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LIQUEFACTION IT'S SUSCEPTIBILITY AND METHODS OF PREVENTION IN PUNE REGION

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ABSTRACT

Liquefaction is the phenomena when there is loss of strength in saturated and cohesion-less soils because of increased pore water pressures and hence reduced effective stresses due to dynamic loading. It is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Out of the various seismic hazards, soil liquefaction is a major cause of both loss of life and damage to infrastructures and lifeline systems. Soil liquefaction phenomena have been noticed in many historical earthquakes after first large scale observations of damage caused by liquefaction in the 1964 Niigata, Japan and 1964 Alaska, USA, earthquakes. Due to difficulty in obtaining high quality undisturbed samples and cost involved therein, in-situ tests, standard penetration test (SPT) and cone penetration test (CPT), are being preferred by geotechnical engineers for liquefaction potential evaluation with limited use of other in-situ tests like shear wave velocity tests and Baker penetration tests.

Keywords: Liquefaction, Earthquakes, Standard Penetration Test (SPT), In-Situ Tests

I. INTRODUCTION

Rapid urbanization is a factor that calls for construction of mega-structures. The main reason for human loss and property damage is when due importance is not given for adequate preparation for possible seismic hazard. Regional hazard zonations do not incorporate local and secondary effects induced by the earthquakes and liquefaction, leading to its infeasibility in land use, development and planning, hazard mitigation and management, and structural engineering applications which are site-specific. It is necessary to overcome these limitations, especially in the highly populated urban centers with unplanned urbanization practices therefore, envisaged to subdivide a region into sub regions in which different safeguards must be applied to reduce, and/or prevent damages, loss of life and societal disruptions.

1.1 Liquefaction

Liquefaction is the phenomena when there is loss of strength in saturated and cohesion-less soils because of increased pore water pressures and hence reduced effective stresses due to dynamic loading. It is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. It is also defined as "A phenomenon where in mass of soil loses a large percentage of its shear resistance, when subjected to monotonic, cyclic, or shock loading, and flows in a manner resembling a liquid until the shear stresses acting on the mass are as low as the reduced shear resistance.” Liquefaction occurs in saturated soils and saturated soils are the soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that. The water pressure is however relatively low before the occurrence of earthquake. But earthquake shaking can cause the water pressure to increase to the point at which the soil particles can readily move with respect to one another. Although earthquakes often triggers this increase in water pressure, but activities such as blasting can also cause an increase in water pressure. When liquefaction occurs the strength of the soil decreases which results in decrease in ability of a soil-deposits to

support the construction above it. Soil liquefaction can also exert higher pressure on retaining walls, which can cause them to slide or tilt. This movement can cause destruction of structures on the ground surface and settlement of the retained soil.

1.2 Effects of Liquefaction

The origins of rupturing and shifting of the earth’s surface may be traced to the collapse of soils or rock which occurs at certain depths in the ground. Some of this rupturing may be attributed to the large-scale fault movement of rocks which takes place several kilometers beneath the ground surface. Other hazards may be non-tectonic and merely surface phenomena occurring within several tens of meters from the surface. In some cases, observed surface ruptures can be distinguished without difficulty whether they are due to deep-seated fault movement or whether they are formed by the standing in and around weak soil deposits. However, violent distortions or displacements occurring in subsurface soils are not a new phenomenon. The frequent occurrence of liquefaction and differential compaction is evidenced by the description of the damage characteristics noted in old documents. Thus, it may be of interest to reexamine the case history records of old earthquakes and try to determine common features in cases where the subsurface ground was shaken by the violent tremors of earthquakes

II MATERIALS AND METHODS

2.1 Introduction and Site Selection

For testing susceptibility of liquefaction in Pune region the site is selected with respect to time required for construction, money invested in the implementation of project, size of project, site condition and geology of site. The selected site is in Hinjewadi Phase 3 on site there is variation in soil depth is found means there is soil on surface then hard rock is for small depth and then soil with varying depth. The site is used to construct a multistoried R.C.C, building. So load on the soil is very high. The water table is also available near by the soil belt in ground. Water table is also changes in that region during rainy season more frequently.

For the site geological investigation more than 150 bore holes are drilled to check the geotechnical properties of soil by the owner with the help of soil testing laboratory in Pune named Durocrete Engineering Services. All the data of SPT is taken from them with the soil sample.

Fig. 2.1.1 Location Image (ref. Google map)

2.2 Flow Chart of Methodology

Site Selection

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Standard Penetration Test

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Collection of Sample

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Find Out The Basic Characteristics Of Soil Sample By Performing Laboratory Tests

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Making Of Sample For Liquefaction Test

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Performing Shake Table Test

↓

Recording Readings

↓

Making Results and Conclusions

↓

Decide The Soil Type And Site Is Prone To Liquefaction Or Not.

2.3 Penetration Testing

i. Raise and drop the hammer 0.76 m successively by means of the rope and cathead, using no more than 2 1/4 wraps around the cathead. The hammer should be operated between 40 and 60 blows per minute and should drop freely.

ii. Continue the driving until either 0.45 m has been penetrated or 100 blows has been applied.

iii. Record the number of blows for each .15 m of the penetration. The first 0.15 m increment is the "seating" drive. The sum of the blows for second and third increment of 0.15 m penetration is termed "penetration resistance or "N-value".

Fig. 2.3.1 Drilling Of Bore Hole

iv. If the blow count exceeds 100 in total, terminate the test and record the number of blows for the last 0.30 m of penetration as the N-value.

v. If less than 0.30 m is penetrated in 100 blows, record the depth penetrated and the blow count.

If the sampler advances below the bottom of the hole under its own weight, note this condition on the log.

2.4 Shake Table Test for Liquefaction

Shake table test is used to determine generally triggers due to earthquake. so shake table test is important the susceptibility of liquefaction because its give the same impact of earthquake vibration

2.4.1 Preparation Of Sample

i. For sample for testing soil used is oven dry and free form impurities such as wood sticks, big stone cheeps, plastic bags etc.

ii. The sample is then taken in the plastic pan having size 16cm x 14cm x 7cm

iii. The samples are then batched according to weight.

iv. Weight of each sample is 500 gm

III RESULT AND DISCUSSION

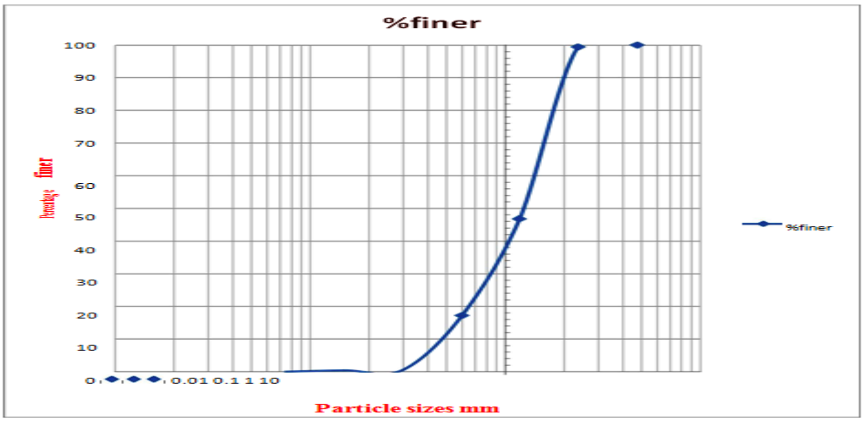

Fig 3.1: Particle size distribution curve of the natural soil

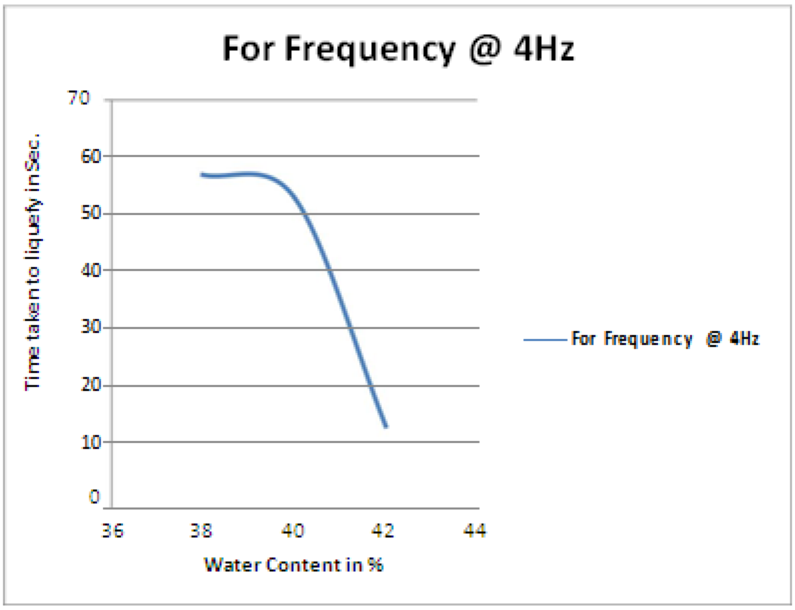

Fig.3.2 for Frequency @ 4Hz

The above graph shows the time variation with respect to different water contents at constant frequency of 4Hz. The soil starts to liquefy slowly at 38% and from 39-40% it begins to liquefy rapidly.

Table 3.3 Geotechnical Properties of the Soils used.

Parameters	Lateritic clay
Specific gravity	1.18
Liquid Limit %	40
Plastic Limit %	18
Plastic Index %	34.4

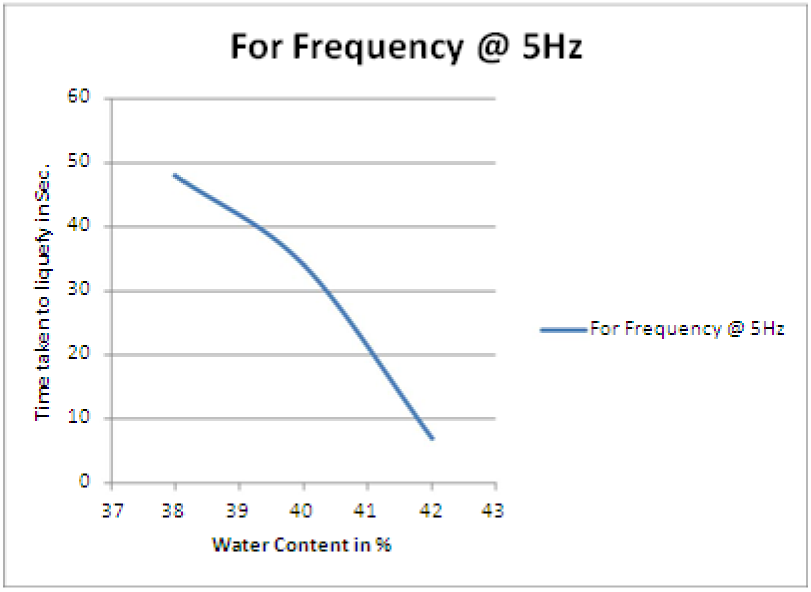

Fig.3.3 For Frequency @ 5Hz

The above graph shows the time variation with respect to different water contents at constant frequency of 5 Hz. The soil starts to liquefy at 38% and from 39-40% it begins to liquefy rapidly.

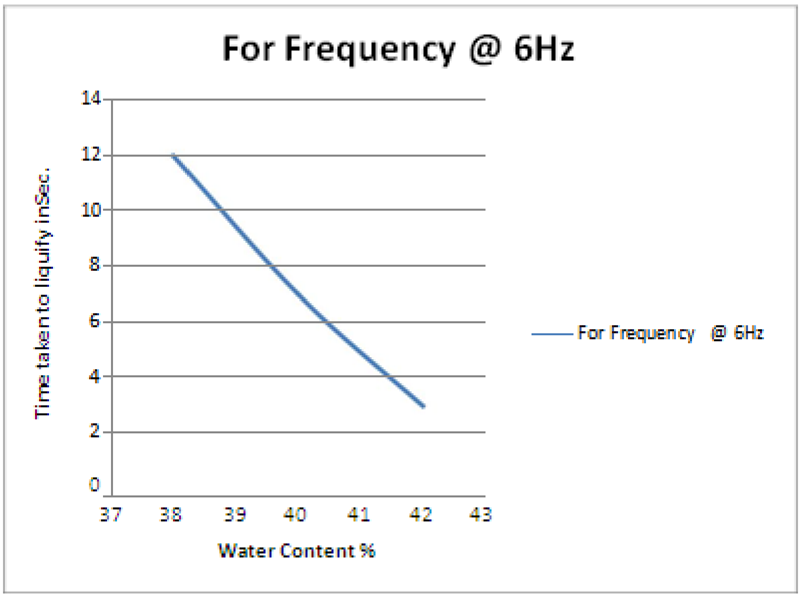

Fig.3.4 For Frequency @ 6Hz

The above graph shows the time variation with respect to different water contents at constant frequency of 6 Hz. For this the soil starts to liquefy at 38% and from 39-40% it begins to liquefy rapidly.

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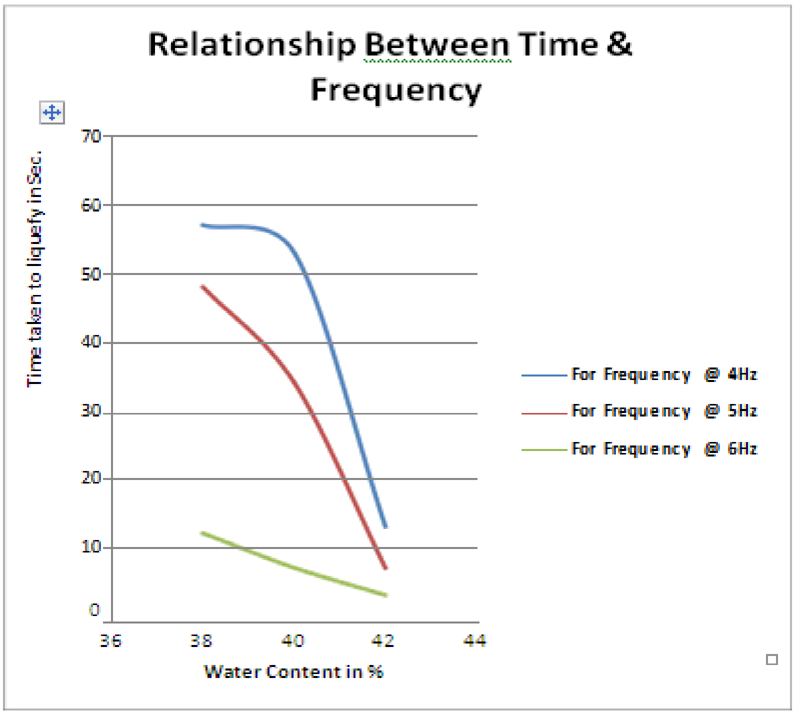

Fig.3.5 Relation between Time and Frequency

The graph is plotted for water content and time to show how frequency affects them. The above graph shows exact relation between water content and time required for liquefaction and how the frequency of earthquake or shake table can affect these two factors directly.

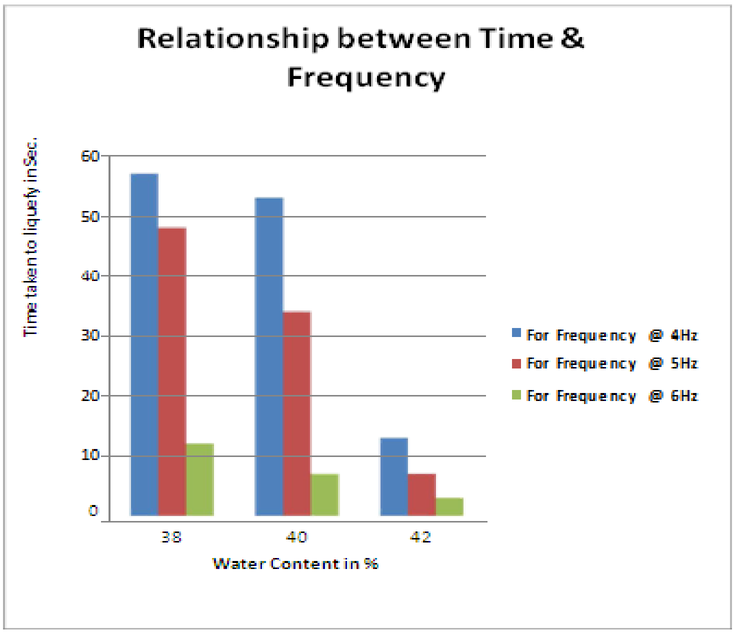

Fig.3.6 Relation between Time and Frequency

The above bar chart is plotted between water content vs. time required for liquefaction for different frequencies.

It shows in very simple manner how the constant water content affects the various frequencies of earthquake and how behavior of soil changes and which affects directly to the time taken by soil to get liquefy.

IV CONCLUSION

4.1 Conclusion Standard Penetration Test

All the N- values of the bore holes are less than 15 (<15) and Generally those are fall under E-type which has N-value less than 15 are prone to liquefaction after an earthquake and having low bearing capacity at wet condition.

4.2 Conclusion for basic soil test

Soil having 1.81 specific gravity and coefficient of uniformity C_u=3.04 coefficient of curvature C_c=1.148 Hence the soil is well graded soil and can be liquefy.

4.3 Conclusion of Shake Table Test

In this test the time required for liquefaction of soil is decreased as water content is increased with the proportion to the frequency of vibrations. The read lateritic soil can be liquefy when the water content in soil is about to 38 to 42. All graph of time vs. water content shows that at 38 % water content soil starts to liquefy slowly and at 40 to 41% its totally loss its shear strength and can't sustain to any load on it and failure occurs. The change in the water content and soil proportion also affects the time required to fail the soil due to liquefaction. So control in the water content of soil helps to reduce the pore water pressure and indirectly to make red lateritic soil liquefaction proof. Which concludes that red lateritic soil in Pune region can be liquefying when the favorable conditions are occurs such as increase in water table in ground, earthquake, and increase in pore water pressure. It shows that the susceptibility of liquefaction can be found by the performing shake table test. The site selected is under the zone E as per IBC (2000) on basis of N values obtained by performing the standard penetration test and it is liquefaction prone at the time of earthquake.

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