International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 12, December 2016
www.ijarse.com

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

COMPARISON OF SHEAR STRENGTH OF PLASTIC AND NON-PLASTIC FINES IN SOIL

Ms. Aarti Hiremath

Department of Civil Engineering, D.Y.Patil College of Engineering,
Pune. Savitribai Phule Pune University, Pune, (India)

ABSTRACT

The flow failures of the alluvial sandy ground cause catastrophic damage such as tilting of structures, floating up of structures, permanent later displacement of ground. In order to quantify the tendency of flow characteristics of sandy soils, a simple and reliable concept of steady state strength approach has been used. To evaluate the same, total ten tests are conducted with relative density varying as 30% and 45% and for same effective consolidation pressure of 120kPa. It was observed that with an increase in plastic and non-plastic fines the undrained shear strength of soil varies.

Keywords: Non-Plastic Fines, Threshold Fines Content, Undrained Shear Strength

I. INTRODUCTION

Past research has debated the effect of non-plastic silt content on liquefaction potential of sand. Many studies suggested that liquefaction resistance increases with increase in silt content (Seed et al.1983,1985; Tokimastu and Yoshimi 1983; Salgado et al. 2000; Polito and Martin 2001). However, other studies concluded that potential for contractive behavior is based on the deposition state either loose or dense (Lade and Yamamuro 1997; Kuerbis 1989; Zlatovic and Ishihara 1997). The focus of this study was to study the determination of equivalent granular state parameter and its effect on the residual shear strength of the soil. Systematic variation in fines content (0%, 5%, 15%, 25% and 30%) and densities (low and medium) were used to determine how each affects the liquefaction potential of sandy silt.

II. EXPERIMENTAL INVESTIGATION

The testing program has been decided based on literature survey & the objective of the proposed work. In the present study, triaxial equipment is used and tests are conducted on the sand with fines varying before and after limiting fines content. The present work includes instrumentation for various parameters in triaxial test & conduct test on clean sand and sand with fines of specific gradation.

III. EXPERIMENTAL SETUP

The testing was done in conventional triaxial apparatus. Fig 1. shows triaxial testing apparatus with mounted sample.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

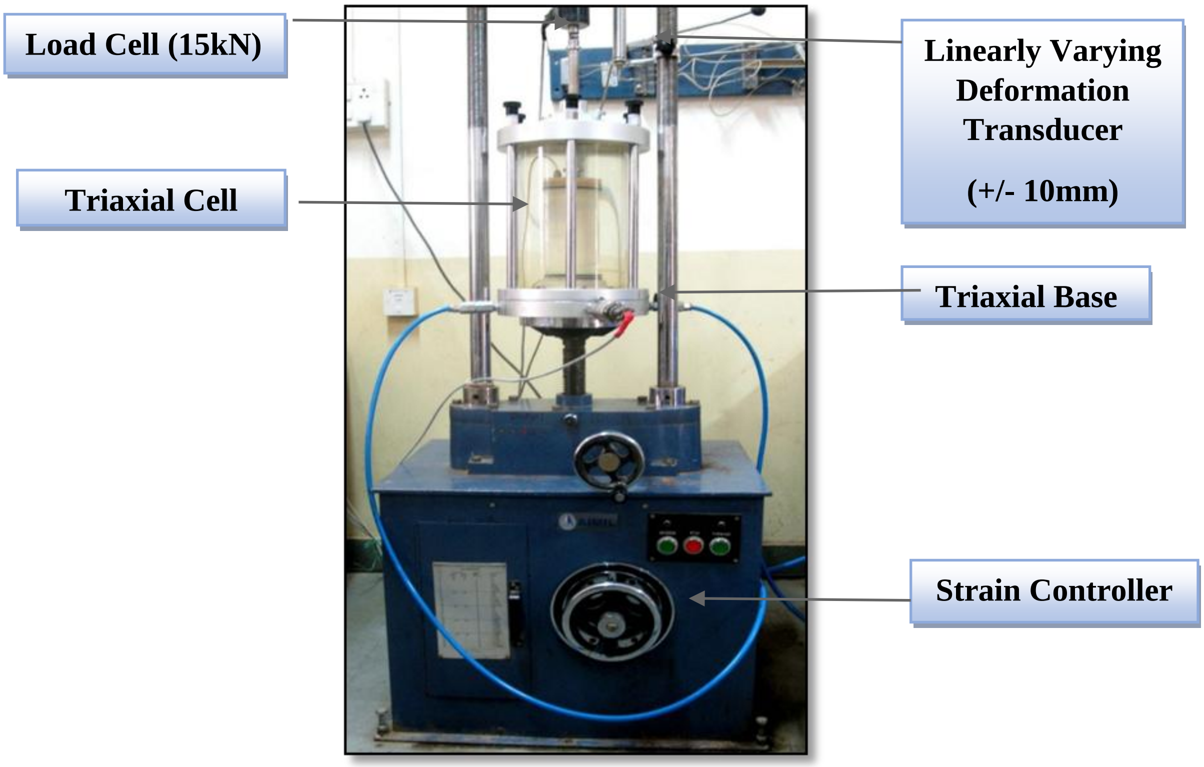
It consists of the following components;

i. **Triaxial base**

It consists of four valves out of which one is used to apply confining pressure, pore pressure transducer, back pressure and last valve is former used to apply vacuum then carbon-di-oxide.

ii. **Triaxial Cell**

The triaxial cell is used to enclose the reconstituted sample on the triaxial base and make it easy to simulate field conditions.



Photograph 1. Triaxial Assembly

iii. Load Cell

The load cell is used to apply the axial load to the specimen. It has a capacity of 15kN.

iv. Linearly varying deformation transducer (LVDT)

LVDT is mounted on the triaxial cell in such a way that it records the axial deformation of the soil specimen during the shearing stage.

v. Strain controller

Strain controller is set to the desired strain rate as per the requirement.

IV. INSTRUMENTATION

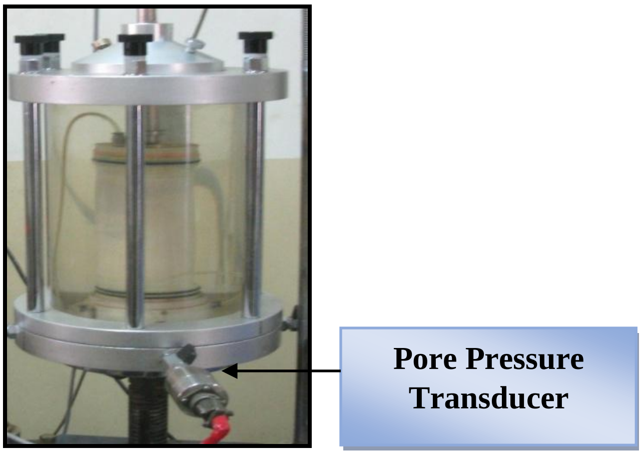
For any experimental work, instrumentation has become an integral part now-a-day. As it produces controlled observations, accurate results and minimize the errors. To study the initiation of liquefaction using this

International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 12, December 2016
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

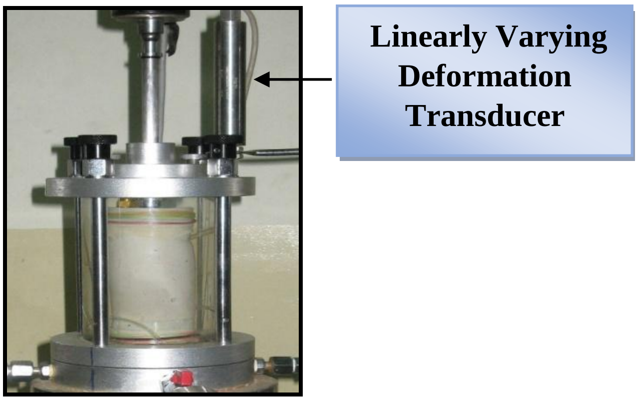
equipment one transducer, LVDT and load cell are used. The transducer to measure pore water pressure, LVDT to measure axial strain and load cell to apply axial load Capacity of pore pressure transducer is with least count 0.1 kPa, the capacity of LVDT is 10 mm with least count of 0.1 mm & capacity of the load cell is 15 kN.

Pore pressure transducer is connected to the triaxial base as shown in Photograph 2 .to measure the pore water pressure

LVDT is mounted on the triaxial cell as shown in Photograph 3. to measure axial deformation



Photograph 2. Pore Pressure Transducer



Photograph 3. Linearly Varying Deformation Transducer

Calibration of instruments & its compatibility with Data Acquisition system: Calibration is necessary for making instruments compatible with data acquisition system. Calibration involves the conversion of analog signals from Display units of instruments to the exact output of instruments and records for given time interval.

Calibration quantifies and improves the measurement performance of the instrument. Benefits of maintaining properly calibrated equipment include reduced measurement errors, consistency between measurements and the assurance of accurate measurements.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

V. SELECTION OF SOIL SAMPLE

Grain size distribution affects the behaviour of sand and silt mass during vibrations. Fine and uniform sand are believed to be more prone to liquefaction. Also, uniformly graded clean sands are more susceptible to liquefaction than well graded Sand Hence sand selected is uniform fine sand whose particles are discussed in subsequent section.

Clean sand.

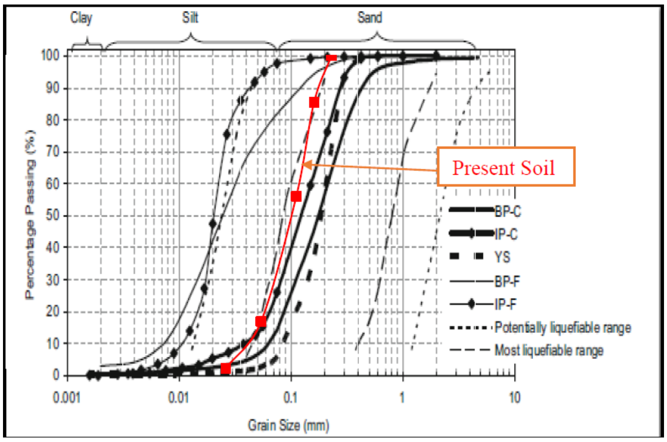


Figure 1. Grain size distribution curve for clean sand used in the proposed research work along with grain size distribution of soils susceptible to liquefaction proposed by Tsuchida (1970)

Clean silt

Grain size distribution or the percentage of various sizes of soil grains present in given dry soil sample is an important soil grain property. The sieve analysis procedure is confirming to IS 2720 Part 4 using a hydrometer. Grain size distribution curve of the silt used for testing is as shown in Figure 2.

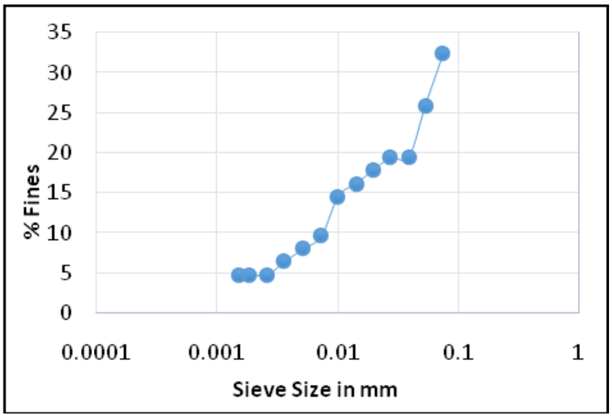


Fig 2. Grain Size Distribution curve for clean silt used in the Proposed Research Work

International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 12, December 2016
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Determination of Maximum density (γ_{max}) and Minimum density (γ_{min}) of sand and silt respectively

The maximum and minimum density have been computed by a procedure confirming to IS 2720 Part 14. Using these values, e_{max} and e_{min} are calculated

$RelativeDensity$ (%)= $((e_{max} - e)/(e_{max} - e_{min}))$ x100 ……………………………..……***eq (1.)***.

Where $e = G \times \gamma_w \gamma_d$ -1

Where γ_w= Density of water (9.81 kN/m^3)

Using these relations and basic equations in Soil Mechanics, the quantity of sand required to fill the known volume is calculated. Also, the quantity of water is calculated. And the required relative density is achieved. Table 1. Show the properties of clean sand and Table 2. Show properties of clean silt.

Properties Of Sand	Value	IS Code
γ_{max}	18.12 kN/m^3	IS : 2720 (Part 14)-1983
γ_{min}	15.34 kN/m^3	IS : 2720 (Part 14)-1983
G	2.67	IS : 2720 (Part 3/sec 1)-1980
e_{max}	0.8093	IS : 2720 (Part 14)-1983
e_{min}	0.5725	IS : 2720 (Part 14)-1983
D_{50}	0.28 mm	IS : 2720 (Part 4)-1985
C_u	2.56	IS : 2720 (Part 4)-1985
C_c	1	IS : 2720 (Part 4)-1985

Table 1.Properties of clean sand

Properties Of Sand	Value	IS Code
γ_{max}	15.17 kN/m^3	IS : 2720 (Part 14)-1983
γ_{min}	11.91 kN/m^3	IS : 2720 (Part 14)-1983
G	2.67	IS : 2720 (Part 3/sec 1)-1980
e_{max}	1.1070	IS : 2720 (Part 14)-1983
e_{min}	0.6547	IS : 2720 (Part 14)-1983
D_{50}	0.02mm	IS : 2720 (Part 4)-1985
C_u	1.6	IS : 2720 (Part 4)-1985
C_c	0.056	IS : 2720 (Part 4)-1985
LFC	27.07	H. K Dash & T.G.Sitharam

Table 2. Properties of silt

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

VI. TESTING PROGRAM

The test was planned with moist tamping method for size 75mm x 150 mm and fines varying before and after 'Threshold Fines Content'. The detailed testing program is given in Table 3.

VII. TESTING PROCEDURE

Initially, a weighed amount of soil is determined from relative density , then it is mixed with five percent of water. The split mould along with a membrane is placed on the triaxial base. The mould is filled with an approximately same amount of soil with fixed amount of blows. After the mould is completely filled with soil, its end is made water tight using O-rings. After the specimen is prepared it is subjected to vacuum to avoid the disturbances during further process. Now, the spilt mould is removed and the density of the specimen is ensured by measuring the height of the specimen. The triaxial cell is placed over the specimen. The cell is completely filled with water by means of a motor and if there is no leakage detected than carbon-di-oxide is supplied to accelerate the saturation rate of the specimen. By simultaneous application of confining pressure and back pressure, the specimen is saturated till 100%. The 100% saturation is measured by using Skempton's Pore pressure parameter (B value) defined as ratio of change in confining pressure to the change in the pore pressure. The B value greater than 0.96 indicated the specimen is 100% saturated.

The specimen is isotropically consolidated at an effective stress of 120kPa. Now, the specimen is sheared at a constant rate of 0.01 %/min, this is a minimum possible strain at which there is a uniform dissipation of pore water pressure. The LVDT is mounted on the cell to measure the deformation during shear. The readings are recorded till a visual failure pattern of the specimen.

Sr. No.	Name of Test	Fines Content	Relative Density	Voids Ratio	Effective Stress
1	M-00	0%	30%	0.7382	120 kPa
2			45 %	0.7072	120 kPa
3	M-05	5%	30%	0.6769	120 kPa
4			45 %	0.6461	120 kPa
5	M-15	15%	30%	0.6141	120 kPa
6			45 %	0.5761	120 kPa
7	M-25	25%	30%	0.5951	120 kPa
8			45 %	0.5569	120 kPa
9	M-30	30%	30%	0.6389	120 kPa
10			45 %	0.5987	120 kPa

Table 3. Testing Program

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

VIII. RESULTS AND DISCUSSION

Determination of undrained shear strength of the sand with varying fines content.

The concept given by Castro and Polous,1985 (Figure 3.) was used to determine the undrained shear strength of the silty sand.

$S_{su} = q_s \cos \Phi_s$ ………………………………… *eq (2.)*

$\sin \Phi_s = q_s /(\sigma'_{3s} + q_s)$………………………......*eq (3.)*

$q_s =(\sigma'_{1s} - \sigma'_{3s})/2$………………………….……*eq (4.)*

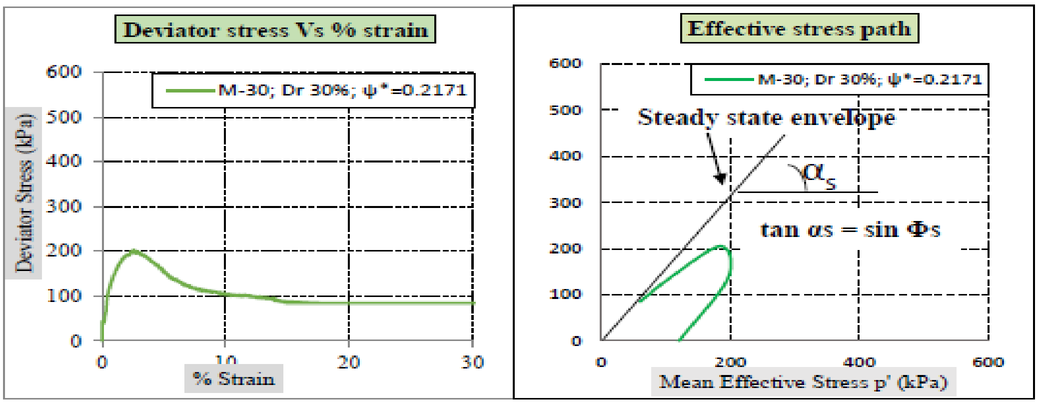


Figure 3. Determination of internal angle of friction (Φ_s)

Fines content (%)	α_s	φ_s	Ψ*	Ssu (kPa)
0	41	60.37	0.02	123.11
5	42	64.21	0.057	40.78
15	43	68.83	0.121	28.89
25	44	74.94	0.367	5.59
30	43	71.61	0.23	13.38

Table 4. Undrained shear strength of sand silt mixture for RD =30%

Fines content (%)	α_s	φ_s	Ψ*	Ssu (kPa)
0	41	57.07	0.02	138.7
5	42	60.37	0.057	55.61
15	43	64.21	0. 058	42.85
25	44	68.83	0.09	21.66
30	43	66.39	0.052	42.67

Table 5. Undrained shear strength of sand silt mixture for RD 45%

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

IX. COMPARISON OF RESULTS WITH PREVIOUS RESEARCH WORK

9.1 Undrained shear strength and global voids ratio

The fines content play an important role in the determination of equivalent granular state parameter [Md. Mizanur Rahman . S. R. Lo, Md. Abdul Lahil Baki. (2011)].The residual shear strength is investigated in the present research work by comparing the results obtained from the present study with previous research work [Noureddine Della et. al. Acta Polytechnica Hungarica(2010)], as shown in Fig 4 and Fig 5.

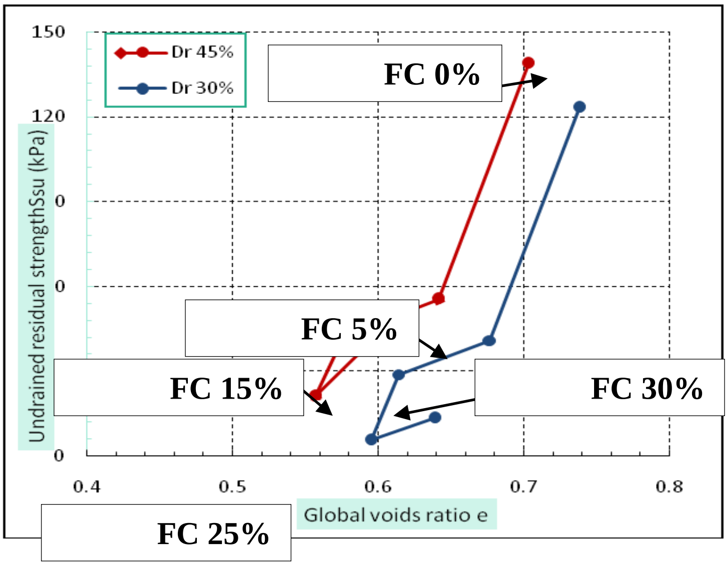


Fig 4. Undrained Residual Strength Vs.Global voids ratio

Fig 4 shows that with an increase in fines content the undrained shear strength decreases till threshold fines content later on it increases. Whereas, in Fig 5 it was observed that with an increase in fines content goes on reducing irrespective of the threshold fines content as shown in Fig 5. In present work, the role of non-plastic fines was considered and in previous work, the role of plastic fines was considered.

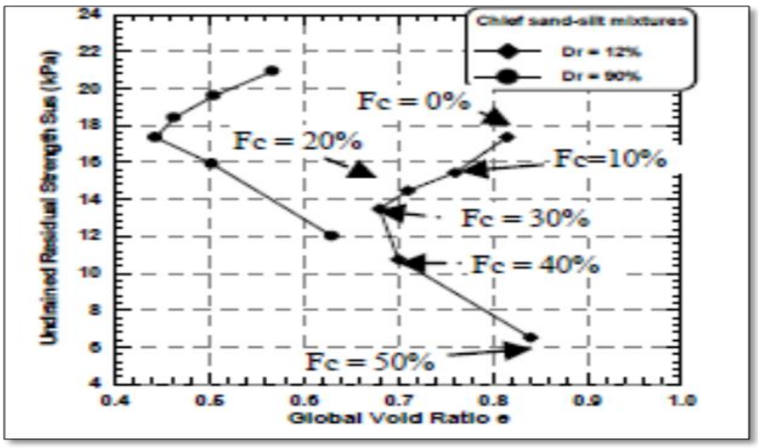


Fig 5.Undrained Residual Strength Vs.Global voids ratio[Ref:Noureddine Della et. al. Acta Polytechnica Hungarica(2010)]

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

9.2 Undrained shear strength and relative density

As relative density increases the natural voids ratio decreases and due to close packing of the soil mixture, the undrained shear strength increases. Fig 6 shows that with an increase in relative density from 30% to 45% the shear strength increases for all fines content. The residual shear strength of clean sand is maximum as compared to sand with varying fines content. These observations as in good correlation with the previous work done by Noureddine Della et. al. Acta Polytechnica Hungarica(2010), Fig 7

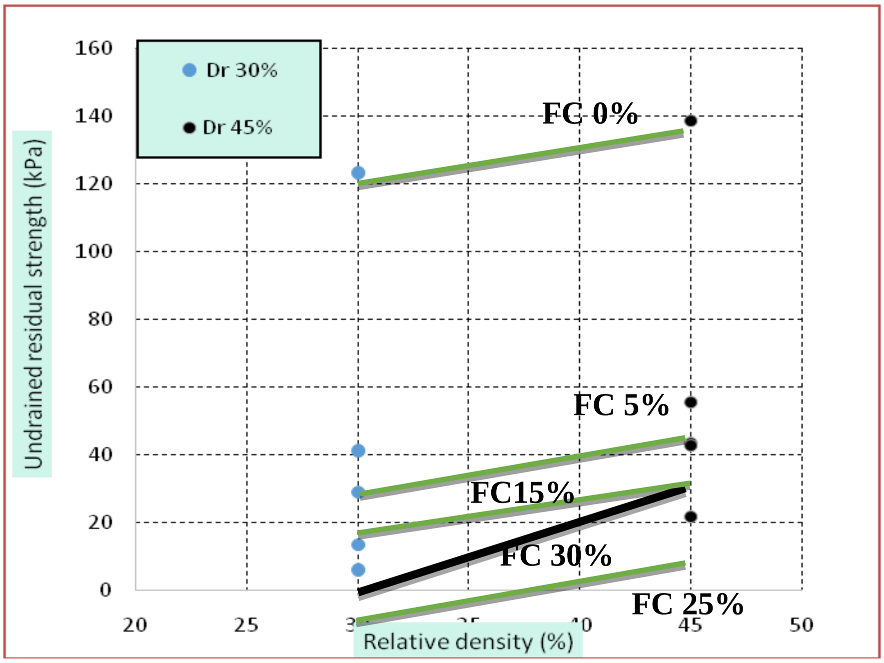


Fig 5.Undrained Residual Strength Vs.Relative Density

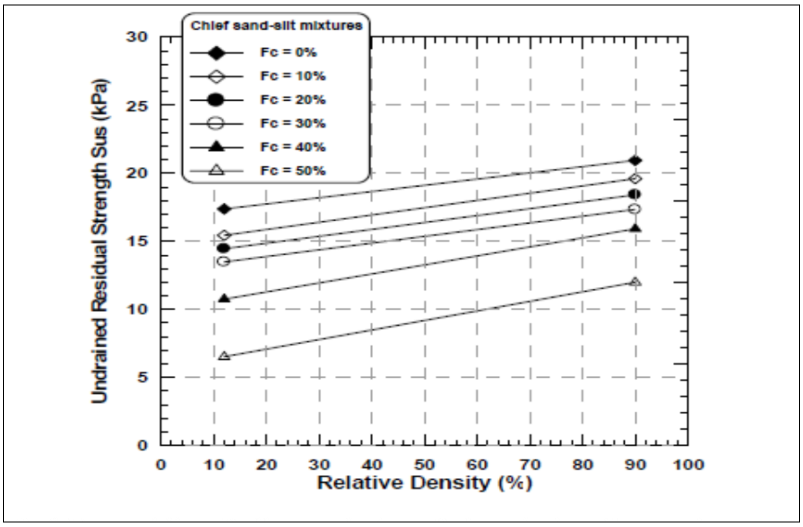


Fig 6. Undrained Residual Strength Vs. Relative Density [[Ref:Noureddine Della et. al. Acta Polytechnica Hungarica(2010)]

X. CONCLUSIONS

Based on the experimental work carried out in the present study, the following conclusions are drawn:

1. The undrained residual strength reduces with increase in fines content (non-plastic), global voids ratio and equivalent granular voids ratio up to 25% fines content. Beyond that it reduces with increase in fines content, global voids ratio and equivalent granular voids ratio whereas the undrained residual strength reduces with increase in plastic fines content
2. The undrained residual strength increases with increase in relative density.
3. The strength of silty sand up to 25% non-plastic fines content is less than that of clean sand. It means that the strength of soil is weakened with an increase in fines content upto 25%. Whereas the strength of silty sand with plastic fines content increases with increase in fines content without any threshold fines content.

REFERENCES

[1] Anuchit Uchaipichat, Cheevin Limsiri (2012) Static Liquefaction Phenomenon in cemented Loose Sand . *Department of Civil Engineering, Vongchavaltitkul University, Nakhon Ratchasima, Thailand . ISSN 1450 – 216 X Vol 77 No1* .120-133

[2] Carl D.Loiggio,, Jerry A. Yamamuro, and Poul V.Lade. (2009) Effect Of Fines Content On Voids Ration , Compressibility and Static Liquefaction of Silty Sand. *Geotechnic and Engineering Vol 1(1) 1-15*

[3] N.Della, A. Arab, M. Belkhatir (2011) Effect of confining pressure and depositional method on undrained shearing response of medium dense sand. *Journal of Iberian Geology 37(1*) 37-44

[4] P. V. Lade, J. A. Yamamuro, "Effects of Non-Plastic Fines on Static Liquefaction of Sands", 1997,*Canadian Geotechnical Journal, Vol. 34,*918-928

[5] Lo, S. R., Rahman, M. M., and Bobei, D. C. "Limited flow behaviour of sand with fines under monotonic and cyclic loading." *Geomechanics and Geoengineering, 2010: 5(1), 15-25.*

[6] Rahman .M.M ,Lo S.R The prediction of equivalent granular steady state line of loose sand with fines. *Geomechanics and Geoengineering* 2009: 3(3):179-190

[7] D.C.Bobie, S.R. lo, C.T.Ganenadran, and M.M. Rahman. (2009) Modified State parameter For Characterizing Static liquefaction of Sand With Fines. *Canadian Geotechnical .J.46: 281-295*