Comparison of Shear Strength Parameters of Well Graded & Poorly Graded Sand with Percentage Fines Replaced with Percentage Kaolin

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Abstract— Shearing resistance of soil is very important while designing various structures which have direct contact with soil, for example, sheet piles, retaining walls and shallow foundations. Also, materials forming part of rock fill dams, glacial tills, mudflows, debris flows, soli fluctuation sheets, residual and colluvial soil deposits have a distinct structure, consisting of a mixture of large particles (gravel or hard clay fragments) and a soft matrix of clay. Mainly the foundation structures are designed with the consideration that it would be resting either on pure sand or clay bed, but on contrary to this stratified soil deposits pertain in the actual field, this makes the study of shear strength of made up soils an important factor to be evaluated. For the purpose of evaluating the same, the present research aims to study the shear strength parameters of well graded and poorly graded sand compacted at maximum dry density under varying degree of saturation as 0%, 50%, 75% and 100% with and without percentage fines (i.e. soil particles passing 75µ IS sieve) replaced by equivalent percentage of kaolin. For fulfilling the agenda of present study total 36 numbers of direct box shear test were performed. Direct box shear test was commenced taking Indian Standards as reference. Results depicted that as degree of saturation increased the angle of internal fiction and cohesion decreased in both the condition i.e. with and without replacement of percentage fines with percentage kaolin.

Key words: Sandy Soil, Kaolin, Direct Box Shear Test, Degree of Saturation

I. INTRODUCTION

The mechanical behavior of clean sands was investigated first by Coulomb in the 18th century [1]. Studies of the mechanical behavior of pure clays were reported only approximately 150 years later [2]. Studies of these soils continued over the years as clean sands and pure clays define distinct boundaries of a wide spectrum of natural soils and thus set limits on expected performance. Most of the studies concerning the stress–strain and shear strength behavior of granular soils mainly inspected the response of clean sands. However, field observations show that granular soils may contain a considerable amount of clay and/or silt. Therefore, these fines should be expected to influence the engineering behavior of sandy soils. The purpose of these investigations was to quantify the effect of fines on the shear strength of sandy soils. Wasti and Alyanak [2] have worked on sand-clay mixtures and stated that when clay content is just enough to fill the voids of the granular portion at its maximum porosity, the structure of the mixture changes and the linear relationship between the Atterberg limits (plastic and liquid limits) and the clay content is no more valid and soil changed its behavior from sand to clay. Novais - Ferreira [3] performed consolidated-drained direct shear tests on artificial mixtures with increasing proportions of clay, including two types of sand (fine and coarse) and a montmorillonitic clay. They found that maximum and limiting shear stresses showed a tendency to decrease as the clay content increased. Georgiannou [4], made an investigation on the behavior of clayey sands under monotonic and cyclic loading. He concluded that the fine content has a remarkable influence on the stress-strain response of the soil mass. As the fines content increases, the dilatant behavior of the soils is suppressed, and the response gradually becomes controlled by the fine matrix at about 40% fine content. The literature referred indicate that till date many authors have worked on artificially made sand-clay mixture and due to lack of ample amount of literature on shear strength characteristics of the soil whose percentage fines are replaced by the soil of another category, this paper aims to fulfilling this gap by evaluating shear strength characteristic of the sand whose percentage fines were replaced by percentage kaolin, the sand was compacted at maximum dry density and subjected to 0%, 50%, 75% and 100% degree of saturation.

II. MATERIAL & EXPERIMENTAL PROGRAME

The experimental study follows four stages*:*

- Separation of the various particles size ranges by sieving from procured sand.(fig.1)
- Creation of well graded sand from separated particles size ranges.
- Preparation samples of well graded and poorly graded sand with and without replacement of percentage fines by percentage kaolin.
- Direct shear test on prepared samples of well graded and poorly graded sand compacted at maximum dry density with varying degree of saturation.

Fig. 1: Separation of Particles by Sieving

A. Properties of Sand & Kaolin

A uniform sand sample was used as coarser grain matrix. The finer grain matrix was composed of kaolinite clay. The index parameters of sand and kaolinite clay shown in Table1 were

determined by means of sieve, specific gravity, and consistency limit tests, relative density test. These tests were performed in accordance with Indian Standards.

B. Sample Preparation

For the preparation of samples, first of all particles of different sizes were separated by sieving. As the procured sand was classified as poorly graded sand, the well graded sand was created by blending of different size of particles in different proportion by making number of trials. The sample of replaced fines was prepared by passing sand from 75µ sieve and fines were replaced by Kaolin on dry weight basis. Total 4 numbers of samples were prepared.

Group-1: Poorly graded sand, Group -2: Poorly graded sand with percentage fines replaced by percentage kaolin, Group -3: Well graded sand, Group: Well graded sand with percentage fines replaced by percentage kaolin. Total 32 numbers of direct box shear test, compacted at maximum dry density with 0%, 50%, 75% and 100% degree of saturation had been performed. The unconsolidated undrain direct shear test were conducted and the size of shear box apparatus was 60*60*2.5 mm. The direct shear test were performed in accordance with Indian Standards under the normal load of 0.5 kg/cm^2, 1.0 kg/cm^2, 1. 5kg/cm^2.

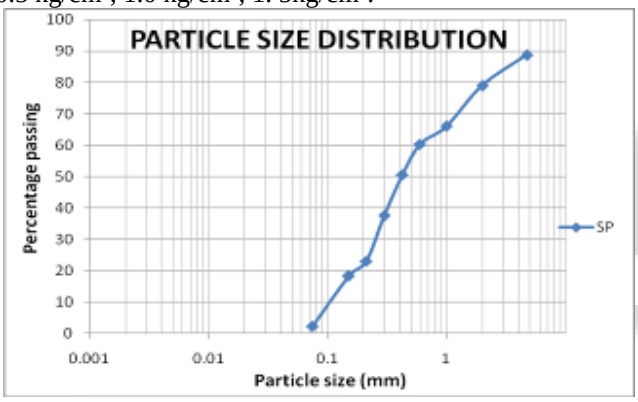
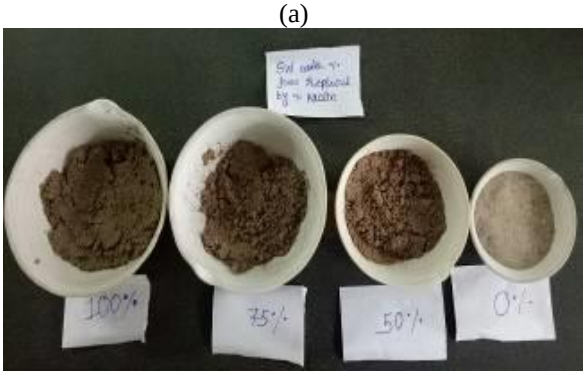


Fig. 2: Particle Size Distribution Curve

	Sand	Kaolin
Coefficient of uniformity,Cu	3.44	
Coefficient of curvature,Cc	1.3	
Liquid limit, wL (%)	-	62
Plastic limit, wP (%)	-	22.7
IS soil classification	SP	CH
Specific gravity,G	2.66	2.64
Minimum density,γd min	1.8gm/cm^3	
Maximum density,γd max	1.55gm/cm^3	

Table 1: Index Properties of Sand & Kaolinite used in Experimental Program

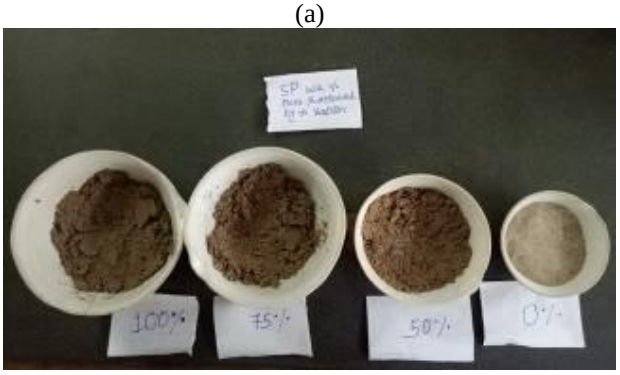
(a)



(b)

Fig. 3: Samples of SW with S= 0%, 50%, 75%, and 100% (a) Without Replacement of fines (b) with Replacement of fines

(a)



(b)

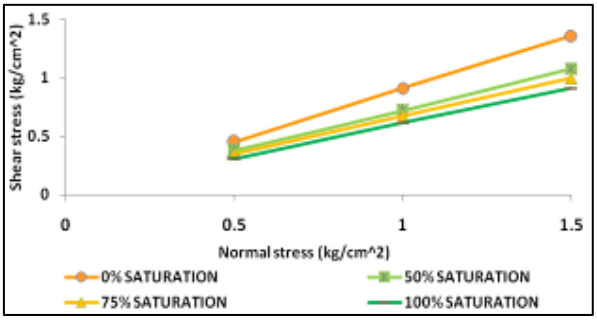
Fig. 4: Samples of SP S= 0%, 50%, 75%, and 100% (a) Without Replacement of fines (b) with Replacement of fines

III. RESULTS & DISCUSSION

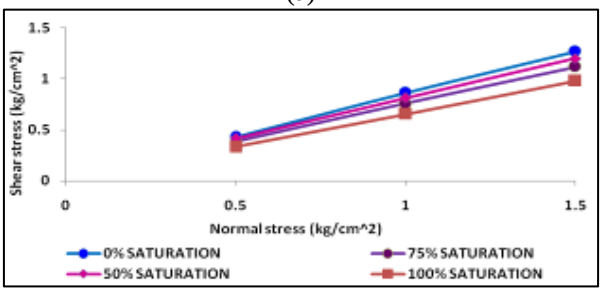
Undrained unconsolidated (UU) direct shear test at strain rate of 1.25 mm/min had been performed on prepared test samples of well graded and poorly graded sand, compacted at maximum dry density with varying degree of saturation.

Maximum dry density of well graded sand was 1.9 gm/cc whereas that of poorly graded sand was 1.8 gm/cc.

A. Test Results of Well Graded Sand



(a)

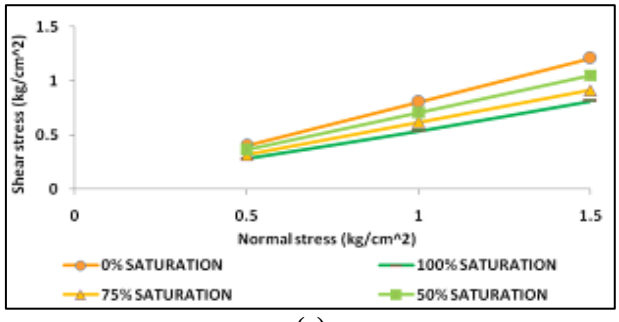


(b)

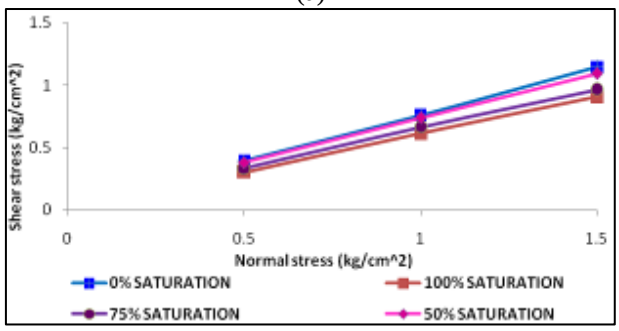
Fig. 5: Shear Stress vs Normal Stress (a) Without Replacement of Fines (B) with Replacement of Fines

Degree of saturation (sr)	Well graded sand			
	Without replacement		With replacement	
	Ø (degree)	C(kg/cm2)	Ø (degree)	C(kg/cm2)
100%	31.16	0.0053	32.996	0.0060
75%	33.06	0.0221	36.14	0.0236
50%	34.98	0.0259	38.05	0.0273
0%	42.22	0	39.96	0.0155

B. Test Results of Poorly Graded Sand



(a)



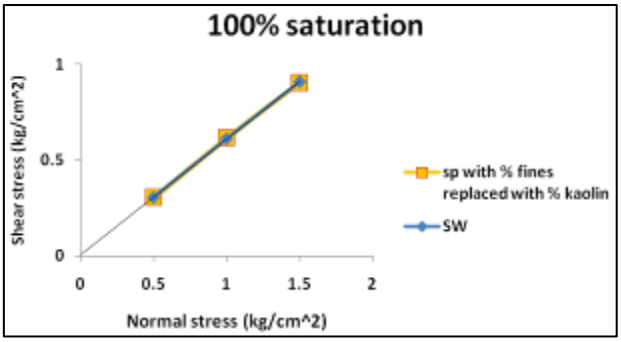
(b)

Fig. 6: Shear Stress vs Normal Stress (A) without Replacement of Fines (B) with Replacement of Fines

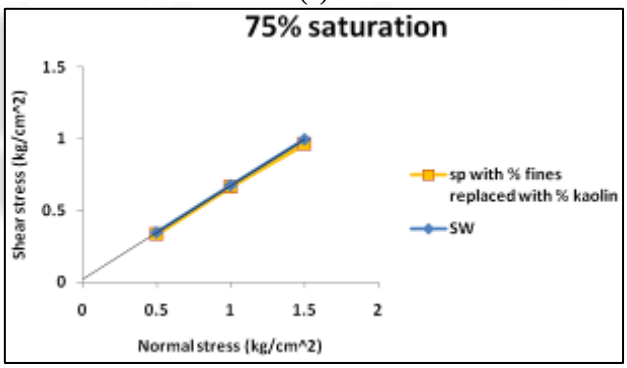
Degree of saturation (sr)	Poorly graded sand			
	Without replacement		With replacement	
	Ø (degree)	C(kg/cm^2)	Ø (degree)	C(kg/cm^2)
100%	28.22	0.0064	31.01	0.0070
75%	30.78	0.0216	32.24	0.0233
50%	34.31	0.0251	35.4	0.0275
0%	38.88	0	36.95	0.0154

Table 3: Angle of Intenal Friction & Cohesion for SP

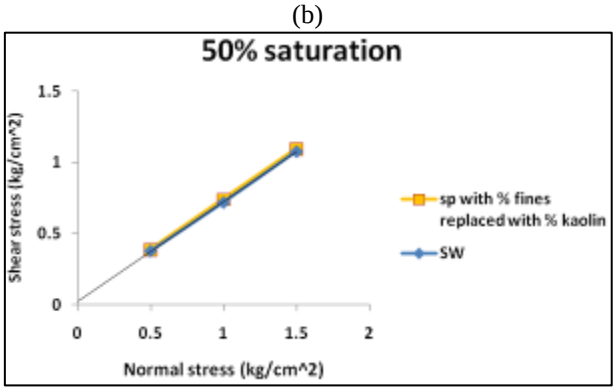
C. Comparison of Test Results



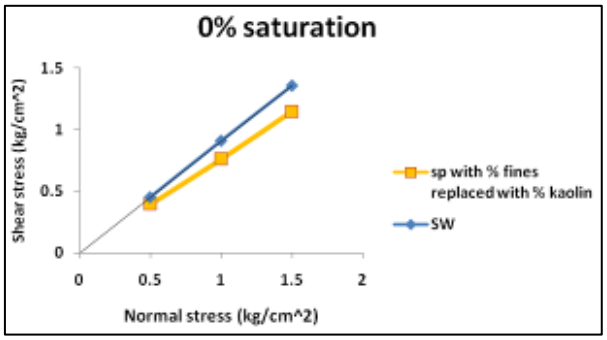
(a)



(b)



(c)



(d)

Fig. 6: Shear Stress vs Normal Stress for SW without Replacement and SP with Replacement of Fines (a) S= 100%, (b) S= 75%, (c) S= 50%,(d) S= 0

IV. Conclusion

From the above study, the following conclusions are drawn:

- With increase in degree of saturation of soil whether it may be with or without replacement the cohesion and angle of internal friction of soil were found to decrease for 50%, 75% and 100% saturation.
- Contrary to the above statement for 0% saturation i.e for the dry condition on replacement of fines by kaolin angle of internal friction was found to decrease whereas the cohesion increased.
- Angle of internal friction of soil was found to decrease in the order as well graded sand, poorly graded sand either with or without replacement.
- With replacement of fines by Kaolin, whether it may be well grade or poorly graded sand, the strength of sand is increased.
- Shear strength of poorly graded sand when fines were replaced by kaolin was found nearly equivalent to that of well graded sand without replacement for 50%, 75% and 100% saturation

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