EVALUATION OF STRENGTH PARAMETERS AND LIQUEFACTION POTENTIAL OF SOIL USING STATIC CONE PENETRATION TEST

[1]Assistant Prof. Bhavna Mistry, [2]Assist.Prof.Darshika Shah, [3]Lect. Darshan Prajapati
Civil Engineering Department, GTU
ASOIT, Ahmedabad, India

Abstract: The paper is based on the tests carried out for the evaluation of the strength parameters and the liquefaction potential of the soil using the SCPT (Static Cone Penetration Test). The approach combines with a literature review of the various similar carried out analysis of the soil to know the venture of failure and classify if the soil is succumbed to liquefaction or not as well as the detailed description of the instrument used. Determining the area whether it is or it isn't prone to liquefaction one can have an insight before utilizing it for having a safer approach towards the same. This in return provides us invaluable information of the behavior of the soil and gives us a proper glance of the usability factors for the same as well as brings about the precautionary measures to be taken. We get a detailed layer by layer understanding of the soil characterization which is the most important factor before heading towards any construction above the surface of the same and hence the action towards the same can be taken accordingly.

1. *INTRODUCTION*

1.1 General

The cone penetration test is a type of in-situ techniques commonly used for investigating unconsolidated near surface sediments which provide continuous profiling of geo-stratigraphy and soil properties evaluation and to survey the subsoil in detail by logging the nature and sequence of the subsurface strata (geologic regime), groundwater conditions, physical and mechanical properties of the subsurface strata in the soil during and after soil penetration to the ground.Static cone penetration test is very useful insitu testing equipment for soil. This equipment can be used to perform the static cone penetration test as per IS 4968. This equipment is increasingly being used for site investigation and geotechnical design.The cone assembly with friction jacket, enables to determine local skin friction of different sub soil strata and the friction ratio so obtained enables to identify various soil types penetrated by the cone.

Hence the requirement to know the nature of the soil whether it be below a pavement or a huge structure as a whole the settlement criteria should be given any residue or any freedom as such as the failure of the soil in the nature of sliding or any other way which is the consequence of the failure of the soil and subsequent failure of the structure above it and the its contagious effect on structures surrounding the same. To nullify the failure of the same, efforts are applied to increase the endurance of the soil to as much extent as possible and to record the same we use many techniques and experiments which tell us what must be the bearing capacity of the soil to face the impact stresses of the structures built on the soil and forecast the settlement and failure modes and in total magnitude.In particular, the whole relevancy of the safety parameters are implied on the alleged and comprehensive way of having the ascertained results to be used on the grounds such that whole of the experimental phase are levied in completeness and can be mitigated with the adversity of alternating the percentages.

1.2 Need of Present Study

With the increased concerns of many settlement prone areas alongside with as many as of the parameters related to the failure of the soil the need of the research in the field of soil stability and other geotechnical perimeters has a lot more emphasis these days and is a big area of research which would acknowledge to as many things which are relevant to it and have the emphasis laid on the safety of any structure which is built above it and have its establishment for long time.

1.3 Objective of Study

The main objective of the soil stability here stands in respect to the direct stresses which are levied on the same and are comprehensively in the process of prototyping as many of the options which are available and which are more relevant to be used such that the convenience of the most may be allocated to the real time usage and hence can be used on the large scale and on a long term. This being said the main emphasis of it would be certainly laid on the grounds of the basis laboratory tests and the results which are observed are concluded with a certain motive such that the real time application is directly implied to know whether the particular soil is prone to Liquefaction or not.

1.4 Scope of work

With the increased demand of the soil stabilization field, many of the tests are conducted on trial basis to get an abrupt increase in strength using various implications and additives which would directly imply on the certainty of the objective. On knowing the Soil being prone to liquefaction on a sequential basis of depth which attributes comprehensively directly to the results which are obtained from the test, one can ascertain the various measures which can be employed to have safe measures which would avoid the sinking of the foundation and having the superstructure standing safe.

2. Fundamental concepts of Liquefaction

Due to cyclic load where the straining reduces the void ratio of the soil by a certain amount it is important to note that the threshold shear strain, below which no soil densification can take place, irrespective of the number of cycles. Decrease in volume of the sand, can take place only if drainage occurs freely. However, under earthquake conditions, due to rapid cyclic straining this will not be the condition. Thus, during straining gravity loadings is transferred from soil solids to the pore water. The result will be an increase of pore water pressure with a reduction in the capacity of the soil to resist loading.

This is schematically shown in the figure. In this figure, let A be the point on the compression curve that represents the void ratio (e_0) and effective state of stress (σ'_A) at a certain depth in a saturated sand deposit. Due to a certain number of earthquake related cyclic straining, let AB=Δe be the equivalent change of void ratio of the soil at that depth if full drainage is allowed. However, if drainage is prevented, the void ratio will remain as e_0 and the effective stress will be reduced to the level of σ'_c, with an increase of pore water pressure of magnitude Δu. So the state of the soil can be represented by point C. If the number of cyclic straining is large enough, the magnitude of Δu may become equal to σ'_A, and the soil will liquefy.

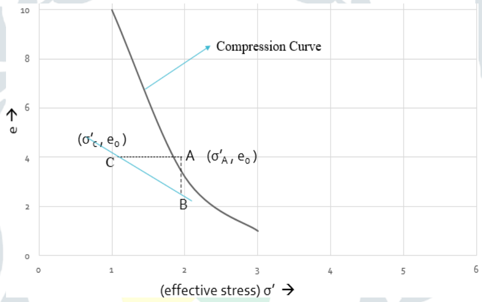


Figure 1 Mechanism of pore water pressure generation due to cyclic loading in untrained conditions

Liquefaction resistance: Always the liquefaction resistance of the silty sand is larger than that of the clean sands. This is due in clean sand voids are occupied by silt particles and thus these may inhibit a quick volume change behavior.

Co-relation with the Cone penetration Resistance.

$q'_c = C_N\, q_c$ (For clean sand)

Where, q_c= field cone penetration resistance (kg/cm2) C_N=correction factor.

q'_c=corrected cone penetration number (kg/cm2) If the value of q'_c for $\sigma'v$=100kPa, then use

$$\boxed{C_N = 9.78\sqrt{(1/\sigma_v')}}$$

Also q'_c = AN'.

Where A=4 to 5 for clean sands.

3. EXPERIMENTAL WORK

3.1 Stage I: Setting Up the Equipment

The initial step is the setting up the whole equipment where we intend to take the Cone Penetration Test which involves sequenced and careful steps. This involves initially taking the dimension of the whole base which is taken for the obtaining of the points with the preciseness in millimeters as they are the points on which the anchors will be placed.

Four labors were taken for putting the anchors in the ground, with one anchor taking approximately around 45 minutes for the same. To the plotted circles as shown in the picture given below, the distance maintained exactly with the rectangle maintained on the ground too by cross checking with the measuring of the diagonals, the exact point on the ground were plotted for the drilling of the anchors in to the ground and hence the base for the placing of the truss on which the whole machine would be kept was set up. This is in the way that the load transferred from the machine is transferred equally onto the trusses and the trusses placed above the anchors transfer the pressure on the same reaching the ground eventually. This helps the proper and equal transfer of stresses and vibrations to the ground and are well in placed with careful measurements every time.

3.2 Stage II: The experiment carried out.

After the Cone Penetrometer was set up, the dial gauges of the same were put out after proper oiling and careful installation, which otherwise brings about the damage of the same being quite vulnerable. Following the same, the working of the machine is checked by operating the hydraulics which would be used to insert the rods into the soil for the proceedings of the experiment. There are many obstacles involved in the same at every point of having the machine operated, from the time of perfect fixing of the machine, the fixing of the dial gauge, the proper engagement of the hydraulics to work perfectly on the same and have a collaborate and proper functioning of the instrument.

After everything was perfectly placed and working, the experiment was carried out, readings of the cone resistance and the slip friction was consecutively taken for the same till the 1.2m. On the other days, the same was continued and the rods were immersed up to a depth of about 4m .With the cone rod of 1m depth is inserted into the soil, with every of it the reading is taken into consideration and is explicitly recorded in the terms of the Cone Penetration, the Sleeve resistance and the Pore Pressure resistance, here the machine not capable of calculating or recording the latter one, only the cone penetration readings and the total resistance is taken into the Observation table and is enacted upon the same consecutively with the relevant procedural analysis which would be giving us the various strength parameters required for the same as we as the main agenda to find out whether the soil is prone to the liquefaction or it is safe for the building of any structure upon it and is approved for further actions.

3.3 Stage III. Observation

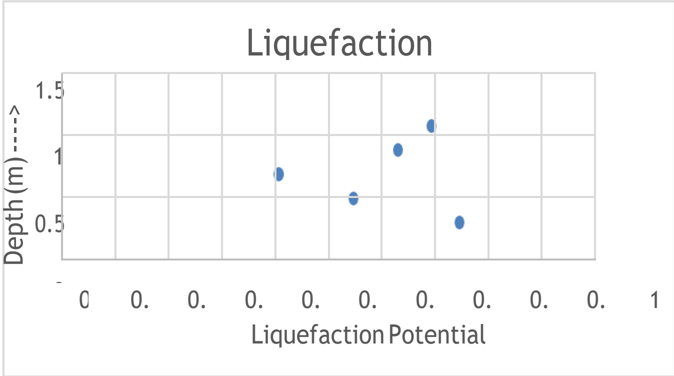
Table 1 Observation Table for SCPT

Depth (m)	Cone Resistance (MPa)	Total Resistance (MPa)
0.4	28	70
0.60	50	62
0.8	70	77
1.0	40	55
1.2	27	35
1.4	19	21
1.6	5	15
1.8	15	20
2.0	1832	30
2.2	20	86
2.4	20	89
2.6	26	88
2.8	19	2124
3.0	21	30
3.2	20	30
3.4	15	22
3.6	17	23
3.8	19	21
4.0	17	20

4 RESULTS AND DISCUSSION

From the Static Cone Penetration Test we are able to categories the soil whether it is prone to the liquefaction or not and hence we are able to acknowledge the soil in the perspective of utility and other aspects related to the same which is one of the most important factor to be considered before any part of it is used. The analysis part gives us the result in a layer by layer information which gives us various parameters which are to be used to gather all the relevant information for the same and have it used for a purpose which corresponds to the real time practices.

The following graph gives us the layer by layer representation of the soil whether prone to the liquefaction or not.



In the above graph, after the analysis of all the data recorded, we can interpret the values of the liquefaction potential and as seen in the above graph we can notice that all the values of the liquefaction potential are below the value 1 and hence we can conclude that the particular location where the Cone Penetration test was carried out isn't prone to the liquefaction and hence considered safe if prone to Earthquake of magnitude 7.5 and below.

Hence in a matter of safety this is very relevant information which brings about the exact denomination of the characteristics of the soil which is present around that particular area and is in the zone of safety.

References

1. Braja M. Das., G.V Ramana, " Principle of Soil Dynamics", 2nd Edition, 2011 *PWS Kent*. Journals

1. Geological Survey Professional Paper 1551-F, U.S. Geological Survey, Reston, VA, F35–F49.Kramer, S. L. (1996). *Geotechnical earthquake engineering*, Prentice-Hall, Upper Saddle River, NJ.
2. T. L. Youd, I. M. Idriss, Ronald D. Andrus, Ignacio Arango, Gonzalo Castro, John T. Christian, Moriwali, Maurice S. Power, Peter K. Robertson, Raymond B. Seed, and Kenneth H. Stokoe II, *Liquefaction Resistance of Soils: Summary Reprot from the 1996 NCEER ad 1998 NCEER/NSF workshops on Evaluation of Liquefaction Resistance of Soils.* Journal of Geotechnical and Geo environmental Engineering, Vol. 127, No 10, October, 2001. ASCE, ISSN 1090-0241/01/0010-0817
3. Quishi Chen, Chaofeng Wang and C. Hsein Juang., "CPT based Evaluation of Liquefaction Potential Accounting for Soil Spatial Variability at Multiple Scales." Journal of Geotechnical and Geoenvironmental Engineering, 2016, 142(2):04015077