Study on ElastoPlastic Analysis of Tunnel Model with Permeation Grouting By Bentonite

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Abstract— The construction of structure on weak ground often requires the soil to be improved in order to ensure the safety and stability of surrounding structure. Due to this poor construction activity the building can face many problems like settlement. The low bearing capacity of foundation bed causes shear failure and excessive settlement. sanaz sayehvand et.al, (2012) vol-17 To overcome these problems many ground improvement techniques are used. Ground improvement techniques are used to strength sub soil properties in terms of bearing capacity james joyco et.al, (1992), shear strength, settlement characteristics and drainage. It consist two techniques which can be selected according to loading condition, Nature of weak soil.

In this project the permeation grouting is used to overcome this problem. Permeation grouting is an effective way to send grout into the sub surface without disturbing the soil subsurface nature. For permeation grouting process the bentonite is used is used as a grout to increase the bearing capacity of soil Kong Sio-Keong (2005). The main aim of this project is to increase the bearing capacity of sandy soil and reduces the settlement aamal, a.h, al-saidi(1997).The experimental results revealed that the increase betonite content Increases the load carrying capacity and decreases the settlement of sandy soil.

Design and analysis of tunneling and underground structures is one of the challenging area of geotechnical engineering. In present study, analysis is taken for the problems arising in the tunnel section due to the soil & rock behavior in underground. To avoid collapse or failures in tunnels, proper bearing capacity improvement of the ground is essential so to improve the ground in well and good manner the proper analysis of section is expected to be done. In the present work, I have analyzed the sections before excavation & existed tunnel. So, for the purpose, PLAXIS-2D software is used, as it is fast, economical and accurate, and the tunnel section can modeled as plain strain. In this project by using the PLAXIS-2D software the deformation and stress analysis and their distribution in different situation are done. PLAXIS-2D is a 2-dimensional indirect Finite element program and can be used for the elastic stress/elasto-plastic analysis of underground excavations. Here we have used plain strain conditions with elasto-plastic model. Displacement vectors and deformed boundary shape are plotted to illustrate general deformation trends. Here, it has been tried to distinguish the displacement and stress distribution of the tunnel section in different position under sloped region as well. after founded all the deformation and stress distribution critical point in the soil mass i started to adopt the suitable ground improvement technique through the laboratory model, in present work i utilized permeation grouting by bentonit, to improve the bearing capacity of the sandy soil and to improve the engineering property of the soil

The construction of tunnel on weak ground often requires the soil to be improved in order to ensure the safety and stability of surrounding structure. Due to this poor construction activity the building can face many problems like settlement. The low bearing capacity of foundation bed causes shear failure and excessive settlement. sanaz sayehvand et.al, (2012) vol-17 To overcome these problems many ground improvement techniques are used. Ground improvement techniques are used to strength sub soil properties in terms of bearing capacity James joyco et.al, (1992), shear strength, settlement characteristics and drainage. It consist two techniques which can be selected according to loading condition, Nature of weak soil.

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INDEX TERMS— **Design and analysis Underground Structures, Failures in tunnels, PLAXIS -2D, Permeation grouting, bentonite Stress distribution and deformation mess**

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1 INTRODUCTION

The construction of the structure on weak ground often requires the soil sand to be improved in order to ensure the safety and the stability of surrounding building. Ground improvement granular sand can be achieved by different methods such as vibro – Floatation, compaction piles, compaction with explosives, excavation and replacement, well point system, reinforced earth, grouting ect…

The selection of most suitable method depends on a variety of factors, such as sand condition, required degree of the compaction, type of structures to be supported,

Maximum depth of compaction, type of structure to be supported. Maximum depth of compaction, as well as site specific consideration Such as sensitivity of adjacent structures or installations, available time of completion of the Project contractor's competition, availability of materials

And equipment's ect..

A question has been raised as how to increase the relative density of loose sand located within shallow depths. It is an inevitable problem in dynamic soil improvement method that vibrates induced on the ground surface tends to loosen the cohesion less soils. Hence alternative methods for density and strength of

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Loosen sand at shallow depths are required Soil stabilization with grouts injections under pressure, has come into wide spread use in construction. At present the method of grouting is highly prevalent in a number of branches of structural engineering and in foundation engineering, beneath the buildings and structures as well for strengthening the soils in their beds. The permeability and the dispersivity of the admixture- water suspension, which can be characterized by its grain size distribution, serve as criteria

for groutingMoreover this method is sufficiently economic, and does not require complex equipment, and is also economically safe for the environment. Permeation grouting substantially alerts the strength, modulus

Failure strain and mode of failure of sand. It would be both practical and useful to estimate the properties of grouted sand from the constituent properties that will lead to proper selection of grouts. The compressive behavior of the grout the grout sand adhesion (bonding), and the properties of the sand.

The physical or chemical interaction or both of two materials at their interface is known as adhesion or bonding. The strength and type of this bond plays an important, through poorly understood, role in the mechanical behavior of chemically grouted geomaterials. Grouting by impregnation in granular media is a widely used technique in civil engineering applied in order to improve the mechanical characteristics of soils.

Setting of admixtures grout in the pore in the spacing increases both the strength and stiffness. Grouting is mainly responsible for the gain in cohesion by the material and only marginally affects the friction angle. The cohesion linearly varies with admixture content, the magnitude of the cohesion grained by grouting and also the friction angle is a slightly increasing function of grout content.

The increase in angle of friction is negligible with respect to cohesion. The relative density of the soil and increase in proportion with the admixture to water ratio.

Introduction of an admixture agent into sand imparts two components of strength, one due to the admixture itself and the other due to friction. The friction angle of the grouted sand. In this process of permeation grouting, admixture is used to fill the voids of the soil mass and to render it impervious to percolating water and improve the strength and elastic property of the sandy soil.

The strength of the sandy soil increases in cohesive strength and angle of internal friction arising from the bonding between sandy soil grains and hydrated admixture. The water ratios have much influence in the control of strength gain of sandy soil.

Admixtures are used in the grouting as cement,bentonite, antibleederfluidizer, expander etc…these admixtures added to impart some additional properties , may affect the basic requirements such as viscosity and bleeding of grouts. At lower water ratio, the increase in viscosity is not significant but viscosity considerably increases with higher water ratios.

As grouting reduces pore size and alters pore structures of soil, the engineering properties such as strength, stiffness ect…are also influenced to a great extent. Even today the grouting operations are based on thumb rules and Existing practices rather than design principles and well defined procedures substantiated by research data. In this project an attempt of grouted loose sand bed by Permeation grouting using an admixture BENTONITE

2.3 CONCLUSION FROM THE REVIEWS

The reviews of literature gives an over view of researches were done permeation grouting. The above literatures the various prevention methods of low bearing capacity and settlements are briefly given. From thoseLiteratures the guidelines of researches, the grout ratio of permeation grouting and its corresponding test methods for the permeation grouting has been chosen. The permeation grouting method should increase the bearing capacity and decrease the settlement of sandy soil.

3 SAMPLE COLLECTIONS

We collected the disturbed soil sample from Aranthangi in pudhukottai district. The soil sample is collected at the depth of 2.0 m from the existing ground level. River sand was used in the present study and was graded. Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions. In terms of particle size as used by geologists, sand particles range in diameter from 0.0625mm (l/16mm) to 2mm.

3.1 GENERAL

An individual particle in these range size is termed as sand grain. Sand grains are between gravel (with particles ranging from 2mm up to 64mm) and silt (particles smaller than 0.0625mm down to 0.004mm). The size specification Between sand and gravel as remain constant for more than a century.

From ISO 14688 grade sand as fine medium and coarse with ranges 0.063mm to 0.2mm to 0.63mm to 2.0mm.the sand is commonly divided into five sub categories based on size. Very fine sand (l/16 to l/8mm dia), fine sand l/8mm to l/4mm, medium sand(l/4mm to l/2mm) coarse sand(l/2mm to lmm)very coarse sand(lmm to 2mm).

DETERMINATIONOF SOILPROPERTIES

SPECIFIC GRAVITY TEST

The specific gravity of a material is defined as the ratio of the mass of a unit volume of a material to the mass density of gas-free distilled water at a stated temperature. The specific gravity of a soil is used in the phase relationship of air, Water and solids in a given volume of the soil.

General

A material with a specific gravity greater than water is denser than water so it will not float in water. Specific gravity is used in computations involving phase relationships that are expressed in terms of unit weight, where unit weight is defined as the weight of material per unit volume. The specific gravity of soil solids falls within the following ranges of values.

Pycnometer is a glass jar of about 900 ml capacities with a conical brass cap having 6 mm diameter hole in the center screwed with a rubber washer as shown in fig. 4.2.

4.1.2 The uses of Specific Gravity are:

1. To determine size to particles by stokes law..
2. To determine void ratio of fully saturated soil on knowing its water content.
3. To determine unit weight of soil on knowing other properties of soil.
4. May be useful in mineral classification

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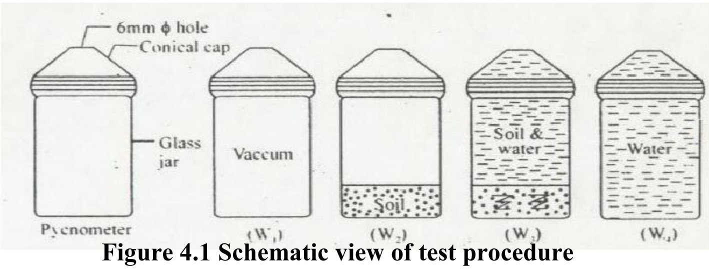

Figure 4.1 Schematic view of test procedure

Figure 4.2 Pycnometer test arrangement

Gravity (G) = (w2-wl)/ [(w2-wl)-(w3-w4)]

Where,

Wl = weight of empty pycnometer
W2 = weight of pycnometer with sand
W3 = weight of pycnometer with sand and water
W4 = weight of pycnometer with water

Table 4.1 the specific gravity of sandy soil for various

S.NO	Description	Trail 1	Trail 2	Average
1	weight of empty pycnometer,w1 (gm)	0.470	0.470	0.470
2	weight of pycnometer with sand,w2 (gm)	1.300	1.200	1.290
3	Weight of pycnometer with sand andwater,w3 (gm)	1.720	1.720	1.720
4	weight of pycnometer with water,w4(gm)	1.200	1.200	1.200

Table. 4.1 The specific gravity of sandy soil for various trial observations

4.1.3 CALCULATION:

Specific gravity G = (w2-w1)/ [(w2-w1)-(w3-w4)]

= (1.29-0.47)/[(1.29-0.47)-(1.72-1.29)]

G = 2.68

RESULT:

Specific Gravity of Project Sample, (G) = 2.68

1.2 PERMEABILITY TEST

The permeability test is used to identify the water permeability rate of the soil at the particular instance of time. The coefficient of permeability of the soil can be identified by using this test

General

The different type of soils having different kind of permeability nature, based on the porosity, cohesiveness and Fineness value of the soil the permeability will be varied .If the soil having low permeability value the soil will become higher Load bearing capacity and lower void ratio. If the permeability value is higher than the soil become poor load bearing capacity and high porosity.

Table4.2 Result of Permeability Test without grout stage

S.no	Time (sec)	Head (cm)	Discharge (cm3/sec)	Coefficient of Permeability (cm/sec)
1	20	121	18	1.18*10^-3
2	20	121	17	1.13*10^-3
3	20	121	16	1.10*10^-3

CALCULATION

K =Ql/ath

= 18*12.5 / 78.53*20*121

Avg = 1.1367cm/sec

= 1.18*10^-3 cm/s

= 0.10 m/day

4.2 SIEVEANALYSISTEST (SIEVE SHAKER)

Grain size analysis means determination of percentage by means of fraction of different sizes of particles in the soil sample. It is also known as mechanical analysis. Mechanical analysis for coarse grained soil (Grains larger than 75 microns) can be done by method of sieving. The dry sieve method is suitable for non-cohesive soils of particle size distribution curve. The curve obtained after plotting all the results of mechanical analysis on semi-logarithmic graph paper is called particle size distribution curve.In this curve, percentage finer is taken as ordinate on a natural scale and particle diameter (D) on logarithmic scales as the abscissa. The curve gives an idea about the type and gradation of soil.

Coefficient of uniformity:

The ratio of D_{60} to D_{10} is called coefficient of uniformity.

$Cu=D_{60}/D_{10}$

D_{10} represents a particle size in mm such that 10% of the particles Are finer than this size. D_{60} means 60% of the particles are finer Than the size of the particle at 60% point on the curve.

Coefficient of curvature:- The shape of the particle size indicated by coefficient of curvature (Cc).

$Cc = (D_{30})^2 / (D_{10}*D_{60})$

D_{30}= Particle size corresponding to 30% finer

Table 4.3 Result of Sieve Analysis Test

S.No	Sieve size	Weight Retained (gm.)	Precentage Weight Retained %	Cumulative Percentage Retained %	Percentage of fineness %
1	4.75mm	120	6	6	94
2	2.36mm	100	5	11	89
3	1.18mm	570	28.5	39.5	60.5

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4	600µ	380	19	58.5	41.5
5	300µ	620	31	89.5	10.5
6	150µ	180	9	98.5	1.5
7	90µ	30	1.5	100	0
8	75µ	0	0	100	0
9	PAN	0	0	100	0

Uses of particle size distribution curve:

It can be used for classification of coarse grained soils. It is used to know the susceptibility of soil to frost action Particle size distribution curve is required for the design of drainage filters.

The particle size distribution provides us idea about shear strength of soil. Generally a well-graded compacted soil has higer shear strength

Compressibility of soil should also be judged form its particle size distribution curve. A uniform soil is more compressible than a well graded soil.

The particle size distribution curve is useful in soil stabilization and for design of pavements.

The coefficient of permeability of a coarse grained soil depends to a large extent on the particle size. An approximate value of the coefficient of permeability can be determined from the particle size.

The particle size distribution curve of a residual soil may indicate the age of the soil.

It may indicate the mode of deposition of a soil, for example a agape graded soil indicated deposition by two different agencies.

The semi-log plot for the particle size distribution has following advantages over natural plots.

The soil of equal uniformity exhibit, the same shape irrespective of the actual particle size.

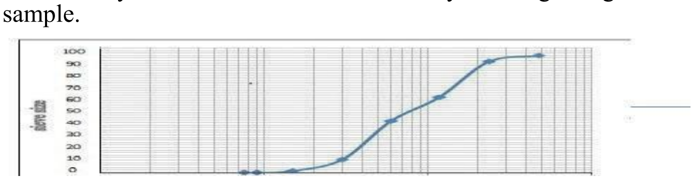
As the range of the particle sizes is very large, for better representation, a log scale is required.

Grading of soils: -

The distribution of particles of different sizes in a soil mass is called are grading of soils and can be determined from the particle size distribution curves. Particle size distribution curves of different soils are shown. A curve with a hump, such as curve A, represents the soil in which some of the intermediate size particles are missing. Such a soil is called Gap-graded or skip graded soil. A flat S-Curve such as curve B represents a soils which contains the particles of different sizes in good preparation. Such a soil is called a well-graded or uniformly graded soil.

A steep curve, like C, indicates a soil containing the particles of almost the same size. Such soils are known as Uniform soils. The particles size distribution curve also reveals whether a soil is coarse - graded or fine-graded. A curve situated higher up and to the left (Curve – D) indicates a relatively fine-grained soil, where as a curve situated to the right (Curve E) indicates a coarse grained soil.

The particles size distributions of sandy soil are shown in table 4.2 by the observation of sieve analysis using 2 Kg of sand sample.



CALCULATION:

Percentage of retained = (120/2000) x 100 = 6%
Percentage of fineness = 100-cumulative %
=100-6
=94%

RESULT

Effective size of the sample, D_{10} = 0.22
Co efficient of uniformity, Cu = 5
Fineness modulus = 0.61%
Co efficient of curvature Cc = 0.84
Co effective of permeation K = 4.84

DIRECT SHEAR TEST

The shear strength of soil means is its property against sliding along internal planes within itself. The stability of slope in an earth dam of hills and the foundation of the structure built on different types of soil depend upon the shearing resistance offered by the soil along the possible slippage surface. Shear parameters are also used in computing the safe bearing capacity of the foundation soils and the earth pressure behind retaining walls.

GENERAL

The parameter for a particular soil depends upon its degree of saturation, density and the condition of laboratory testing.

In a direct shear test, the sample is sheared along a horizontal plane. This indicates that the failure plane is horizontal. The normal stress (a) on this plane is the external vertical load divided by the area of the soil sample. The shear stress at failure is the external lateral load divided by the corrected area of soil sample.

Planes other than the plane of shear are not known during the test.

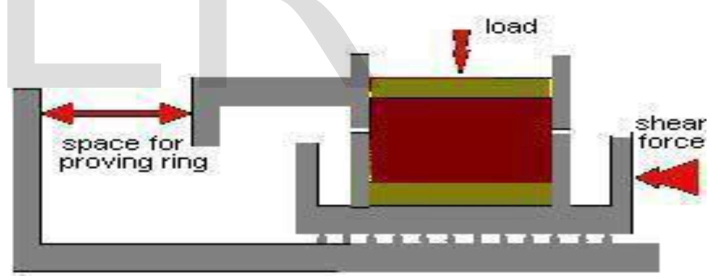


Table 4.4 Tabulated Result of Direct Shear Test

S.NO	Normal strength (kn/m²)	Proving reading	load (KN)	shear load (kg)	shear stress (kg/cm²)
1	0.05	2	4	407.74	11.33
2	0.1	4	8	815.49	22.65
3	0.15	6	12	1223.24	33.98
4	0.2	7.2	14.4	1467.89	40.77
5	0.25	9	18	1834.86	50.96

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Fomula

(Nominalstress σ) = normal load applied / area of C.S

Ultimate shear stress = shear force at failure / area of C.S

τ σ tan Φ

θ = (l/tan) (τ/φ)

The shear strength of sandy soil is determined by using direct shear test. The observations are given in table 4.3 and the shear angle friction is determined by using relationship between shear stress and normal strength is shown in fig. 4.4

The direct shear box dimensions are given in table 4.4 and the fig 4.5 shows the direct shear test box setup.

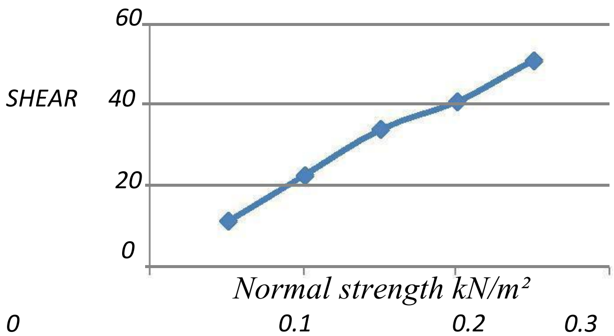

Figure 4.4 Relation between normal Vs shear

CALCULATION

Load = 4N

Shear load = (4 x 1000) / 9.81
= 407.75

θ = (1/tan) (τ/φ)
= (1/tan) x (11.33 / 0.05)

θ = 41'44"

The direct shear box dimensions are given in table 4.4 and the fig 4.5 shows the direct shear test box setup.

RESULT

From the above observations, following results are obtained.

From calculation Φ = 41'44"

From graph = 41'43"

COLLECTION OF ADMIXTURE BBENTONITE

Bentonite clay is a fine-grained rock composed mainly of montmorillonite minerals. The formation of bentonite is an in situ alteration of rhyolitic volcanic ash. Pyroclastic material was ejected into the atmosphere by volcanic activity and deposited as sediment in a marine environment.

Sodium Type - This type has sodium in the crystal lattice and is sometimes referred to as Wyoming Bentonite. This type swells when wet and can increase as much as fifteen times its original volume when wet. Wyoming bentonite occurs in the Big Horn Basin, the Powder River Basin and along the western edge of the Black Hills. Because of this unique characteristic, Wyoming Bentonite is used as the standard against all other bentonite in the world is measured.Its yellow, Bentonite feels and appears yellow or waxy and when wet it is highly plastic and slippery.

ADVANTAGES

1. Bentonite with high swelling,
2. Instantaneous thixotropy,
3. Fine Base Exchange Capacity,
4. Best gelling (100 % gelling by 2 %
5. Meeting All International Specification In Piling
6.Environmentally safe and does not affect the water, live stock or wild life when properly applies.
7.Resistant to erosion & harrowing animals, Provide encasement for critical foundations and as replacement for
8.completed clay when construction take place in wet and cold condition

ADMIXTURE (BENTONITE) SOURCE

The bentonite admixture has been collected from English Indian Clays Ltd., Veli, Trivandrum is shown in fig.5.1

PROPERTIES OF THE SOIL FROM THE ABOVE CONDUCTED TESTS

Property description	Identified value
Specific gravity (G)	2.68
Coefficient of uniformity (Cu)	5
Coefficient of curvature (Cc)	0.84
Angle of internal friction (0)	41.44"
Optimum Water content (w)	14 %
Bulk density (r)	2.48 g/cc
Coefficient of permeability (K)	1.01*10^-3 cm3/s
Cohesiveness (c)	10 KN/m2
Elastic modulus (E)	2*10^5N/MM2
Dry density (rd)	2.15 g/cc
Poission ratio (u)	0.27

Bentonite Grout Use

Bentonite grout needs to be pumped at higher pressures than cement grout. Mix it with a paddle mixer and pump it while it is still viscous and has not started to swell and set. To delay rapid setting, add granular sodium bentonite, chemical drying additive or calcium bentonite. Calcium bentonite expands less than sodium bentonite.

Physical properties

Name of property	Values
Ph	12-14
Specific gravity	2.75 - 3.25
Bulk density (kg/m³)	1100 - 1250

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EXPERIMENTAL SETUP

The efficiency of the grouting process was also verified through plate load tests (laboratory model) conducted on ungrouted/ grouted sand beds. The initial tests for the assessment of improvement in load carrying capacity through densification were filling the sand at the desired densities in small tanks of size 30cm*30cm*30emThe density of the loosest state and at densest state was 13.1 KN/m^3 and 16.2 KN/m^3 respectively. Improvement in shear strength of the soil can be obtained by improving Φ values. Grouting which alters the pore structures and enhances the bonding and interlocking between particles can gives considerable improvement in C as well as Φ values. To place the grout within the pores of the granular medium. In this case, the grouting the mould is prepared in the size (10x10x10) inches at the loosest density of 13.1 KN/m^3.

The bentonite grout was uniformly mixed by using 10:1 ratio with the help of stirrer. The PVC pipes of 3mm diameter holes are inserted into the sample and the bentonite grout was poured into the pipes after the grout poured the pipes was removed.

PROJECT MODEL SETUP

The project model setup of 30cm x 30cm is shown in fig.6.1

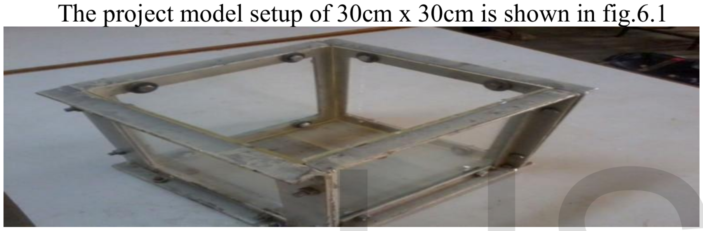

Figure 6.1 Grout laboratory model box

Following figure shows the sample prepared for grouting in project model setup. The PVC pipes are inserted for pouring of grout.

Figure 6.2 grouting arrangement of the soil sample

GROUTING PROCESS OF SAMPLE

The sandy soil is filled in mould and compacted well at each layer and the PVC pipes of 3 mm diameter hole through which the bentonites are grouted as shown in fig.6.3

In above fig the liquid grout material of bentonite can be inserted through the pipes fixed at the corners. The pipe material contains no of holes in all the side the grouting liquid can be speeded through the holes to the soil sample

Fig 6.3 Liquid grout inserting process

Fig 6.4shows well grouted sample for certain curing period

PLATE LOAD TEST GENERAL

Plate Load Test is a field test for determining the ultimate bearing capacity of soil and the likely settlement under a given load. The Plate Load Test basically consists of loading a steel plate placed at the foundation level and recording the settlements corresponding to each load increment. The test load is gradually increased till the plate starts to sink at a rapid rate. to

The total value of load on the plate in such a stage divided by the area of the steel plate gives the value of the ultimate bear ing capacity of soil. The ultimate bearing capacity of soil is divided by suitable factor of safety (which varies from 2 to 3) arrive at the value of safe bearing capacity of soil.

This is the method of conducting the load test on soils and the evaluation of bearing capacities and settlement from this test. This method assumes that down to a depth of influence of stresses the soil strata is reasonably uniform. This should be verified by boring or sounding.

This apparatus consists of bearing plates, loading equipment and instruments to measure the applied loads and resulting settlement. Loading settlement consists of a reaction or dead load and a hydraulic jack. The reaction frame may suitable be loaded to give the needed reaction load on the plate. The load applied may be measured either by a proving ring and dial gauge assembly or a pressure gauge connected to the output end of the hydraulic jack.

ADVANTAGES OF THE TEST

Plate bearing test can give bearing capacity of subsoil up to the depth about twice of plate diameter only.

There is a scale effect due to size of testing plate is smaller than the actual footing.

PLATE LOAD TEST AT WITHOUT GROUT STATE

The following figure shows the plat load test arrangement at without grout state. The plate load testing box has fixed between the stages and loading arrangement the dial gauge will show the reading corresponding to the load application and settlement.

The Rectangular plate has fixed at top of the soil .the size of the plate is 1/3 of total size of the box. The load will be applied on the top of the plate and it will spread into all the areas. The settlement value can be taken from the dial gauge reading versus load application

Fig 7.1Plate load testing of loosest state of sandy soil

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Table 7.1 shows the settlement value of the soil corresponding to the load application at without grout state

S.No	Applied load (KN)	Settlement (mm)
1	5	1.8
2	10	2.4
3	15	3.2
4	20	3.7
5	25	4.3
6	30	4.6
7	35	5.4
8	40	5.8
9	45	6
10	50	7

PLATE LOAD TEST AT WITH GROUT STATE

The following test arrangement shows the plate load test at with grout state the grouted soil sample can be placed between the stage and load cell the settlement value can get corresponding to the load application

Fig.7.2 Plate Load test with grout state

FORMULA

qu(f) = qu(p) * (Bf/Bp)

qu(f) = ultimate bearing capacity of proposed foundation

qu(p) = ultimate bearing capacity of plate load

Bf = width of foundation

Bp = width of plate load

Sf = Sp((Bf (Bp+0.3)) / ((Bp (Bf + 0.3)))^2

Sf = settlement of foundation

Sp = settlement of plate

Table 7.2 plate load test of soil sample with grout state

The following test result which is obtained from the soil sample in with grout state

The Table 7.2 shows various settlement observations has Taken corresponding to different load application

S.No	Load (KN)	Settlement (mm)
1	5	0.6
2	10	0.9
3	15	1.25
4	20	1.8
5	25	2.25
6	30	2.85
7	35	3.4
8	40	3.65
9	45	4
10	50	4.5

CALCULATION:

For loosest state:

Sp = 0.35 cm (plate settlement)

qu(f) = 12.5 (25/13)

= 24.038 kN/cm^2

Sf = 0.35 [(25*(13+0.3))/(13*(25+0.3))]^2 = 0.357 cm

For Grout state:

Sp = 0.15 cm (plate settlement)

qu(f) = 19 (25/13)

= 36.53 kN/cm^2

Sf = 0.15 [(25*(13+0.3))/(13*(25+0.3))]^2

= 0.153 cm

RESULT

From the above plate load test the settlement decreases and bearing strength increases gradually by using admixture bentonite is given in table 7.4.

Table 7.3Comparative result of two stages

Soil state	Ultimate Bearing Strength qu(f) , (KN/cm²)	Settlement of Foundation (mm)
For loosest state	24.04	0.357
Grouted state (after3 days)	36.53	0.153

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CONCLUTION AND DISCUSSION

From above analysis the bearing capacity of the soil sample has improved by the application of grouting .the grouted soil sample settlement is comaritively low.so the grouted soil sample have high load bearing capacity against the load which has low settlement value corresponding to the load application. The grouting process is effectively working in the loose soil

PERMEABILITY TEST

The permeability test is used to identify the water permeability rate of the soil at the particular instance of time. the coefficient of permeability of the soil can be identified by using this test

GENERAL

The different type of soils having different kind of permeability nature, based on the porosity, cohesiveness and fineness value of the soil the permeability will be varied .If the soil having low permeability value the soil will become higher load bearing capacity and lower void ratio. If the permeability value is higher than the soil become poor load bearing capacity and high porosity

Table 8.1 Test result of permeability test

Traial No	Time(t) (Sec)	Head (Cm)	Discharge(q) (Cm3/sec)	Coefficient of Permeability (k) (Cm/sec)
1	20	121	12	0.78*10^-3
3	20	121	16	0.59*10^-3
2	20	121	14	0.92*10^-3

CALCULATION

K = Ql /ath
= 12*12.5 / 78.53*20*121
= 0.78 *10^-3 cm/s
Avg permeability =0.7633cm/sec
K = 0.0655 m/day

COMPARITIVE ANALYSIS

The following table 8.2 shows the comparative analysis of two stages

Table 8.2 Comparative Result of Two Stages

Iteration	State	Permeability Value (m/day)
1	Loosed State soil without grout	0.100
2	Grouted state	0.065

CONCLUSION

From above result the permeability value is comparatively reduced at grouted state. So the grouting process is effectively working for the loose soil. The reduced level of permeability will helpful to attain the higher bearing capacity

RESULT AND DISCUSSION

The following properties which is finded from the laboratory tests.it can be used to create the tunnel model

TEST RESULTS OF SOIL PROPERTIES

The following properties has been found from various test result, literature papers

SPECIFIC GRAVITY

Specific gravity of soil sample, G = 2.68

PARTICLE SIZE DISTRIBUTION

Effective size of the sample, D10 = 0.22
Co efficient of uniformity Cu = 5
Fineness modulus = 0.61 %
Co efficient of curvature Cc = 0.84
Co efficient of Permeation K = 4.84

DIRECT SHEAR TEST

Shear angle of internal friction Φ = 41'44"

PROCTOR COMPACTION TEST

Optimum Water content = 14 %
Dry density = 2.15 g/cc
Bulk density = 2.48 g/cc

PERMEABILITY TEST (BEFORE GROUT STATE)

Coefficient of permeability K = 0.10 m/day

PERMEABILITY TEST (AFTER GROUT STATE)

Coefficient of permeability (K) = 0.0655 m/day

LITRATURE PAPER

Elastic modulus = 2*10^5N/MM2
Poission ratio = 0.27
Cohesiveness = 15 KN/m2

DISCUSSION

Based on the above conducted test the properties of the sample have been found. Some of the unknown properties are taken from the literature papers which is common to all the trails of exercise .it will not vary at any test

10.1 PERMEABILITY PROPERTY BEFORE GROUTING (TRIAXIAL TEST)

The following figure shows the permeability value of the soil mass in without grout stage. The without grout stage permeability value is utilized for this test

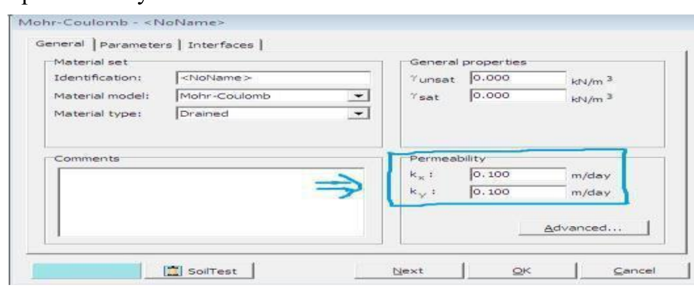

Fig 10.1 Permeability Property Before Grouting

The loosed state permeability value has been entered as the permeability value
In the software

TRIAXIAL TEST RESULT OF BEFORE GROUT STAGE

The following figure 10.2 shows the triaxial test result of with grouted state soil sample. The variation of the graph shows the improvement of bearing capacity

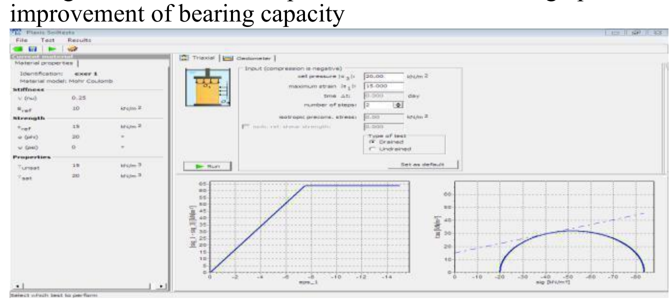

Fig. 10.2 Triaxial test result of before grout stage

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PERMEABILITY PROPERTY OF AFTER GROUTING

The following figure 10.3 shows the permeability value of the soil mass in which grout state. The identified permeability value can be utilized as a input data to do the test

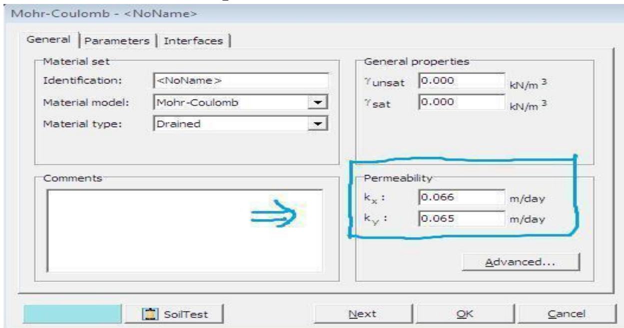

Fig. 11.3 Test Property of After Grouting

TRIAXIAL TEST RESULT OF AFTER GROUT STAGE

The following figure shows the triaxial test result of with grout state of soil sample. The variation of the graph will shows the improvement of bearing capacity

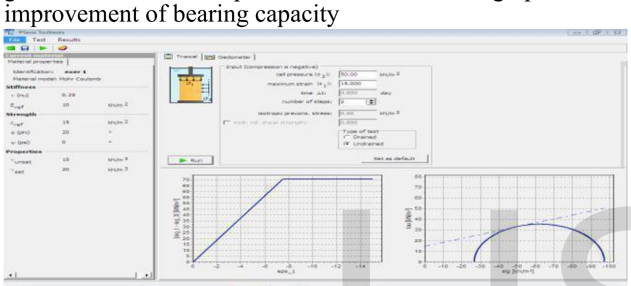

Fig. 11.4 Triaxial Test Result of After Grout stage

RESULT AND CONCLUSION

Triaxial test has been conducted by two stages which results are given below. The following tabulation contain peak value of the soil for various permeability value which has received from two stage

Table 10.1 Comparative Result of Triaxial Test at two stages

Iteration	Stage	Permeability value (m/day)	Cell pressure (kn/m2)	Peak value stress (kn/m2)	Mohr Coulum Value (kn/m2)
1	Sample without Grouting	0.100	20	64	30
2	Sample with Grouting	0.0655	20	71	35

CONCLUSION

From above tabulated result the peak value of the soil is comparatively increased at the grouted state. So it says the grouting process is helpful to improve the bearing capacity of the soil. Then the Mohr coulomn is helpful to improve the bearing capacity of the soil. Then the Mohr colomb failure value is also improved at the same level of the cell pressure. The permeability Value also comparatively reduced in this stage of grouted soil sample

IMPLIMENTATIONOF TUNNEL SECTION GENERAL

Tunnel is the most important structure it contains many applications but sometimes due to the poor maintenance work the tunnel will undergo to collapse. To avoid this problem the proper analysis process will helpful to identify the failure pattern and maximum bearing capacity ect

TUNNELMODELWITH NONGROUTEDPERMEABILITY VALUE

The following figure 12.1 shows the model of tunnel with the three layers the first top layer is the tested sample layer. The loosed state permeability value has used

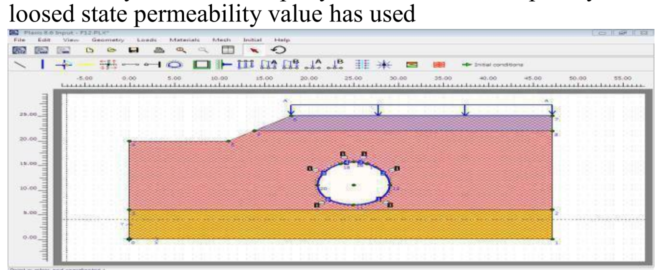

Figure 12.1 Tunnel Model with loosed state Permeability value

DEFORMATION OF THE SOIL MASS BEFORE GROUT STATE

The following figure 12.2 shows the stress distribution of the model

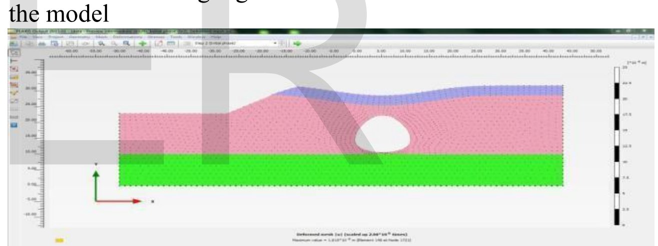

Figure 11.2 Determination of soil mass before grout state

STRESS DISTRIBUTION AFTER GROUT STATE

The following figure 12.3 shows the stress distribution of the soil mass at the stage of without grout. From The following figure the corner of the slope is very higher stress distribution that stage is very dangerous

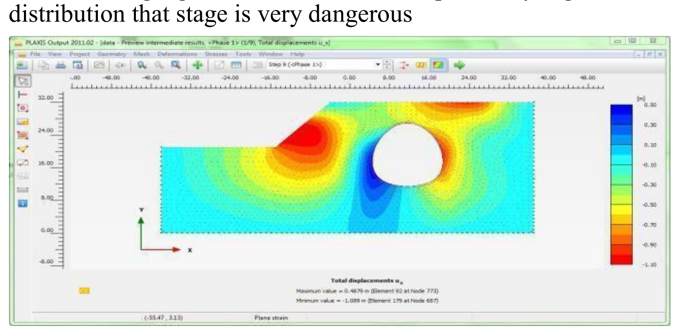

Figure 11.3 Stress distributions before grout state

TUNNELMODEL WITH GROUTEDPERMEABLITY VALUE

The following Figure 12.4 shows the model of tunnel which has three layers. The first top layer is tested sample layer. The grouted permeability value has used on this

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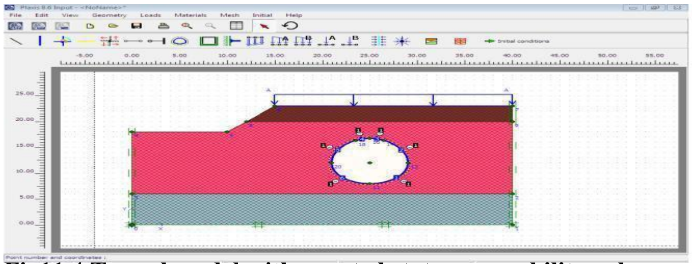
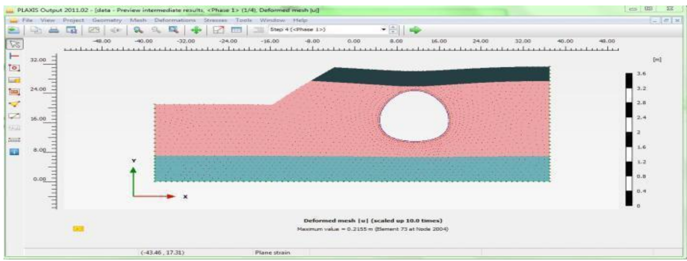


Fig11.4 Tunnel model with grouted state permeability value

DEFORMATION OF SOIL MASS BEFORE GROUT STATE

The following Figure11.5 shows the stress distribution of the model



11.5 Deformation of soil mass after grout state

STRESS DISTRIBUTION BEFORE GROUT STATE

The following Figure 12.6 shows the stress distribution of the soil mass at grouted stage.In this case the stress at corner of the slope is very low compared to previous case. This case has higher safety in the area of stress distribution.

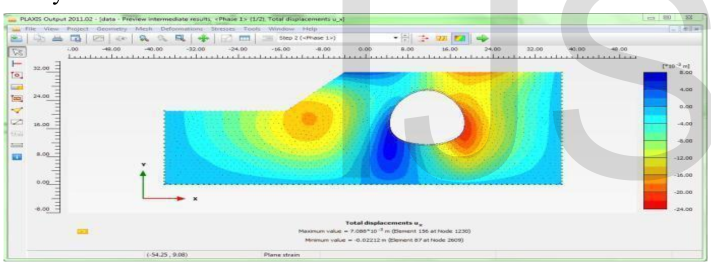


Figure 11.6 Stress distributions after grout state

RESULT AND DISCUSSION

The following Table 12.1 shows the comparative analysis Result of the two stages

S.No	Model	Permeability (m/Day)	Deformation (m)	Stress Distribution Soil Mass
1	Without Grout application	0.100	0.2511	Uneven stress Distribution
2	Withgrout Application	0.0655	0.1015	Even Stress Distribution

DISCUSSION

From the above results deformation value is comparatively reduced and stress distribution is evenly attained in with grout state. So the grouting process is effectively working. the bearing capacity of sandy soil is very low based on the relationship between and N value from ISΦ6403:1981. To overcome these problems the Bentonite grout was used to increase the bearing capacity of sandy soil. From the plate load test (laboratory model) results shows the bearing capacity of sandy soil increases and settlement decreases gradually with respect to curing period. Load settlement chart of loose sand grout with Bentonite shows the considerable improvement in the bearing capacity.

CONCLUSION

From above conducted tests In with grout state the permeability value is comparatively decreased and settlement value is also decreased and bering capacity of the soil is improved in with grout state . Hence the engineering property of the soil can be improved by adopting this method.Bearing capacity of sandy soil is very low based on the relationship between O and N value from IS 6403:1981. To overcome these problems the bentonite grout was used to increase the bearing capacity of the sandy soil. From the plate load test (laboratory model) results shows the bearing capacity of sandy soil increases and settlement decreases gradually with respect to grout application. Load settlement chart of loose sand grout with Bentonite shows the considerable improvement in the bearing capacity

Based on the experimental investigations and test results, the following conclusions are made. The shear strength O of the loose sand soil steadily increases with increase in admixture content and also with curing period. The rate of increase in shear strength is very high at higher percentages of admixture (Bentonite) than at lower percentage.The bearing capacity of loosest state sandy soil was 24.04 kN/cm^2 . After the Bentonite grouting for proper curing the bearing capacity of sandy soil increases 12.5 % to 26 % respectively and settlement also decreases gradually with respect to curing period.It can be concluded that permeation grouting using bentonite is an effective technique to improve the bearing capacity and reducing the settlement of loose sandy soils.

By the software analysis the proper investigation and analysis can be done.it has to be done to avoid the defect and sudden collapse and the proper maintenance will helpful to attain the longer life.

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