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ABILITY OF MINERAL PRESENTED IN THE SOIL

BY

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Abstract. The important and essential characteristics of earth structure are the transmission of load to the earth and maintaining its allowable deformation, settlement, tensile crack and providing acceptable stability, in this regard characteristics of 16 mixed soil types were investigated and results of this analytical interpretation of mixed soil are provided feasible data which could be used in construction of safe soil structure and help to solve geotechnical problems. In the same time obtained results to understand that soil mineralogy could increases the soil strength and reduction of soil structure failure. It is observed lack of some important minerals which affect the whole soil structure characteristics, and it is possible the development of a soil with new characteristics if requirement minerals added.

Key words: mixed soil strength; safe soil structure; mineralogy; morphology; new soil characteristics.

1. Introduction

A soil consisting of several minerals with different intensities, the presence of minerals in the soil represent one of the important elements in controlling soil behavior; another soil characteristic is soil morphology, which represents a factor having an important role in soil bearing capacity.

The soil bearing capacity could be determined by several methods like bearing capacity tables in various building codes, analytical methods, and plate bearing test, penetration test, model test, prototype tests and laboratory test [1], [2]. It is required an analysis of soil bearing capacity together with consideration of soil mineralogy and morphology simultaneously to achieve trustable result.

In what follows an investigation regarding the behavior aspect of soils mixed with fly ash to improve the load bearing capacity of the soil is performed.

The main goal of that investigation was to assess the usefulness of fly ash as a soil admixture, and permits to improve the engineering properties of soil to make it capable of taking more load from the foundation structures [3]. It has been reported that soft tropical peat has unique characteristics and moots serious problem in construction industry due to its low bearing capacity [4]. It is presented the ground improvement work by deep mixing method using binder which becomes more popular in construction industries [5]. This paper contains the obtained results of a scientific research concerning the improvement of the load-bearing capacity of peat soil by stabilizing it with ordinary Portland cement [6]. Some field and laboratory study were performed to find engineering properties of peat soil and to stabilize these ones [7]. It has also been studied the influence of root trees on slope stability and different factors like geologic materials, stratigraphy, hydrology, and the local effects of shore processes [8]. The author made an attempt to identification of influence exerted by soil minerals on soil ability; in this regard several soil types were evaluated to find best possible mineral in increasing soil load acceptability.

2. Methodology and Experiments

To understand the soil improvement capacity, results of XRD, SED, direct shear test, sieve analysis test and origin software were used, to evaluate 16 mixed soil types under loose optimum moisture content (OMC) condition. The 16 mixed soil types from red plastic soil and black, green, dark brown, yellow and light brown non plastic soils (Table 1) were used to development of suitable mixed soil type which has resulted from combination of soil minerals. The XRD results of six soil samples used as starting materials for mixture are given in Table 1. The minerals present in the soils were identified by use of the standard *D*-spacing and mineral intensity. The morphology of six soils samples was studied using scanning electron microscopy (SEM). These studies helped to understand the micro to macro surface features. SEM studies of the six soil samples of the investigations were carried out using as research instrument an JSM-840A, JEOL-Japan apparatus. In this investigation regarding different types of availability of soil, sometimes in small area in Mysore, India, may appear differential settlement for structure. The author has carried out laboratory tests to analysis bearing capacity of mixed soils under loose and optimum moisture content (OMC) condition. The experiments were carried out in the Geo-Technical Laboratory of the S. J. College of Engineering in Mysore. 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 a 1.5 m depth and 2.5 m × 2.5 m widths for square footing, to improvement of site characteristics by selecting of different types of soils, which consist of natural minerals, attempt was to find a scientific way to improve the soil characteristics which could; lead to obtain better earth structure and soil foundation.

Table 1
Mixed Soil Types [9]

Model No	Red soil %	Black soil %	Green soil %	Dark brown soil %	Yellow soil %	Light brown soil %
1	100	0	0	0	0	0
2	55	0	0	0	0	45
3	55	45	0	0	0	0
4	55	0	45	0	0	0
5	55	0	0	45	0	0
6	55	0	0	0	45	0
7	90	2	2	2	2	2
8	80	4	4	4	4	4
9	70	6	6	6	6	6
10	60	8	8	8	8	8
11	50	10	10	10	10	10
12	70	10	10	10	0	0
13	70	10	10	0	10	0
14	70	10	10	0	0	10
15	70	10	0	10	10	0
16	70	10	0	10	0	10

3. Results and Discussion

It is clear that the soil at a construction site always could not support structures and sustain against all types of loads, to overcome geotechnical problems by economical and shortest method, laboratory and analytical identification of soil characteristics; by application of different scientific methods are ways of approaching accurate behavior of soil structure affected by any types of loads. If improvement of soil isn't clearly analysed, it is possible the collapse of soil structure, during the construction or service. One of the main reasons of soil structure failure is the development of tensile cracks due to less soil tensile strength and availability of overload on the structure. To investigation of mixed soil bearing capacity when it is under loose OMC condition (Table 2) the minerals of the soils namely: muscovite, biotite, carbonates and fluorapatite, illite, saponite, sauconite, pyrophyllite, ortho-chamosite, brucite, clinochlore, nacrite, odinite, amesite, chamosite, cancrisilite, chamosite and orthochamosite were evaluated (Table 3).

The results of direct shear tests (Table 2) indicate a soil model type 7 which consists of 90% of red plastic soil and 2% of black, green, dark brown, yellow and light brown non plastic soils resulted of maximum safe bearing capacity under loose OMC condition, due to sufficient minerals availability in this mixed soil type (Table 3). In the types 10 and 11 mixed soil when percentage of red soil decreased and percentage of other soil increased the result of safe bearing capacity is unacceptable compared to mixed soil type 7. It could be deduced that low level of different kind of minerals presented in the mixed soil types have a positive effect on soil characteristics, if intensity of minerals

Table 2
Mixed Soil Type under Loose and Optimum Moisture Content (OMC) Condition [17]

Model No	Optimum moisture content %	γ kN/m^3	Φ degrees	*C* kN/m^2	SBC kN/m^2
1	11.2	10.8	27	10	279.61
2	14.56	11.2	26	2	336.61
3	22.39	11.35	24	6	171.96
4	18.86	11.62	31	4	324.93
5	14.56	14.41	20	10	157.56
6	14.23	11.08	28.5	10	326.59
7	16.83	10.11	32	10	445.97
8	18.27	10.6	25	8	199.20
9	16.76	11.8	20	24	243.72
10	20.21	12.23	17	14.5	142.12
11	18.68	11.2	21	14	178.69
12	19.34	11.5	21	10	166.03
13	16.55	9.99	23.5	20	291.38
14	21.14	11.27	18	19	191.16
15	20.79	12.89	13	20	145.73
16	16.31	10.05	26.5	8	230.78

Table 3
Minerals of Soil Sample [9]

Soil 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

increases, chemical interaction between them could have negative results on soil bearing capacity. From Tables 3,…,6 and Figs. 1,…,4 could be observed the influence of mineralogy and morphology on mixed soil bearing capacity and SEM analysis has revealed that the red and black soils fractions have exhibited relatively tabular, needle, polyhedral 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 and large uniform size; Table 5 and Fig. 2 indicate that the mixed soils types 1, 7, 8, 9, 10 and 11 have closely particle size. Providing of sufficient minerals from other soils to mixed soil type represents the best result. It could be observed that the effect of mineralogy is more pronounced than that of morphology when mixed soil consists of fine aggregate. It could be suggested that increasing of soil bearing capacity in the mixed soil consisting from fine aggregate represents the best way to improve the soil mineralogy. In the mixed soil under the loose moisture condition, minerals of soil not only affect the soil cohesion but affect the soil angle of friction and the unit weight.

The soil mixing process will be affected by several factors simultaneously [9], [10]. The proper selection and evaluation of a soil improvement technique for use at a particular site is neither a simple nor a single outcome proposition [11]. Ground improvement by soil mixing method is highly variable, and this has a nonlinear impact on reliability analyses for soil foundation supported structures [12]. Deep soil mixing method is an extremely valuable competitive and useful in ground engineering technology if applied correctly, designed properly, and constructed efficiently [13]. It is important when the building structure is a high one with possible concentrated loading and the ground on which the building rest on poor bearing capacity soil or affected by natural phenomena like rising water table [14]. Also the foundation should be designed and constructed to maintain or promote constant moisture in the foundation soils. For example, the foundation should be constructed following the wet season if possible [15]. The liquefaction potential of a soil mass during an earthquake depends on both seismic and soil parameters [16]. If compaction technique is not possible due to placement of site in the neighboring of a monument, one of the fast and economical method to improve the soil is the use of mixed soil technique, taking advantage of mixing soil minerals. Proper mineralogy, OMC and well application of mineral presented in the soil mixed could support stability of soil foundation and make sure the disabling forces are applied to the soil foundation and it lead to safety of structure. Remediation of loose soil during seismic loading is a major problem in geotechnical earthquake engineering, the improvement of soil strength with mineral of soil depends on the soil grading. The effect is significant for soil with mineral content. The mineral presence in the soil is very sensitive and nonlinear. The bearing capacity of soil foundation depends on the performance of mineral selection in creation of mixed soil model. The present results have revealed that the introduction of mineral studies in geotechnical engineering could introduce a new method of design of soil foundation and earth structure. Provision of mineral in design of mixed soil could decreases the intensity of liquefaction, lateral force on the system, considerably and increases the stability of the model which results in a reduction of unsustainable deformation and differential settlement. In the absence of some minerals the stability of soil foundation could be reduced during the application of forces and increases the level of stress. The mineral contained by soils permits that the structures be capable to reduce the magnitude of shear stress and shear strain.

Table 4

Sieve Analysis Result

Diameter of sieve mm	Cumulative passing finer mixed soil type 1	Cumulative passing finer mixed soil type 2	Cumulative passing finer mixed soil type 3	Cumulative passing finer mixed soil type 4	Cumulative passing finer mixed soil type 5	Cumulative passing finer mixed soil type 6
4.75	100	100	98.6212	100	99.8184	100
2	99.5832	96.4408	96.0934	99.5908	94.867	99.5908
1	94.1648	84.6407	89.4359	96.5207	74.361	96.3407
0.6	88.1212	76.9067	84.7331	93.0167	64.7711	92.8367
0.425	86.2456	74.2551	82.7823	91.8951	62.4682	91.6251
0.3	71.2408	60.8725	69.5653	83.3725	49.1302	81.3921
0.212	61.8628	52.2046	61.3735	77.9446	41.4296	73.0842
0.150	58.9452	47.9899	58.0219	76.0699	39.0984	66.2595
0.075	55.4024	44.6914	53.9593	73.3114	35.6969	61.071
Received	0	0	0	0	0	0

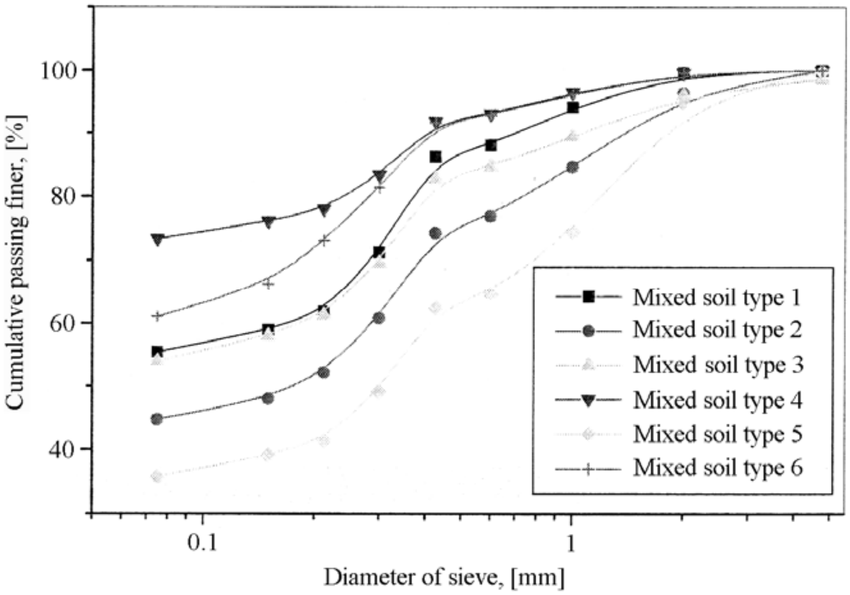

Fig 1 – Sieve analysis of mixed soil type 1, 2, 3, 4, 5 and 6.

Table 5
Sieve Analysis Result

Diameter of sieve %	Cumulative passing finer mixed soil type 1	Cumulative passing finer mixed soil type 7	Cumulative passing finer mixed soil type 8	Cumulative passing finer mixed soil type 9	Cumulative passing finer mixed soil type 10	Cumulative passing finer mixed soil type 11
4.75	100	99.9306	99.8613	99.7919	99.7226	99.6532
2	99.5832	99.0794	98.5758	98.072	97.5684	97.0646
1	94.1648	92.8525	91.5403	90.228	88.9158	87.6035
0.6	88.1212	86.8615	85.6019	84.3422	83.0826	81.8229
0.425	86.2456	84.9921	83.7387	82.4852	81.2318	79.9783
0.3	71.2408	70.7131	70.1857	69.6582	69.1298	68.6023
0.212	61.8628	61.7171	61.5716	61.4261	61.2796	61.1341
0.150	58.9452	58.6213	58.2977	57.974	57.6493	57.3257
0.075	55.4024	55.0342	54.6664	54.2984	53.9295	53.5616
Received	0	0	0	0	0	0

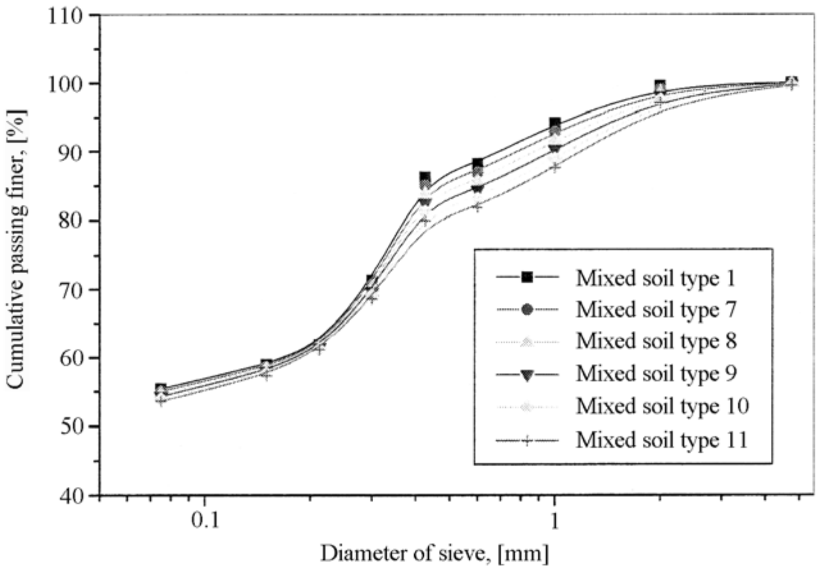

Fig. 2 – Sieve analysis of mixed soil type 1, 7, 8, 9, 10 and 11.

Table 6

Sieve Analysis Result

Diameter of sieve %	Cumulative passing finer mixed soil type 1	Cumulative passing finer mixed soil type 7	Cumulative passing finer mixed soil type 8	Cumulative passing finer mixed soil type 9	Cumulative passing finer mixed soil type 10	Cumulative passing finer mixed soil type 11
4.75	100	99.9306	99.8613	99.7919	99.7226	99.6532
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1	94.1648	92.8525	91.5403	90.228	88.9158	87.6035
0.6	88.1212	86.8615	85.6019	84.3422	83.0826	81.8229
0.425	86.2456	84.9921	83.7387	82.4852	81.2318	79.9783
0.3	71.2408	70.7131	70.1857	69.6582	69.1298	68.6023
0.212	61.8628	61.7171	61.5716	61.4261	61.2796	61.1341
0.150	58.9452	58.6213	58.2977	57.974	57.6493	57.3257
0.075	55.4024	55.0342	54.6664	54.2984	53.9295	53.5616
Received	0	0	0	0	0	0

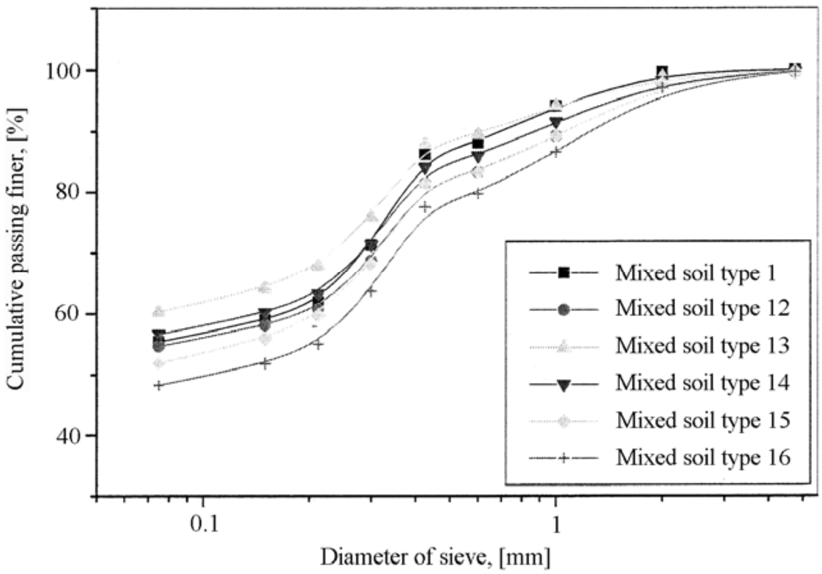
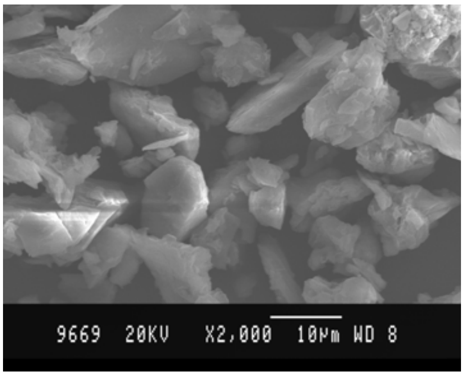
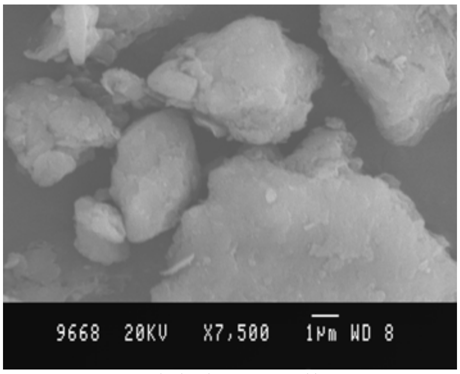


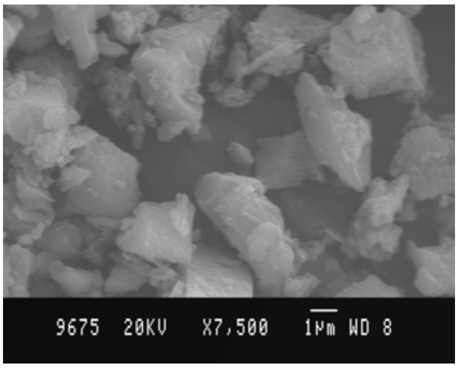
Fig. 3 – Sieve analysis of mixed soil type 1, 12, 13, 14, 15 and 16.



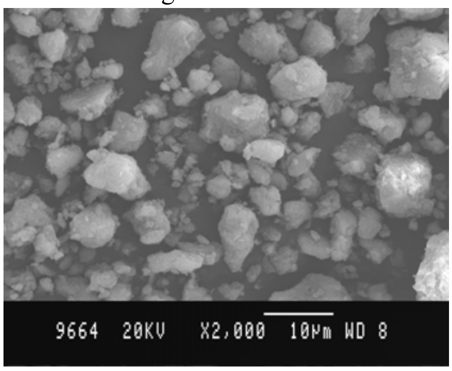
Red soil



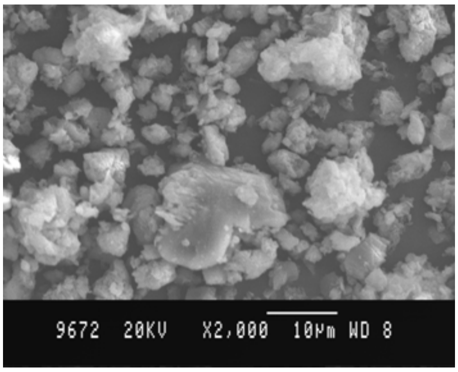
Light brown soil



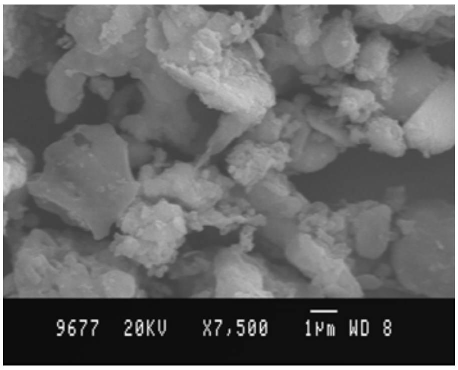
Black soil



Dark brown soil



Yellow soil



Green soil

Fig. 4 – SEM photos of six soil samples [9].

4. Conclusions

1. The mixed soil type consists of fine aggregate, changing soil mineralogy resulted of changing soil bearing capacity.

2. The mixed soil type consists of coarse and fine aggregate, soil mineralogy and morphology controlled of soil bearing capacity.

3. The mixed soil made up from fine aggregate, its characteristics depending on soil mineral; it is possible to develop new type of mixed soil if required mineral is identified and added.

4. In the mixed soil under the loose moisture condition, mineral of soil not only affects the soil cohesion, it also affects the soil angle of friction.

5. Performance of soil mineral is similar to the steel in reinforcement concrete.

6. Soil mineral is a factor in controlling soil differential settlement and deformation.

Notations

Φ – friction angle, [°];
C – soil cohesion, [kN/m^2];
OMC – optimum moisture content, [%];
SBC – safe bearing capacity, [kN/m^2];
γ – unitary weight, [kN/m^3].

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IMPORTANŢA MINERALELOR PREZENTE ÎN PĂMÂNTURI

(Rezumat)

Caracteristicile esenţiale ale structurilor din pământ sunt: transmiterea încărcărilor la mediul de fundare, menţinerea deformaţiilor şi tasărilor în limite admisibile, în condiţiile asigurării stabilităţii. În această privinţă 16 tipuri de amestecuri de pământuri au fost studiate ca posibilitate de utilizare în realizarea structurilor din pământ, în condiţii de siguranţă. Rezultatele obţinute arată că structura mineralogică a pământurilor ar putea creşte rezistenţa pământului şi reduce, astfel, riscul de cedare.