EFFECT OF KAOLIN AND DEGREE OF SATURATION ON SHEAR STRENGTH PARAMETERS OF SILTY SAND

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ABSTRACT

The properties of clean sands pertaining to shear strength have been studied extensively. However, natural sands generally contain significant amount of silt and/or clay. The mechanical response of such soils is different from that of clean sands. 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. This paper addresses the effect of percentage kaolin on the shear strength parameters of sand. The strength behavior of silty sand can be interpreted from its relative compaction, mean confining pressure and relative dilatancy. The present work considers direct shear test results on silty sand at different degree of saturation. A series of direct shear test was performed on samples of silty sand with and/or without replacement of percentage fines replaced by percentage kaolin under varying degree of saturation as 0%, 50%, 75%, and 100%, compacted at maximum dry density. 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.

Keyword: - *Degree of saturation, Kaolin, Direct Shear test.*

1. Introduction

Materials forming part of rock fill dams, glacial tills, mudflows, debris flows, solifluction sheets, residual and colluvial soil deposits have a distinct structure, this consisting of a mixture of large particles (gravel or hard clay fragments) and a soft matrix of soil (clay, sand or sand- silt- clay mixture) (Deere and patton, 1971; Vallejo, 1979). In order to analyze the stability of slopes made of granular material – clay mixtures, their shear strength needs to be determined. 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. Soil cohesion and friction are affected by several factors, particularly soil density and moisture content. McKyes [3] reported that soil shear strength increases with the decrease in soil water content. Gitau et al. [4] found that the relationship of internal friction angle and water content of a sandy clay loam followed a second order polynomial equation. A number of shallow – depth slope failures have taken place during or just after heavy rainfall. Some of them seem to be caused not only by an increase of pore water pressure in soils resulting from a rise in the ground water level but also by the degradation of soil strength forming the slopes. The issue associated with reduction in shear strength due to the increase in degree of saturation have been addressed and investigated for the several types of soils. (Uno and Miyashita, 1981; Kutara and Ishizuka, 1982 ; Kuwano et al., 1988; Kuwano and Chen, 1990). This paper aims to evaluate shear strength characteristic of the silty 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.

2. Methodology

2.1 LABORATORY DIRECT SHEAR TESTS (DST)

Laboratory DSTs were conducted to measure shear properties of a sandy soil, including cohesion (c), and soil internal friction angle (Ø), as affected by different degree of saturation and maximum dry density. The following sections describe the apparatus and procedure of the DSTs.

2.2.1. TEST APPARATUS

Direct shear tests were conducted using an apparatus as shown in Fig. 1a. The apparatus consisted of a soil shear box, a loading head, a weight hanger, and weights to generate normal loads. The shear box had two square rings for holding soil sample (Fig. 1b). The cross-section of the box was 60 60 mm and the height was 50.8 mm. Horizontal displacement of the movable ring was achieved with a motor. A load cell measured the shear force. Two potentiometers measured the horizontal and vertical displacements. Values of shear force and horizontal displacement were recorded by a computer data acquisition system.

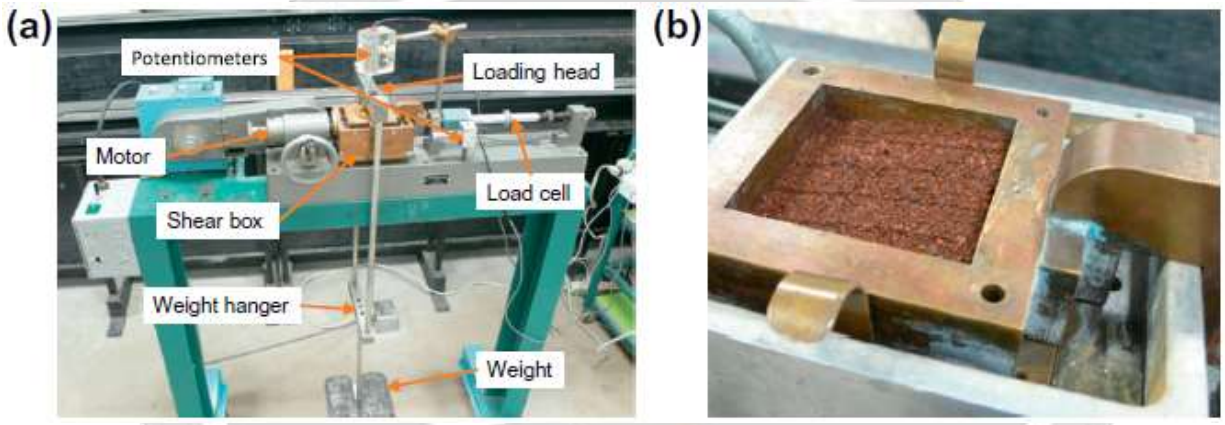

Fig -1: Direct shear test apparatus: (a) test setup; (b) shear box.

2.2 MATERIAL AND EXPERIMENTAL PROGRAME

The experimental study follows four stages:

- Separation of the various particles size ranges by sieving from procured sand.(fig.2)
- Creation of silty sand from separated particles size ranges.
- Preparation samples of silty 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 -2 Separation of particles by sieving-

2.2.1 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 silty 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 2 group of samples were prepared at 0%, 50%, 75% and 100% degree of saturation. Group 1- silty sand without replacement of fines by kaolin. Group 2 – silty sand with replacement of fines by kaolin.

Table -1: Properties of prepared silty sand and Kaolin

	Silty Sand	**Kaolin**
Percentage finers (75µ sieve passing)	**17%**	**-**
Liquid limit, w_L (%)	**-**	**62**
Plastic limit, w_P (%)	**-**	**22.7**
IS soil classification	**SM**	**CH**
Specific gravity,G	**2.65**	**2.64**
Minimum density,$\gamma_{d\ min}$	**1.9gm/cc**	**-**
Optimum moisture content (%)	**11**	**-**

3. Results and Discussion

Undrained unconsolidated (UU) direct shear test at strain rate of 1.25 mm/min and at normal load of 0.5 had been performed on prepared test samples of Silty sand, compacted at maximum dry density with varying degree of saturation. Maximum dry density of Silty sand was 1.9 gm/cc.

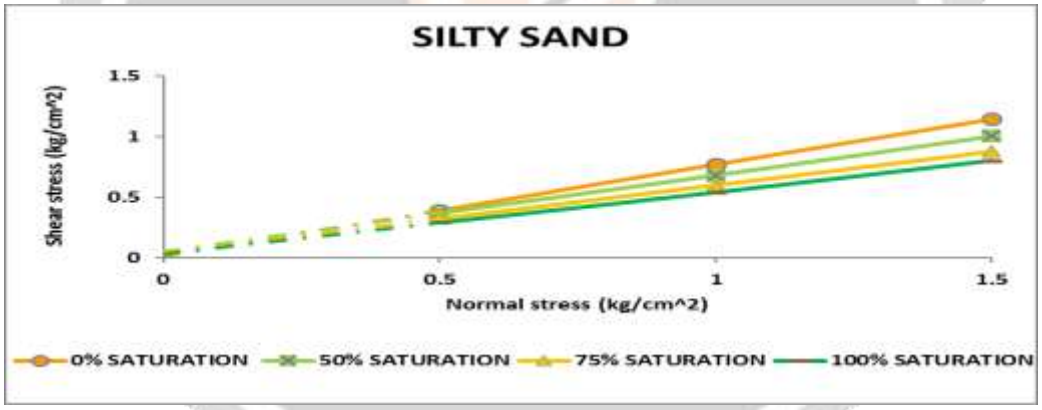

Fig -3: Shear stress vs normal stress Without replacement of fines

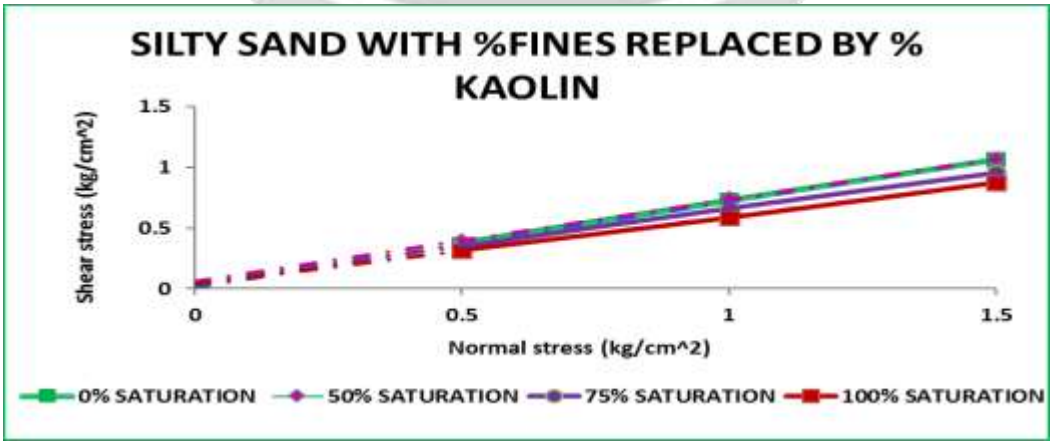

Fig -4: Shear stress vs normal stress with replacement of fines

3.1 Comparison of shear parameters

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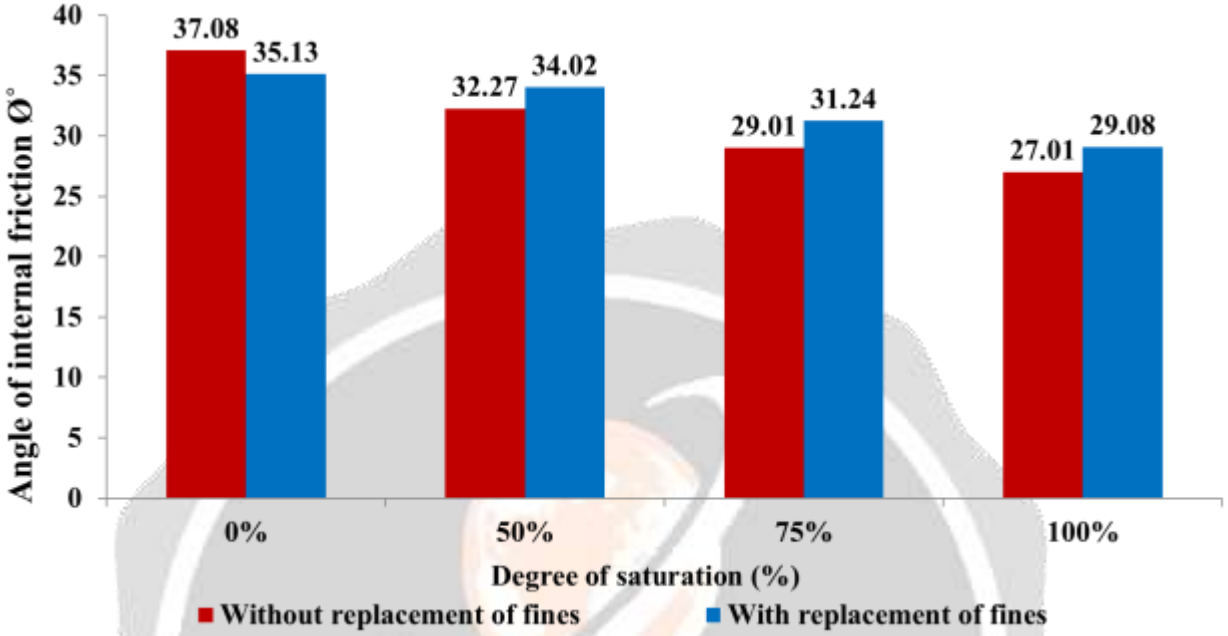

Fig -5: Comparison of angle of internal friction for both samples

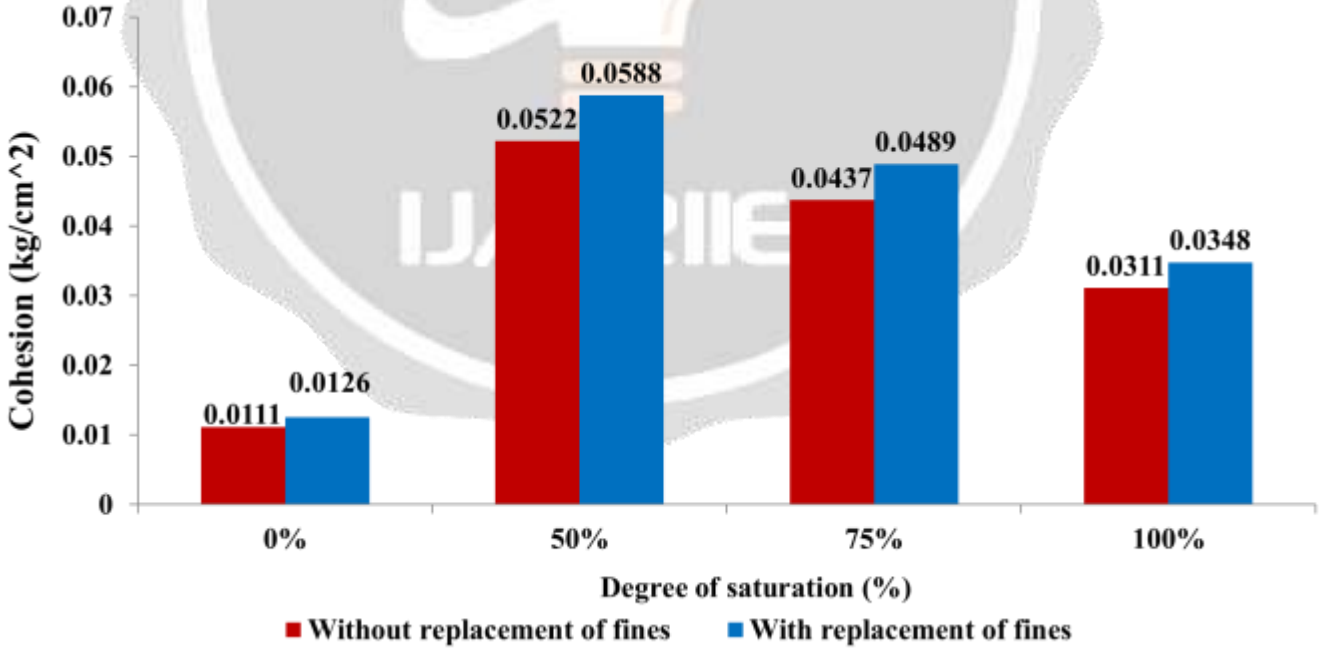

Fig -6: Comparison of Cohesion for both samples

Table -2: Test result of direct shear test for silty sand

Degree of saturation (SR)	Without replacement		With replacement	
	Ø (degree)	C (kg/cm²)	Ø (degree)	C (kg/cm²)
100%	27.01	0.0311	29.08	0.0348
75%	29.01	0.0437	31.24	0.0489
50%	32.27	0.0522	34.02	0.0588
0%	37.08	0.0111	35.13	0.0126

4. CONCLUSIONS

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.
- For Silty sand (SM), the angle of internal friction at 50%, 75%, and 100% degree of saturation shows increment of 5.42%, 7.69% and 7.66% respectively, whereas for 0% saturation i.e. for the dry condition it shows decrement of 5.26%.
- With replacement of fines by Kaolin, the strength of sand is increased.

5. ACKNOWLEDGEMENT

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