International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

IMPROVEMENT OF BEARING CAPACITY OF SANDY SOIL BY GROUTING

[1]Abolusoro S.A.; [2]Gana A.J; [3]Adewara Sunday O. & [2]*Olaitan A.O.*
[1]Department of Agriculture, Landmark University Omu-Aran, Kwara State
[2]Department of Civil Engineering, Landmark University Omu-Aran, Kwara State Nigeria
[3]Department of Economics, Landmark University Omu-Aran, Kwara State
Email: phildebo123@gmail.com; oladewara02@gmail.com

ABSTRACT
This research work is on improvement of bearing capacity of sandy soil by grouting. The sample was collected from Isaac area, Landmark University and subjected to various tests such as Compaction test, California Bearing Ratio (CBR), permeability, natural moisture content, and sieve Analysis Test. In relation to the subject matter, view of some scholars and authors were reviewed and the data collected which are presented and analysis accordingly, Conclusion and recommendation are made at the end of this research. However, the research work is not on itself as it is recommended further studies.
Keyword: improvement, bearing capacity, Sandy Soil, Grouting.

INTRODUCTION
Soil liquefaction is describing a phenomenon whereby a saturated or partially saturated soil substainlly loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid. Liquefaction is one of principal concern to the geotechnical community as well as those involved in the building and development of structural foundations. Ground improvement techniques are often used to strengthen sub soil properties in terms of its bearing capacity, shear strength, settlement characteristics and drainage (sanaz sayehv and et al, 2012). There are various grouting methods namely: compacting grouting, permeation grouting and jet grouting. I will be using the permeation grouting. The term ground improvement and ground modification is said to be the improvement or modification in the engineering properties of the soil that are carried out at a site where the soil in its natural state does not process properties that are adequate for the proposed civil engineering activity. Ground improvement is referred to as any procedure undertaken to increase the shear strength, reduce the permeability and compressibility or render the physical properties of soil more suitable for projected engineering use. A large number of soil improvement technic has been developed over the years which includes drainage, compaction, Preloading, reinforcement, grouting, electrical. Chemical or thermal methods. Among the various soil stabilization procedure, the most suitable one is selected depending upon the type of soil available, time, and cost involved.

The construction of structure on weak ground often requires the soil to be improved in order to ensure the safety and the stability of surrounding buildings. The selective of the most suitable method meant for the improvement of a particular soil sample depends on various factors such as: specific considerations available time for completion of the project, availability of

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

equipment and soil conditions, required degree of compaction, types of structure to be supported, as well as site materials etc. Soil compaction can offer effective solutions for many foundation problems and his especially useful for reducing total settlement in sand. Sandy soil means most of the soil particles are bigger than 2mm in diameter. It gives good water drainage and has a low capacity to hold nutrients. Sandy soil does not hold moisture very well. It is granular and consist of rock and mineral particle that are very small. Therefore, the texture is gritty and is formed by the disintegration and weathering of rocks such as limestone, granite, quartz and shale. Is also easier to cultivate it if it is rich in organic materials but then it allows drainage more than needed. This results in over drainage and dehydration of the plant in summer. It warms very fast in the spring season. Grouting on the other hand is a process whereby stabilizes either in the form of suspension or solution is injected into sub surface soil. Sandy soil is the largest particle in the soil when you rub it, if feels rough. This is because it has sharp edges and it does not hold many nutrients.

RESEARCH METHODOLOGY

Research methodology refers to the systematic producers for investigation of research problems. According to God and Hait, research methodology is logic or scientific investigation and Osuala (1982), research is simply the process of arriving at dependable solution to problem through the planned and systematic inquiring analysis and interpretation of data. That is to say research is the most important aimed at providing information to solve problem. Research is the most important tool for advancing knowledge and for the progress it enables man to relate more effectively to his environment, accomplish his purpose and resolve his conflict.
One of the objectives in this research is towards a better knowledge and good information to public that can make this study very significant. In this research work, detail investigation is used. Sample of Sandy soil will be taken from landmark university Omu-aran, Kwara state and the test will be practicalized in the laboratory at geotheanic and soil laboratory at landmark university Omu-aran, Kwara state.

Method of Data Collection

Compaction Test

Aim: To determine the relationship between moisture (water) and soil as it is been compacted at a particular comparative effort.
Compaction is a process by which the soil particles are artificially rearranged and packed together into a closer state of contact by mechanical means in order to decrease the porosity (or voids ratio) of the soil and this increase its dry density. The compaction process may be accomplished by rolling, tamping or vibration. It occurs when the weight of heavy machinery compresses the soil causing it to lose pore space. Soil compactment may occur due to a lack of water in the soil particles.

Apparatus:

1. Compactment mould 100mm diameter x *125mm* high with a 50mm high extensions collar, 2. Balances (0.01kg sensitivity and 0.1 sensitivity), 3. Compactment rammer *(4.5kg)*, 4.4.75mm

sieve (ASTM), 5 Moisture Can, 6.Steel straight edge, 7.Large mixing pan, 8.Dry oven, 9.Scoop and 10. Mould oil

Required Measurement

1. Weight of the empty mould, 2. Weight of the compactment mould with compacted soil,
3. Weight of moisture can, 4.Weight of the moisture can with wet sample and5. Weight of the moisture can with dry sample

Procedures:

Sample Preparation: The soil will be served through No 20 (44.7mm sieve) (ASTM) we obtained 8kg of the soil passing the sieve and poured it on a large mixing pan for proper mixing with specified water content.

Mould Preparation: The mould will be fixed to the base plate and weighed; the weight is recorded as MI, then we attached the collar to the mould and lightly oiled.

Compaction Procedures

i. The soil Sample was thoroughly mixed widely with the total weight of the sample and left for some time to cure before compaction commence.

ii. The soil was divided into approximately three equal parts.

iii. The first part of the soil sample (mixed) was filed into the mould given 25 blows of rammer evenly distributed over the surface of the soil.

iv. The remaining two parts are treated the same way but the last layer must be at least 6mm above the top of the mould when the collar was removed.

v. When the extension collar is removed, the excess soil is trimmed off with the straightedge to flush with top of the mould.

vi. The mould with the compacted soil was weighted without collars and the weight is recorded as M2.

vii. The sample was extruded from the mould and broken down with the representative sample taken from top for the moisture content determination.

viii. Step I to VII is repeated unit the weight of the soil and mould falls.

ix. I detained the moisture contact of the samples obtained for each test by oven dry it after the wet weight has been known.

California Bearing Ratio Test Procedure

Aim: The test is aimed at determining the suitability of a soil, this method covers the determination of the California Bearing Ratio (CBR) as a soil that is obtained by measuring the relationship between force and penetration when a cylindrical plunger of cross-sectional is area 1935mm^2 is made to penetrate the soil at a given rate. At any value of penetration, the ratio of the force to a standard force is defined the California Bearing Ratio (CBR). Because of the plunger size, the test is appropriate only to materials having a maximum particle size of 20mm.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

The test is more applicable in those tropical and subtropical areas where drier conditions prevail under roads and air fields.

Apparatus: The following apparatus were used
1. 20mm Bs test sieve 2. A cylindrical metal mould having an internal diameter of 152mm and an internal effective height of 127mm with detachable base plate and a collar 50mm deep, 3. A cylindrical metal plunger of cross-section area of 1935mm, 4. A machine for applying the test force through the plunger,5. A means of measuring penetration of the cylinder into the specimen, 6. Three annular surcharge discs each having a mass of 2kg an internal diameter of 52mm to 54mm and external diameter of 145mm to 150mm, 7. A metal rammer, 8. A steel straightedge, 9. A balance capable of weighing up to 25kg readable and accurate to 5g
10. Apparatus for moisture content determination and 11. Filter papers 150mm in diameter

Procedure

Compaction Stage

I. The soil sample was air dried
II. We obtained 8kg representative specimen of the soil sample which is to be tested. Break all soil lumps in a mortar with a rubber covered pestle and sieve the soil through a *4.75mm* sieve
III. I weighed the empty mould (with the base plate but without the extension collar) to 0.01kg and records its mass in the space provided on the data sheet
IV. The inner surface of the mould was printed with mould oil slightly and the filter paper is placed on the base plate
V. The soil was mixed in the mixing tray properly with the amount of water equal to the optimum moisture content of the soil which has been obtained from earlier compaction test
VI. The soil was divided into five equal parts and each part is compacted into the mould should be such that the last layer must be at least 6mm above the top of the mould when the collar is removed
VII. The extension collar was removed and the excess soil is trimmed off with steel straightedge to flush with the top of the mould.

Load Penetration Stage

The load penetration test may be carried out either in the soaked state but this practical deals with the unsoaked state.

Procedure:

1. The mould was placed on the lower plate of the CBR Machine and the machine adjusted unit the piston makes contact with the top of the sample
[Ensuring that no load is applied].
2. The penetration dial gauge was adjusted until is makes contacts with the mould and both load and penetration gauges were adjusted to zero.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

3. A suitable gear was selected so that a uniform penetration rate of about 1.27mmlmm is obtained
4. The proving reading [load reading] at penetration reading of 0.25mm,0.5mm, 0.75mm……..7.50mm are taken.
5. The mode was inverted and step iv was repeated on the button and the reading recorded on the data sheet.

Permeability

Theory

Permeable is a measure of the ease in which water can flow through a soil volume. It is one of the most important geotechnical parameters. However, it is probably the most difficult parameter to determine. In large part, it controls the strength and deformation behavior of soils. It directly affects the following:

a) Quantity of water that will flow toward an excavation
b) Design of cut -offs beneath dam on permeable foundations.
c) Design of the clay layer for a landfill liner.
d) For fine grained soil Failing head permeable test is done, whereas constant head.
e) Permeability test is done for the coarse-granted soil.

Apparatus/ Equipment

Combination permeameter assembly, Stop watch, Graduated cylinder (250 or 500ml), Balance sensitive to 0.01 1b, Moisture cans, Drying oven and Thermometer

Experimental Procedure

a) I compacted the sample in the lower chamber section of the permeameter, in layers approximately 1.5 cm deep, to within about 2 cm of the lower chamber rim. Use an appropriate tamping device to compact the sample to the desired density.
b) I removed the upper section of the chamber tie rods and place the upper porous stone on the specimen, securing the upper section of the chamber with spring to the unit.
c) then I measured and record the length of the specimen
d) clamp was used to attach the falling head burette to the support rod. Position the burette as high as is possible for practicality. Place the meter stick directly behind the burette, so the height of water in the burette above the c hanber outflow port may be read.
e) I then saturated the specimen, following the steps outlined above
f) I measured the height of the two levels from t he outflow level.
g) After a stable floe, has been established, note the drop-in head (Δh) in 2 hours. (Use a stop watch).

RESULT AND CALCULATION

The lab reports shall include the following:

a) Sample calculations.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

b) Table showing the calculation pertinent to the permeability of the soil.
c) average value of the permeability
d) Calculate the void ratio by oven drying the specimen and taking the dry mass.

Equation Used

$$k = \frac{aL}{At} \ln \frac{h_o}{h_1}$$

Where,
K = coefficient of permeability
a = area of the burette
L = length of soil column
A = area of the soil column
ho = initial height of water
h1 = final height of water =ho-Δh

Sieve analysis test

The grading of an aggregate is the quantitative distribution of its various articles sizes in terms of the proportion passing through sieves with square opening of different standard of apparatus. grading is determined by a sieve analysis on a sample to aggregate, in which a series of standard sieves are tested on stacked one on top of another with increasing apertures size from bottom to top and through which a sample of aggregate is passed from the usually aided by shaking or vibrating the sieves.

Unconfined compression test (use)

Scope

The unconfined compression test is used to measure the shearing resistance of cohesive soils which may be undisturbed or remolded specimens. An axial load is applied using either strain-control or stress-control conditions. The unconfined compressive strength is defines as the maximum unit stress obtained within the first 20% strain.

Apparatus

1. Hydraulic-actuated loading piston electronically controlled, with the capacity of infinite rates of strain and stress loads.
2. A load cell of 44.5KN or 222.5KN capacity is fastened to the piston to measure load on specimen. test data are displayed on control panel board readouts

Preparation on Sample

1. No special trimming is required when specimen obtained with the California sample are used in this test. Extrude the soil from the 101.6mm high sample retainer in which it is received by pushing it in same direction it entered the tube, and then place sample directly into position on the loading device.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

2. Trim soil which is received in a Shelby tube or a block sample to a 38.1mm x 38.1mm x 76.2mm rectangular block specimen for testing.
3. begin test immediately after the specimen is removed from the following formula:
qu= (P/A)(1-[? H/H])

Where:
qu = the unconfined compressive strength in kpa
P = maximum load in KN
A = initial cross-section area of test specimen in square millimeters.
H = initial height of test specimen.
H = reduce in height of test of specimen.
I- (? H/H) = correction for increased area assuming constant volume.

PROCEDURE

1. The first step in the procedure is to examine the loading frame. Turn the crank and learn how to read the load and deformation dial gages. Determine the calibration constant for the proving ring and the units of the deformation dial gauge.
2. I shared the samples at a strain rate of 1% per minute. From the length of your soil sample, determine the deformation at 1% strain. Depending on the units of the vertical deformation dial gauge (usual 0.001 inches), determine the number of dial divisions per 1 strain-practice turning the crank at his number of dial divisions/minute. It is important that the soil sample not be sheared faster than this specified rate
3. I measure the initial height and diameter of the soil sample with calipers. It is unlikely that the sample will be a perfect right cylinder. Therefore, it will be necessary to find the average height and diameter by taking several measurements in different places along the soil sample. The measurements should be taken by more than one member of a lab team to be sure that the caliper is read correctly. If you have any question about how to take measurements with calipers, ask the laboratory instructor for instruction.
4. I Recorded the weight of the soil sample and determine the total (most) unit weight.
5. I placed the soil sample in the loading frame, seat the proving ring and zero the dials.
6. I recorded the load applied at specified strain value. It is recommended that readings be taken at strains 0,0.1,0.2,0.5,1,2,3,4,5,6,8,10,12 14,16,18 and 20 percent. We will prerecord the vertical deformation dial readings at these strain values. With the measured initial height of sample (Ho),the desired percent strain(ε) and the initial dial reading (So), calculate the dial readings (S) as follows:

00)
100
SS (H ε
=+

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

7. Reading of force (F) are taken from the proving ring dial gauge and the ends of the sample (σ1 or major principal stress) is computed as follows:
=F 1 σ
Where A is the cross- sectional area of the sample. Because the soil sample height decreases during shear and the volume of the sample remains constant, the cross sectional area must increase. For a saturated soil that undergoes no volume change during shear (no flow of water into or out of the sample), the equivalent or average area (A) at any strain (e) is computed from the initial area (Ac) and the assumption that volume is conserved:
- ε
=
1
0 A A

Specific Gravity Test

Aim

To determine the specific gravity of soil fraction passing 4.75 mm I.S sieve by density bottle.

Need and Scope

The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.

Defination

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled waters at the temperature both weights taken in air.

Apparatus Required

1. Density bottle of 50ml with stopper having capillary hole, 2. Balance to weigh the materials (accuracy 10gm).
3. Wash bottle with distilled water and 4. Alcohol and water.

Experimental Procedure

1. I Clean and dry the density bottle
a .I washed the bottle with water and allows it to drain.
b .I washed it with alcohol and drains it to remove water.
c. finally I washed it with either, to remove alcohol and drain either.
2. i then Weighted the empty bottle with stopper (W_1)
3. I took about 10 to 20gm of oven soil sample which is cooled in desiccators. Transfer it to the bottle. Find the weight of the bottle and soil (W_2).
4. I put 10ml of distilled water in the bottle to allow the soil to soak completely. Leave it for about 2 hours.
5. Again filled the bottle completely with distilled water put the stopper and keep the bottle under constant temperature water baths (TX0).
6. I took the bottle outside and wipe it clean and dry note. Now determine the weight of the bottle and the constant (W_3).

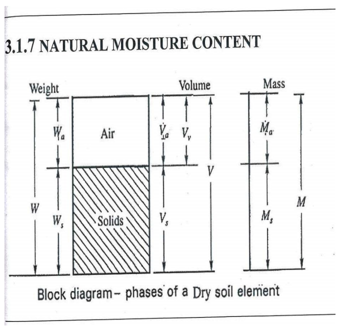
7. I now empty the bottle and thoroughly clean it. Fill the bottle with only distilled water and weigh it. Let it be W_4 at temperature (Txo C).
8. 1 repeated the same process for 2 to 3 times, to take the reading of it.

RESULTS AND CALCULATIONS

PRECAUTIONS

1) I ensured the pycnometer is cleaned and dried before commencing the test, 2) I Avoided parallax error.
3) I was very careful with the pyrometer to avoid breakage.

Natural Moisture Content



For Oven Drying Method

i. Metal container with lid (air tight, non-corrodible).
ii. Balance (0.01g sensitivity for fine grained soils and 0.1g sensitivity for medium grained soils).
iii. Oven (interior for non -corrodible material, controlled at 105 - 110 C temperature).
iv. Desiccators
v. Tong (one pair).

Grouting Material

Group can be generated in various ways. The selection of the appropriate grout compound to be injected depends on the effect to be achieved and on the properties of the injected materials to be permeated. Two classes of grouting material are generally recognized; suspension types grouts and solution types grouts. The suspension type grout includes soil, cement, lime, asphalt, emulsion e.t.c. While the solution type grouts include a wide variety of chemicals such as sodium silicates acrylamide lignosulphonates, aminoplast e.t.c. The type of cement to be used is processed cement such as (Portland cement). Which will be mix with water and injected directly into the soil void?

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

RESULTS AND ANALYSIS

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger sized particles and fine particles. The information by this test is used in soil classification for engineering purposes. After this process the soil was confirmed to be sandy and started fit for the experiment.

Table 4.2 Natural Moisture Content

WEIGHT OF CAN (g)	WEIGHT OF WET SAMPLE + CAN (g)	WEIGHT OF DRY SAMPLE + CAN (g)	MOISTURE CONTENT (%)
20.5	28	26.5	25
20.5	32.5	31	14
20.5	29	27.7	18
20.5	S30.5	29	18
			19

The above table shown the result of test carried out on finding the moisture content of the soil sample. With this result it has stated clearly that sandy soil is not fit for most engineering purposes. With this result above few properties of this sample were stated such as Bearing Capacity of soil, Settlement, state of the soil in the field. Therefore the strength of sandy soil is needs to be increased in order to get maximum strength and help for engineering constructions.

Table 4.3 Specific Gravity

MASS 1	MASS 2	MASS 3	MASS 4	SG	
16	33.5	78	67	2.69	
16	34	77.5	67	2.40	
16	36	76	67	1.82	AVERAGE
16	32.5	75	67	1.94	2.21

Unless or otherwise specified specific gravity values reported shall be based on water at 270C. The specific gravity of the soil particles lie within the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2.0. Soils having heavy substances may have values above 3.0.

Therefore the result of this test falls 3.0 which means the sample does not contain heavy substance and above 2.0 which disproves that the sample contains organic matter and porous particles.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Table 4.4.1 PERMEABILITY AT 0%

S/N	VOLUME	TIME (S)	TEMP (	h_o	h_1	K(COP)
1	100	35	26.5	50	167	1.63E-05
2	200	38	26.5	35	124	1.5736E-05
3	300	42	26.5	15	60	1.56033E-05
4	400	45	26.5	18	76	1.51311E-05
5	500	49	26.5	35	133	1.28794E-05
6	600	54	26.5	45	254	1.51507E-05
7	700	59	26.5	48	55	1.09074E-05
8	800	65	26.5	8	52	1.36131E-05
9	900	68	26.5	12	76	1.2832E-05
10	1000	73	26.5	80	94	1.04433E-06
						1.19E-05

This above table shows the results of the permeability test carried out on the soil sample before the grout was added to the soil

Table 4.4.2 Permeability at 2%

S/N	VOLUME	TIME (S)	TEM (C	h_1	° h_o	K(COP)
1	100	35	26.5	36	80	1.08E-05
2	200	38	26.5	35	124	1.5736E-05
3	300	42	26.5	15	60	1.56033E-05
4	400	45	26.5	18	80	1.56699E-05
5	500	49	26.5	35	133	1.28794E-05
6	600	54	26.5	45	254	1.51507E-05
7	700	59	26.5	48	55	1.09074E-06
8	800	65	26.5	8	58	1.44073E-05
9	900	68	26.5	17	117	1.01938E-05
10	1000	73	26.5	79.5	94	1.08493E-06
						1.12E-04

This results shows how the soil tested after 2% of grout has been added to the soil.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Table 4.4.3 Pemeability at 4%

S/N	VOLUME	TIME	TEMP ^0C	h_1	h_o	K(COP)
1	100	204	26.7	50	88	1.31E-06
2	200	473	26.5	45	65	3.67513E-07
3	300	653	26.5	50	105	5.37112E-07
4	400	920	26.6	45	107	4.45066E-07
5	500	1130	26.7	24	88	5.43546E-07
6	600	1400	26.7	45	93	2.45122E07
7	700	1519	26.6	50	88	1.75931E-07
8	800	1799	26.6	15	85	4.55805E-07
9	900	2018	26.7	16	93	4.12292E-07
10	1000	2304	26.7	15	88	3.63017E-07
						4.86E07

Above table shows the permeability of the soil when 4% grout was added to the soil sample.

Table 4.4.4 Permeability at 6%

S/N	VOLUME	TIME	TEMP	h_1	h_o	K(COP)
1	100	170	25.5	50	78	1.24E-06
2	200	396	26.4	34	80	1.02146E-06
3	300	625	25.5	65	82	1.75727E-07
4	400	856	25	61	75	1.14103E-07
5	500	1051	25	63	87	1.4518E-07
6	600	1437	25.5	54	90	1.68045E-07
7	700	1708	25.8	58	95	1.36569E-07
8	800	2011	26	59	94	1.09486E-07
9	900	2321	25	65	120	1.24873E-07
10	1000	2655	26	42	97	1.49037E-07
						3.38E-07

Above table shows the permeability of the soil sample after 6% of grout has been added.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

TABLE 4.4.5 PERMEABILITY 8%

S/N	VOLUME	TIME	°C TEMP	h_1	h_0	K(COP)
1	100	204	25.5	50	60	4.22E-07
2	200	429	26.4	25	75	1.21059E-06
3	300	689	25.5	50	87	3.80024E-07
4	400	881	25	50	62	1.15425E-07
5	500	1301	25	36	136	4.82951E-07
6	600	1867	25.5	50	100	1.75506E-07
7	700	2185	25.8	50	89	1.24751E-07
8	800	2515	26	45	75	9.60164E-08
9	900	2933	25	38	87	1.33505E-07
10	1000	3353	26	36	89	1.27609E-07
						3.2E-07

Result of the permeability test of the soil sample when 8% of grout was added.

TABLE 4.4.6 PERMEABILITY AT 10%

S/N	VOLUME	°C TIME	h_0 TEMP	h_1		K(COP)
1	100	430	26.9	50	88	6.21E-07
2	200	951	26.9	44	104	4.27593E-07
3	300	1541	26	35	100	3.2205E-07
4	400	1630	27.1	50	160	3.37333E-07
5	500	2607	27	50	135	1.80106E-07
6	600	2810	27	43	134	1.91217E-07
7	700	3400	27.1	15	94	2.55168E-07
8	800	3922	27	40	88	9.50345E-08
9	900	4300	27	10	83	2.32654E-07
10	1000	4711	27	11	87	2.07516E-07
						2.87E-07

As one would expect, the permeability decreases with increase in the percentage of cement. The reduction in permeability is only marginal in ` case of specimens cured for 7 & 14days, whereas the reduction is substantial as the curing period is increased to 28days.
Test result for permeability of the sample for 10% grout added.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

TABLE 4.4.7 SUMMARY OF PERMEABILITY

S/NO	%CEMENT	Permeability (k)
1	0	0.00000119
2	2	0.00000112
3	4	0.000000486
4	6	0.000000338
5	8	0.000000327
60	10	0.000000287

Similarly increased use of cement beyond 10% can influence the permeability at higher curing periods only.

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

TABLE 4.5 CALIFONIA BEARING RATIO

TABLE 4.5.1 CBR AT 0%

Time	Penetration (mm)	Dial Gauge Reading (mm)	Dial Gauge Reading (mm)	Force (KN)	Force (KN)	Swelling	Dial readings (mm)
0	0	TOP	BOTTOM	TOP	BOTTOM	Begin of soak	
25″	0.50		0		0.000	1 Day	
50″	1.00		16		0.350	2 Day	
1′35″	1.50		36		0.800	3 Day	
2′	2.00		54		1.200	4 Day	
3′	2.50		74		1.650	Linear swelling DI = mm	
4′	3.00		107		2.375	Linear swelling Relative DI/I =	%
6′	4.00		140		3.100	CBR value at penetration of 2.5mm	5.0mm
8′	5.00		178		3.950	Top 0.00	0
10′	7.50		250		5.550	Bottom 12.50	18.8
12′	10.00		355		7.900	**CBR(%)**	19.8
14′	12.50		485		10.800		

This above table shows the result for the cbr test carried out on the soil sample at 0% grout.

CBR Value at penetration of	2.5mm	5.0mm
Top	0.00	0
Bottom	12.50	19.75
CBR (%)	19.8	

TABLE 4.5.2 CBR AT 2%

Time	Penetration (mm)	Dial Gauge	Dial Gauge	Force (KN)	Force (KN)	Swelling	

		Reading (mm)	Reading (mm)				
0	0	TOP	BOTTOM	TOP	BOTTOM	Begin of soak	
25''	0.50		20		0.433	1 Day	
50''	1.00		40		0.866	2 Day	
1'35''	1.50		50		1.082	3 Day	
2'	2.00		70		1.515	4 Day	
3'	2.50		80		1.732	Linear swelling Dl = ________ mm	
4'	3.00		90		1.948	Linear swelling Relative Dl/l = ________ %	
6'	4.00		170		3.680	CBR value at penetration of 2.5mm	5.0mm
8'	5.00		216		4.787	Top 0.00	0
10'	7.50		650		14.017	Bottom 13.12	23.933
12'	10.00		1500		32.042	**CBR(%)** 23.9	
14'	12.50		1870		39.711		

The above table shows the result of CBR test on the soil sample at 2% grout.

CBR Value at penetration of	2.5mm	5.0mm
Top	0.00	0
Bottom	13.12	23.9325
CBR (%)	23.9	

TABLE CBR AT 4%

Type of soil		Sampling location	
Sampling depth		Date	

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Optimum moist content (%)		Dry density (Mg/m^3)	2.003
Weight of sample (kg)		Water content of sample	
Water additive (ml)		Soaking (days)	
Soaking Period (days)		Surcharge (kg)	4
Stabilization		Operator	

Calculation of achieved compaction			Moisture content	A	B
Wt. of wet soil + mould (g)	G1	11339	Container no.	RW	OK
Weight of empty mould(g)	G2	6306.5	Wt. of wet soil + container (g)	61.5	69.5
Wt. of wet soil (g)	G3=G1-G2	5032.5	Wt. of dried soil + container (g)	57.5	64.5
Volume mould (cm^3)	Vm	2303	Wt. of container (g)	23.5	23.5
Wet density (Mg/m^3)	D=G3/Vm	2.185	Wt. of water (g)	4	5
Dry density (Mg/m^3)	$d_d=d/1+W$	2003	Wt. of dried soil (g)	34	41
				11.8	12.2
Achieved compaction ____________%			Average	12.0	

Time	Penetration (mm)	Dial Gauge Reading (mm)	Dial Gauge Reading (mm)	Force (KN)	Force (KN)	Swelling		
0	0	TOP	BOTTOM	TOP	BOTTOM	Begin of soak		
25″	0.50		40		0.866	1 Day		
50″	1.00		50		1.082	2 Day		
1′35″	1.50		80		1.732	3 Day		
2′	2.00		90		1.948	4 Day		
3′	2.50		115		2.489	Linear swelling Dl = ____________mm		
4′	3.00		170		3.680	Linear swelling Relative Dl/l = ________%		
6′	4.00		200		4.329	CBR Value at penetration of	2.5mm	5.0mm
8′	5.00		300		8.543	Top	0.00	0
10′	7.50		475		10.278	Bottom	18.86	43

International Journal of Engineering and Emerging Scientific Discovery
ISSN: 2536-7250 (Print): 2536-7269 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

12′	10.00		818		17.576	CBR(%)	42.7
14′	12.50		1327		28.382		

The table above shows the result of CBR test out on the soil sample for which the grout was 4%.

CONCLUSION

From the practical carried out, it indicates that the grouting method plays an important role in the area of improvement of soil strength among many other forms of soil improvement techniques. The values of safe bearing capacity computed from the results conducted on samples of the sandy soil of different grout percentage certifies this procedure shows that the maximum safe bearing capacity achieved by maximum CBR in the laboratory is up to 87.8% that will make soil very suitable for most construction works.

Some of the improved soil can be reused for construction projects. When additives such as cement are used during soil improvement, they increase the bearing capacity of soil for construction works. The soil will help the engineer in knowing the intended materials to be used in stabilizing the soil. The share strength of the soilwill determine the type of engineering construction the soil can be used for. When the bearing capacity of soil is known, the load to be imposed on such soil will be well calculated and such soil will be fit to carry the load.

RECOMMENDATION

It is quite possible to make use of sandy soil without grouting but because of the properties of sandy soil, it has made it unreliable type of soil for most engineering construction works. It has loose soil particles and high permeability and affects it bearing capacity, grouting is an engineering technique which is most suitably recommended to make it strong and increase the strength and bearing capacity of the loose sandy soil. The selection of the stabilization method should be based as much as possible on the compositional elements of the soil (grain size distribution of clay content, organic matter, and area contents) type of clay, and the physiological characteristics of the region. The above factors will exit in predicting the performance a given stabilizing admixture before laboratory test on actual work is committed, which may results and end waste of resources. In order to increase the number of alternative for the selection of the sandy soil materials, the uses of soil survey maps, geological tools notably electrical resist and reaction subsume should be considered.

The standard that have prescribed for soil in temperature regions should be used cautiously in deterring the stability of sandy soil for use in construction most often the soil properties are changed during sample preparations and bead to the rejection of lateric soil. This would not have otherwise performed satisfaction in the field. This may also leads to prescribing wrong sterilization methods on the other good sandy soil.

REFERENCES

Al-awad, M.N.J., (2002). Simple correlation to evaluate Mohr Coulomb failure criterion using unaxial compression strength. Riyadh; Saud University Press.

Arenzena, L. Krizek, R.J., and Pepper, S. F (1989). Injection of dilute microfine cement suspensions fine sands. Brazil; New Age press.

Ata A. and Vipulanadam C. (1998): Cohesive and adhesive properties of silicate grout on grouted and behavior. London, Oxford Printing Press.

Bolgncsi, A.J.L and Moretto, O. (1993): Stage grouting preloading of large piles on sand. Moscow, Engineering press Inc.

British Standard 1377 (1967). Method of test soil for Civil Engineering Propose. Lomdon; British standard institute.

Clarke, W.J., Royal, M.D and Helal, M. (1992). Ultrafine cement tests and dam test grouting. New York; Pretence Hall Inc.

De Paoli, B., Bosco, B., Granata, R. and bruce, D.A. (1992). Fundamental observation on cement based grouts. New York, McGraw Hill Highness Education.

Deere, D.U. (1982). Cement – Bentonite grouting for dams. New York; New York; New edge Press

Eklund, D. and stille, H. (2007). Penetrability due to filtration tendency of cement based grouts. London. Tunneling and underground space technology press.

Heh, K.S (1990). Dynamic compaction of sand. Brooklyn, Brooklyn Polytechnic University Printing Press.

Ibragimov. M. N, (2005): Soil stabilization with cement grouts. Singapore Nanyang Printing Press.

Jaritngam, S. (1996): Method of reducing soil movements for deep excavations in soft clay. Singapore; John Wiley and Sons.

John, A.A (1982). Cement Grouting practice. California: Wadsworth Publishing Company.

Lewis W.A (1958): Further studies in the compaction of soil and the performance of compaction plan. London; Oxford University Press Ltd.

Lovely, K.M, (1998): Effect of admixtures on the behavior of cement grouts. New Delli; Indian Geotech Press.

Mehta, P.K and Monteiro, P.J.M (2002). Concrete Microstructure, Properties and materials. Chennai; Indian Concrete Institute.

Nonveiller, E. (1989). Grouting theory and practice. New York; Elsevier Publishing Company.

Osual, E. Resta (1972). The Research Methodology. 2nd Edition, Onitsha; Afrocana Fep. Publishers Ltd.

Shroff, A.V and Shah, D.L. (1992). Grouting technology in tunneling and dam construction. New Delhil; Oxford and IBH Publishing Company.

Terzaghi. K., Peck. R.B. and Mesri. G. (1996). Soil mechanics in engineering practice Singapore; John Wiley and Sons.