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Shear Strength Behaviour of Sand Clay Mixture

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ABSTRACT: The occurrence and distribution of soils in nature is such that, the various type of soil can be found together. Most of the engineering design methods and parameters of structures on soil have been developed for ideal soils such as pure sands or pure clays; which mostly deviates from the reality. A study of the existing literature presents a brief idea of testing by means of sand-clay mixtures to understand the change in the parameters due to inclusion of fine or coarse particles. With this in view, efforts have been made in the present study to study the effects of addition of plastic fines to sand on the behaviour of shear strength sand and vice versa by addition of coarser content to fine grained soil and determining the effect on the compressibility of clayey soil. Such a study would be handy to understand the deviation of the properties due to structural change in the soil

KEYWORDS: Shear Strength, Sand-Clay Mixture

I.INTRODUCTION

The mechanical behaviour of clean sands was investigated first by Coulomb in the 18th century [1]. Studies of the mechanical behaviour 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 behaviour of sandy soils. In the guidelines of earth retaining structures, soils with fines are disqualified as backfill materials. For example, according to the AASHTO (American Association of State Highway and Transportation Officials) specifications, the content of fines used in a reinforced soil retaining wall must be less than 15%. However, geotechnical engineers usually face practical concerns, like the availability of good quality backfill materials and the construction costs in meeting these criteria .in the process it was aimed to observe shear strength behaviour of sand - clay mixtures. Three 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. Bc soil is used as fine material. Shear strength parameters, failure strains, secant moduli of mixtures, stress - strain behaviours were studied. Changes in basic characteristics such as void ratios, particle size distributions, consistency limits and soil index properties were also studied. These properties were then correlated with shear strength.

However, most of the engineering design methods and parameters have been developed for idea soils such as pure sands or pure clays (Tembe et al, 2010). In a sand and clay mixture, it is very difficult to classify the soil into as sand or clay since it possesses both properties of sand and clay. It was established by Investigations into the influence of clay content on the engineering properties of sandy soils have been carried out by various researchers in the past using reconstituted sand and clay mixture, Mehmet and Ozden (2007), Rozalina and Yanful (2012), Panagiotoponlos et

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al (1997), Naser Al Shayea (2001), Shanyoug et al (2009), Mohammad et al (2011), Yongshan and James (2002), Lius and Roger (2000). Naser Al Shayea (2001) concluded that for a clay and sand mixture, the cohesion increases with increasing clay content while the friction angle decreases with increasing clay content. Shanyoug et al (2009) researched into the influence of clay content on the engineering properties of sand and stated that the clay content plays an important role on the mechanical response of soils, especially when the soils are subjected to loading. In general, by increasing clay content, the plasticity and the coefficient of secondary consolidation (creep) increase, while the friction angle and permeability decrease (Kim et al, 2005). Mehmet and Ozden (2007) stated that field observations show that granular soils may contain a considerable amount of clay and/or silt and these fines are expected to influence the engineering behavior of sandy soils.

This paper is based on investigation that were carried out to determine the influence of clay content on the strength and compressibility of sandy soils in clay content in the naturally occurring soil. Field observations show that the predominant soil type of the Voltain formation is mainly sands, however, the sand occurs with different amounts of clay, silt and gravel. The clay is expected to influence the engineering behaviour of the sand. Knowledge of the influence of clay content on strength and compressibility parameters of the Voltain sandy soils is fundamental in the interpretation of their properties for engineering design

.II. RELATED WORK

1. Particle size plays an important role on the strength behaviour of granular materials. The size of the particles in the granular mass alters the fabric and is responsible for the variation of strength behaviour. When granular materials are subjected to loading, particle size and their associated voids play an important role in the dissipation of energy. The load transformation mechanism of the granular mass depends on the individual soil grains as load transfer particle to particle and the macroscopic response of granular mass is the resultant of the individual response of the particles.
2. To evaluate the influence of particle size, numerous laboratory as well as numerical tests have been performed in the last few decades. The diversity of the conclusions of conducted research revealed an ambiguity which lead to further investigations. Moreover, theoretical relationships between the particle size and stress-strain and strength are still elusive. In laboratory experiment, different types of testing apparatus (direct shear test, triaxial test etc.) and in numerical analysis 2D-DEM and 3D-DEM (Discrete Element Method) were adopted. Frederick (1961) pointed out that macroscopic response of granular materials changed with the alteration of particle size. Kolbuszewski and Frederick (1963) reported that macroscopic behaviour of the granular mass is the summation of the individual response of the particles and the deformation of the mass before crushing depends on the individual soil grain size. In order to investigate the effect of particle size, Kolbuszewski and Frederick (1963) used ballotini (glass beads) and concluded that maximum porosity decreases and compressibility increases with the increase of particle size. Particle size effects dilatancy component during the triaxial test. Zolkov and Wiseman (1965) conducted triaxial tests to study the effect of particle size and observed that the angle of shearing resistance increases as particle size increases. Kolbuszewski and Frederick (1963) reported similar conclusions to Zolkov and Wiseman (1965) but Kirkpatrick (1965) found a different result. According to Kirkpatrick (1965) the angle of shearing resistance decreases with the increase of particle size, which agreed with the findings reported in Marschi *et al.*, 1972. To determine the effect of particle size Chattopadhyaya (1981) performed direct shear tests using Mogra sand and described that the fabric of the granular mass is a function of the particle sizes and their distribution and the maximum void ratio increase with the decrease of particle size while Kirkpatrick (1965) reported maximum and minimum void ratios remain constant with the particle size. From the numerical observations (2D-DEM) Sitharam (2000) suggested that due to change of the particle size and gradation, stress-strain behaviour of granular mass changes.
3. 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. In this chapter, the shear strength characteristics of granular and cohesive soils and the factors that control them will be discussed (Das, 1983). In 1910, Mohr presented a theory for rupture in materials.

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According to this theory, failure along a plane in a material occurs by a critical combination of normal and shear stresses, and not by normal or shear stress alone. Figure 2.1. If the normal and shear stresses on a plane in a soil mass are such that they plot as point A, shear failure will not occur along that plane. Shear failure along a plane will occur if the stresses plot as point B, which falls on the failure envelope. A state of stress plotting as point C cannot exist, since this falls above the failure envelope; shear failure would have occurred before this condition was reached (Das, 2005).

The functional relation between normal and shear stress on the failure plane can be given by

$$\tau_f = f(\sigma_f) \quad (2.1)$$

where τ_f is the shear stress at failure and σ_f is the normal stress on the failure plane. The failure envelope defined by Eq. 2.1 is a curved line, as shown in Figure 2.1.

In 1776, Coulomb defined the function $f(\sigma)$ as

$$\tau_f = c + \sigma_f \cdot \tan \phi \quad (2.2)$$

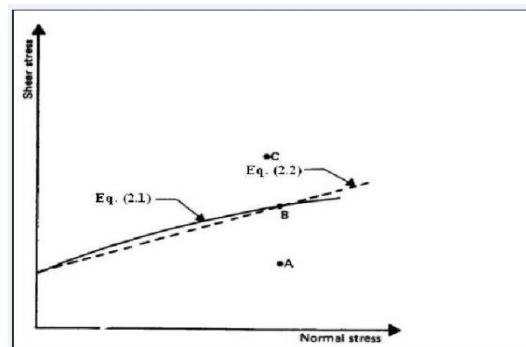


Figure 2.1 Mohr-Coulomb failure criteria (Das, 1983)

$$\tau_f = c + \sigma_f \cdot \tan \phi \quad (2.3)$$

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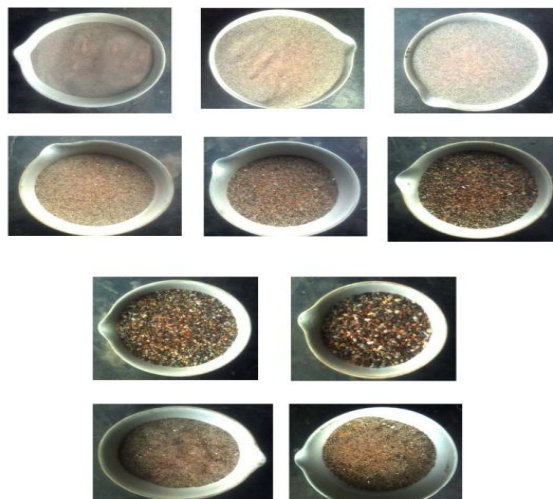
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III . TEXT IMPAINTING

The soil mixtures were obtained by blending clayey silt and sandy soil mechanically. The clayey silt soil used here was natural clay and the sand was available commercially. Clean sand with three different grain size distributions has been mixed with 15, 20, 30 and 40 % natural clay to form different sand-clay soil mixtures. The index properties of clay, sand and soil mixtures are given in Tables 1 to 3. The grain size distributions of several different types of mixture, obtained by sieve and hydrometer analyses, are shown in Figures 1 to 3. The results of Atterberg limits tests showed that the liquid limit and plastic limit of the soil mixture was low respectively (plastic index of clay is 12). According to USCS (Unified Soil Classification System), mixtures were classified as SC and CL. Based on AASHTO; the amount of fines for a reinforced soil retaining wall must be less than 15% with PI less than 6%, whereas the amount of fines for reinforced slopes must be less than 50% with PI less than 20. Obviously, the blended soil did not meet the requirements of AASHTO in the construction of reinforced retaining walls and reinforced slopes. Standard Proctor compaction tests were conducted to find out the maximum dry unit weight and optimum water content of the soil mixtures. Based on the test results, the maximum dry unit weight γ_d, \max and the optimum water content W_{opt} were obtained and are given in the Tables 4 to 6. The purpose of making this study was to observe the effects of fraction of fine and sand gradation on the Mohr-Coulomb failure envelope and the parameter of m . The compacted samples of different sand-clay mixtures were prepared at the optimum water content and placed into the shear box of direct shear device. The samples were then consolidated to the stress of 1600 KPa incrementally before they were unloaded to the stress at which they were sheared. The samples were sheared under effective normal stresses of 50, 100, 150, 200, 300 and 400 KPa at speed of 0.1 mm/min.

EFFECT OF PARTICLE SIZE ON THE SHEAR STRENGTH BEHAVIOUR OF SANDS



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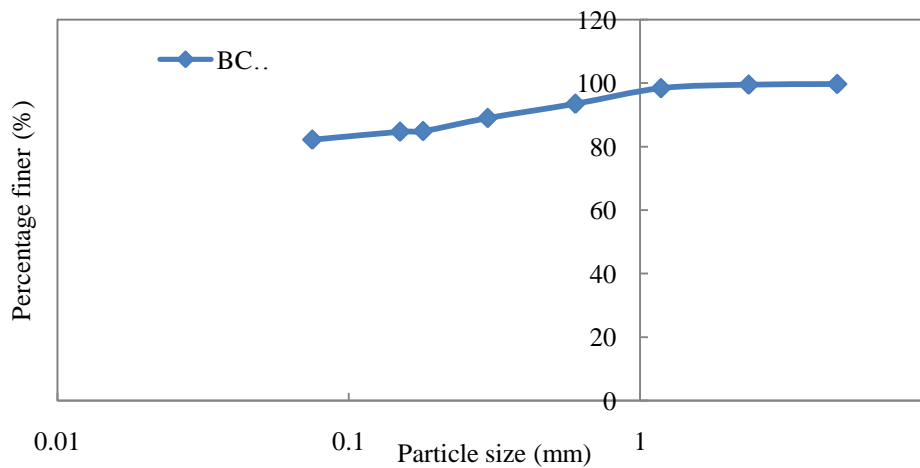
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IV. EXPERIMENTAL RESULTS

Table 4.1 Properties of BC soil and sand

Property		Clay	sand
Specific Gravity	G	2.71	2.39
Gravel (%)		0	0
Sand (%)		18	48
Silt (%)		65	47
Clay (%)		17	5
Consistency limits			
Liquid Limit	LL	26	0
Plastic Limit	PL	21	0
Plasticity Index	PI	5	0
Classification		clay	sand
OMC (%)		16	17.54
MDD (g/cc)		1.93	1.42

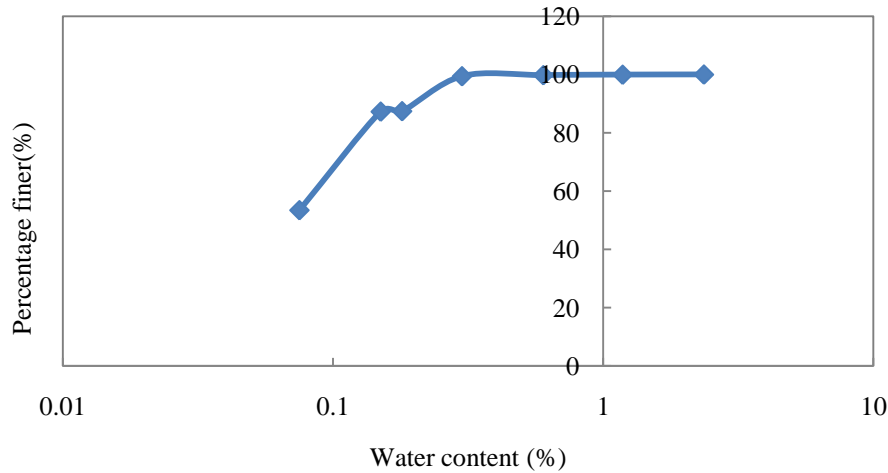


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1.2.1 Figure of Wet sieve analysis On BC soil



1.2.2 Figure of Dry sieve analysis of Sand

Triaxial test of black cotton soil (1DIV=0.365KG/CM²)

LOADS	COMPRESSION DIAL GAUGE READING	PROVING RING DIAL GAUGE READING	COMPRESSION OF SPECIMEN IN CM (0.2*0.001)	STRAIN (E) (4/7.60)	ORIGINAL AREA OF SPECIMEN (CM ²)	CORRECTED AREA OF SPECIMEN	LOAD (KG)	DEVIATED STRESS (KG/CM ²)	VERTICAL STRESS (KG/CM ²)
1	2	3	4	5	6	7	8	9	10
1	500	42	0.50	0.065	11.346	12.134	15.3	1.263	2.263
2	550	61	0.55	0.072	11.346	12.226	22.3	1.820	3.820
3	600	81	0.60	0.078	11.346	12.305	29.6	2.402	5.402

$$X = \frac{1}{2}(\sigma_1 + \sigma_3)$$

1=1.631
2=2.910
3=4.201

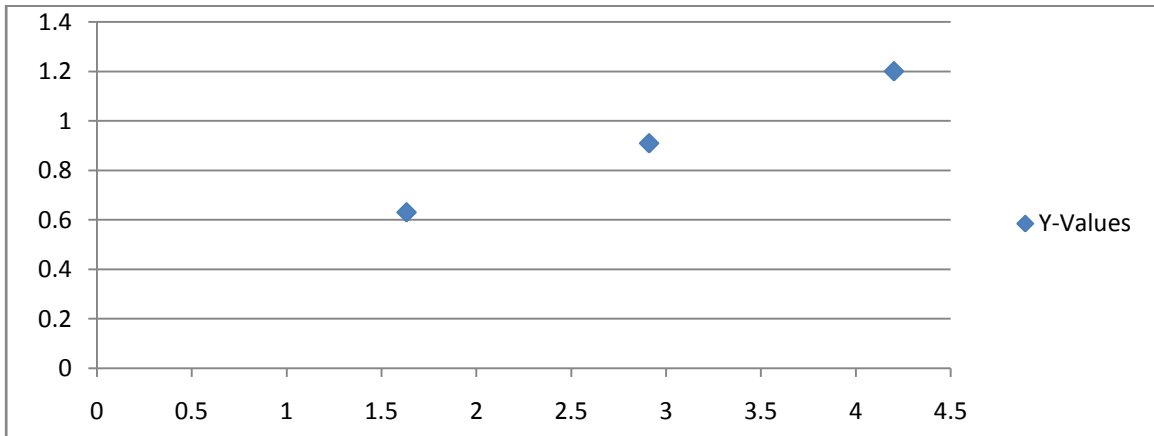
$$Y = \frac{1}{2}(\sigma_1 - \sigma_3)$$

1=0.631
2=0.910
3=1.201

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$C = 0.25 \text{ KG/CM}^2$

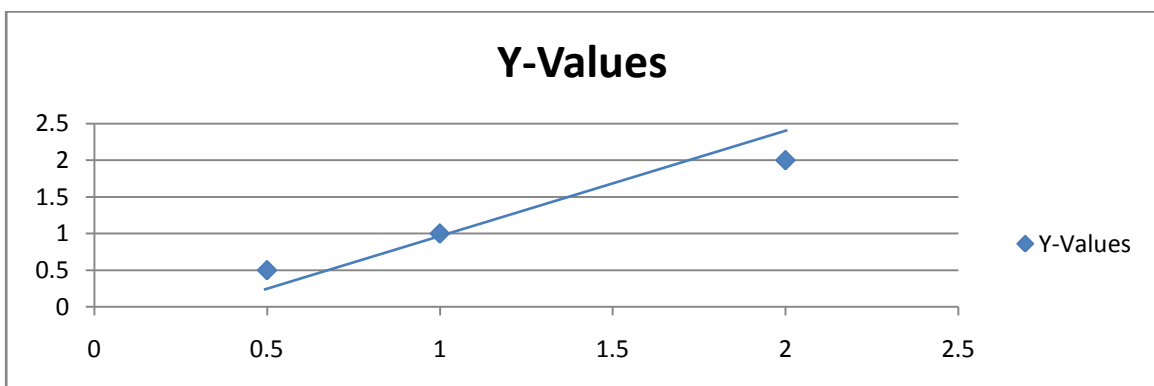
$\phi = 13^\circ$

The above is the test results of the tri axial shear stress and the c and ϕ are been obtained

DIRECT SHEAR TEST RESULTS OF SAND (1 DIVISION=0.364KG/CM)

SL.NO	DISPLACEMENT DAIL GUAGE READING	DISPLACEMENT (CM)	ORIGINAL AREA	CORRECTED AREA	PROVING RING	LOAD	HORIZONTAL STRESS
1	350	0.35	36	31.824	11	4.004	0.125
2	400	0.40	36	31.212	16	5.824	0.186
3	450	0.45	36	30.60	24	80736	0.285

GRAPH



$C = 0.075$

$\phi = 6$

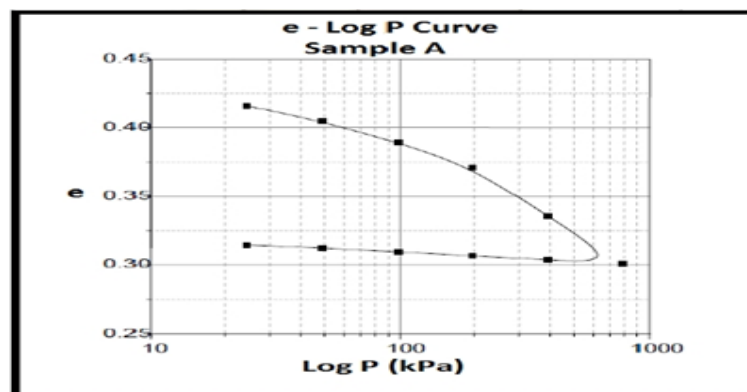
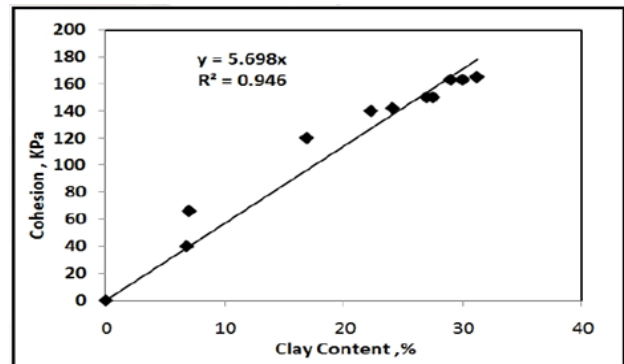
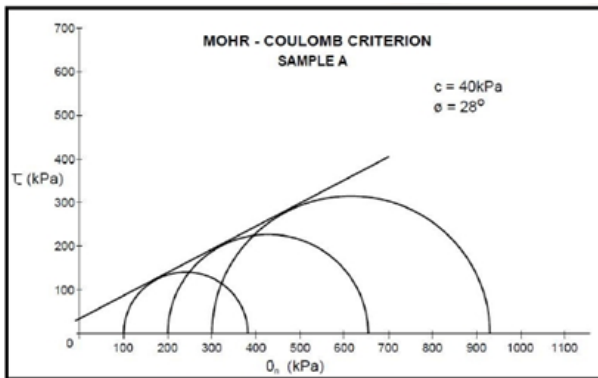
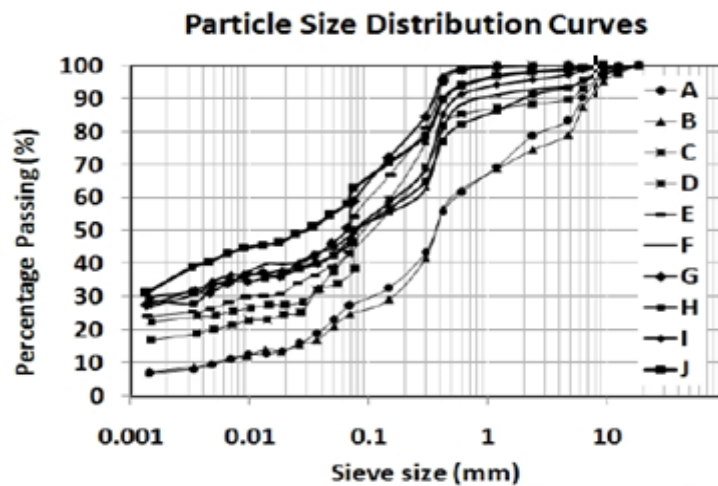
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V. RESULTS AND DISCUSSIONS

In order to establish the relationship between the clay Content and shear strength of sandy soil, the shear Strength parameters were plotted against the clay content. And the graph were used to determine the correlation. Fig 5 shows a graph of the clay content and the cohesion. Increases with the increase in the clay content as the more. As the more clay is been introduced in the sandy material. By this the cohesion increases and the shear strength also Increased.



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A graph of clay content and friction angle is shown fig 6 the graph indicates the inverse relation b/w Two paramenters the friction decreases with the Increase in the clay content (vice versa)

VI. CONCLUTION

The correlation coefficient from graphs indicates a strong correlation between the clay content and the strength and compressibility parameters. The influence depends on the amount of the clay in the sandy soil. Based on this current study using the clay content as observed in natural samples in the study area, the following conclusions have been drawn.

1. The plasticity index of the soils increase linearly with the amount of clay occurring in the soil. For areas with high clay content the soil becomes highly plastic that can sometimes lead to problems in foundation construction resulting in higher costs.
2. Clay content also increases the cohesion and decreases the friction angle. For such cases, the foundations can be designed as C - \emptyset soils using the appropriate bearing capacity equations. Assumptions that, the Voltaian soils are mostly sands and foundations designed as granular soils (\emptyset soils) can lead to catastrophic failures
3. In this way the series of experiments take place and in the first series we have 100% sand and in the second series we have 90% sand and 10% clay in the same way intermix sand and clay by which the voids in the clay gets occupied by the sand and the friction between them increases and the shear strength of the soil increases and the soil will be stabilised in this way his is the main criteria of my study

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