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A Review of Laboratory Investigation on Sand with Different Grades

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Abstract: The density index of a granular cohesion less soil is a superior indicator for identifying its level of compaction i.e. coarser soil put side by sided to relative compaction. It has been also noted that sands are a more desired material for using as filler material in foundation or base, because of its property to be less influenced by pore water pressure as compared to cohesive soils. The cause may be due to their greater size of void, which contains more air than water. Practically it is very complicated to acquire homogeneous sands during various cut and fill actions or other functions of construction. This leads to obtaining sand from diverse sources, which result in heterogeneous (mixed) properties in the sample used. Various articles have been reviewed, it has been observed that there has not been suitable attempt to set up a relationship or association among density index, capacity to bear load (bearing capacity) and sand gradation, i.e. the dissimilar fractions of fine, medium and coarse sand.
Keywords: Sand; mixed Grading; Density Index; Compaction; Bearing capacity; Particle size

I. INTRODUCTION

Density Index may be defined as the expression used to signify the relative looseness or compactness of cohesion-less granular soil. It is one of the major properties which decide its practice. Density index provides a practical useful assessment of compactness of cohesion less soils, preferably recognized as one of the index properties for sand. The compressible features of cohesion less soils and related characteristics of such soils are reliant on parameters like shape of individual particles and grain size distribution. Density index is also influenced by these parameters and provides correlation between properties of soils. Numerous soil properties such as compressibility, compaction friction angle, penetration resistance, permeability and California bearing ratio are found to establish simple relations with density index. Thus, for such reason it is essential to find out minimum and maximum density of soil.

II. GOALS AND OBJECTIVES

A. Goals

To find the laboratory investigation on sand with different grades.

B. Objectives

To study and analyze the consequences of sand gradation i.e. dissimilar proportions of fine, coarse and medium sand on-

1) Density index
2) Bearing capacity

III.LITERATURE SURVEY

[1] White and Walton (1937) focused on the particle packing and shape. Density index, minimum void ratio and maximum void ratio of sand were calculated to be greatly influenced by particle sizes, their way of packing and shapes.

[2] A correlation has been proposed by Burmister (1948) about the limit densities of sands. Density of sands considered as important as the properties like the coefficient of curvature (C_c), mean particle size (D_{50}), uniformity coefficient (C_u) and particle shape, among others, when giving a complete account of sand. Density or void ratio limits assist to explain the material under consideration in a more accurate manner and are necessary when calculating the density index of in-place soils.

[3] Wasti and Alyanak (1968) did work on sand and clay mixtures and concluded that when clay content is just sufficient to pack the voids of the granular portion at its utmost porosity, the structure of the mixture varies and the linear relationship among the Atterberg limits (plastic and liquid limits) and the clay content is no more applicable and soil changed its behaviour from sand to clay. For blend including kaolin clay at its liquid limit, they revealed that this threshold value is about 20 to 25% kaolin content.

[4] Mathematical formulation has been proposed by Masih (2000), to get the density of soil. He used the mathematical constraints of the grain size distribution to correctly estimate the maximum dry density of the soil and then applied the fine biasness coefficient to

predict the novel density after mixing any random quantity of fine particles with the original one. Comparison of Lab results with the results of the prediction shows that the error percentage was found to be less.

[5] Barton et al. (2001) performed an experiment study on mixed grading effects on the maximum dry density of sands and showed an increment in the maximum dry density of the specimen with the grading moving more towards the ideal features for intense packing. Also, the experimental outcomes were observed to be more than the forecasted outcomes for the parent sands

[6] The maximum and minimum void ratio characteristics of sand study by Cubrinovski and Ishihara (2002) revealed that influence of existence of fines, grain-size composition and particle shape on the maximum and minimum void ratios and on the difference between the two. They also suggested empirical relations between the sand void ratios at densest state & loosest state and the material properties.

[7] Omar et al. (2003) examined the compaction features of granular soils in United Arab Emirates. A study was carried out to evaluate the compaction features of such soils and to develop the governing analytical equations. In this study, 311 soil specimens were gathered from a variety of locations in the United Arab Emirates and tested for different including grain-size distribution, plasticity index, specific gravity of soil solids, liquid limit, maximum dry density of compaction and optimum moisture content following ASTM D 1557-91 standard procedure C. A novel set of 43 soil specimens were accumulated and their compaction outcomes were used to test the legality of predictive model. The variety of variables for these soils were as follows: % retained on US sieve #4 (R#4): 0–68; % passing US sieve #200 (P#200): 1–26; Liquid limit: 0 to 56; Plasticity index: 0 to 28; Specific gravity of soil solids: 2.55 to 2.8. Based on the compaction tests results, multiple regression analyses were carried out in order to develop mathematical models and nomographic solutions to forecast the compaction properties of soils. The outcomes specified that the nomographs could forecast well the maximum dry density within ±5% confidence interval and the optimum moisture content within ±3%.

[8] Pakbaz et al. (2007) executed direct shear tests on natural over consolidated clay specimens as well as over consolidated compacted mixtures of sand and bentonite. They stated that the friction angle decreased with the increase in bentonite content. They also stated that with reduction in sand grain size with constant bentonite content of 20% the shear strength amplifies.

[9] A series of experiments has been carried out by Mehmat salih olmez (2008) observe the outcome of kaolin in sand-clay mixtures on the shear strength behavior of mixtures. Undrained and drained triaxial tests and also direct shear tests were executed. He stated that the shear strength properties and the stress-strain features of mixtures of sand-kaolin proved a significant change at kaolin content of about 20%.

IV. MOTIVATION

It has been observed that density index better point outs the compaction of granular soil, i.e. coarser soil as put side by side to relative compaction. Also, sands are more superior foundation/base material as its propensity to be less influenced by neutral pressure (pore pressure) as compared to cohesive soils which may be attributed to its larger void size, which grasps more air than water. During cut and fill actions, compaction using sand from dissimilar sources may be done, consequential in mixed sand which will have different compaction features than those of the parent sands. Also it is impracticable to obtain fines-free sand for construction purpose.

From the numerous studies done, there has not been a good effort on establishing the link between density index and sand gradation, i.e. coarse, medium and fine sand. Hence, an attempt through means of experimental study is being made to come across a relation among the two, if probable a mathematical one. Also to make the results more practicable in the field, the effect of different amounts of fines present in the specimen would also be considered. As the mathematical formula states density index in terms of the void ratios in the natural, loosest and densest soil states, and numerous lab experiments would be carried out for determining the dissimilar void ratios for different mixes of sand grades. Prior to it, the tests for the grain size analysis to find out the proportion of fines present in the specimen and the mix of different sand grades to be added in the specimen would also be taken up.

V. METHODOLOGY

The project being an experimental effort needs the protocol of accumulating specimens, analyzing them, executing a range of tests and obtaining conclusions from the outcome. The project can be separated in the following parts-

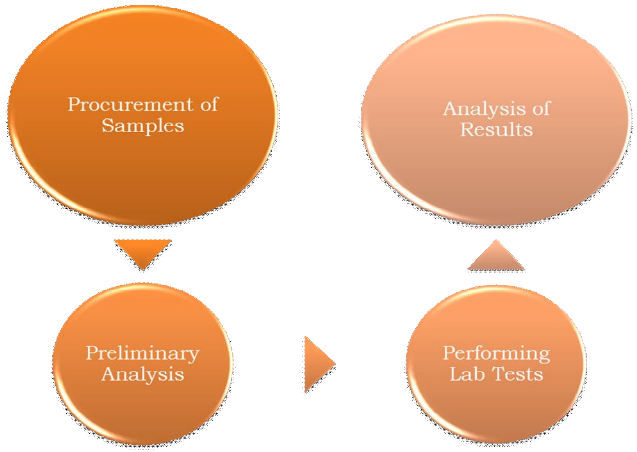

Figure 1 – Methodology adopted

A. Accumulation of Specimens

Sand specimens were accumulated from the 4 diverse sources i.e. the riverbanks of Narmada, Tawa and Shipra at Madhya Pradesh. The specimens were brought for the construction purposes at the campus site, so they are fit to be employed for construction purposes.

B. Preliminary Analysis

Specimens collected from different sources, sieve analysis was conducted for sand gradation. The fractions of fine, coarse and medium sand in the specimen was found out, which furnished us the idea of the fractions at the riversides. First round tests for finding out main properties like dry unit weight, specific gravity etc. were also carried out.

C. Performing Lab Tests

From the accumulated sand specimens, 17 sets were made with different fractions to locate the density index of the sand specimen were executed by the vibratory table test method. Attaining the maximum and minimum void ratios, the relative densities were calculated.

After density index, direct shear tests or box shear tests were performed to find out the angle of internal friction and compute the bearing capacities for the dissimilar specimens with the aid of IS 6403:2002-Code of Practice for Determination of Bearing Capacity of Shallow Foundations.

D. Analysis of Results

The outcomes of several density index and bearing capacities for dissimilar sand grade fractions achieved were analyzed. Empirical relations have also been set up between gradation, bearing capacity and density index.

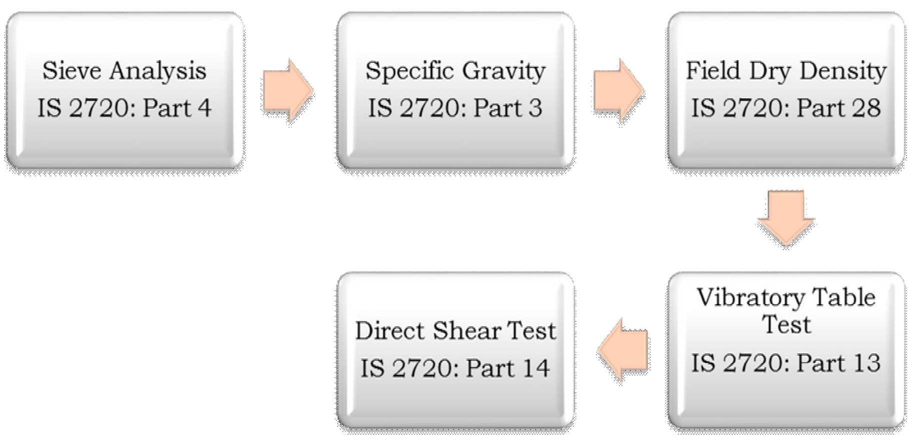

Figure 2 – Experiments performed during the project

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VI. RESULTS

A. Sieve analysis

Sieve Analysis was conducted on the specimens accumulated and the following results were found. From the plot between particle size and percentage finer, the values of D_{10}, D_{30}, D_{50}, D_{60}, C_u and C_c were calculated. D_{10}, D_{30}, D_{50} and D_{60} are observed from the gradation curve plotted.

Table – 1 Data sets of the specimens accumulated for Sieve Analysis

Sample	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	Coefficient Of Uniformity (C_u)	Coefficient of Curvature (C_c)
1	10	62	28	0.16	0.46	0.77	1	6.25	1.32
2	5	69	26	0.19	0.48	0.8	1.2	6.32	1.01
3	0	88	12	0.13	0.64	0.7	0.8	6.15	3.94
4	14	76	10	0.5	0.8	1.1	1.4	2.8	0.91

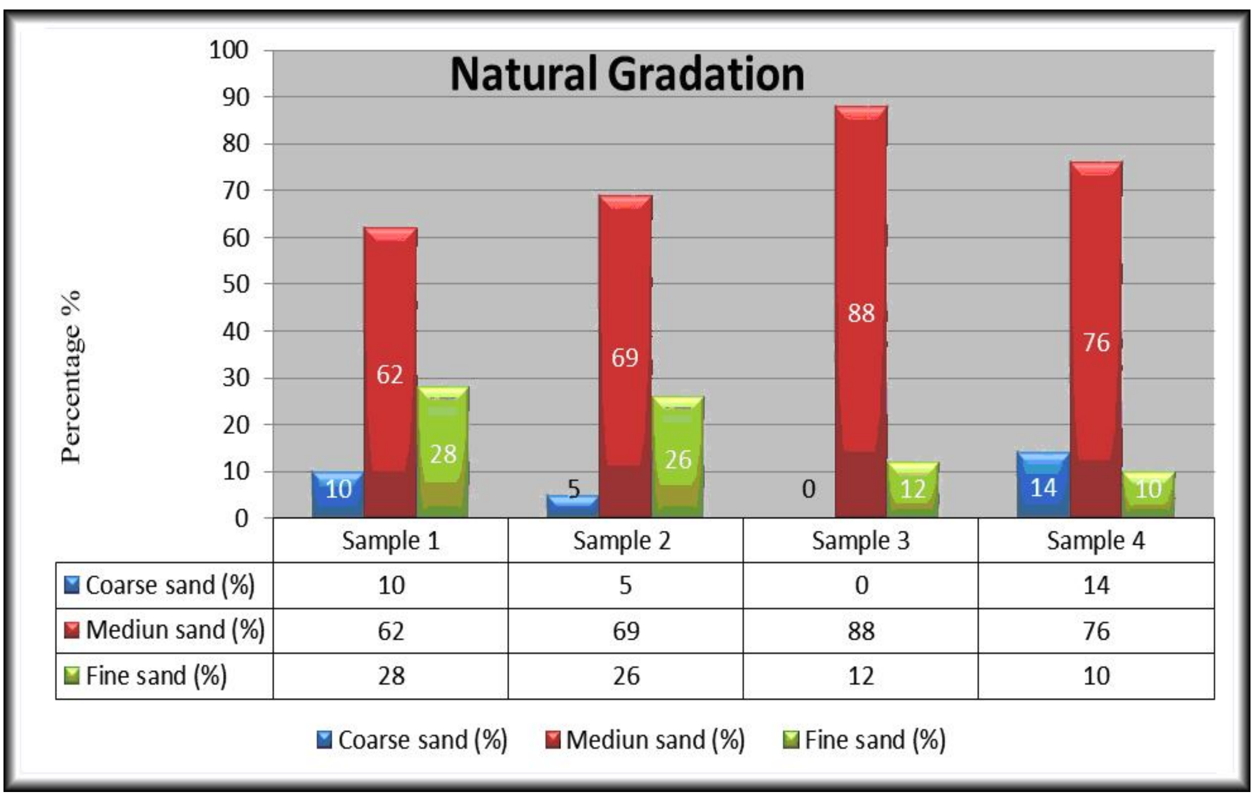

Figure 3 – Natural Gradation of the accumulated samples

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B. specific Gravity

Table – 2 Specific Gravity results of obtained specimens.

SAMPLE	1			2			3			4		
	I	II	III	I	II	III	I	II	III	I	II	III
Wt. of Pycnometer (gm)	100	100	100	100	100	100	100	100	100	100	100	100
Wt. of Pycnometer + Sand (gm)	150	150	150	150	150	150	150	150	150	150	150	150
Wt. of Dry Sand W1 (gm)	50	50	50	50	50	50	50	50	50	50	50	50
Wt. of Pycnometer + Water W2 (gm)	343	351	351	347	351	349	347	349	341	347	344	346
Wt. of Pycnometer + Water + Sand W3 (gm)	374	382	382	378	382	380	378	380	371	378	375	377
G_s	2.65	2.63	2.66	2.58	2.63	2.60	2.57	2.59	2.54	2.63	2.65	2.66
Average G_s		2.64			2.60			2.57			2.65	

C. Vibration Table Test

The density index for the 17 prepared specimens.

Mass of Mould	(M1) = 10.631 kg
Height	(H) = 17 cm
Diameter	(D) = 15 cm
Area of Cross-section	(A) = 0.018 m^2
Volume	(V) = 0.003 m^3
Unit Weight of water	(Υ_w) = 1000 kg/m^3

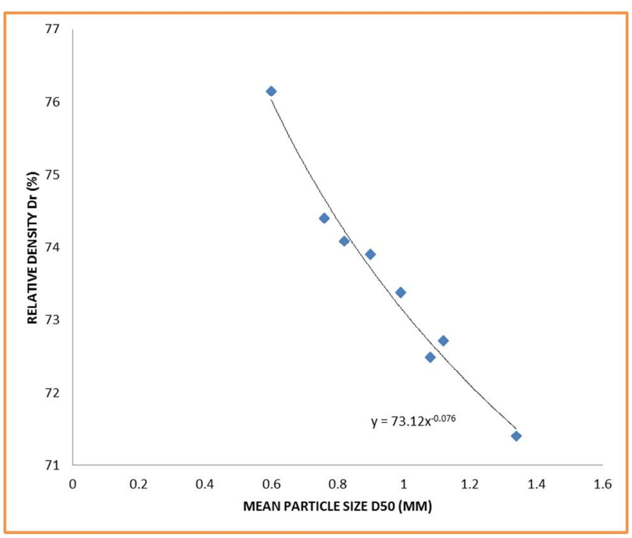

Figure 4 – Density index v/s. mean Particle Size

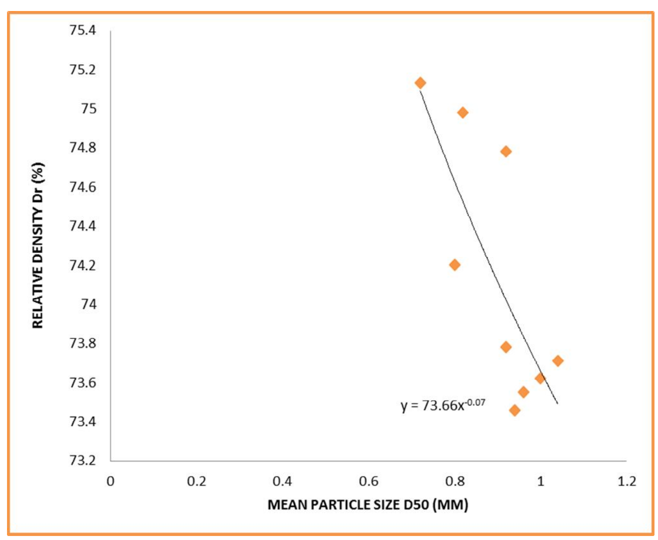

Figure 5 – Density index v/s. mean Particle Size

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Figure 4 and 5 shows the graph of relation between density index and mean particle size for by varying the natural gradation of sand. As the both graphs are declining one, which shows that the density index and mean particle size are inversely proportional to each other. After considering the two equations, an empirical relation has been recognized between density index and mean size particle i.e.

$$\mathbf{D_r = 73\ D_{50}^{-0.07}}$$

Where D_r is the Relative Density (%) and D_{50} is the mean particle size (mm).

D. Direct Shear Test

Table – 3 Angle of internal friction (ϕ) and Bearing capacity of Specimen 1

Specimen No	Coarse (%)	Medium (%)	Fine (%)	D50 (mm)	Normal Stress (kg/cm²)	Proving Ring Reading (a)	Shear Force = (a)*3.0672N (b)	Shear Stress = (b) / 36 (kg/cm²)	Angle Of Internal Friction (ϕ) (°)	Unit Weight (ϒ) (gm/cc)	Bearing Capacity Factor N_Υ	Ultimate Bearing Capacity (kN/m²)
1.	10	50	40	0.6	4.91	54	165.60	4.60	43.14	1.96	211.37	2071.38
2.	20	50	30	0.82	4.91	50	152.64	4.24	40.86	2.04	137.33	1400.81
3.	30	50	20	1.12	4.91	47	142.92	3.97	38.96	2.12	84.37	894.29
4.	10	60	30	0.76	4.91	52	160.92	4.47	42.31	2.03	184.42	1871.82
5.	20	60	20	0.99	4.91	47	143.28	3.98	39.03	2.09	97.50	1018.90
6.	30	60	10	1.34	4.91	42	129.60	3.60	36.30	2.15	76.26	819.85
7.	10	70	20	0.9	4.91	48	148.32	4.12	40.01	2.06	109.73	1130.27
8.	20	70	10	1.08	4.91	44	133.92	3.72	37.16	2.10	74.55	782.73

Table – 4 Angle of internal friction (ϕ) and Bearing capacity of Specimen 2

Specimen No	Coarse (%)	Medium (%)	Fine (%)	D50 (mm)	Normal Stress (kg/cm^2)	Proving Ring Reading (a)	Shear Force = (a)*3.0672N (b)	Shear Stress = (b) / 36 (kg/cm^2)	Angle of Internal Friction (ϕ) (°)	Unit Weight (gm/cc)	Bearing Capacity Factor N_Υ	Ultimate Bearing Capacity (kN/m^2)
1.	5	65	30	0.72	4.91	54	166.68	4.63	43.31	2.02	216.89	2190.55
2.	5	70	25	0.8	4.91	47	144.72	4.02	39.34	2.03	101.31	1028.27
3.	5	75	20	0.96	4.91	43	133.20	3.70	37.01	2.06	72.70	748.86
4.	10	65	25	0.82	4.91	53	163.80	4.55	42.86	2.04	202.27	2063.20
5.	10	70	20	0.92	4.91	47	145.44	4.04	39.46	2.06	91.73	944.85
6.	10	75	15	0.94	4.91	45	137.52	3.82	37.92	2.08	71.60	744.64
7.	15	65	20	0.92	4.91	50	154.44	4.29	41.16	2.08	147.08	1529.58
8.	15	70	15	1	4.91	48	147.24	4.09	39.80	2.09	82.65	863.67
9.	15	75	10	1.04	4.91	45	137.88	3.83	37.98	2.10	60.06	630.64

E. Bearing Capacity

Ultimate bearing capacity of soil can be calculated by

$$q_d = cN_c + q\,(N_q - 1) + 0.5\,B\,\Upsilon\,N_\Upsilon$$

[Is 6403:2002-Code Of Practice For Determination Of Bearing Capacity Of Shallow Foundations]

In view of the fact that the sand is cohesion-less, no surcharge is to be used here and assuming that the footing to be of unit width, as a result the first two terms are ignored and the working formula becomes

$$q_d = 0.5\,\Upsilon\,N_\Upsilon$$

Several factors such as effect of water table, eccentricity of loading, shape of footing etc. are not considered in the above formulations, as this project does not include any practical testing of bearing capacity for the sand specimens.

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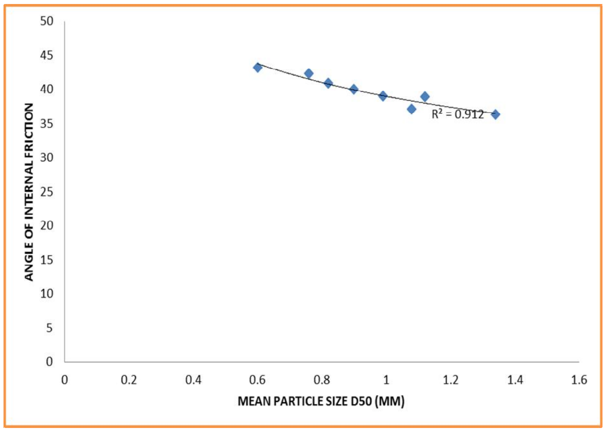


Figure 6 – (ϕ) v/s. D_r for (Narmada) Sample – 1

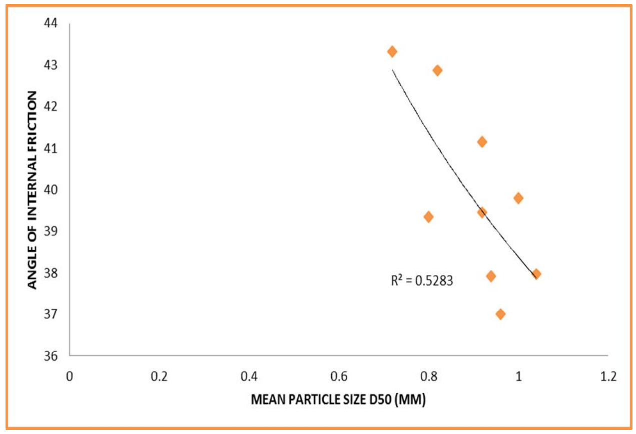


Figure 7 - (ϕ) v/s. D_r for (Tawa) Sample – 2

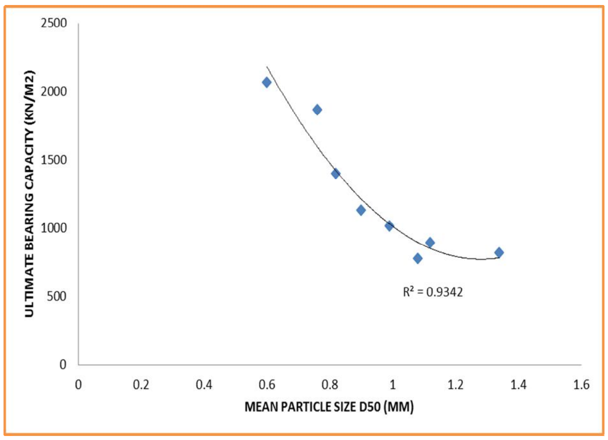


Figure 8 – (q_d) v/s. D_r for (Narmada) Sample – 1

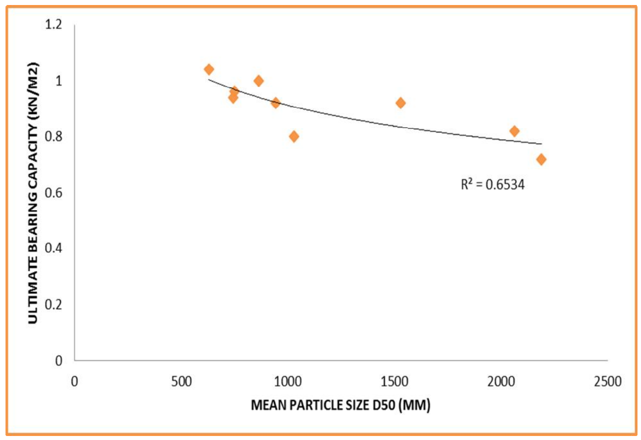


Figure 9 – (q_d) v/s. D_r for (Tawa) Sample – 2

VII. DISCUSSION

Among different parameters which affect relative density of soil, sand gradation has been selected. A range of research papers of different authors in this field have been reviewed and it has been noticed that mean particle size is found to be most important parameter affecting the density index.

A. Out of 4 samples, samples 1 & 2 are taken up for experimentation because content of only these two samples are well graded.
B. By pycnometer test it has been observed that out of 4 samples, sample no. 4 has maximum and sample no. 3 has minimum specific gravity.
C. Figure 4 and 5 shows graph between mean particle size and density index reveals that obtained graph is decreasing one and mean particle size and density index are inversely proportional to each other.
D. Figure 6 and 7 shows a declining graph between angle of internal friction and mean particle size for sample 1 and sample 2 respectively.
E. Figure 8 and 9 shows a decreasing graph between ultimate bearing capacities and mean particle size for both samples which concludes that as the mean particles increases ultimate bearing capacity decreases.

VIII. CONCLUSION

On the basis of experimental study, following conclusions are drawn

A. Well graded samples i.e. sample whose uniformity coefficient is more than 6 (C_u >6) and coefficient of curvature is between 1 to 3 (1< C_c <3) for sand are appeared to be denser than the other samples i.e. they have higher density index around greater than 70%, which is classified as ‘dense sand’.

B. Density index, Bearing Capacity and angle of internal friction are found to vary inversely to the mean particle size.

C. The density index and angle of internal friction conform to the empirical relation given by Meyerhof (1956), positioned between the range of +/- 5% error.

D. The mean particle size is found to be most important parameter in affecting the index property i.e. density index for cohesion-less soils taken. Thus an empirical relation is suggested from the present experimental work as

$$D_r = 73\ D_{50}^{-0.07}$$

E. Density index (D_r) and Ultimate Bearing Capacity (q_d) of soil were found to be directly proportional.

IX. LIMITATIONS

In this study no surcharge is used here and assumed that the footing to be of unit width which may not be found on field. So in practical conditions, outcomes may found to be different.

Some parameters like eccentricity of loading, effect of water table, footing type etc. are not considered in the formulations, as this project does not consist of any practical testing of ultimate bearing capacity for the sand specimens.

X. SCOPE OF FURTHER STUDY

It is necessary to analyze the impact of angularity and particle shape on the maximum and minimum void ratio and therefore on the relative density of sand. It’s suggested to derive empirical equations of relative densities at any energy state of compaction. Correlation will be done by considering each vibration moreover as impact force whereas crucial the relative density in laboratory simulating to field conditions. Parameters such as eccentricity of loading, effect of water table, footing type etc. Could be considered for obtaining more reliable and accurate empirical relations.

REFERENCES

[1] White, H. E., Walton, S. F. (1937). “Particle Packing and Particle Shape”, Journal of the American Ceramic Society, Vol. 20, Issue 4, pp. 155-166.

[2] Burmister, D. M. (1948), “The Importance and Practical Use of Relative Density in Soil Mechanics,” ASTM Proceedings, Presented at the Meeting of Committee D-18 on Soils for Engineering Purposes held during the Fifty-first Annual Meeting, Detroit, Michigan, Vol. 48, pp.1249–1268.

[3] Wasti, Y. and Alyanak, I, "Kil Muhtevasının Zeminin Davranışına Tesiri .İnşaat Mühendisleri Odası", Türkiye İnşaat Mühendisliği 4. Teknik Kongresi. Ankara 1968.

[4] Masih, R. (2000). “Formula to get desired soil density”, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 126, No. 12, pp. 1145-1150.

[5] Barton, M. E., Cresswell, A., Brown, R. (2001). “Measuring the effect of mixed grading on the maximum dry density of sands”, Geotechnical Testing Journal, ASTM, Vol. 24, No. 1, pp. 121-127.

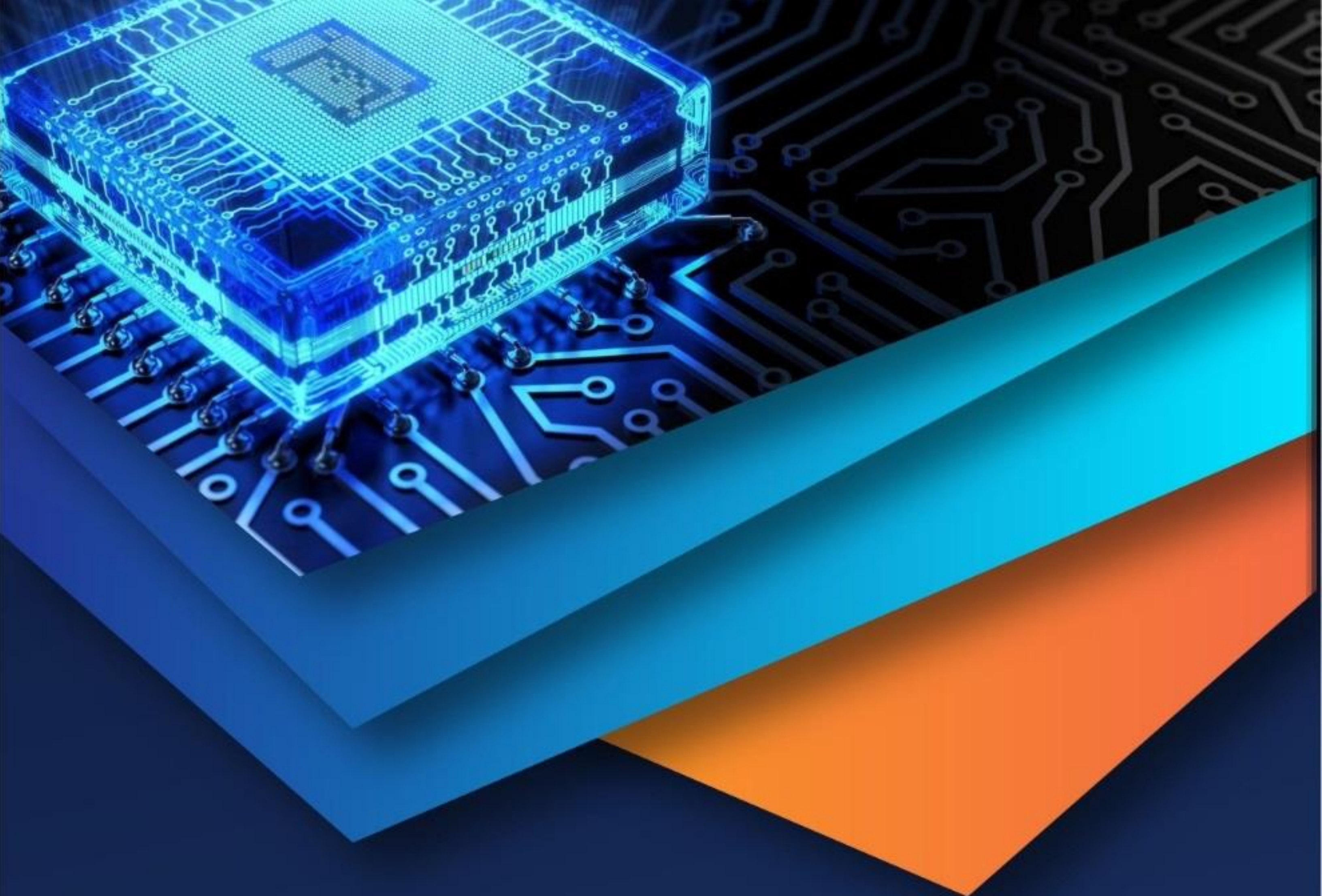
[6] Cubrinovski, M. and Ishihara, K. (2002). “Maximum and minimum void ratios characteristics of sands”, Soils and Foundations, JGS, Vol. 42, No. 6, pp. 65-78.

[7] Omar, M., Shanableh, A., Basma, A., Barakat, S. (2003). “Compaction characteristics of granular soils in United Arab Emirates”, Journal of Geotechnical and Geological Engineering, Vol. 21, pp. 283–295.

[8] Das B.M, Principles of Geotechnical Engineering. Cenage Learning, 2006.

[9] McCarthy, D. F. (2007). “Essentials of soil mechanics and foundations”, Seventh edition, Pearson Prentice Hall Publication.

[10] Pakbaz,M. S. and Boroumanszadeh,B, " Evaluation of factors affecting parameter m in drained shear strength of over consolidated soils, international j. soil science,2007, pp 127-137.



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