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Prediction of Relative Density of Sand from its Effective Size(D_{10}).

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Abstract: *Sand being an integral aggregate in the construction industry and at the same time, its proportion in soil affecting the properties to a large extend, it is imperative to study its properties and how these are affected. One of the important phenomenon's regarding sand is compaction. So, it is imperative to study about compaction of sand. Various equipment are employed in field for the compaction of sand. Different equipment imparts different compaction energies. For the calculation of amount of compaction in soil we have a parameter called relative density, which is a better indicator of compaction of granular soils. In soil mechanics, relative density is defined in terms of void ratios. But these void ratios themselves depend upon the grain size. But we don't have a direct relationship between grain size and relative density. Various researchers have tried to relate relative density with mean grain size, and the results have been encouraging. In this research work I have tried to relate relative density with effective grain size (D_{10}). In this dissertation, the effect of mean grain size on the relative density of sand has been studied at different compaction energies. In order to arrive at the above, 21 number of clean sands having D_{10} ranges from 0.2 to .410 mm collected from different tributaries of river Jehlem from Anantnag, Sangam and Pampore, have been tested in the laboratory. 7 samples from each site were collected. Tests were conducted at NIT Srinagar. Specific gravity of all the 21 samples was calculated using a pycnometer. Standard IS sieve was used for the particle size distribution. e_{max} & e_{min} for all the 21 samples was calculated in the lab. Void ratios corresponding to different energies levels was also calculated. Experimental values of relative density for all the 21 samples was calculated. An empirical relationship was formulated between relative density and effective grain size. Values of relative density were predicted from this relationship. These experimental values and predicted values were compared.*

Key words: compaction, compaction energy, relative density, effective size, void ratio

1. INTRODUCTION:

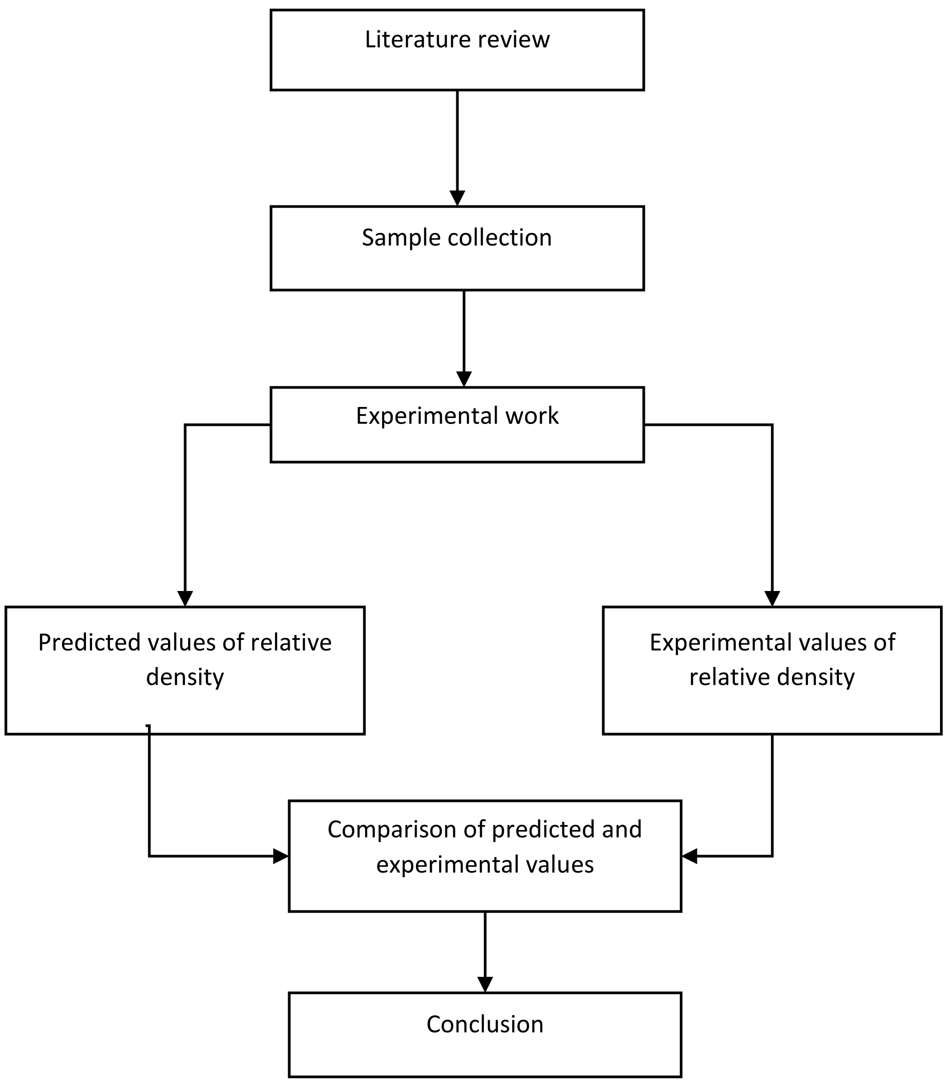
Compaction is a mechanical operation of improving the properties of soil, it is generally done with the help of a mechanical instrument and is one of the most common method of soil stabilization and is also economical method of compaction. By compaction we alter the various properties of a soil which is meant for a specific application, viz soil used in pavements, foundations, or abutment of a bridge etc. To check the effectiveness/usefulness of the mechanically controlled process of compaction various density measurements are done, in which the aim is to improve the behaviour of soil which then have a vast range of applications in the field of geo technical engineering. These density measurements can be done in-situ as well as in the lab. Compaction test is the starting point of any geo technical project. Compaction test is the one of the tests that should be mostly carried out before the geo technical project work is about to be started. The various parameters of soil like type of soil, density of soil, moisture content of soil is determined using the compaction tests. These parameters influence the strength of the soil. compaction and its effectiveness depend on various factors like compaction energy/effort, moisture content, type of soil etc. out of which compaction effort (equipment type, equipment's weight, number of blows, vibration during compaction etc.) is one of the most important factor that influence the compaction sweepingly. Field compaction of coarse soils i.e. sand, usually engage different machinery/equipment with the compaction energy showing substantial variation. Different compaction tests like, the modified Proctor tests and standard Proctor tests are done with varying energy levels and then there results had been used to show the comparisons. Various action, operations and activities have been detected which will be used to the objectives of project, i.e., literature survey/review, then conducting several tests related to the proposed research work in the laboratory, determining various parameters of the sand like density, grain size distribution, MDD, various void ratio's coefficient of uniformity, coefficient of curvature, mean size of sand, effective size of sand and then analysing these results obtained from various laboratory tests to reach a conclusion or to support the proposed research work. When the compaction effort or compaction energy is increased The Maximum Dry. Density of soils also increases but the Optimum Moisture Content or OMC shows the opposite trend its value reduce with higher values of compaction effort or compaction energy. In case of cohesionless soils having small quantity of fines or zero percent fines the water content has significant influence on the density or we can say compacted density. For the low water content & generally under a lesser compaction effort or compaction energy the density of the soil may reduce. If we compare it to that soil on which same compaction effort was applied but it was an air dried or oven dried soil. The main reason for this decrease is capillary tension, and this capillary tension is not fully compensated by the compaction effort or compaction energy, this capillary tension holds the soil particles in loose state. During fully saturated condition the cohesionless soil has maximum density. Again, this maximum density may not be very much larger than dried condition if we compare it to the air or oven dried condition. This maximum density at full saturation condition is not because of lubricating action of water but is because of reduction in effective pressure between soil particles by pressure which is hydrostatic in nature. Sand being an integral aggregate in the construction industry and at the same time, its proportion in soil affecting the properties to a large extend, it is imperative to study its properties and how these are affected. Based on this purpose, this study was conducted and 21 samples of river Jhelum sand were taken and analyzed. More focus was given on the relative density of the sample with respect to different compaction energies (viz standard and modified proctor compaction energy). Maximum and minimum void ratio were also evaluated. An attempt was also made to check any correlation between relative density and effective size. Since previous studies have only referred to relate relative density and mean grain size.

2. TEST METHODOLOGY

The following test methodologies have been employed in order to achieve the objectives of this research work:

1. Grain size analysis
2. Determination of specific gravity
3. Determination of e_{min}
4. Determination of e_{max}
5. Determination of $e_{natural}$

The following flow chart shows the various interrelated methodologies that have been taken up in order to achieve the objectives:



3. EXPERIMENTAL PROCEDURE:

For the purpose of this research natural sand was used. Samples of sand were collected from different tributaries of River Jehlem of Jammu & Kashmir. Total of 21 samples were collected from three different locations (Anantnag, Sangam & Pampore), 7 samples from each location. For the purpose of experimentation, 21 samples were used. For the determination of index properties, various tests were conducted on these 21 samples of sand. These tests include, grain size distribution, determination of mean size, effective size, coefficient of uniformity, coefficient of curvature, maximum void ratio, minimum void ratio & relative density.

4. Results:

Table-1: Sand sample index properties

Sample No.	G	D_{50}	D_{60}	D_{30}	D_{10}	Cu	Cc	e_{max}	e_{min}
1	2.580	1.00	1.250	0.500	0.300	4.240	0.710	0.596	0.303
2	2.574	1.100	1.300	0.420	0.260	5.000	0.520	0.521	0.288
3	2.557	1.250	1.500	0.430	0.270	5.560	0.450	0.618	0.341
4	2.537	1.300	1.500	0.970	0.410	3.660	1.530	0.621	0.331
5	2.554	1.400	1.450	0.760	0.310	4.680	1.280	0.548	0.292
6	2.617	1.150	2.000	0.370	0.260	7.690	0.260	0.498	0.297
7	2.593	1.600	2.000	0.600	0.270	7.410	0.670	0.492	0.223
8	2.770	0.379	0.401	0.313	0.256	1.560	0.954	0.715	0.399
9	2.700	0.523	0.530	0.419	0.300	1.767	1.104	0.671	0.364
10	2.690	0.385	0.455	0.329	0.246	1.850	0.967	0.665	0.358
11	2.730	0.401	0.497	0.350	0.296	1.680	0.830	0.690	0.379
12	2.650	0.454	0.501	0.423	0.301	1.664	1.186	0.640	0.338
13	2.645	0.399	0.450	0.303	0.289	1.557	0.706	0.637	0.336
14	2.700	0.350	0.395	0.301	0.297	1.330	0.772	0.671	0.364
15	2.696	0.349	0.400	0.320	0.240	1.670	1.070	0.802	0.543
16	2.687	0.590	0.400	0.280	0.230	1.740	0.850	0.808	0.543
17	2.683	0.381	0.700	0.400	0.310	2.260	0.740	0.731	0.482
18	2.667	0.352	0.410	0.320	0.200	2.050	1.250	0.760	0.515

19	2.678	0.341	0.370	0.310	0.230	1.610	1.130	0.831	0.568
20	2.669	0.359	0.360	0.300	0.200	1.800	1.250	0.852	0.565
21	2.706	0.360	0.370	0.300	0.200	1.850	1.220	0.918	0.632

Table-2: Percentage deviation shown by predicted & experimental relative density values in case of standard proctor test.

Sample No.	Standard proctor test.		
	Experimental D_r values	Predicted D_r values	%age deviation
1.	57.67918	48.97922	15%
2.	83.2618	51.08779	38.6%
3.	64.25993	50.56063	21.3%
4.	66.55172	43.18161	35.1%
5.	72.65625	48.45211	33.31%
6.	76.61692	51.08779	33.32%
7.	70.26022	50.56063	28%
8.	45.88608	51.29865	11.8%
9.	65.47231	48.97922	25.19094%
10.	62.86645	51.82583	17.56202%
11.	58.84244	49.19007	16.40376%
12.	54.63576	48.92651	10.44966%
13.	58.47176	49.55906	15.24274%
14.	55.70033	49.13736	11.78264%
15.	67.56757	52.14214	22.82964%
16.	76.22642	52.66933	30.9041%
17.	61.04418	48.45211	20.6278%
18.	73.06122	54.25098	25.74586%
19.	77.94677	52.66933	32.42911%
20.	64.1115	54.25098	15.38027%
21.	62.93706	54.25098	13.80122%

Table-3: Percentage deviation shown by predicted & experimental relative density values in case of modified proctor test.

Sample No.	Modified proctor test.		
	Experimental D_r values	Predicted D_r values	%age deviation
1.	86.68942	75.99622	12.33507%
2.	86.69528	75.99808	12.33885%
3.	71.84116	75.99761	-5.78561%
4.	71.37931	75.99109	-6.46095%
5.	91.01563	75.99575	16.50253%
6.	82.08955	75.99808	7.420518%
7.	72.86245	75.99761	-4.30285%
8.	56.01266	75.99826	-35.6805%
9.	81.75896	75.99622	7.048451%
10.	62.54072	75.99873	-21.5188%
11.	67.20257	75.9964	-13.0856%
12.	66.55629	75.99617	-14.1833%
13.	83.72093	75.99673	9.226128%
14.	61.23779	75.99636	-24.1004%
15.	67.95367	75.99901	-11.8394%
16.	87.92453	75.99948	13.56282%
17.	83.13253	75.99575	8.584822%
18.	76.32653	76.00087	0.426667%
19.	84.41065	75.99948	9.964584%
20.	86.06272	76.00087	11.6913%
21.	69.23077	76.00087	-9.77903%

5. CONCLUSION:

Sand being an integral aggregate in the construction industry and at the same time, its proportion in soil affecting the properties to a large extend, it is imperative to study its properties and how these are affected. Based on this purpose, this study was conducted and 21 samples of river Jhelum sand were taken and analyzed. More focus was given on the relative density of the sample with respect to different compaction energies (viz standard and modified proctor compaction energy). Maximum and minimum void ratio were also evaluated. An attempt was also made to check any correlation between relative density and effective size. Since previous studies have only referred to relate relative density and mean grain size. Following conclusions were drawn from the study

1) A correlation exists between relative density and void ratio of sand, however the relation is not direct.
2) The correlation existing between relative density and void ratio ranges from narrow and wide deviation. The overall deviation of the correlation was observed to be more than 5 % in comparing experimental and predicted values.
3) Due to deviation greater than 5%, the correlation doesn't hold good for field purposes. However, it may be used only for predicting the relative density of sand on average basis.
4) Different parameters of sand like e_{max}, e_{min}, e_s, e_m have shown significant variation when correlated with effective grain size.

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