

Effect of Sand Gradation on the Shear Parameters in the Soil Sample a Case Study in Kadapa District

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ABSTRACT: Shearing strength of a soil is the most difficult to comprehend in view of the multitude of factors known to affect it. A lot of maturity and skill may be required on the part of the engineer in interpreting the results of the laboratory tests for application to the conditions in the field. The shear strength of soils is an important aspect in many foundation engineering problems such as the bearing capacity of shallow foundations and piles, the stability of the slopes of dams and embankments, and lateral earth pressure on retaining walls.

A soil has been mixed with different gradations of sand to form a different soil-sand mixture. The main purpose is to observe the effects of different soil-sand mixtures on behavior of shear strength. The direct shear test is conducted with shear boxes without performing initial consolidation in large boxes. The test procedure is conducted about 50% soil-50% sand mixtures seems to be threshold composition and changes are found by increasing the gradations of sand content in drained shear test. Mainly Direct Shear test is conducted to find out the soil-sand mixture which tends to maximum shear strength is 1.58 kg/cm², Maximum cohesion and Minimum angle of internal friction will be 1.16 kg/cm² and 15°48', and decreases the seepage through the sand.

I. INTRODUCTION

'Shearing Strength' of a soil is perhaps the most important of its engineering properties. This is because all stability analyses in the field of geotechnical engineering, whether they relate to foundation, slopes of cuts or earth dams, involve a basic knowledge of this engineering property of the soil. 'Shearing strength' or merely 'Shear strength' may be defined as the resistance to shearing stresses and a consequent tendency for shear deformation.

Shearing strength of a soil is the most difficult to comprehend in view of the multitude of factors known to affect it. A lot of maturity and skill may be required on the part of the engineer in interpreting the results of the laboratory tests for application to the conditions in the field.

Granular soils of sands may derive their shear strength from the first two sources, while cohesive soils or clays may derive their shear strength from the second and third sources. Highly plastic clays, however, may exhibit the third source alone for their shearing strength. Most natural soil deposits are partly cohesive and partly granular and as such, may fall into the second of the three categories just mentioned, from the point of view of shearing strength. The shear strength of a soil cannot be tabulated in codes of practice since a soil can significantly exhibit different shear strengths under different field and engineering conditions.

In this study, it was aimed to observe shear strength behaviour of soil - sand mixtures. Two series of experiments were performed. In all series, behaviour of shear strength under different testing conditions was investigated against increasing fine materials in the mixtures.

1.1 Objectives of the present study:

1. To study the properties of soil
2. To study the properties of sand
3. To calculate the shear parameters of soil-sand

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II. LITERATURE REVIEW

Direct shear testing, as was first used by Coulomb in 1776 (Lamb and Whitman 1969), has long been used to estimate the strength parameters for the analysis of slope stability, retaining wall, and bearing capacity problems. More recently, direct shear testing techniques have been extended to measure interface friction between soils and reinforcing elements in reinforced soil applications (Hausmann 1990; Lee and Manjunath 2000) and soils and foundation elements (Abderrahim and Tisot 1993).

The effect of particle size on shear strength of granular materials is investigated using direct shear tests. Small direct shear test (60 mm by 60 mm by 24 mm deep) were conducted for particles passing the sieves with opening size of 2.36 mm. Meanwhile, particles passing the standard 20 mm sieves were tested using large direct shear test (300 mm by 300 mm by 200 mm deep). The large direct shear tests and the small direct shear tests carried out using the same shearing rate of 0.09 mm/min and similar normal stresses of 100, 200 and 300 kPa. The results show that the peak and residual shear strength increases as particle size increases.

The experimental results were compared with the values predicted by the suggested approach and showed good agreement. As the developed model depends on the residual interface friction angle (δ_r) between the helix surface and the surrounding sand, results of δ_r , extracted from different sand samples, are presented for use in this suggested relationship on site. Also, the values of K_T found in this work were compared with those of field and laboratory tests on helical piles in sand reported in the literature.

III. STUDY AREA

Sample is collected from EGUPALLE near KADAPA. The soil sample is collected from a vast area of black cotton soil. The experiments are conducted in Geotechnical laboratory of KSRM College of Engineering, which is located near Krishnapuram village, KADAPA.

IV. MATERIALS AND METHODOLOGY

4.1 MATERIALS

In this process the materials are locally available soil sample and river sand. The soil sample is collected from Egupalle near Kadapa. The experimental investigations on soil sample are done to understand the index and engineering properties of the collected soil sample. This experimental study helps to classify the soil. The obtained values of index and engineering properties of the soil.

The sand samples are collected from the Pennariver near chennuru and the experimental investigations on sand sample are done to understand the index and engineering properties of the collected sand sample. Finally we determine the shear stress variation to changing the percentages of sand and soil samples.

4.2 METHODOLOGY

In this study, the soil sample is collected from Egupalle near Kadapa. The experimental investigations on soil sample are done to understand the index and engineering properties of the collected soil sample. This experimental study helps to classify the soil. The index and engineering properties of the soil are Liquid limit (IS: 2720-Part-5-1970), Plastic limit (IS: 2720-Part-5-1970), Plasticity index, Standard proctor compaction test (IS code-2131-1981), Free swell index (IS 2720-part-40-1977), Sieve analysis (IS 2720-part-4-1975), Specific gravity (IS 2720-Part-3, sec-1, 1980), and Direct shear test (IS 2720-part-13-1972)

In this study deals with experimental investigation carried on sand to classify the sand sample. The sand sample is collected from the Penna River near chennuru. The index and engineering properties of the sand are Sieve analysis (IS 2720-part-4-1975), Specific gravity (IS 2720-Part-3, sec-1, 1980), Direct shear test (IS 2720-part-13-1972).

We are collecting the sand sample will be separated with gradations. The sand gradations are 4.75mm, 2mm, 1mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm, 0.075mm. Each gradation of sand will be mixing with 50% soil and 50% sand. Then direct shear test will be conducted to the soil and sand mixture. The values will be identifying the cohesion and angle of internal friction.

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V. RESULT AND DISCUSSIONS

5.1 EXPERIMENTAL INVESTIGATION ON SOIL SAMPLE:

Table 5.1.1: Properties of the soil

SL.NO	NAME OF THE PROPERTY	VALUE
1	Natural moisture content	2%
2	Liquid limit (W_L)	82%
3	Plastic limit (W_P)	50%
4	plasticity index (I_P)	32%
5	Optimum moisture content by Standard proctor test	17.2%
6	Maximum dry density	1.4gm/cc
7	Free swell index	58.64%
8	Sieve analysis	Coefficient of uniformity=3.8 Coefficient of curvature=0.98
9	Specific gravity	2.52
10	Direct shear test	Cohesion $c = 1.2\text{kg/cm}^2$ Angle of internal friction= $11^\circ 2'$

5.1.2 Shear strength of soil (IS 2720-part-13-1972)

The shear strength is calculated for the 100% soil sample based on (IS 2720-part-13-1972) values are tabulated in table 5.1.2. The curve is plotted by taking normal stress on x-axis and shear stress on y-axis

Table: 5.1.2 Data sheet for shear strength of soil

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	48.07	1.33	1.473
2	2	53.58	1.48	
3	3	58.17	1.61	

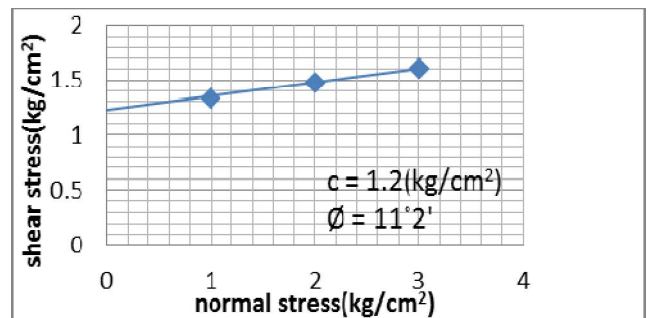


Figure 5.1.3 : variation between normal stress and shear stress of soil

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Result :

From the table 5.1.1 the soil will be classified as clayey silt.
From the table 5.1.2 shear strength of soil is 1.473 kg/cm²
From the graph 5.1.3 the cohesion is 1.2kg/cm² and angle of internal friction is 11°2' .

5.2 EXPERIMENTAL INVESTIGATION ON SAND:

Table 5.2.1: Properties of the sand

SL.NO	NAME OF THE PROPERTY	VALUE
1	sieve analysis	Coefficient of uniformity=1.87 Coefficient of curvature=0.87
2	Specific gravity	2.65
3	Direct shear test	Cohesion c= 0 kg/cm ² Angle of internal friction=35°1'

5.2.2 Shear strength of the sand (IS 2720-Part-13-1972)

The shear strength is find out for the 100% sand sample based on (IS 2720-Part-13-1972) and the values are tabulated in table 5.2.2

Table 5.2.2: Data sheet for shear strength of sand

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	23.88	0.66	1.22
2	2	33.37	1.22	
3	3	64.60	1.79	

Graph

The curve is plotted by taking normal stress on x-axis and shear stress on y-axis

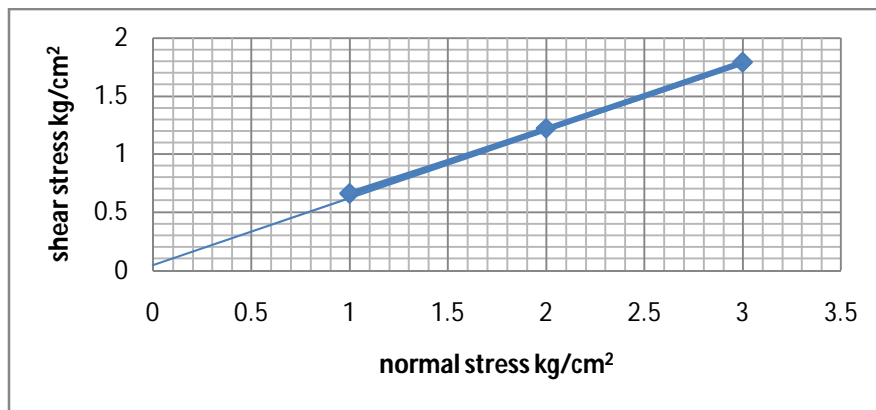


Figure 5.2.3: variation between the normal stress and shear stress of sand

Result:

From the table 5.2.1 the sand will be classified as poorly graded sand.
From the table 5.2.2 shear strength of sand is 1.22 kg/cm²

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From the graph 5.2.3 the cohesion is 0 kg/cm² and angle of internal friction is 35° 1'.

5.3 EXPERIMENTAL INVESTIGATION ON SOIL - SAND MIXTURE

In this study shear parameters of soil will be mixing the sand in different gradations (4.75, 2, 1, 0.6, 0.425, 0.3, 0.15, 0.075 mm) and shear parameters were determined. In this the each grade of sand will be mixed with soil. The study on the variation of cohesion and angle of internal friction for each grade is done in the respective chapter.

In this study the shear strength is calculated for the mix proportion of 50% sand retained on 2 mm sieve and clay of 50% and the values are tabulated.

Table 5.3.1: 2 mm-RETAINED SAND (50%) and CLAY (50%)

S.no	Normal Stress (kg/cm ²)	Maximum Shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	18.72	0.52	0.89
2	2	34.2	0.92	
3	3	44.28	1.23	

In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

Table 5.3.2: 1 mm RETAINED SAND (50%) and CLAY (50%)

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	20.54	0.57	0.97
2	2	39.78	1.02	
3	3	46.99	1.33	

Table 5.3.3: 0.6 mm RETAINED SAND (50%) and CLAY (50%)

In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	29.27	0.6	1.02
2	2	39.5	1.03	
3	3	43.02	1.44	

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Table 5.3.4: 0.425 mm RETAINED SAND (50%) and CLAY (50%)

In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	23.14	0.64	1.06
2	2	34.26	1.05	
3	3	54.65	1.51	

Table 5.3.5: 0.3mm RETAINED SAND (50%) & CLAY (50%)

In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	38.67	1.07	1.45
2	2	50.49	1.52	
3	3	64.33	1.78	

Table 5.3.6: 0.15 mm RETAINED SAND (50%) & CLAY (50%)

In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	44.25	1.22	1.55
2	2	60.32	1.58	
3	3	67.36	1.87	

Table 5.3.7: 0.075 mm RETAINED SAND (50%) & CLAY (50%)

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In this study the shear strength is calculated for the mix proportion of 50% sand and clay of 50% and the values are tabulated.

S.no	Normal stress (kg/cm ²)	Maximum shear force (kg)	Shear stress (kg/cm ²)	Shear strength (kg/cm ²)
1	1	49.42	1.37	1.66
2	2	57.5	1.59	
3	3	73.48	2.04	

Results:

Results for Shear strength:

From the table 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6, and 5.3.7 shear strength of soil-sand mixture is 0.89 kg/cm², 0.97 kg/cm², 1.02 kg/cm², 1.06 kg/cm², 1.45 kg/cm², 1.55 kg/cm², 1.66 kg/cm². In this study the sand gradation is decreasing in the soil then the shear strength of soil-sand mixture will be increasing.

The graph plotting between the normal stress and shear stress

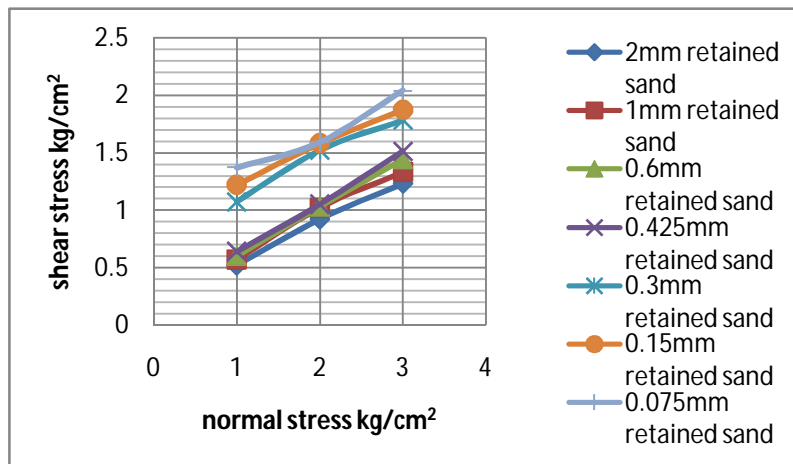


Fig 5.3.8: C – Ø graph for each gradation of sand sample

Results for angle of internal friction:

From the graph 5.3.8 angle of internal friction of soil-sand mixture at each sand gradations of 2mm, 1mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm, and 0.075mm is 35°25', 33°2', 32°3', 25°48', 22°48', 19°19', and 15°48'. The sand gradation will be decreasing in the soil sample then the angle of internal friction will be decreasing.

Graph

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The curve is plotted by taking sand gradation on x-axis and angle of internal friction on y-axis

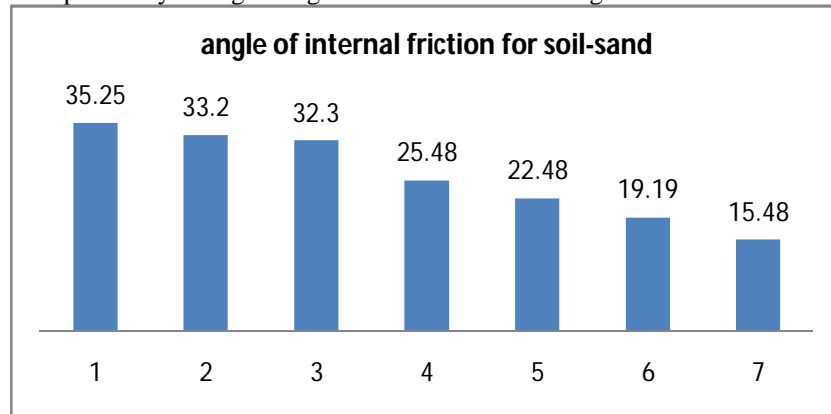


Figure 5.3.9: comparison of angle of internal friction for soil and different gradations of sand retained

Results for cohesion:

From the graph 5.3.8 cohesion of soil-sand mixture is at each sand gradations of 2mm, 1mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm, and 0.075mm is 0.18 kg/cm², 0.19 kg/cm², 0.2 kg/cm², 0.58 kg/cm², 0.61 kg/cm², 0.84 kg/cm², and 1.16 kg/cm². The sand gradation will be decreasing in the soil sample then the cohesion will be increasing.

Graph

The curve is plotted by taking sand gradation on x-axis and cohesion on y-axis

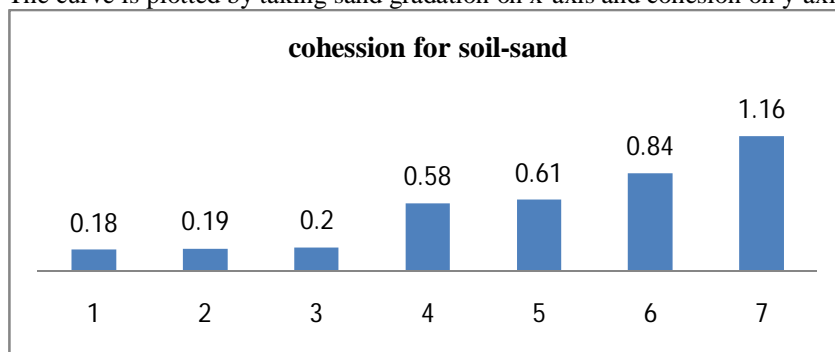


Figure 5.3.10: comparison of cohesion for soil and different gradations of sand retained

VI. CONCLUDING REMARKS

1. The density considered to conduct experimental investigation on sand-clay mixture is 2.1gm/cc.
2. Shear strength of soil sand mixture will be increasing to changing the gradations of sand in the soil sample.
3. The value of cohesion will be increasing to changing the gradations of sand in the soil sample.
4. The value of angle of internal friction will be decreasing to changing the gradations of sand in the soil sample.
5. Maximum cohesion will be 1.16(kg/cm²) and minimum cohesion will be 0.18 (kg/cm²)
6. Angle of internal friction will be at maximum 35°25' and minimum 15°48'.
7. Shear strength of soil sand mixture will be at maximum 1.58(kg/cm²) and minimum 0.89 (kg/cm²)

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