RESEARCH PAPER | Engineering | Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

Evaluation of Liquefaction Potential of Soils

KEYWORDS: Liquifaction, Earthquake Shaking, Shear strength of soils

Dr. R.P.Rethaliya	Kanan Thakkar
Applied Mechanics Department, BBIT, Vallabh Vidhyanagar-Gujarat.	P.G.Scholar, SPIT, Mehsana, Gujarat.

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.

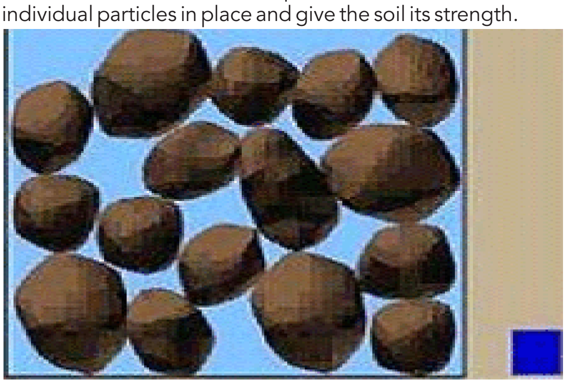
Liquefaction occurs in saturated soils, that is, soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other.

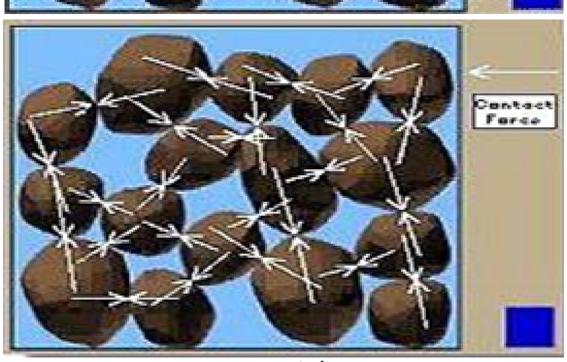
Earthquake shaking often triggers this increase in water pressure, but construction-related activities such as blasting can also cause an increase in water pressure. When liquefaction occurs, the strength of the soil decreases and, the ability of a soil deposit to support foundations for buildings and bridges is reduced as seen in the photo of the overturned apartment complex buildings in Niigata in 1964. The type of ground failure shown above can be simulated in the laboratory. This paper deals with evaluation of zone of liquefaction and use of SPT in evaluating liquefaction potential of soils.

MECHANISM & THEORY

Liquefaction is a phenomenon in which saturated cohesion less soil under oscillatory motion during earthquake loses all is shear strength due to pore water pressure and flows like a liquid.

To understand liquefaction, it is important to recognize the conditions that exist in a soil deposit before an earthquake. A soil deposit consists of an assemblage of individual soil particles. If we look closely at these particles, we can see that each particle is in contact with a number of neighboring particles. The weight of the overlying soil particles produce contact forces between the particles - these forces hold individual particles in place and give the soil its strength.





pressure is low.

Liquefaction occurs when the structure of a loose, saturated sand breaks down due to some rapidly applied loading. As the structure breaks down, the loosely-packed individual soil particles attempt to move into a denser configuration. In an earthquake, however, there is not enough time for the water in the pores of the soil to be squeezed out. Instead, the water is "trapped" and prevents the soil particles from moving closer together. [Increased water pressure is caused by the soil particles trying to rearrange and pushing on the water. The increased water pressure reduces the contact forces between the individual soil particles, thereby softening and weakening the soil deposit.]

For cohesion less soils,

$S = \sigma' \tan \Phi$

Where, S = shear strength

$\sigma' = \sigma n - u$

σn = overburden pressure = $\gamma' . z$

u = pore water pressure

If the soil deposit is subjected to ground vibrations, it tends to compact decrease in volume. However, if drainage is prevented, pore water pressure increases.

When pore water pressure becomes equal to overburden pressure, σ' becomes zero.

Therefore, shear strength (S) becomes zero and the soil behaves like a liquid. This phenomenon is called liquefaction.

For liquefaction to occur, all the following five conditions must be satisfied.

1. The soil must be cohesion less.
2. The soil must be loose.
3. The soil must be saturated.
4. There must be dynamic force.
5. Un drained conditions in the soil.

1. Soil must be cohesion less:

For liquefaction to occur, the soil must be granular.

For cohesive soil,

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

S = C + σ' tan Φ

If σ'= 0, shear strength becomes S = C, hence, cohesive soil does not liquefy.

2. The soil must be loose:

For liquefaction to occur, the soil must be loose.

If soil is dense, negative pore water pressure will develop and the shear strength of soil will increase.

σ'= σn –(-u)= **σ**n +u, i.e. **σ'** will increase and the soil will not liquefy.

3. The soil must be saturated:

For liquefaction to occur, the soil must be saturated. If soil is dry, there is no pore water pressure and hence there is no liquefaction. Due to vibratory compaction of dry soil, shear strength will increase.

4. Dynamic force:

For liquefaction to occur, dynamic force must be there. If the force is static, pore water will get sufficient time to escape pore water pressure will not rise. There will be consolidation of the soil.

Earthquakes accompanied with liquefaction have been observed for many years. In fact, written records dating back hundreds and even thousands of years have descriptions of earthquake effects that are now known to be associated with liquefaction. However, liquefaction has been so common in a number of recent earthquakes that it is often considered to be associated with them. Some of those earthquakes are

(1) Alaska, USA(1964)

(2) Niigata, Japan(1964)

(3) Loma Prieta, USA(1989)

(4) Kobe, Japan (1995)

(5) Bhuj, India (2001)

Effects of liquefaction

Sinking of structure in to the ground.

Excessive settlement of structure.

Cracking of structure due to settlement

Prevention of liquefaction

The following measures can be adopted to prevent liquefaction of soils.

1. Providing deep foundations like piles.
2. Compacting soils and increasing its relative density.
3. Replacing the liquefiable soils with a well compacted soil.
4. By injection grouting.
5. By ground water pumping.
6. By providing proper drainage of soils.
7. Providing stone columns.

8. Application of surcharge.

Kishida (1970)[4] observed the grain size distribution of boils ejected at Nanaehama Beach, Japan during the Tokachioki earthquake of 1968. The boils consisted of sandy silt with clay contents less than 10% . Kishida indicated that the grain size distribution of the boils showed good agreement with the grain size distribution of soils located at a depth of 1m to 12m. These soils ranged from silty sand to sandy silt also with clay contents less than 10% . The grain size distribution of the boils did not however match those soils at a depth of 12m to 17m. These soils had a clay content greater than 10% and appeared to have not liquefied.

ZONE OF LIQUEFACTION

In a sand deposit, consider a soil column of height h and unit cross sectional area subjected to a maximum ground acceleration amax. Assuming the soil column to be a rigid body, maximum shear stress τmax at depth is given by:

τmax= [r h /g] amax

where, g is the acceleration due to gravity, and r is the unit weight of soil

Since the soil column behaves as a deformable body, the actual shear stress at depth h is given by

(τmax)act=rd [r h /g] amax

where rd is the stress reduction factor

Seed ad Idris(1971)[1] recommended a chart for obtaining the value of rd at various depths. The critical depth for development of liquefaction is less than 12m.

As per Seed and Idris(1971) the average shear stress is

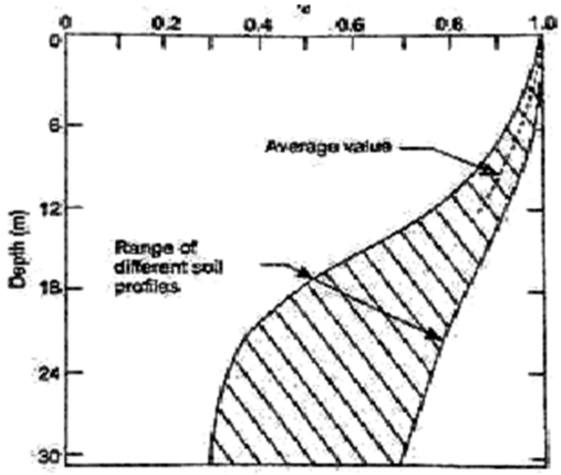


Fig.2 Reduction factor rd versus depth[Seed and Idris, 1971]

The corresponding number of significant cycles Ns for corresponding values of Richter magnitude M are:

Richter E.Q. Magnitude	Ns
7.0	10
7.5	20
8.0	30

Design earthquake is established and Ns is obtained. Also obtain peak ground acceleration amax. Obtain average shear stress (**τ**)av at a depth h below ground surface.

Determine (**σ**d/2)/ **σ**3 for D50 of soil.

Determine [**τ**n]/ σ' for relative density DR i.e. relative density of 50%.

Determine **τ**n required for causing liquefaction.

Liquefaction will occur if (τ)av is greater than **τ**n.

Seed et al. (1983) outlined criteria, derived from case histories in China (Wang, 1979), which provided a basis for partitioning clayey soils vulnerable to severe strength loss as a result of earthquake shaking. The clayey soils vulnerable to severe strength loss appeared to have the following characteristics:

Clay Content (defined as % finer than 0.005mm) <15%

and Liquid Limit <35

and Water Content >0.9 x Liquid Limit

Critical zone for grain size distribution curves, for grain size most susceptible to liquefaction is shown in Fig.3

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

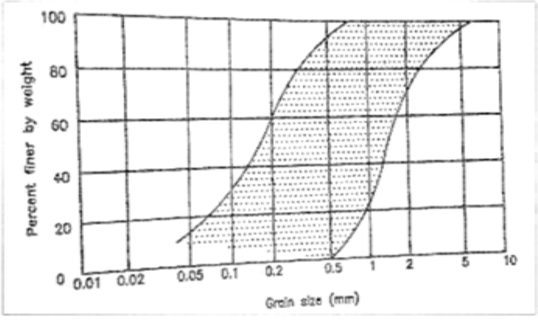


Fig.3 Critical zone for grain size distribution curves [Oshaki 1970]

Liquefaction potential of soil can also be evaluated by standard penetration test[SPT] value. Liquefaction is very likely when S P T value is below 10 and is very unlikely when

SPT value isabove 40.

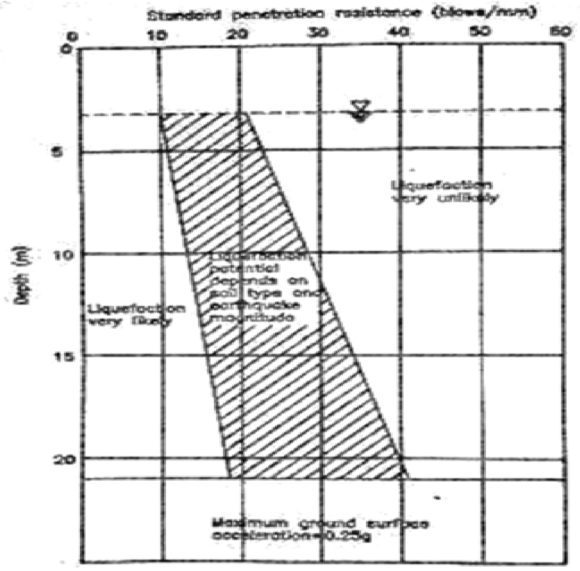


Fig.4 Liquefaction potential evaluation chart [Seed & Idris, 1971]

CONCLUSIONS

For liquefaction to occur, soil must be cohesion less, loose, saturated and there must be a dynamic force like earthquake.

The critical depth for development of liquefaction is less than 12m.

Liquefaction will occur if $(\tau)_{av}$ is greater than n.

Liquefaction is very likely when SPT value is below 10 and is very unlikely when SPT value is above 40.

REFERENCE [1] H.B.Seed and I.M. Idris[1971], " Simplified procedure for evaluating soil liquefaction potential " Journal of Soil Mechanics and Foundati Division, ASCE, 97 (9), 1249-1273. | [2] H.B.Seed and K.L.Lee[1966], " Liquefaction of saturated sand during cyclic loading " ASCE, JGE, Vol.92, No.6, pp.105-134. | [3] S.Prakash, J.N.Mathur, [1965] " Liquefaction of fine sand under dynamic loads "Proceedings of 5th symposium of the civil and Hydraulic engineering Dept. IISC, Banglore, India. | [4] H.Kishida (1970). "Characteristics of Liquefaction of Level Sandy Ground During the Tokachioki Earthquake". Soils and Foundations, Vol. 10, No. 2, pp 103-111. | [5] J. P.Koester (1992)." The Influence of Test Procedure on Correlation of Atterberg Limits with Liquefaction in Fine-Grained Soils". Geotechnical Testing Journal, Vol. 15, No. 4, pp 352-360.