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Analysis of Mixed Soil Model Characteristics

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Abstract

Improvement of any site could be possible, if soil characteristics of site were clearly identified. 15 soil mixture models were developed. The angle of friction (Φ) and cohesive (C) of mixed soil under the direct shear test at different level of moistures have been studied and corresponding bearing capacity were calculated. The angle of friction and cohesive of the mixed soil have positive correlation with the bearing capacity. The results also revealed that the mixed soils, which composed of good binding particles exhibited relatively high angle of friction, cohesive, shear strength and low degree of compressibility and settlement in the soil foundation.

Keywords: Soil Mixing, Angle of friction, Cohesive, Bearing Capacity, Terzaghi Method

1. Introduction

The bearing capacity is an important characteristic of the soil, which determines the safety of the structure built on it. Severe damage can be observed in the built structures during seismic force acting up on subsoil due to weak soil bearing capacity. The better method to reduce magnitude of damage caused to the structure due to weak bearing capacity of soil is excavating and replacement of some part or the whole of the soil foundation. There are other alternative methods through which the bearing capacity of the soil could be enhanced are geo-grid, Geo-textile, dewatering, compaction and micro pile methods.

The soil bearing capacity could be determined by analytical methods, plate bearing test, penetration test, model test, prototype tests and laboratory test (Venkataramaiah; 1993 and Murthy; 2002). There is also report on the improvement of ultimate bearing capacity by the soil confinement using a non-dimensional factor called the bearing capacity ratio (BCR). It has been observed that such confinement resists the lateral displacement of soil underneath the footing leads to a significant decrease in the vertical settlement and hence improving the ultimate bearing capacity (Vinod Kumar et al; 2007). Analysis of the condition of complete bearing capacity failure, usually termed general shear failure, can be made by assuming that the soil behaves like an ideally plastic material. The concept was first developed by Prandtl, and later extended by Terzaghi, Meyerhof and others (PUNMIA; 1988). There are also reports on determination of bearing capacity of soils by combining elasto-plastic finite element analysis with random field theory (Gordon & Griffiths; 2000). Here the authors made an attempt to investigate the bearing capacity of mixed soil types. The mixed soils were consisted of soils, sand and gravels representing around Mysore.

2. Methodologies and Experiment

Here the experiments have been performed to determine the bearing capacity of soils with spatially random shear strength. The main objective of the investigation was to determine the extent to which spatial variability in soil properties affects the distribution of the computed bearing capacity and find out the best and economical soil mixer which could be a trustable soil foundation for any type of structures. The authors were carried out laboratory tests to calculation of bearing capacity for the mixed soils. The soil samples, sand and gravels were dried at 110°C for 24 hours to dehydrate. In the present experiments, 15 different mixed soil types consisting of soils-sand-gravels were prepared (table1). The density of the each models under different moisture conditions (0%, 3%, 6%) were measured (fig.1). The direct shear test experiments for all the types were carried out (At different moisture content at the Geo-technical Engineering Laboratory, S. J. College of Engineering in Mysore) and cohesive of mixed soil (C), angle of fraction (Φ) were measured. The results were illustrated in table 2. Using C, Φ and density values and adopting Terzaghi's method, the bearing capacity for all mixed soil types were calculated, assuming 1.5 m depth and 2.5m* 2.5m widths for square footing (figure 3).

Formulas used for calculation bearing capacity are as follows (PUNMIA; 1988): $q_f = 1.3C\,N_c + \gamma D N_q + 0.4\,\gamma B N_\gamma$. Also N_q, N_c and N_γ are the general bearing capacity factors and depending upon Depth of footing, Shape of footing and angle of friction.

3. Results and Discussion

In the present investigations, the experiments were conducted for finding the best and economical mixed soil type, which could be a trustable soil foundation for any type of structures. The maximum and minimum densities were exhibited in mixed soil types 3 and 2 respectively. The figure 1 has indicated negative correlation in general among density and moisture content (up to 6%) under ambient conditions. The similar relationships could be observer between moisture and angle of friction (Φ) (fig 2) and also between moisture and soil bearing capacity (fig 3). As the moisture content increases, the soil become saturated and resulted decrease in internal friction among soil particles. There is a direct relationship between angle of friction and bearing capacity. At the 0% moisture the maximum and minimum bearing capacity could be observe in models 5, 8 (483835 Kg/m^2, 96781Kg/m^2) respectively (table 2). High bearing capacity could be attributed since the type 5 of only red soil, gravels and sand representing in different sizes and shapes, which, drastically reduced voids percentage and increased friction between grains of the mixtures. This condition prevailed up to 3% of moisture and further increased of moisture content, lead to the saturation point of the mixture with moisture, which drastically reduced the bearing capacity of the model. Where as in type 8 consists of red and dark brown soils, where friction reduced due to morphology characteristics. This more prominent in model consist of only red soil at higher percent of moisture. The remaining soil mixture exhibited relatively lower bearing capacity but linearity with moisture content. The nature of mixed soil type and its morphology are the main factors controlling the bearing capacity. In a model with good binding of particles which lead to withstanding compressive well with high level of angel of friction, cohesive and eventually appeared good enough shear strength. Binding of particles is depending on shapes and sizes of them. The angular and differential sizes have more binding. Good binding of particles could reduce settlement and compressibility of soil.

The interaction between the coarse and fine-grained matrices affects the overall mechanical behavior of the mixture of the soils (Cabalar; 2008). The existing unusual soil volume change behavior like settlement under effective stress decrease during wetting and massive settlement near saturation, another odd behavior was encountered during laboratory inundation tests at different net stress (Md. Noor; et al 2008). Adding some granular soils to pure plastic clay will increase the stiffness of the clay material and decrease the differential behavior of any earth structure (Husseini; 2002). The results clearly revealed the soil mixture consisting of red soil, sand and gravels has exhibited high degree of bearing capacity and mechanical strength.

4. Conclusion

Soil Mixing is a technique, which could improve the physical characteristics of soil. The moistured soil mixtures have exhibited negative correlation with density, angle of friction and almost positive correlation with cohesive of soil mixtures. The angle of friction of soil mixtures has positive correlation with the bearing capacity. The soil mixture consists of red soil, sand and gravels is a better ground for the basement of structures under dry and low moisture conditions. The nature of mixed soil and its morphology are also the main factors determine the bearing capacity. A model with good binding of particles increased, angle of friction, cohesive and shear strength and also decreased compressibility and settlement of soil foundation.

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Table 1. Mixed Soil models

Sl. No	RD (%)	S (%)	GL 4.75 mm (%)	GL 2 mm (%)	B S (%)	GS (%)	DBS Soil (%)	YS (%)	LBS (%)
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	55	0	0	0	0	0	0	0	45

Red Soil=RD, Sand= S, Gravel= GL, Black Soil= BS, Green Soil=GS, Dark Brown Soil= DBS, Yellow Soil=YS, Light Brown Soil=LBS

Table 2. Experiments Results

MN	Moisture (%)	γ Kg/m^3	Φ [°]	C Kg/m^2	B .C Kg/m^2	MN	Moisture (%)	γ Kg/m^3	Φ [°]	C Kg/m^2	B .C Kg/m^2
1	0	1203.9	38	0	210935	2	0	1278.3	35	0.1	133590
	3	1105	30	0.02	59063		3	1172.3	35	0	122505
	6	1074.4	25	0.06	30891		6	1018.3	31	0	63669
3	0	1420	36.5	0.14	198607	4	0	1295.6	42	0	461739
	3	1357.8	36	0.1	173902		3	1246.7	38	0.06	218478
	6	1246.7	31	0.2	77960		6	1203.9	37	0	182559
5	0	1357.6	42	0	483835	6	0	1172.3	37	0.12	177779
	3	1345.6	39.5	0.1	283348		3	1202.3	36	0.04	154059
	6	1048.9	34	0	94138.8		6	1048.9	33	0	84620
7	0	1234.5	36	0	158102	8	0	1351.7	32	0	96781
	3	1111.1	34	0	99721.2		3	1202.9	32	0	86127
	6	1080.5	33	0	87169.3		6	1111.1	29	0	53899
9	0	1160	35	0	121220	10	0	1048.9	37	0.04	159059
	3	1246.7	32	0	89263.7		3	1160	31	0.1	72534
	6	1111.1	31	0.04	69473.7		6	1111.1	29	0	53899
11	0	1111.1	36	0	142299	12	0	1258.9	33	0	101562
	3	1129.5	34	0	101373		3	1258.9	32	0	90137
	6	1172.3	31	0.05	73300.7		6	1185.5	28.5	0	54580
13	0	1172.3	35	0	122505	14	0	1296.6	36	0	166056
	3	1372.2	33	0.06	107076		3	1296.6	34	0	116370
	6	1234.5	27.5	0.06	50740.4		6	1129.5	32.5	0.04	85999
15	0	1141.7	37	0	173127						
	3	1160	36	0	148561						
	6	1111.1	34	0	99721.2						

MN= Model No, D=Degree, W=Width, S.B.C= Bearing capacity, OMC= Optimum Moisture Content and L=Length

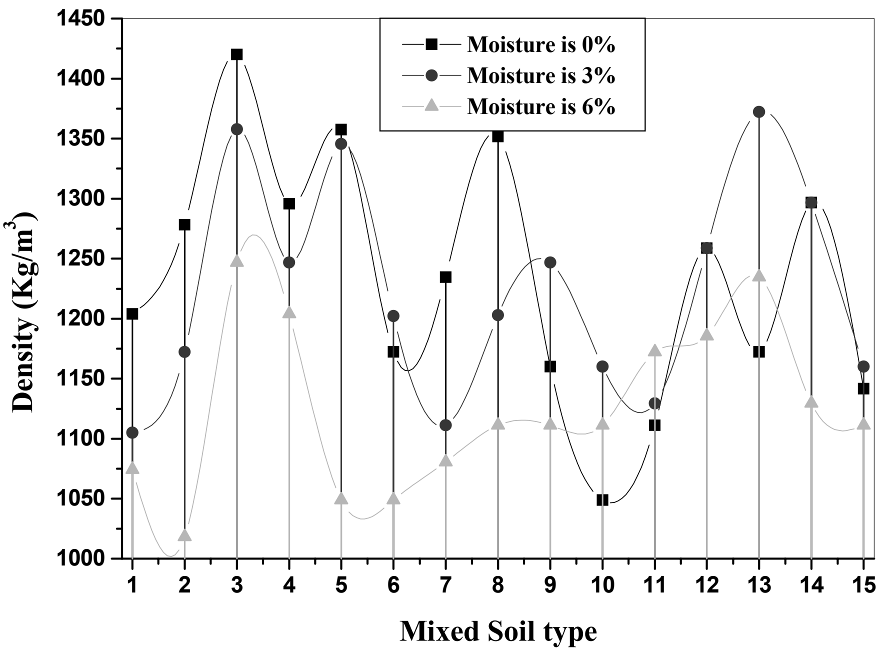

Fig . 1 . Mixed Soil type vs Density (Kg/m^3)

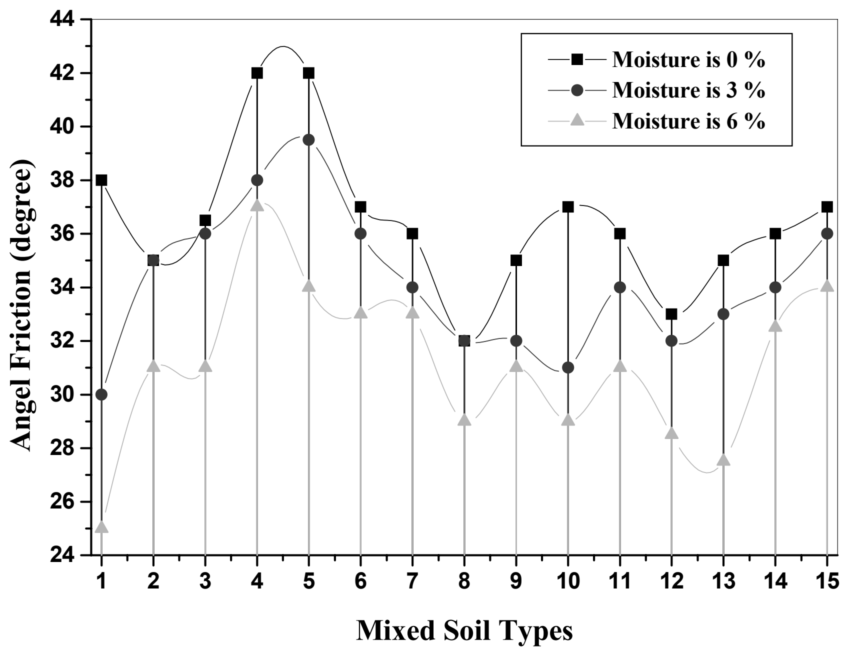

Fig . 2 . Mixed Soil Type vs Angel of Friction

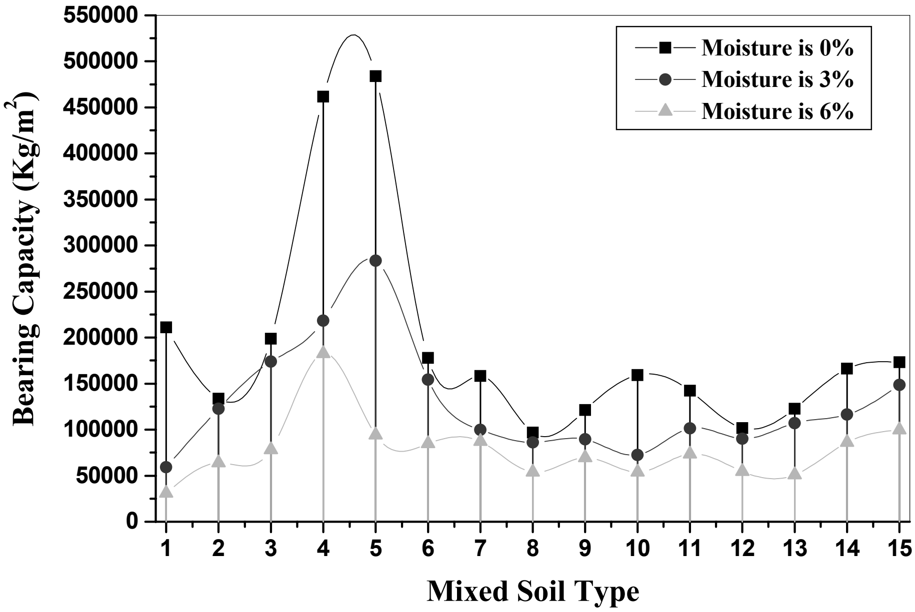

Fig . 3 . Mixed Soil Type vs Bearing Capacity (Kg/m^2)