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Comparative Stability of Over Head Tanks Based on Soil Properties in Different Localities of Lucknow

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ABSTRACT*: Many a times, we come across instances of settlements of structures in a particular area. These settlements could be differential or uniform (beyond a specified limit).This poses a threat to safety and well-being of the residents in the vicinity, while leading to huge economic losses. Thus this research is aimed at analyzing the characteristics of the soil samples collected from various localities of the city of Lucknow, situated in Uttar Pradesh, India and drawing out a comparative study of stability of structures based on the data recorded and to propose any solutions if applicable. For the analysis, soil samples were collected from Jankipuram, Lalkuan, Civil Lines, Cantonment area and Malihabad in Lucknow. Various laboratory tests such as Sieve analysis test, Atterberg's limit test, Specific gravity test, direct shear test etc were conducted and the best and worst areas for construction were spotted. Adequate remedial measures were provided.*

KEYWORDS*: overhead tanks, construction, stability, soil tests, Lucknow sites, Lucknow buildings*

I. INTRODUCTION

To prevent settlement of structures, numerous factors such as ground properties, shape and size, construction techniques, properties of materials used etc. are responsible. In this study I have sought out to focus on the impact of soil properties such as the Atterberg's limits, consistency, porosity, shear strength etc. on the stability of buildings and houses.

Significance of the study

It is imperative to determine the stability of a structure such as an overhead tank or a building constructed at a particular place, based on preliminary tests conducted on the soil collected from the site. This ensures the safety of not only the residents of the particular residential establishment under consideration but also of people in the neighborhood.

It also enables the constructors to choose a better locality for constructing a house or a building, to fend off the economic losses due to subsequent settlements. It'll also help to reduce the cost involved in construction, due to extrication of costs involved in ground improvement.
Furthermore it helps to determine the corrective measures to be employed in a particular construction site.

Objective

To collect the soil samples from different localities of Lucknow and to determine the best and worst areas for construction of Overhead tanks based on tests conducted and to provide suggestions for ground improvement.

Comments on the treatment of topic

The topic being "comparative study of stability of buildings in different localities of Lucknow", I collected the soil samples from 5 different areas, viz. Jankipuram, Lalkuan, Civil Lines , Cantonment area and Malihabad and performed various tests on them.

Research Questions:

There were various questions which needed to be answered. Such as-
Which locality amongst the ones considered is best for the construction of an overhead tank in Lucknow?
Which locality amongst the ones considered is worst for the construction of an overhead tank in Lucknow?
What solutions could be provided for improving the ground conditions in certain localities, where ground improvement is needed?

II. DATA COLLECTION

Methodology*:*
1) About 1 kg of soil sample was collected from the aforementioned 5 different localities of Lucknow.
2) Adequate weight of soil sample was used for various tests conducted on the soil samples.

Data Analysis:

The following tests were conducted on the soil samples-

Sieve Analysis Test
1) Sieves are stacked one upon another such that each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver.
2) The column is typically placed in a mechanical shaker. The shaker shakes the column, for some fixed amount of time.
3) After the shaking is complete the material on each sieve is weighed. The weight of the sample of each sieve is then divided by the total weight to give a percentage retained on each sieve.
4) The size of the average particle on each sieve is then analysed to get a cut-off point or specific size range, which is then captured on a screen.

Liquid Limit Test:
1) Adjust the liquid limit device by means of the adjustment plate on the device and the gauge on the handle of the grooving tool, so that the centre of the wear point on bottom of cup is lifted exactly 1 cm above the base. Secure adjustment plate by tightening screws.
2) Place approximately 100 grams of prepared soil in the evaporating dish and add 15 to 20 ml of water and mix water thoroughly with the soil. Then add sufficient water and thoroughly mix to form a uniform mass of stiff consistency.
3) Place mixture in the cup over the spot where the cup rests on the base and spread into place with as few strokes as possible to a depth of 10 mm.
4) Divide the soil in the cup with a firm stroke of the grooving tool along the diameter through the centreline of the cam follower.
5) Turn the crank to raise and drop the cup twice per second until the two sides of the grooved sample come in contact at the bottom of the groove for a distance of 12.5 mm.
6) Record the number of blows.
7) Plot a no. of blows vs. water content graph.
8) The water content corresponding to 25 blows is the liquid limit.

Plastic Limit Test:
1) Place approximately 20 grams of the prepared soil in evaporating dish and thoroughly mix with water until the mass becomes plastic enough to be shaped into a ball.
2) Take approximately 8 to 12 grams of the moistened soil and form into a uniform mass roughly elliptical in shape.
3) Roll the ball of soil by hand on the rolling surface with just enough pressure to form an elongated thread as rolling proceeds.
4) If the soil can be rolled to a thread 3 mm thick without crumbling, amass it and re-roll it.
5) Repeat rolling and amassing until the soil crumbles under slight pressure required for rolling. Crumbling may occur when the soil has a diameter greater than 3 mm; however, this is considered a satisfactory end point, provided the soil has been previously rolled into a 3 mm thread.
6) Gather portions of the crumbled soil and place in tarred aluminium can and weigh, then oven dry at 110oC to a constant weight and weigh again after cooling.

Water Content Determination:
1) Record the moisture can and lid number. Determine and record the mass of empty, clean, and dry moisture can with its lid.
2) Place the moist soil in the moisture can and secure the lid. Determine and record the mass of the moisture can (now containing the moist soil) with the lid.
3) Remove the lid and place the moisture can (containing the moist soil) in the drying oven that is set at 105 °C. Leave it in the oven overnight.
4) Remove the moisture can. Carefully but securely, replace the lid on the moisture can using gloves, and allow it to cool to room temperature. Determine and record the mass of the moisture can and lid (containing the dry soil).

1. Empty and clean the moisture can and lid.

Specific Gravity Test

1) Determine and record the weight of the empty clean and dry
2) Pycnometer.
3) Place 10g of a dry soil sample passing 4.75 mm sieve in the pycnometer.
4) Determine and record the weight of the pycnometer containing the dry soil.
5) Add distilled water to fill about half to three-fourth of the pycnometer. Soak the sample for 10 minutes.
6) Apply a partial vacuum to the contents for 10 minutes, to remove the entrapped air.
7) Stop the vacuum and carefully remove the vacuum line from pycnometer.
8) Fill the pycnometer with distilled (water to the mark), clean the exterior surface of the pycnometer with a clean, dry cloth.
9) Determine the weight of the pycnometer and contents.
10) Empty the pycnometer and clean it. Then fill it with distilled water only (to the mark). Clean the exterior surface of the pycnometer with a clean, dry cloth. Determine the weight of the pycnometer and distilled water.
11) Empty the pycnometer and clean it.

Direct Shear Test:

1) After the specimen is placed in the box, and all the other necessary adjustments are made, a known normal load is applied.
2) Then a shearing force is applied. The normal load is held constant throughout the test but the shearing force is applied at a constant rate of strain.
3) The shearing displacement is recorded by a dial gauge.
4) Dividing the normal load and the maximum applied shearing force by the cross-sectional area of the specimen at the shear plane gives respectively the unit normal pressure and the shearing strength at failure of the sample.
5) These results may be plotted on a shearing diagram where normal pressure is the abscissa and shearing strength the ordinate. The slope of the line gives the angle of shearing resistance and the intercept on the ordinate gives the apparent cohesion.

Consolidation Test:

1) Weigh the empty consolidation ring together with glass plate.
2) Measure the height (h) of the ring and its' inside diameter (d).
3) Extrude the soil sample from the sampler, generally thin-walled Shelby tube. Determine the initial moisture content and the specific gravity of the soil as per Experiments 1 and 4, respectively (Use the data sheets from these experiments to record all of the data).
4) Cut approximately a three-inch long sample. Place the sample on the consolidation ring and cut the sides of the sample to be approximately the same as the outside diameter of the ring. Rotate the ring and pare off the excess soil by means of the cutting tool so that the sample is reduced to the same inside diameter of the ring. It is important to keep the cutting tool in the correct horizontal position during this process.
5) As the trimming progresses, press the sample gently into the ring and continue until the sample protrudes a short distance through the bottom of the ring. Be careful throughout the trimming process to ensure that there is no void space between the sample and the ring.
6) Turn the ring over carefully and remove the portion of the soil protruding above the ring. Using the metal straight edge, cut the soil surface flush with the surface of the ring. Remove the final portion with extreme care.
7) Place the previously weighed Saran-covered glass plate on the freshly cut surface, turn the ring over again, and carefully cut the other end in a similar manner.
8) Weigh the specimen plus ring plus glass plate.
9) Carefully remove the ring with specimen from the Saran-covered glass plate and peel the Saran from the specimen surface. Centre the porous stones that have been soaking, on the top and bottom surfaces of the test specimen. Place the filter papers between porous stones and soil specimen. Press very lightly to make sure that the stones adhere to the sample. Lower the assembly carefully into the base of the water reservoir. Fill the water reservoir with water until the specimen is completely covered and saturated.
10) Being careful to prevent movement of the ring and porous stones, place the load plate centrally on the upper porous stone and adjust the loading device.
11) Adjust the dial gauge to a zero reading.
12) With the toggle switch in the down (closed) position, set the pressure gauge dial (based on calibration curve) to result in an applied pressure of 0.5 tsf (tons per square foot).

13) Simultaneously, open the valve (by quickly lifting the toggle switch to the up (open) position) and start the timing clock.
14) Record the consolidation dial readings at the elapsed times given on the data sheet.
15) Repeat Steps 11 to 13 for different preselected pressures (generally includes loading pressures of 1.0, 2.0, 4.0, 8.0, and 16.0 tsf and unloading pressures of 8.0, 4.0, 2.0, 1.0 and 0.5 tsf)
16) At the last elapsed time reading, record the final consolidation dial reading and time, release the load, and quickly disassemble the consolidation device and remove the specimen. Quickly but carefully blot the surfaces dry with paper towelling. (The specimen will tend to absorb water after the load is released.)
17) Place the specimen and ring on the Saran-covered glass plate and, once again, weigh them together.
18) Weigh an empty large moisture can and lid.
19) Carefully remove the specimen from the consolidation ring, being surenot to lose too much soil, and place the specimen in the previously weighed moisture can. Place the moisture can containing the specimen in the oven and let it dry for 12 to 18 hours.
20) Weigh the dry specimen in the moisture can.
21) Determine the required values.

Graphs

Following are instances of graphs obtained for various tests-

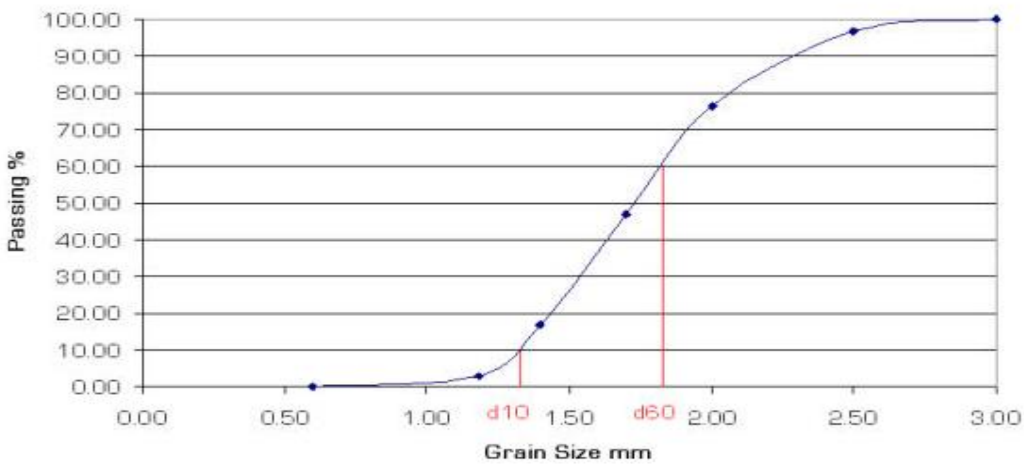

Fig1. Sieve analysis test

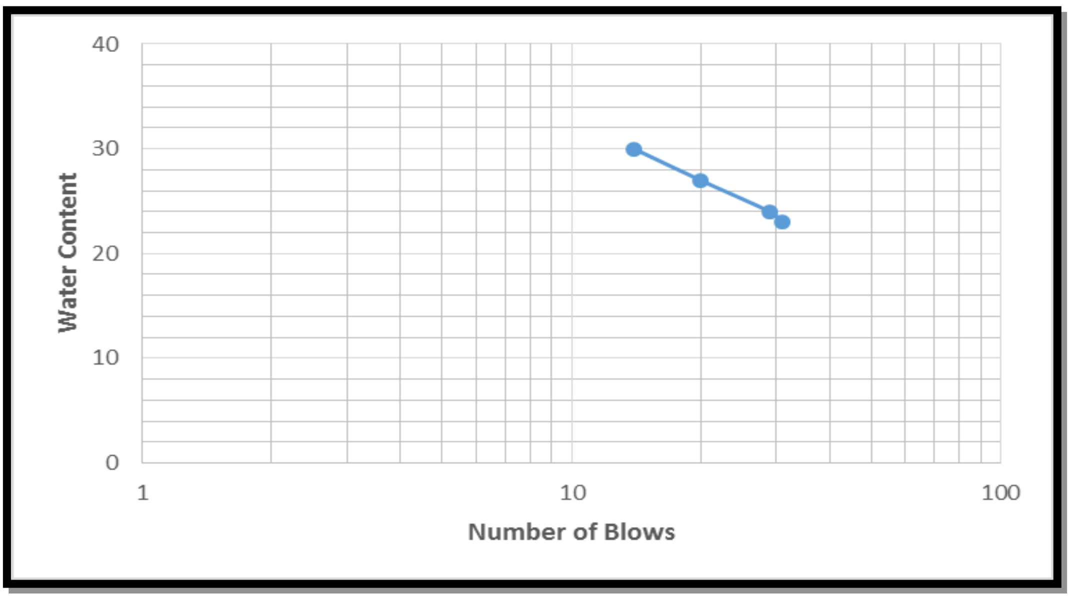

Fig2. Liquid limit test

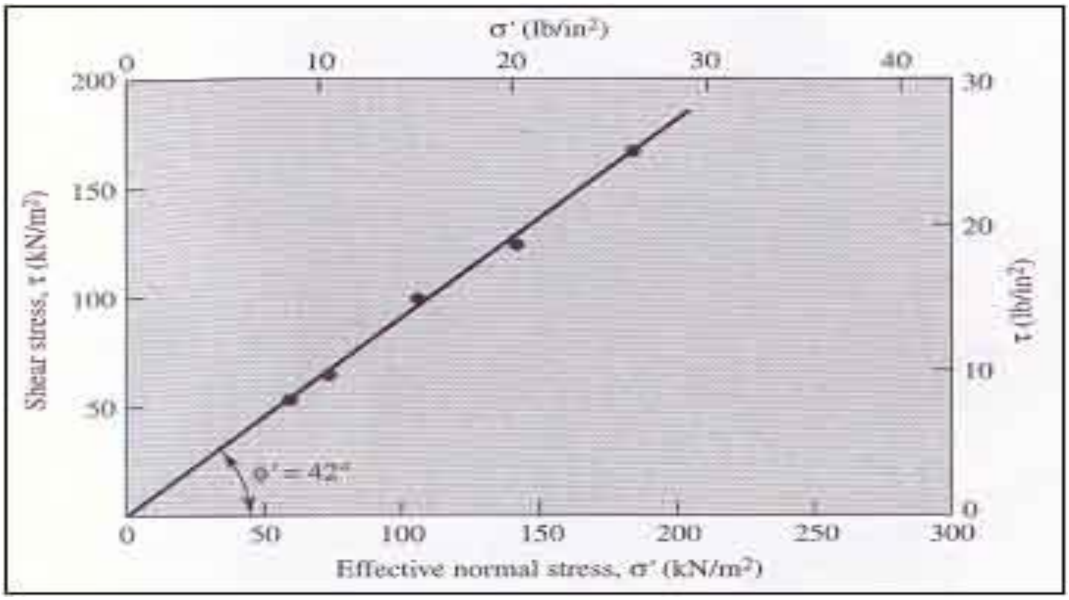

Fig3. Direct shear test

Results

The following results were obtained from the aforementioned tests conducted on the soil samples-

Jankipuram-

i. % passing sieve-
1.75 mm- 100
1.00 mm- 100
0.425 mm- 100
0.0075 mm- 99

ii. % Particle size –
Gravel (>4.75 mm) – 0.0
Sand (4.75- 0.075 mm) – 1.0
Silt (0.075-0.002 mm) – 68.0
Clay (>0.002 mm) – 31.0

iii. Atterberg's Limits –
Liquid Limit (LL %) – 47
Plastic Limit (PL %) – 24

iv. I.S. Group classification – MI (inorganic silt of Intermediate plasticity)

v. % Moisture content (W) – 29.0

vi. Indices-
Plasticity Index (PI) = (LL- PI %) – 23
Liquidity Index ((W- PL)/PI %) – 0.217

vii. Dry unit weight of soil (Y_D gm.) – 15.6

viii. Specific Gravity (G) – 2.72

ix. Void ratio (e) = $((G^* Y_w / Y_D) - 1)$ – 0.710

x. Porosity (n) = (e/(1+e)) – 0.415

xi. Shear Parameters-
Cohesion (c Kg/cm^2) – 0.0
Angle of internal friction (φ deg.) – 28
Shear Strength (c + Shear stress* tan (φ) Kg/cm^2) - 0.265

xii. Compressive index- 0.151

Lalkuan -

i. % passing sieve-
1.76 mm- 100
1.01 mm- 100
0.425 mm- 100
0.0075 mm- 94

ii. % Particle size –
Gravel (>4.75 mm) – 0.0
Sand (4.75- 0.075 mm) – 6.0
Silt (0.075-0.002 mm) – 78.0
Clay (>0.002 mm) – 16.0

iii. Atterberg's Limits –
Liquid Limit (LL %) – 33
Plastic Limit (PL %) – 20

iv. I.S. Group classification – ML (inorganic silt of low plasticity)

v. % Moisture content (W) – 22.7

vi. Indices-
Plasticity Index (PI) = (LL- PI %) – 13
Liquidity Index ((W- PL)/PI %) – 0.208

vii. Dry unit weight of soil (Y_D gm.) – 16.3

viii. Specific Gravity (G) – 2.67

ix. Void ratio (e) = $((G^* Y_w / Y_D) – 1)$ – 0.607

x. Porosity (n) = (e/(1+e)) – 0.377

xi. Shear Parameters-
Cohesion (c Kg/cm^2) – 0.32
Angle of internal friction (φ deg.) – 11
Shear Strength (c + Shear stress* tan (φ) Kg/cm^2) – 0.417

xii. Compressive index- 0.150

Civil Lines -

i. % passing sieve-
1.77 mm- 97
1.02 mm- 95
0.425 mm- 92
0.0075 mm- 89

ii. % Particle size –
Gravel (>4.75 mm) – 3.0
Sand (4.75- 0.075 mm) – 8.0

Silt (0.075-0.002 mm) – 75.0
Clay (>0.002 mm) – 14.0

iii. Atterberg's Limits –
Liquid Limit (LL %) – 30
Plastic Limit (PL %) – 18

iv. I.S. Group classification – ML (inorganic silt of low plasticity)

v. % Moisture content (W) – 22.2

vi. Indices-
Plasticity Index (PI) = (LL- PI %) – 12
Liquidity Index ((W- PL)/PI %) – 0.35

vii. Dry unit weight of soil (Y_D gm.) – 16.3

viii. Specific Gravity (G) – 2.67

ix. Void ratio (e) = $((G^* Y_w / Y_D) - 1)$ – 0.607

x. Porosity (n) = (e/(1+e)) – 0.377

xi. Shear Parameters-
Cohesion (c Kg/cm^2) – 0.32
Angle of internal friction (φ deg.) – 11
Shear Strength (c + Shear stress* tan (φ) Kg/cm^2) – 0.417

xii. Compressive index- 0.146

Cantonment area-

i. % passing sieve-
1.78 mm- 100
1.03 mm- 100
0.425 mm- 100
0.0075 mm- 92

ii. % Particle size –
Gravel (>4.75 mm) – 0.0
Sand (4.75- 0.075 mm) – 8.0
Silt (0.075-0.002 mm) – 79.0
Clay (>0.002 mm) – 13.0

iii. Atterberg's Limits –
Liquid Limit (LL %) – 30
Plastic Limit (PL %) – 19

iv. I.S. Group classification – ML (inorganic silt of low plasticity)

v. % Moisture content (W) – 24.6

vi. Indices-
Plasticity Index (PI) = (LL- PI %) – 11
Liquidity Index ((W- PL)/PI %) – 0.509

vii. Dry unit weight of soil (Y_D gm.) – 16.2

viii. Specific Gravity (G) – 2.49

ix. Void ratio (e) = $((G^* Y_w / Y_D) - 1)$ – 0.508

x. Porosity (n) = (e/(1+e)) – 0.337

xi. Shear Parameters-
Cohesion (c Kg/cm^2) – 0.30
Angle of internal friction (φ deg.) – 12
Shear Strength (c + Shear stress* tan (φ) Kg/cm^2) – 0.406

xii. Compressive index- 0.139

Malihabad-

i. % passing sieve-
1.79 mm- 100
1.04 mm- 100
0.425 mm- 100
0.0075 mm- 93

ii. % Particle size –
Gravel (>4.75 mm) – 0.0
Sand (4.75- 0.075 mm) – 5.0
Silt (0.075-0.002 mm) – 66.0
Clay (>0.002 mm) – 29.0

iii. Atterberg's Limits –
Liquid Limit (LL %) – 41
Plastic Limit (PL %) – 21

iv. I.S. Group classification – MI (inorganic silt of intermediate plasticity)

v. % Moisture content (W) – 27.1

vi. Indices-
Plasticity Index (PI) = (LL- PI %) – 20
Liquidity Index ((W- PL)/PI %) – 0.305

vii. Dry unit weight of soil (Y_D gm.) – 16.1

viii. Specific Gravity (G) – 2.72

ix. Void ratio (e) = $((G^* Y_w / Y_D) - 1)$ – 0.657

x. Porosity (n) = (e/(1+e)) – 0.397

xi. Shear Parameters-
Cohesion (c Kg/cm^2) – 0.46
Angle of internal friction (φ deg.) – 7
Shear Strength (c + Shear stress* tan (φ) Kg/cm^2) – 0.521

xii. Compressive index- 0.137

III. CONCLUSIONS

1. **Based on Plasticity Index**:

Classification of soils based on plasticity is as follows-

- 0 - Nonplastic
- (0-5)- Slightly plastic
- (5-10) - Low plasticity
- (10-20) - Medium plasticity
- (20-40) - High plasticity
- >40 Very high plasticity

Thus from the results it is evident that soil in Jankipuram is most plastic and the soil in Cantonment area is least plastic.

Soil in Jankipuram is of medium plasticity, while in all other areas, it is of low plasticity.

2. Based on Liquidity Index:

Liquidity index of soil in Jankipuram is the least and it is greatest in Cantonment area. Greater liquidity index denotes greater undrained shear strength.

3. Based on Specific Gravity:

The specific gravity of soil samples obtained from all 5 localities lie in the range of 2.65-2.85, thus all the soils are free from considerable amount of organic and porous content. Neither do they contain a considerable amount of heavy particles.

4. ***Based on I.S. Classification:***

Soils in Civil Lines, Cantonment area and Lalkuan is of ML type i.e. Inorganic silt of low plasticity and the soils obtained from Jankipuram and Malihabad are of MI type i.e. Inorganic silt of intermediate plasticity.

5. ***Based on void ratio:***

Void ratio of soil is greatest in Jankipuram and least in Cantonment area. Thus the soil tends to minimize in volume under loading in Jankipuram and it tends to increase in Cantonment area.

Soil in Jankipuram is most permeable and it is the least permeable in Cantonment area.

6. ***Based on porosity:***

Porosity of soil in Jankipuram is the maximum and it is least in soil in Cantonment area.

7. ***Based on Shear Strength of soil:***

Shear strength of soil in Jankipuram is the least and it is greatest in soil in Malihabad. The soil with more shear strength is able to develop more shear resistance.

8. ***Based on Compressive index of soil:***

Compressive Index of soil in Jankipuram is the greatest and it is least in soil in Cantonment area.

Soil with more compression index undergoes more settlement due to consolidation.

IV. OVERALL RESULT

From the above conclusions, it is evident that the overhead tanks and other structures are comparatively most stable in Malihabad and Cantonment area and least stable in Jankipuram.

Charachteristics Of Good Quality Soils For Construction

1) Low moisture retention.
2) High soil infiltration rates.
3) High Shear Strength.
4) Low compaction.

Charachteristics Of Inferior Quality Soils For Construction:

1) High moisture retention.
2) Low soil infiltration rates.
3) Low Shear Strength.
4) High compaction.

V. SUGESSTIONS

The following measures could be adopted to increase the properties of soils, where construction has to be done-

1. Ground improvement through the following methods-

- Chemical–Addition of chemicals such as lime, cement or other chemicals
- Mechanical– Densification
- Preloading
- Thermal–By heating the ground
- Electrical–Electro-osmosis
- By inclusions-Reinforced earth ground.

2. In-situ under reamed soil foundation could be provided.
3. The engineers may adopt design and type of foundation based on the property of soil present on the site.

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