INFLUENCE OF PARTICLE SIZE GRADATION AND RELATIVE DENSITY ON SHEAR PARAMETERS FOR COHESIONLESS SOIL

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ABSTRACT

The wide range of particle shapes and size distribution of sand, by virtue of its sedimentological process of formation plays a significant role in engineering behaviour when used as fill material or foundation material. The relative density of a granular cohesionless soil indicates its degree of compaction. Shear strength parameters increases as we go from lower to higher relative density. The research work includes a series of direct shear tests for performed on granular soils consisting of sand with different particle gradations (i.e. C-M,C-M-F,M-F) and different relative densities (i.e. 30%, 45%, 60%, 75%, 90%) reconstituted in laboratory. Direct shear testing was performed on all gradations for different relative density to determine the angle of internal friction under normal stresses of 50 kN/m^2, 100 kN/m^2, 150 kN/m^2, and 200kN/m^2. The direct shear testing showed that as the particle size within the sample increased, the angle of internal friction also increased.

Keyword: - *sand, relative density, particle size gradation, DST*

1. INTRODUCTION

Sand is the most typical cohesionless granular material. Cohesionless materials include different soils & artificial substance that do not have the tendency of sticking together among the individual grains of the material. The mechanical behavior of granular soil is interestingly dependent on the characteristics The particle shape and size & density of sand are considered to be one of the most important factors that influence the behavior of the soil when it is used for various purposes. These two are the important factors that mainly influence the strength parameter. All stability analysis in soil mechanics involves a basic knowledge of shearing properties & shearing resistance of the soil. From the number of studies done, there has not been any proper literature found regarding correlation between relative density and strength deformation parameters with the different sand gradation, i.e. coarse, medium and fine sand. Hence, an attempt through means of experimental study is being made to find effect of these parameters for that Several lab experiments are being performed for determining the different relative density with different proportions & particle size of sand grades.

Depend on the availability & requirement of the soil for the purpose of constructing foundations, Backfill. embankments etc., it is important to study the effects of mixed sand grading as well as uniform grading on the strength of the sample and hence gives a relationship between the parameters that are mainly affects the strength i.e. Particle Size Gradation & Relative Density & strain rate & shear strength of soil.

Shear strength of cohesionless soil can be determined by direct shear test. There was constant strain is applied to the soil sample. The friction angle of sand is finding by plotting the chart between normal stress to shear stress. The effects of relative density on the bearing capacity of the soil has been a topic of research in the past. Many studies have been done establishing relationship between the relative density and SPT value (N), the SPT value and the bearing capacity, etc. that study is basically focusing on particle size gradation, relative density, and shear strength for sand.

2. METHODOLOGY

For the present work, experimental methodology includes sample procurement followed by preliminary laboratory testing and detailed laboratory testing methodologies. Procured Soil sample is graded by sieve analysis in three different sand as follows.

coarse sand =4.75mm to 2.00mm
medium sand =2.00mm to 0.425mm
fine sand=0.425mm to 0.075mm

There are seven different samples grade is prepared by mixing with different percentage(%) by weight of C:M:F. All laboratory test performed on sample grade prepared as different percentage as shown in table 1.

Table-1 sand gradation percentage

SAMPLE	COARSE	MEDIUM	FINE
SG-1	100%		
SG-2	50%	50%	
SG-3	50%	25%	25%
SG-4		100%	
SG-5	25%	25%	50%
SG-6		50%	50%
SG-7			100%

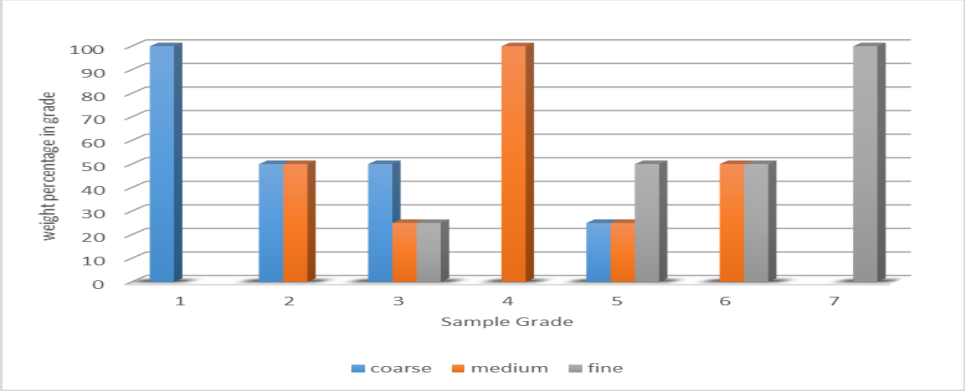

Chart 1 percentage sand gradation

In detailed laboratory testing, Vibratory table has been performed for calculating minimum and maximum density of sample in its loosest and densest state. On the basis of vibratory table test, different relative density values taken and the dry density of soil sample has been calculated at that relative density. Direct shear test has been performed on each density which is find from relative density. Total 14 vibrotary table test & 105 number of direct shear test is done to full fill the need of study. DST is done to get Angle of friction (Φ) at various grade.

3. LABORATORY EXPERIMENT

Sand sample is procumented from the chandola river dholka. Seven sample is prepared by grading the sand as shown in chart 1. Further work done as per requirement

3.1 SIEVE ANALYSIS

Sieve analysis is done on each sample grade to get primary idea of sand, value of coefficient of curvchar(Cc) and coefficient of uniformity(Cu) get from the chart as given in table-2. Sand graded is poorly graded sand.

Table 2-Particle size gradtion

Sample	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	D_{60} (mm)	D_{30} (mm)	D_{10} (mm)	Coefficient of Uniformity	Coefficient of curvature
Natural sand	4	47	49	0.52	0.38	0.27	1.92	1.02
SG-1	100	-	-					
SG-2	50	50	-	2.41	1	0.48	3.85	0.428
SG-3	50	25	25	2.25	0.66	0.42	5.35	0.46
SG-4	-	100	-					
SG-5	25	25	50	0.8	0.39	0.25	3.2	0.79
SG-6	-	50	50	0.72	0.35	0.24	3	0.70
SG-7	-	-	100					

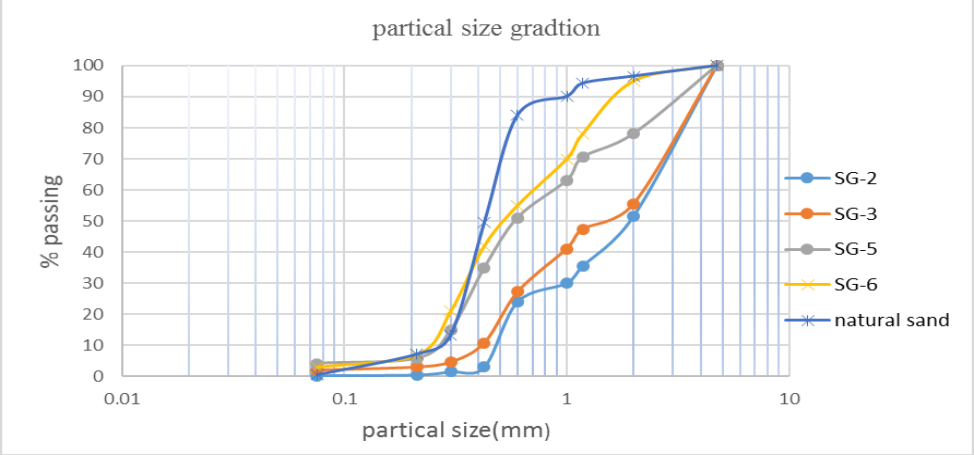

Chart 2- particle size gradtion

3.2 RELATIVE DENSITY

As per the IS code 2720 part 14 relative density test done on vibrotary test device. From that maximum dry density and minimum dry density of sand can be getting as per shown in table.

Table 3-Vibrotary table test data

Sample No.	Sample Type	$\gamma_{min(kN/m2)}$	$\gamma_{max(kN/m2)}$
1.	SG-1(100:0:0)	13.59	15.79
2.	SG-2(50:50:0)	15.11	17.73
3	SG-3(50:25:25)	15.53	18.22
4	SG-4(0:100:0)	14.66	16.14
5	SG-5(25:25:50)	15.60	17.14
6.	SG-6(0:50:50)	15.23	17.83
7.	SG-7(0:0:100)	14.14	15.96

Assuming five relative density value say 30%,45%60%,75%and90% & From the Relative Density formula we have all the value except ρ_d. Find the density of sample grade at five different relative density as per loose to dense state of SG.

$$(D_r) = \left(\frac{\rho d - \rho min}{\rho max - \rho min}\right) X \frac{\rho max}{\rho d}$$

Dr-Relative density
ρ_d – Dry density of sand
ρ_{max} -Maximum density of sand
ρ_{min} –Minimum density of sand

Table 4 -Dry density value at assumed five relative density value for each sample grade

Sample No.	Sample Type	Dry Density at different Relative Density(kN/m^2)				
		30	45	60	75	90
1	SG-1(100:0:0)	14.18	14.49	14.82	15.17	15.53
2	SG-2(50:50:0)	15.70	16.02	16.36	16.71	17.08
3	SG-3(50:25:25)	16.25	16.64	17.04	17.47	17.18
4	SG-4(0:100:0)	16.08	16.30	16.52	16.75	16.98
5	SG-5(25:25:50)	16.04	16.26	16.49	16.73	16.98
6	SG-6(0:50:50)	15.92	16.30	16.69	17.10	17.36
7	SG-7(0:0:100)	14.64	14.90	15.17	15.46	15.75

3.3 DST

Each sample has been tested for five relative density at 30%,45%,60%,75% and 90%. Direct shear test apparatus is strain control device. That is conventional type of direct shear test apparatus. Box size is 60mm x 60mm x 50mm is used. All test is done at constant strain rate of 1.25mm/min. in that plain strain condition is satisfy. Test is done for the unconsolidated undrain test condition. Test is done under four normal stress as 50KN/m^2,100KN/m^2,150KN/m^2 and 200KN/m^2. Angle of internal friction is find as per mohar culmb theory. IS 2720 part 13 for each sample grade at each relative density.

(A)

(B)

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

4. RESULT AND DISCUSSIONS

The direct shear test is performed on the graded sand sample as per specification. To get the value of the angle of internal friction graph between normal stress and shear stress is drawn, shear stress is finding at four normal load. In table 4 average of three value of shear stress are shown with respect to normal stress. Angle of internal friction for sample grade1(Coarse = 100) is found by plotting the graph between Normal stress and Shear stress as shown in below table.

Table 5 - Stress value for Sample Grade 1

NORMAL STRESS(kN/m^2)	SHEAR STRESS (kN/m$^{2)}$				
	30%	45%	60%	75%	90%
50	50.4	54	64.8	57.6	50.4
100	100.8	108	111.6	118.8	122.4
150	136.8	151.2	151.2	176.4	187.2
200	208.8	198	205.2	230.4	234

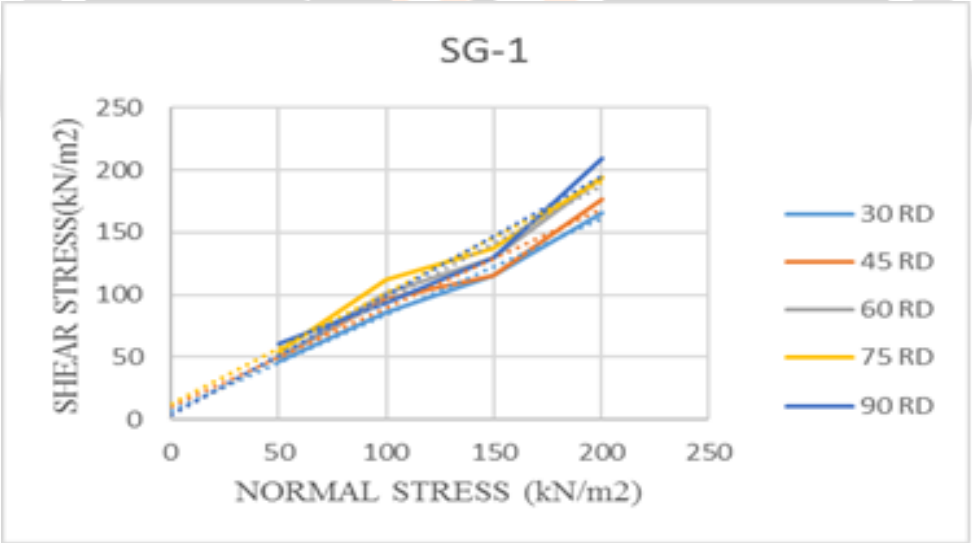

Chart 3-Angle of internal friction for SG-1

TABLE 6- Angle of internal friction for different sand grade

SAMPLE GRADE	ANGLE OF INTERNAL FRICTION(ϕ)				
	30	**45**	**60**	**75**	**90**
SG-1	38.45	41.21	42.71	46.32	48.37
SG-2	37.5	38.2	40.25	41.75	42.37
SG-3	36.51	41.27	41.27	44.32	46.1
SG-4	32.53	32.85	37.75	38.5	40.67
SG-5	34.02	35.55	36.78	38.05	39.85
SG-6	29.31	30.12	32.05	34.58	36.33
SG-7	28.10	30.74	31.09	34.12	38.87

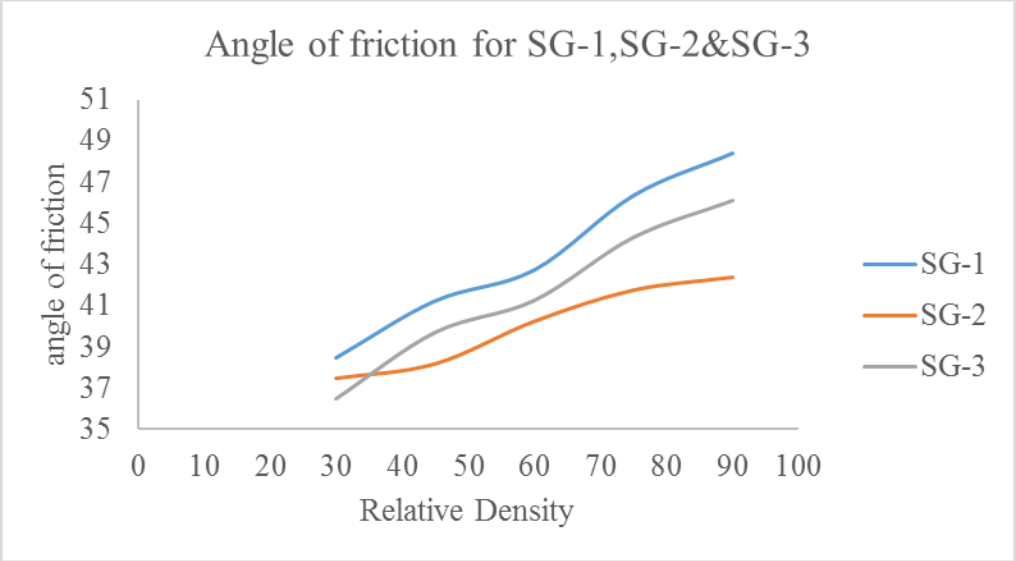

Chart -4 comparison of angle of friction at various Relative density for SG-1 SG-2& SG-3

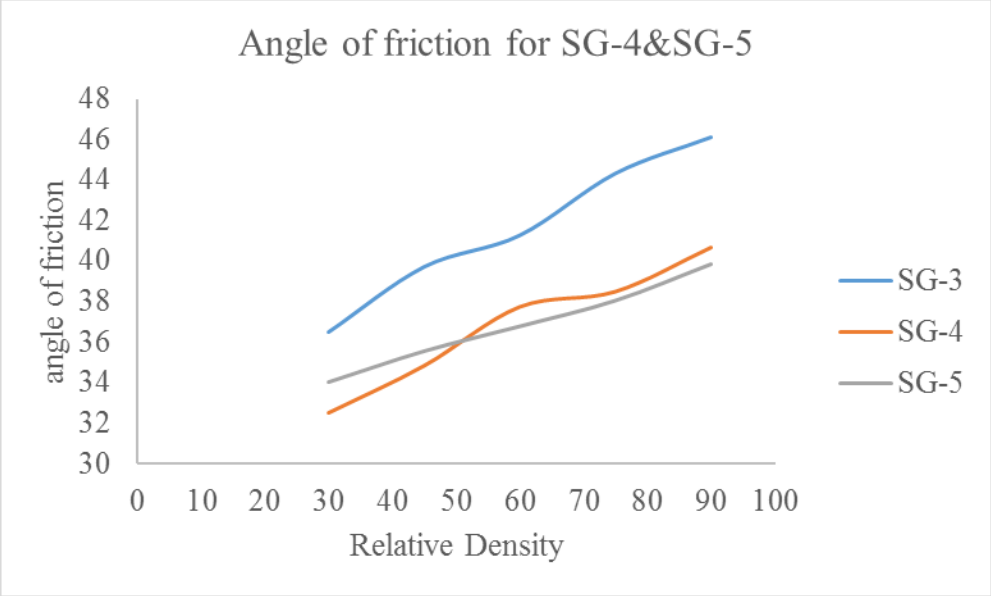

Chart -5 comparison of angle of friction at various Relative density for SG-3 SG-4& SG-5

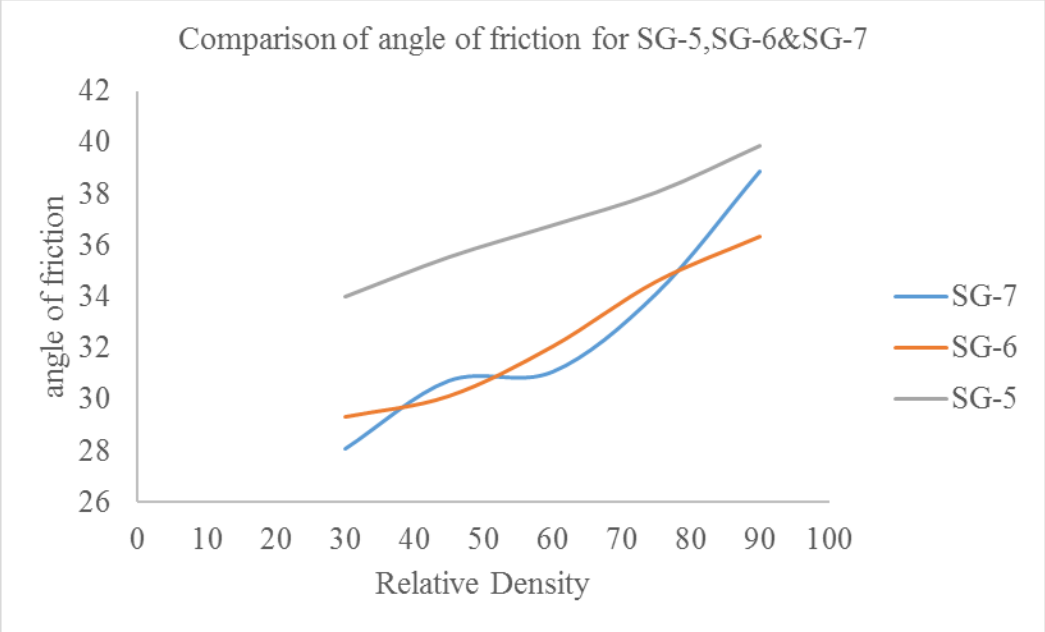

Chart -6 comparison of angle of friction at various Relative density for SG-5 SG-6& SG-7

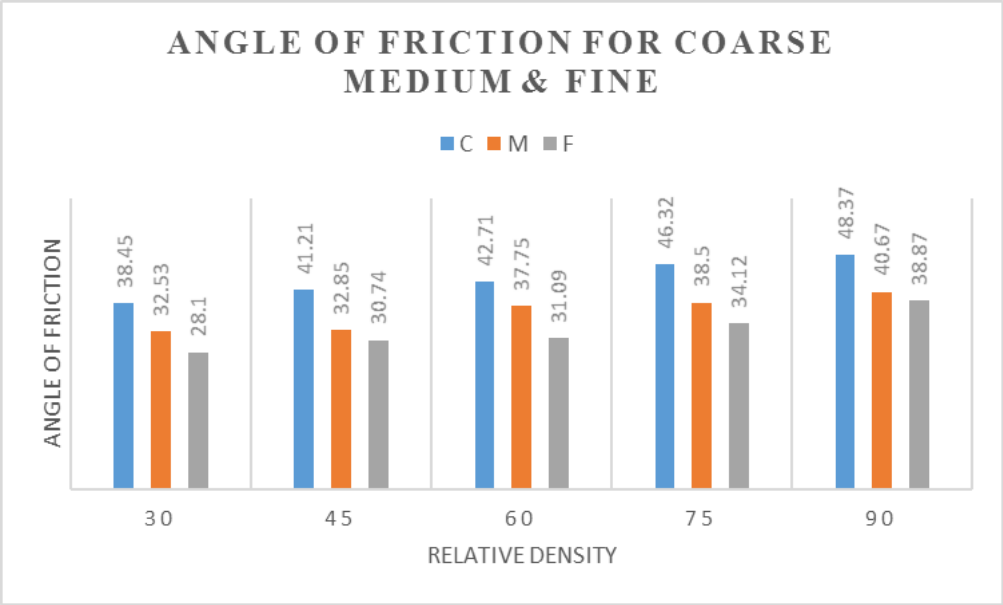

Chart -7 comparison of angle of friction for coarse, medium and fine sand

Here show the comparison between coarse sand, medium sand, and fine sand.

At the 30%, Relative Density compare to fine sand increase in medium sand 15.76% and coarse sand 36.83%. At the 45%, Relative Density compare to fine sand increase in medium sand 6.86% and coarse sand 34.05%. At the 60%, Relative Density compare to fine sand increase in medium sand 21.42% and coarse sand 37.37%. At the 75%, Relative Density compare to fine sand increase in medium sand 12.83% and coarse sand 35.75%. At the 90%, Relative Density compare to fine sand increase in medium sand 4.63% and coarse sand 24.44%.

5. CONCLUSION

In the present research work series of Undrained Direct shear test on various graded sand have been carried out on graded sample of sand. This experiment studied have yielded following major finding.

- From the vibrotary table test as the 50% medium add to coarse, sand density increase with 10% and more 25% fine add the density increase with 14% of coarse. 50% medium add to fine, increase in density is 9.5% aand more 25% coarse add to that then increase of 8.75% of fine sand density.
- The angle of internal friction obtains from laboratory test increase directly with the increase in particle size and relative density.
- For the Course grain side gradation shows variation of the angle of internal friction ranges from 36-46. while for the finer grain side gradation shows angle of internal friction ranges from 28-34.

- Medium size particle add to coarse sand then angle of friction is decreases from 2.47% to 12.40% as relative density increase from 30% to 90%. Mixture of medium and fine add to coarse sand decrees in angle of friction in the range of 4.5% to 5.0%.for relative density increase from 30% to 90%.
- Medium size particle add to fine sand then angle of friction is increases from 2.03% to decrease to 6.53% as relative density increase from 30% to 90%. Mixture of medium and coarse add to fine sand increase in angle of friction in the range of 17.40% to 2.45%.for relative density increase from 30% to 90%.

6. ACKNOWLEDGEMENT

Authors are highly thankful to Prof. Dr. G.P. Vadodariya, Dean L.D. college of Engineering and Prof. A.R.Gandhi, Head of Applied Mechanics Department, L.D. College of Engineering, Ahmedabad, India for providing all necessary research facilities.

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