International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 5 Issue 11|| November 2016 || PP. 68-72

Experimental Approach for Assessment of Liquefaction in Fine Sand and Silty Sand

Meraj Ahmad Khan[1], Dr. M.Z. Khan[2], M.B. Khan[3]
[1]*Resarch Scholar,Civil Engg Department Integral University Lucknow, UP, India*
[2]*Professor, Civil Engg Department,IET Lucknow, UP, India*
[3]*Asst.Professor, Civil Engg Department Integral University Lucknow, UP, India*

Abstract: *The investigation is focused on the comparative study of the silty sand and fine sand soil in respect of the fine contents regarding liquefaction characteristics. The strategy is planned to obtain the locally available silty and fine sand in sufficient quantities. Thereafter these two were sieved to segregate the sand portion and fine contents so as to prepare the reconstituted samples of known percentage of fines in silty sand group and clean sand group, besides, these soil samples were again put to sieve analysis to estimate the grading of individual soil samples and specimen samples are prepared. The results of specimen samples suggested that as the percentage of fines increases then chance of liquefaction decreases.*

I. Introduction

Characteristics of the soil grains like distribution of shapes, sizes, shape, composition etc influence the susceptibility of a soil to liquefy Seed 1979 [1]. Liquefaction resistance of a soil deposit increases with depth as overburden pressure increases. That is why soil deposits deeper than about 15m are rarely found to have liquefied Krinitzky et al.1993[2]. While sands or silts are most commonly observed to liquefy, gravelly soils have also been known to have liquefied. Rounded soil particles of uniform size are mostly susceptible to liquefaction Poulus et al.1985 [3]. Well graded soils, due to their stable inter-locking configuration, are less prone to liquefaction. Natural silty sands tend to be deposited in a looser state, and hence are more likely to display contractive shear behavior, than clean sands. Both clean sands and sands containing fines have been shown to be liquefiable in the field (Mogami and Kubo (1953[4]); Robertson and Campenella (1985) [5]; and Holzer et al.(1989) [6] and in the laboratory (Lee and Seed (1967a) [7]; Chang et al. (1982) [8]; and Koester(1994) [9]. Additionally, non-plastic silts, most notably mine tailings, have also been found to be susceptible to liquefaction (Dobry and Alvarez (1967) [10]; Okusa et al. (1980) [11]; and Garga and McKay (1984) [12]. A review of the literature, however, shows conflicting evidence as to the effect which fines have on the liquefaction resistance or cyclic strength of sand. The main factors that are reviewed here are the effects of non-plastic fines content and the effects of plastic fines content and plasticity.

II. General

The investigation is focused on the comparative study of the silty sand and fine sand soil in respect of the fine contents regarding liquefaction characteristics. The methodology is planned in such a way so as to obtain the soil samples silty sand and fine sand with known percentages of the fine contents. In general the fine sand or clean sand are those sandy soils which contains less than 5 percent of the fines, whereas the silty sand are those sandy soils which contain fines ranging from 12 percent to upto 50 percent. However, the sandy soil containing fines in the range of 5 to 12 percent are occasionally termed as the mixture of these two i.e. the boundary condition of silty and clean sand. Accordingly the reconstituted soil samples required to be made out of the sand and the fines. It was ensured that the fines be of the non plastic characteristics. The strategy is planned to obtain the locally available silty and fine sand in sufficient quantities. Thereafter these two were sieved to segregate the sand portion and fine contents so as to prepare the reconstituted samples of known percentage of fines in silty sand group and clean sand group, besides, these soil samples were again put to sieve analysis to estimate the grading of individual soil samples, as detailed out in the following paragraphs. Thereafter, these sample soil was used to prepare the test specimen by putting it cylindrical tubes of known diameter and height, each corresponding to loose state, medium state and dense state under pre determined relative densities. All these samples were filled with water so as to properly saturate them. Thereafter, these samples were consolidated under the total confining pressure of 50 kPa, 100 kPa and 150 kPa. After ensuring the proper consolidation, each of the soil samples were then put to test for undrained triaxial test at a constant strain rate of 0.50% upto the maximum axial strain of 20%. These test results and the index properties of the reconstituted sample soil, is to be analyzed to arrive at the necessary inferences and to conclude important findings.

III. Properties of Material used for Sample Preparation

Sand and Silt are separated out from the bulk mass of sandy soil. The separated materials viz. Sand and silt, as well as the reconstituted samples out of the Sand and Silt in varying proportions, were also subjected to their Index Properties. The details of the results are being presented in

Table - 1.

SN	Material	%age Fines (f_c)	G	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	C_u	C_c	e_{min}	e_{max}
1	Sand	1%	2.675	0.260	0.380	0.610	0.710	2.731	0.782	0.522	0.864
2		3%	2.678	0.200	0.360	0.600	0.700	3.500	0.926	0.511	0.847
3		5%	2.682	0.160	0.340	0.580	0.680	4.250	1.063	0.502	0.832
4	Silty Sand	15%	2.683	0.070	0.270	0.500	0.600	8.571	1.736	0.451	0.758
5		30%	2.685	0.050	0.150	0.300	0.400	8.000	1.125	0.412	0.704
6		45%	2.686	0.018	0.070	0.200	0.300	16.667	0.907	0.634	0.720
7		50%	2.688	0.019	0.075	0.160	0.280	14.737	1.057	0.600	0.966
8	Silt	100%	2.689	0.060	0.200	0.500	0.600	10.000	1.111	0.713	1.045

IV. Sample Preparation: 4.75MM, 2.00MM, 425µ, 75µ

The sufficient quantity of Silty Sand was procured. The Silty Sand was subjected to a set of sieve consisting of 4.75mm, 2.00mm, 425µ and 75µ attached with a collecting Pan at the bottom. The portion of Silty Sand passing through 75µ sieve size was separated out and stored in a container P-1, being the Silt. The portion of material passing through 4.75mm but retained on 75µ sieve size was separated out sampled as P-2, being the Fine Sand, while that retained on 425µ sieve size was separated out and sampled as P-3, being the Medium Sand and that retained on 2.00mm sieve size also separated out and sampled as P-4, being the Coarse sand. The portion of material retained on 4.75mm sieve was altogether rejected out. The sample soil separated out as P-1, P-2, P-3 and P-4 are subjected to the sieve analysis corresponding to their boundary sizes and with some more intermediate sieve sizes. The results of sieve analysis and graphical presentation are available as **TABLE-2, TABLE-3, TABLE-4** and **TABLE-5** for the Silt, Fine Sand, Medium Sand and Coarse Sand respectively.

P-1 Sample Mass of Sample 2.0kg TABLE-2						
S.No	IS Sieve No	Particle Size(mm)	Mass of Soil Retained(g)	Percentage Retained	Cumulative percentage Retained	Percentage finer
1	75µ	0.075	0	0	0	100
2	50µ	0.050	110	5.5	5.5	94.5
3	20µ	0.020	212	10.6	16.1	83.9
4	10µ	0.010	1014	50.7	66.8	33.2
5	2µ	0.002	656	32.8	99.6	0.4
6	pan	0	0	0	0	0

P-2 Sample Mass of Sample 2.0kg TABLE-3						
S.No	**IS Sieve No**	**Particle Size(mm)**	**Mass of Soil Retained(g)**	**Percentage Retained**	**Cumulative percentage Retained**	**Percentage finer**
1	425µ	0.425	0	0	0	100
2	212µ	0.212	410	20.5	20.5	79.5
3	150µ	0.150	1072	53.6	74.1	25.9
4	75µ	0.075	518	25.9	100	0

P-3 Sample Mass of Sample 2.0kg TABLE-4						
S.No	**IS Sieve No**	**Particle Size(mm)**	**Mass of Soil Retained(g)**	**Percentage Retained**	**Cumulative percentage Retained**	**Percentage finer**
1	2.00	2.00	0	0	0	**100**
2	1.00	1.00	510	25.5	25.5	**74.5**
3	600µ	0.600	820	41	66.5	**33.5**
4	425µ	0.425	670	33.5	100	0

P-4 Sample Mass of Sample 2.0kg TABLE-5						
S.No	**IS Sieve No**	**Particle Size(mm)**	**Mass of Soil Retained(g)**	**Percentage Retained**	**Cumulative percentage Retained**	**Percentage finer**
1	4.75	4.75	0	0	0	100
2	2.40	2.40	512	25.6	25.6	74.4
3	2.25	2.250	810	40.5	66.1	33.9
4	2.00	2.00	678	33.90	100	0

Accordingly these four sample soils are used as primary source for preparation of reconstituted test samples in different proportions of sand and silt mixtures as follows:

SILTY SAND: As per IS Classification, the silty sand is the sand containing > 12% fines i.e. Silt. Accordingly, three sets of samples of Sand are reconstituted. Each of these set is containing 15%, 30% and 45% portion as fines i.e. silt. These are expressed as follows:

85% Sand with 15% Silt	Nos. of samples - 3	(S-41, S-42 and S-43)
70% Sand with 30% Silt	Nos. of samples - 3	(S-51, S-52 and S-53)
55% Sand with 45% Silt	Nos. of samples - 3	(S-61, S-62 and S-63)
		Total samples = 9

CLEAN SAND: As per IS classification, Clean sand is the sand containing < 5% of fines i.e. silt. Accordingly, three sets of samples are prepared each consisting of Sand each with 1%, 3% and 5% portion as fines, i.e. silt. These are expressed as follows:

99% Sand with 1% Silt	Nos. of samples - 3	(S-11, S-12 and S-13)
97% Sand with 3% Silt	Nos. of samples - 3	(S-21, S-22 and S-23)
95% Sand with 5% Silt	Nos. of samples - 3	(S-31, S-32 and S-33)
		Total samples = 9

V. Specimen Sample Preparation

The samples were then placed in the samplers having 50 mm diameter with a length as 75mm in such a way that these were prepared using three layers. All of these samples prepared by low compaction to achieve the loose, medium and dense state corresponding to 20%, 55% and 90% relative density. As each of the layers is compacted, the compaction energy is also transmitted to subsequent lower layers. Therefore the compaction energy given to any layer at the is also transmitted to lower layers which further densities the subsequent lower layers and this process would continue for each of the layer, leading to non homogeneous compactness of layers. Hence, as usual, this unwanted phenomenon is avoided by giving the compaction energy at the increasing relative density levels. As such, the samples for relative density of 20%, 55% and 90% were compacted in each of the three layers with the relative densities of 19%, 20% and 21% for achieving the 20% relative density, 54%, 55% and 56% for achieving the 55% relative density and 89%, 90% and 91% for achieving the 90% relative density. All of the samples so reconstituted in this way were capped and sealed. Thereafter the water was introduced into the specimen sample, through its bottom face and passing through it to reach the top face. The flowing water was then collected in a separate beaker, out of the top face through a drain pipe, till the quantity of collected water becomes equal to the volume of voids in the specimen sample. Thus, the saturated soil samples were ready for further tests. These specimen samples were then subjected to consolidation by using three different confining pressures ranging from 50 kPa, 100 kPa and 150 kPa. The confining pressure and the back pressure was manually adjusted so that the effective consolidation pressure remains to the given value for the respective set of samples.

VI. Analysis of Results

The specimen samples were tested and evaluated for various properties like, grain size distribution, void ratios, maximum void ratio, minimum void ratio and the various particle sizes ranging from D_{10}, D_{30}, D_{50} and D_{60}. Graphic presentation was developed for various relations based on these. And the following relationships are expressed:

(i) Void ratio versus effective diameter and the corresponding percentage of fine contents at the relative densities of 20%, 55% and 90% for each of the three levels of confining pressures.

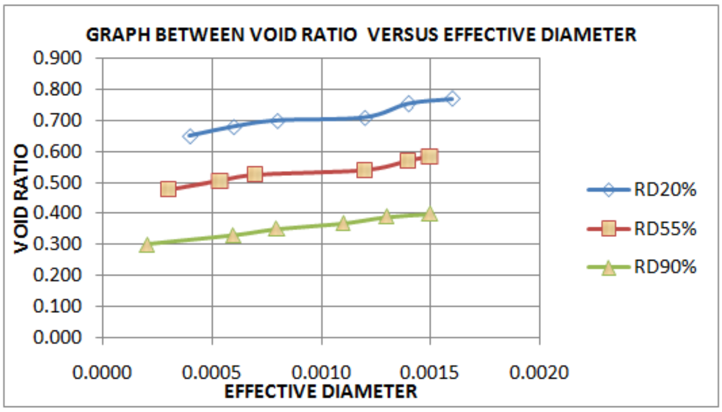

Fig 1

A graph plotted between Void ratio and Effective diameter its shows that if percentage of fines increases particle sizes decreases and void ratio also decrease. It clearly shows that interlocking of particle increases for different relative densities. If interlocking of particle is increases than Liquefaction resistance increases. In this graphical representation a linear relation shows between void ratio and effective diameter.

(ii) Void ratio versus average diameter and the corresponding percentage of fine contents at the relative densities of 20%, 55% and 90% for each of the three levels of confining pressures.

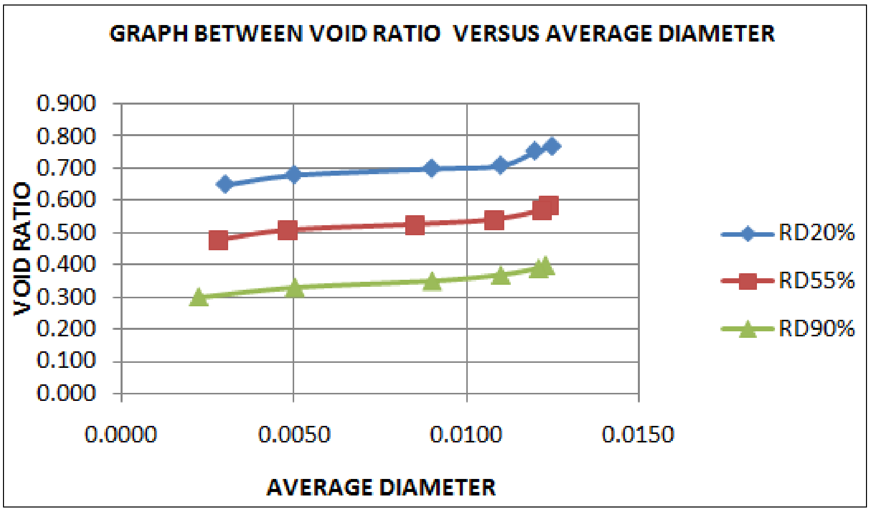

Fig2

A graph plotted between Void ratio and Average diameter clearly shows that if percentage of fines increases particle sizes decreases and void ratio also decreases. Void ratio in average diameter is more in comparison to effective diameter. So it shows that if size of particle increases than chance of liquefaction is more and a relation between void ratio and average diameter. If void ratio is decreases then pore water pressure increases and chance of effective pressure becomes to zero and soil loses its shear strength. Liquefaction resistance will be zero.

(iii) Void ratio versus Coefficient of Uniformity and the corresponding percentage of fine contents at the relative densities of 20%, 55% and 90% for each of the three levels of confining pressures.

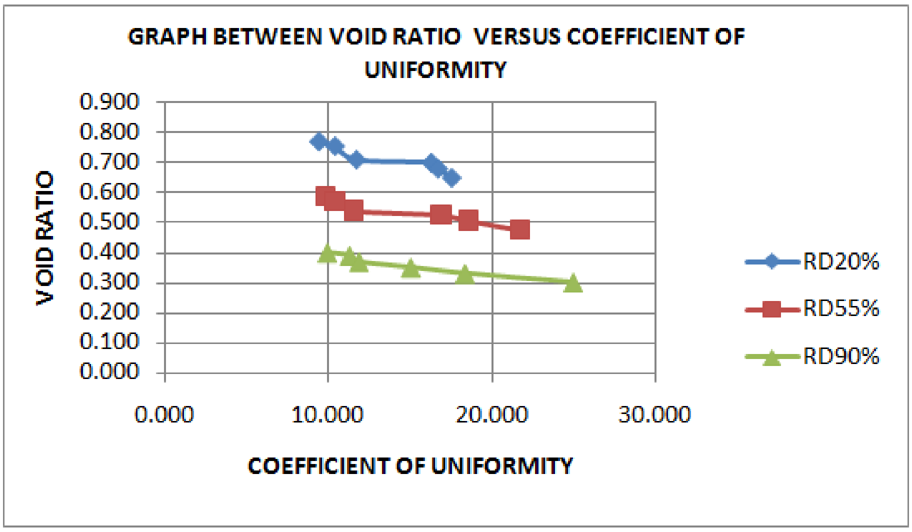

Fig3

A graph plotted between Void ratio and Coefficient of Uniformity of clearly shows that if percentage of fines increases Coefficient of Uniformity decreases in clean sand but in silty sand sharply decreases. Graph also shows that coefficient of uniformity decreases if void ratio decreases. Its means percentage of fines has a relation between void ratio. Void ratio also has a linear relation with coefficient of uniformity. As relative density decreases and coefficient of uniformity increases. Coefficient of uniformity shows that grading of soil particle so it shows that if coefficient of uniformity is less then chance of liquefaction is less.

(iv) Void ratio versus Coefficient of Curvature and the corresponding percentage of fine contents at the relative densities of 20%, 55% and 90% for each of the three levels of confining pressures.

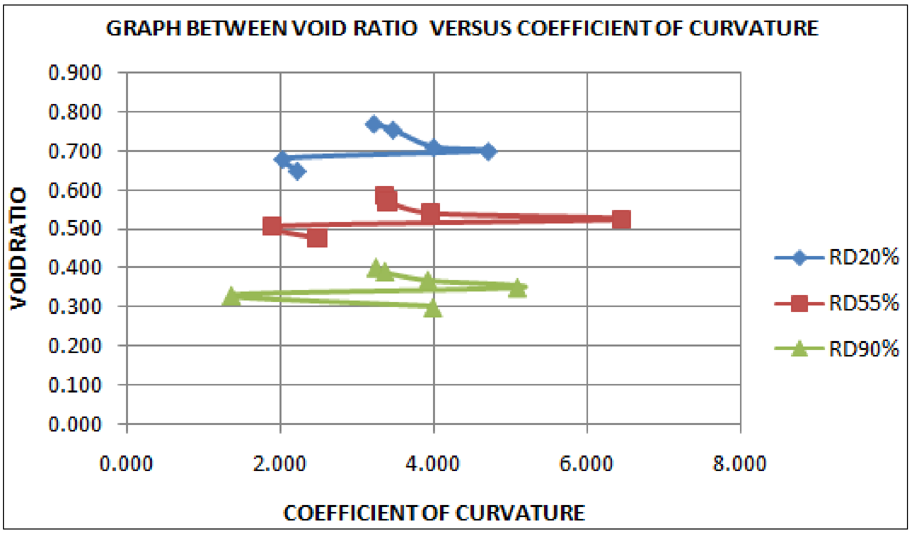

Fig4

A graph plotted between Void ratio and Coefficient of curvature in this graph percentage of fines increases then coefficient of curvature is increases if percentage of fine increases after15% coefficient of curvature is decreases it is zone of silty sand. Graph also show that void ratio increases then coefficient curvature increases at 15% of

VII. Conclusion

Index properties of soil particles connected with liquefaction shows that percentage of fines increases then void ratio decreases. Graphs plotted between Void ratio verses Effective diameter, Average Diameter, Coefficient of curvature, Coefficient of uniformity shows that percentage of fines increases then liquefaction decreases. Chance of Liquefaction is more in fine sand with respect of silty sand.

References

[1]. Seed, H. B. 1979. "Soil Liquefaction and Cyclic Mobility Evaluation for Level Ground During Earthquake,"Journal of Geotechnical Engineering Division, ASCE, Vol 105, No. GT2, pp 201-225

[2]. Krinitzky et al.1993.

[3]. Poulos, S.J., Castro, G., and France, W., 1985. Liquefaction evaluation procedure, J. Geotechnical Engineering Div., ASCE, Vol. 111, No.6, pp. 772-792

[4]. 4 Mogami, T., and Kubo, K., (1953). "The Behaviour Of Soil During Vibration"*Proceedings of the Third International Conference on Soil Mechanics and FoundationEngineering*, Vol. 1, pp. 152-153.

[5]. Robertson, P.K., and Campanella, R.G., (1985). "Liquefaction Potential Of Sands UsingCPT" *Journal of Geotechnical Engineering*, ASCE, Vol. 111(3), pp. 384-403.Vol. 240

[6]. 6. Holzer, T. L., Youd, T. L., and Hanks, T. C. (1989). "Dynamics of Liquefaction Duringthe 1987 Superstition Hills, California, Earthquake" *Science*, Vol. 244, April 7,pp. 56-59.

[7]. Lee, K.L., and Seed, H.B., (1967a). "Cyclic Stress Conditions Causing Liquefaction Ofsand" *Journal of the Soil Mechanics and Foundations Division*, ASCE, Vol. 93, SM1, pp.47-70.

[8]. Chang, N.Y., Yeh, S.T., and Kaufman, L.P. (1982) "Liquefaction Potential Of Clean AndSilty Sands" *Proceedings of the 3rd International Earthquake Microzonation.*

[9]. Koester, J.P. (1994) "The Influence Of Fine Type And Content On Cyclic Strength"Ground Failures Under Seismic Conditions, Geotechnical Special Publication No. 44,ASCE, pp. 17-33.

[10]. Dobry, R., and Alvarez, L., (1967). "Seismic Failures Of Chilean Tailings Dams" *Journalof the Soil Mechanics and Foundations Division*, ASCE, Vol. 93(6), pp. 237-260.

[11]. Okusa, S., Anma, S., and Maikuma, H. (1980). "Liquefaction Of Mine Tailings In The1978 Izu-Oshima-Kinkai Earthquake, Central Japan" *Proceedings. of the Seventh WorldConference on Earthquake Engineering*, Istanbul, Turkey, Vol. 3, pp. 89-96.

[12]. Garga, V., and McKay, L., (1984). "Cyclic Triaxial Strength Of Mines Tailings" *Journalof Geotechnical Engineering*, ASCE, Vol. 110(8), pp.1091- 1105.