Mineralogy and Morphology Evaluation of Mixed Soil.

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ABSTRACT

Improvement of soil foundation by the soil mixing method is a trusted technique to mitigate many geo-technical problems that could be faced by any structure. A total of 31 mixed soil models were considered, to understand design of soil foundation pre their mineralogy and morphology characteristics. The results of the XRD, SEM, and direct shear test revealed that if the mineralogy and morphology of soils were identified, then accurate design of a soil foundation by mixing method in loose and compacted conditions was possible.

(Keywords: soil analysis, soil mineral, particle shape, soil foundation stability)

INTRODUCTION

Mitigation of many geo-technical disasters such earthquakes is not difficult. One way involves soil foundation improvements by the mixed soil method. This technique could increase soil foundation stability and it is the easiest way to achieve maximum safety in any construction activity. Placing soil foundation in a safe condition helps to ensure the future existence of a constructed structure. The bearing capacity of soil foundation is the main factor in controlling structure stability.

The composition of any soil is an important factor which influences many soil properties. The most significant property of clay depends upon the type of mineral composition. The clay minerals impart cohesion and plasticity and hence the study of clay minerals is essential for understanding the behavior of clayey soils [1-2]. Research on clay minerals started in the 1930's, however, with the present body of literature available on the subject, the prediction of clay properties for the benefit of the engineer can be made. [3].

There have been more than one hundred sets of direct shear tests conducted on soils composed of four reference clay minerals and various combinations of them at the Columbia University Clay Mineral Standards Project (A.P.I. 49) [4].

Soil testing is an integral part of analysis and design in soil engineering. A proper evaluation of soil samples and determination of relevant soil properties simulating field-loading conditions are essential components of the practice of foundation engineering [5]. Research in unsaturated soil mechanics considerably developed in the past decades through the simultaneous development of experimental investigations and theoretical analyses [6].

The authors present an investigation to analyze the effect of mineralogy and morphology on the bearing capacities of 31 mixed soils in loose and compacted conditions. The models consisted of soils, sand, and gravels representing the surroundings of Mysore, India.

METHODOLOGY AND EXPERIMENT

To evaluate soil foundation force sustainability, direct shear tests were used. To provide tests of reasoning in soil mixed behavior, X-ray powder diffraction and Scanning Electron Microscopy (SEM) analyses were applied. Additionally, identification of soil morphology and mineralogy have been interpreted in this research.

The collected samples of soil, sand, and gravels were dried at 110°C for 24 hours to dehydrate. In the present experiments, 31 different mixed soil types in 0%, 3%, 6%, and optimum moisture content (OMC) in loose conditions and 31 mixed soils types under compacted in optimum moisture content (OMC) conditions from soils-sand-gravels were prepared (Table1).

Table 1: Mixed Soil Models [10].

Sl. No	% of Red Soil	% of Sand	% of Gravel 4.75 mm	% of Gravel 2 mm	% of Black Soil	% of Green Soil	% of Dark Brown Soil	% of Yellow Soil	% of Light Brown Soil
1	100	0	0	0	0	0	0	0	0
2	55	45	0	0	0	0	0	0	0
3	55	0	45	0	0	0	0	0	0
4	55	0	0	45	0	0	0	0	0
5	55	15	15	15	0	0	0	0	0
6	55	0	0	0	45	0	0	0	0
7	55	0	0	0	0	45	0	0	0
8	55	0	0	0	0	0	45	0	0
9	55	0	0	0	0	0	0	45	0
10	90	0	0	0	2	2	2	2	2
11	80	0	0	0	4	4	4	4	4
12	70	0	0	0	6	6	6	6	6
13	60	0	0	0	8	8	8	8	8
14	50	0	0	0	10	10	10	10	10
15	70	0	0	0	10	10	10	0	0
16	70	0	0	0	10	10	0	10	0
17	70	0	0	0	10	10	0	0	10
18	70	0	0	0	10	0	10	10	0
19	70	0	0	0	10	0	10	0	10
20	70	0	0	0	10	0	0	10	10
21	70	0	0	0	15	15	0	0	0
22	70	0	0	0	15	0	15	0	0
23	70	0	0	0	0	0	0	15	15
24	70	0	0	0	15	0	0	15	0
25	70	0	0	0	15	0	0	0	15
26	70	0	0	0	0	15	15	0	0
27	70	0	0	0	0	15	0	15	0
28	70	0	0	0	0	15	0	0	15
29	70	0	0	0	0	0	15	15	0
30	70	0	0	0	0	0	15	0	15
31	55	0	0	0	0	0	0	0	45

The experiments were carried out at different moisture contents to measure cohesive of soil (C) and angle of fraction (Φ) for all the 31 soil models by direct shear test methods using facilities available in the Geo-technical Engineering Laboratory, S.J. College of Engineering in Mysore, India. Using C, Φ and density values and adopting Terzaghi's method the safe bearing capacity of the soil mixed models were calculated. In calculation of safe bearing capacity at all models has been assumed of 1.5 m depth and 2.5m * 2.5m widths for square footing [9].

RESULTS AND DISCUSSION

The mixed soil method could create an acceptable model for some soils (those which did not have individually good character). Loose soil is always weaker than compacted soil, but it is possible for loose soil improvement by using proper particle size, if the soil behavior identified.

This paper reports scientific laboratory research for effects analysis of morphology and mineralogy on soil foundation stability. SEM analysis has revealed that the red and black soils fractions have exhibited relatively tabular, needle, poly-hedral shape. The remaining soil samples have exhibited sub-rounded to sub-euhedral morphology. The dark brown soil fraction grains have exhibited relatively larger size. The remaining soils have exhibited, by in large, uniform size. From the standard D-spacing, important minerals presented in the soils were identified which are quartz, muscovite, biotite, carbonates, and fluorapatite. Clay minerals like illite, saponite, sauconite, pyrophyllite, orthochamosite, brucite, clinochlore, nacrite, odinite, amesite, chamosite, cancrisilite, chamosite, and orthochamosite were also present as minor constituents [Tables 2-3] and [Figure 1].

Table 2: D-Value of Soils from XRD Results [11].

	Types of the soils					
	Red soil	Black soil	Yellow soil	Light brown soil	Dark brown soil	Green soil
1	4.4447	4.2670	9.3020	4.4624	9.3412	4.2509
2	4.2428	3.3508	7.2725	4.2509	8.4023	4.0442
3	4.0189	3.1974	4.7312	4.0225	4.8075	3.7542
4	3.3360	3.0436	4.2468	3.3385	3.6072	3.6480
5	3.1796	2.4597	3.6450	3.2500	3.5173	3.3459
6	3.1016	2.2851	3.3385	3.1862	3.3732	3.1974
7	2.6915	2.2382	3.1122	2.4532	3.2734	2.9976
8	2.5602	2.1301	2.7396	2.1602	3.1271	2.9417
9	2.5048	1.8199	2.5007	1.8172	2.8860	2.8915
10	2.4532		2.4532		2.5433	2.5308
11	1.8343		2.2795			2.1387
12	1.8152		2.1017			1.7737
13			1.9380			
14			1.8165			
15			1.6996			

Table 3: Mineral of Soil Sample [12].

Sl. No	Soil Name	Minerals in the soil sample
1	Red soil	quartz, illite, muscovite, saponite, sauconite and carbonate- fluorapatite
2	Black soil	quartz, pyrophyllite, carbonate- fluorapatite and orthochamosite
3	Yellow soil	quartz, brucite, clinochlore and sandoite
4	Light brown soil	quartz and carbonate
5	Dark brown soil	nacrite, odinite, amesite, chamosite and biotite
6	Green soil	quartz, cancrisilite, chamosite, orthochamosite and brucite

Table 4: Experiments Results [10, 11, and 13].

Moisture (%)	γ KN/m^3	Φ D	C KN/m^2	S. B .C KN/m^2	Moisture (%)	γ KN/m^3	Φ D	C KN/m^2	S. B .C KN/m^2
Model 1					Model 2				
0	11.80	38	0	701.55	0	12.54	35	10	699.82
3	10.84	30	2	236.21	3	11.5	35	0	412.08
6	10.54	25	6	176.81	6	9.99	31	0	218.20
OMCL	10.8	27	10	279.61	OMCL	10.29	33.5	0	302.58
OMCC	21.94	38	21	2036.22	OMCC	21.83	39	12	1926.51
Model 3					Model 4				
0	13.93	36.5	14	1083	0	12.71	42	0	1522.6
3	13.32	36	10	865.26	3	12.23	38	6	936.03
6	12.23	31	20	622.89	6	11.81	37	0	735.23
OMCL	14.4	23	34	454.31	OMCL	13.61	32	4	416.26
OMCC	23.46	39	46	3334.44	OMCC	23.82	36	28	1833.97
Model 5					Model 6				
0	13.32	42	0	1595.6	0	11.5	37	12	972.18
3	13.2	39.5	10	1337.9	3	11.8	36	4	628.87
6	10.29	34	0	318.13	6	10.29	33	0	287.01
OMCL	13.32	27	16	392.42	OMCL	11.35	24	6	171.96
OMCC	23.02	40	8	2060.95	MCCO	20.09	32	20	888.70

Table 4: (Continued).

Moisture (%)	γ KN/m³	Φ D	C KN/m²	S. B .C KN/m²	Moisture (%)	γ KN/m³	Φ D	C KN/m²	S. B .C KN/m²
Model 7					Model 8				
0	12.11	36	0	529.09	0	13.26	32	0	329.73
3	10.9	34	0	336.99	3	11.8	32	0	293.43
6	10.6	33	0	295.65	6	10.9	29	0	187.15
OMCL	11.62	31	4	324.93	OMCL	14.41	20	10	157.56
OMCC	20.95	32	26	1026.83	OMCC	23.35	18	44	427.74
Model 9					Model 10				
0	11.38	35	0	407.78	0	10.29	37	4	656.88
3	12.23	32	0	304.12	3	11.38	31	10	426.44
6	10.9	31	4	309.23	6	10.9	29	0	187.15
OMCL	11.08	28.5	10	326.59	OMCL	10.11	32	10	445.97
OMCC	20.96	30	28	718.00	OMCC	21.61	36	22	1567.43
Model 11					Model 12				
0	10.9	36	0	476.22	0	12.35	33	0	344.46
3	11.08	34	0	342.56	3	12.35	32	0	307.10
6	11.5	31	5	340.12	6	11.63	28.5	0	190.11
OMCL	10.6	25	8	199.20	OMCL	11.8	20	24	243.72
OMCC	21.56	15	47	349.69	OMCC	21.07	22	49	608.36
Model 13					Model 14				
0	11.5	35	0	412.08	0	12.72	36	0	555.74
3	13.02	33	6	489.90	3	12.72	34	0	393.26
6	12.11	27.5	6	259.01	6	11.08	32.5	4	373.44
OMCL	12.23	17	14.5	142.12	OMCL	11.2	21	14	178.69
OMCC	21.83	21	33	431.67	OMCC	21.179	27	38	786.91
Model 15									
0	11.2	37	0	577.32					
3	11.38	36	0	497.19					
6	10.9	34	0	336.99					
OMCL	11.5	21	10	166.03					
OMCC	20.96	29	8.5	487.99					
Model 16					Model 17				
0	11.5	35	0	412	0	11.93	33	0	332
3	13.02	36	0	568	3	11.5	33	0	320
6	11.8	35	0	422	6	11.02	32	0	274
OMCL	9.99	23.5	20	291.38	OMCL	11.27	18	19	191.16
OMCC	20.31	31	22	834.95	OMCC	21.18	20	27	341.94
Model 18					Model 19				
0	12	35	0	430	0	12.11	37	0	624
3	11.83	33	0	329	3	12.11	32	0	301
6	11.58	32	0	287	6	11.5	30	0	216
OMCL	12.89	13	20	145.73	OMCL	10.05	26.5	8	230.78
OMCC	21.18	20	23	311.26	OMCC	20.96	33.5	12	879.86
Model 20					Model 21				
0	11.02	35	0	394	0	11.51	31	12	464
3	11.38	35	0	407	3	10.9	30	12	398
6	10.78	33.5	0	317	6	11.38	29	12	376
OMCL	10.29	25	18	304.68	OMCL	10.9	22	20.5	271.31
OMCC	20.96	24	23	439.56	OMCC	21.5	23	10	287.22
Model 22					Model 23				
0	12.42	35	0	445	0	11.81	35	8	623
3	12.59	35	0	451	3	10.6	34	10	555
6	11.51	30	4	281	6	11.38	35	0	407
OMCL	10.23	21	15	198.43	OMCL	11.08	12	22	140.26
OMCC	22.05	23	32	503.18	OMCC	21.07	23	22	398.52

Table 4: (Continued).

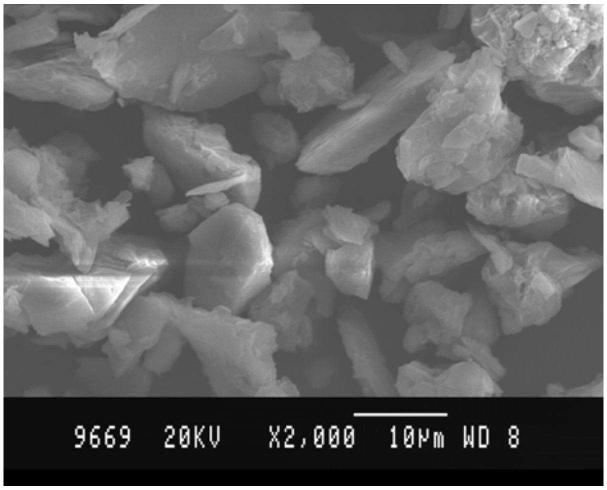
Moisture (%)	γ KN/m³	Φ D	C KN/m²	S. B .C KN/m²	Moisture (%)	γ KN/m³	Φ D	C KN/m²	S. B .C KN/m²
Model 24					Model 25				
0	13.32	34.5	0	136	0	11.51	33	0	321
3	12.53	32	0	311	3	10.6	31	0	231
6	11.5	30.5	0	233	6	10.48	31	0	228
OMCL	9.69	28.5	7	260.23	OMCL	9.99	18	11	129.50
OMCC	20.41	19	22	280.01	OMCC	20.748	22	16	310.33
Model 26					Model 27				
0	12.72	34	0	393	0	14.05	34	0	434
3	11.93	36	0	521	3	12.72	30	0	239
6	11.57	35	0	414	6	12.72	30	0	239
OMCL	10.78	22.5	8	165.55	OMCL	9.99	19.5	2	75.95
OMCC	21.72	21	28	389.32	OMCC	21.94	24	26	479.81
Model 28					Model 29				
0	12.11	32.5	0	319	0	12.72	37	0	655
3	11.81	31	0	257	3	11.81	32	0	293
6	11.81	27	0	163	6	12.41	31	0	271
OMCL	10.9	21	14	194.95	OMCL	10.72	15	16	132.68
OMCC	21.72	17.5	28	298.58	OMCC	22.59	17	9	170.00
Model 30					Model 31				
0	12.72	34	6	530	0	13.02	35.5	0	517
3	12.41	33	6	472	3	12.71	32	0	316
6	11.08	32	0	275	6	12.11	30	0	227
OMCL	10.9	18	14	154.96	OMCL	11.2	26	2	336.07
OMCC	22.47	18	24	286.20	OMCC	21.61	28	26	700.05

D=Degree, W=Width, S.B.C= Safe Bearing Capacity,
OMCL= Optimum Moisture Content Loose Condition and
OMCC= Optimum Moisture Content Compacted Condition,
L=Length, C=Cohesive

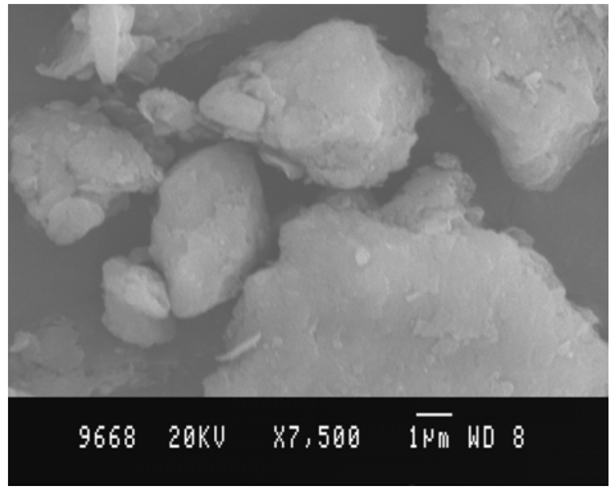
Suitable minerals presented in the soil could help total improvement and increased stability of soil foundation. The mixed soil with OMC under loose condition have negative affected by present of moisture. in such situation employment of standard compaction condition could convert negative effect of moisture on mineral to the maximum positive effect [Table 4].

CONCLUSION

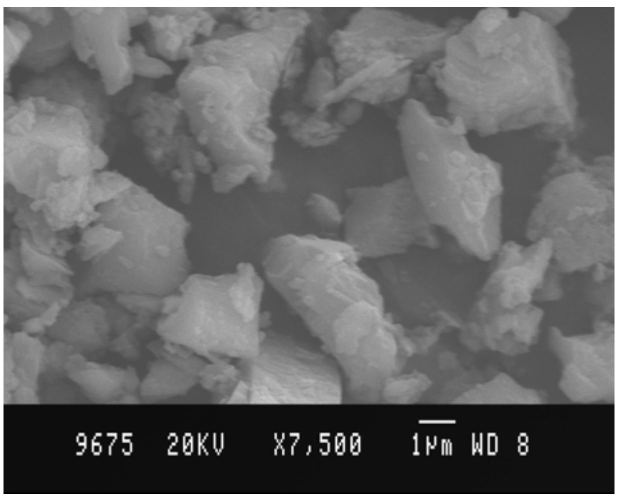
- The suitable interaction between soil minerals resulted improvement of soil foundation stability.
- Small amounts of any minerals could significantly control soil foundation characteristics.
- The mixed soil under loose OMC conditions were extremely affected by moisture and in such a situation employment of standard compaction condition could convert negative effects of moisture on mineral to the maximum positive effect.
- It is possible to highly (more than mentioned in this paper) improve soil foundation by the mixed soil method.



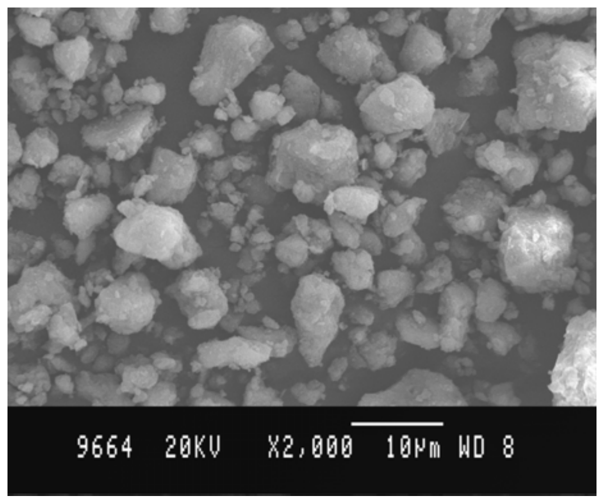
Red Soil



Light Brown Soil



Black Soil



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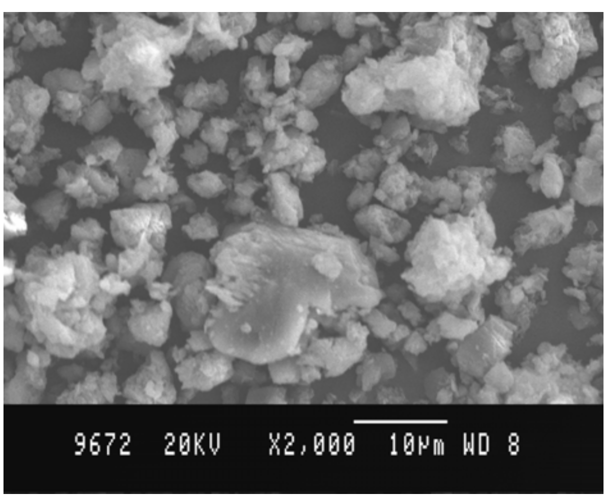
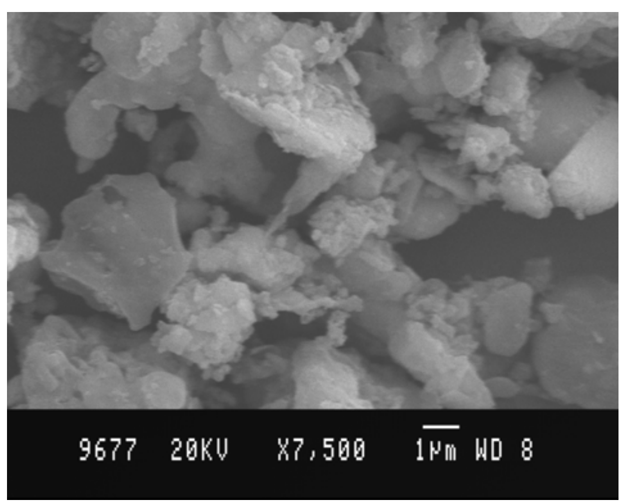


Yellow Soil



Green Soil

Figure 1: SEM Photos of Six Soil Samples [12].

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