
18	6.3	0.16	8.50	8	4	4	4	26.1	21.5
19	6.2	0.11	8.40	4	0	4	4	26.2	21.2
20	6.1	0.15	8..60	4	8	4	4	25.7	20.6
21	5.77	0.17	8.50	4	4	0	4	26.1	20
22	6.30	0.09	8.60	4	4	8	4	25.8	21.7
23	6.0	0.14	8.60	4	4	4	0	25.7	21.25
24	6.3	0.15	8.50	4	4	4	8	26.3	20.9
25	6.3	0.14	8.60	4	4	4	4	26	20.7
26	6.2	0.15	8.40	4	4	4	4	25.9	20.7
27	5.8	0.15	8.50	4	4	4	4	25.9	20.6
28	6.1	0.16	8.50	4	4	4	4	25.9	20.7
29	6.10	0.14	8.60	4	4	4	4	26.0	20.6
30	6.0	0.13	8.60	4	4	4	4	25.9	20.6
31	6.3	0.14	8.50	4	4	4	4	25.8	20.6
32 clay	5.70	0.04	1.10	--	--	--	Blank	29.5	26.1
33 organic clay	6.80	0.02	7.60	--	--	--	Blank	27.5	24.2
34 dry sand							Blank	36.5	35.6
35 water	6.9						Blank	34.5	31.0