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# Liquefaction in Soils

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ABSTRACT

This paper presents a concept for study, analysis and research of one of the major cause regarding shear failure of soil. Liquefaction is a sudden failure of a loose soil mass due to total loss of shearing resistance. Typical causes are shocks or strains that abruptly increases the water pressure between soil particles causing the entire mass to behave similarly to a liquid. Liquefaction has been suggested to only occur at certain grain sizes. Earthquake-induced liquefaction is the loss of shear strength in soil due to increased pore pressure, and is a major factor contributing to infrastructure and lifeline damage during earthquake.

Liquefaction is responsible for extreme property damage and loss of life due to several variations of failure potential. Liquefied ground is no longer stable to withstand the stresses it is subjected to form structural foundation and even its own weight leading to a variety of potential failures.

The witnessed effect on structures with their foundation in a liquefied deposit resembles quick sand with a bearing capacity failure occurring beneath the foundation. The building structures will lean and fall; at times even split open under the strains. Also, dams and retaining walls are common boundaries to many bodies of water and their adjacent shores.

The damaging effects of liquefied soils are not only visible in the structural chauses left behind. The stresses produced during liquefaction can cause tension cracks to form in the soil near the embankment or it can collapse the whole member commonly known as lateral spreading or land sliding. Soils on or near slopes, hills, or mountains can experience the same effects.


## 1. Introduction

**Concept of 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.

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. The water pressure is however relatively low before the occurrence of earthquake. But earthquake shaking can cause the water pressure to increase to the

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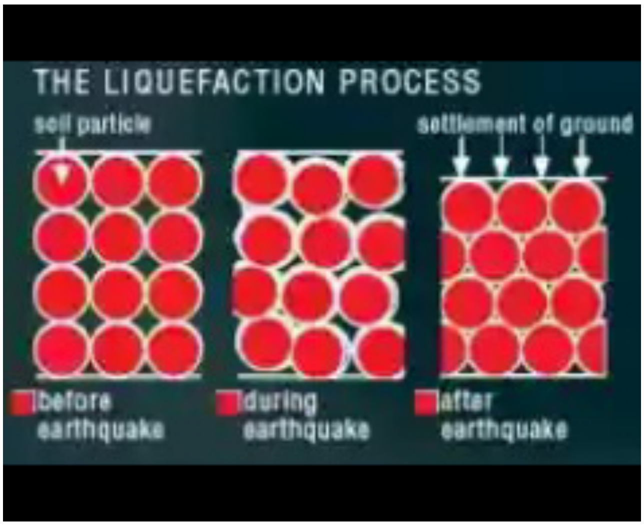
point at which the soil particles can readily move with respect to one another.

Although earthquakes often trigger 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 and the ability of a soil deposit to support the construction above it.

## 2. Review of Literature

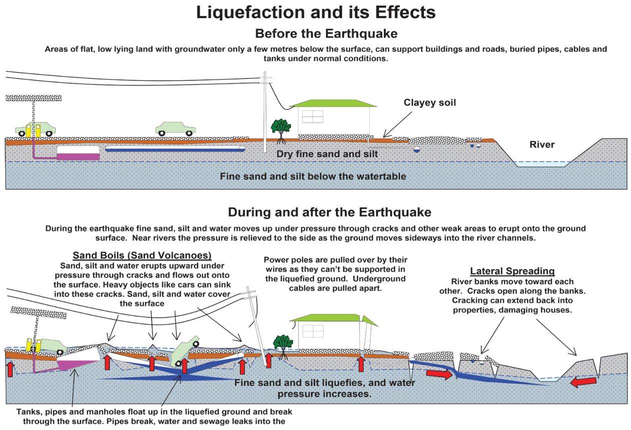
**Process of Liquefaction:**

Liquefaction occurs in water logged "saturated" sediments such as; coastal beach sand. what happens when the water logged sediments are exposed to seismic shaking the pores began to close and the water is forced upward causing things to sink and flood.




**Effect of Liquefaction:**

The recent sequence of earthquakes and aftershocks in the Christchurch area has highlighted a phenomenon that previously has had a very low public profile. Now, 'liquefaction' is visible. Its effects in Christchurch are extensive and have resulted in significant damage to property, buildings and infrastructure, not to mention creating a widespread mess. Silt, sand and water bubbled up in people's backyards, in streets and parks and even through the concrete floors of buildings. Some refer to the sand and silt as liquefaction, but that is not correct. The soil at the surface is a result of liquefaction.




**Damages Occurred in Past Due to Liquefaction:**

Soil liquefaction occurred in non-plastic silty sand deposits has been of great research interests in geotechnical earthquake engineering. During the 1999 Chi-Chi earthquake, serious soil liquefaction damages were observed in central Taiwan including Wu-Feng, Nan-Tou, and Yuen-Lin areas . Post-earthquake study indicated that most soil liquefactions were occurred in silty sand deposits with high fines content. Christchurch city and its vicinity area of New Zealand had also suffered from severe liquefaction damages during series of earthquakes in 2010 to 2011. Non-plastic silly sand again has been recognized as the major sources of soil liquefaction. Moreover, Tokyo bay area and Chiba perfect was suffered from serious soil liquefaction damages during the 2011 Great East Japan earthquake. Preliminary reconnaissance also concludes that majority liquefaction occurred in the reclaimed silty sand deposits.

Silty and Liquefaction at Wu-Feng during 1999, Chi chi earthquate, taiwan

Liquefaction at Katori city near tone river during east Japan earthquake, chiba Japan.

Liquefaction at Central business district of Christchurch Earthquake, New Zealand

**Causes:**

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 sqeezed out. instead, the water is trapped and prevents the soil particles from moving closer together. this is accompanied by an increasing water pressure which reduces the contact forces between the individual soil particles, thereby softening and weakening the soil deposit.

**Prevention From Liquefaction:**

The following measures can be adopted to prevent liquefaction or to limit the caused by liquefaction.

- Providing deep foundations: The structures should be supported on deep foundations, such as piles, that extend through the liquefiable soil to deeper strong and stable strata. since such piles will not be able to resist lateral loads in liquefiable soil. other measures should be adopted to resist lateral loads.
- Compaction of soils: the liquefaction of soil can be prevented by compacting the soil and increasing its relative density. compaction is usually done by means of vibrating rollers, compaction piles, vibro floatation, blasting, e.t.c.

- Replacing the liquefiable soil: if the depth of the liquefiable soil is limited, it can be excavated and replaced with well compacted soil. however, if the depth of liquefiable soil is large it become impractical to replace the soil because it requires extensive dewatering systems.
- Grouting the soil: in the method the soil is established by injecting stabilised by injecting chemicals or cement grout into the soil.
- Groundwater pumping: The effective stress at a point increases as the water table is lowered . By restoring to extensive ground water pumping the liquefaction can be prevented to some extent.
- Drainage of soils: The liquefaction hazard can be reduced to some extent by providing coarse sand blankets and drains in the soil deposit.
- Providing stones columns: In this method, a number of holes are bored in the soil deposit and later filled with gravels and stones. Thus stone columns are formed.

**Recommendation for Future Study:**

The following recommendations are provided to identify areas that need further study.

- Compile additional case studies of ground improvement near pipelines and other lifelines. These case studies should include detailed information about the condition of the lifeline, ground improvement procedures, verification techniques, and
- Compile additional case studies documenting the performance of improved ground during strong earthquake shaking.
- Perform laboratory and field investigations to determine how much ground improvement is needed to protect pipelines and other lifelines.
- Develop less expensive ground improvement techniques, since all the low vibration techniques reviewed are expensive to conduct cost.

## 3. Conclusion

Liquefaction is the process that leads to a soil suddenly losing strength, most commonly as a result of ground shaking during a large earthquake. Not all soils however, will liquefy in an earthquake.

The following are particular features of soils that potentially can liquefy:

- They are sands and silts and quite loose in the ground. Such soils do not stick together the way clay soils do.



- They are below the water table, so all the space between the grains of sand and silt are filled with water. Dry soils above the water table won't liquefy. When an earthquake occurs the shaking is so rapid and violent that the sand and silt grains try to compress the spaces filled with water, but the water pushes back and pressure builds up until the grains 'float' in the water. Once that happens the soil loses its strength – it has liquefied. Soil that was once solid now behaves like a fluid. Liquefied soil, like water, cannot support the weight of whatever is lying above it – be it the surface layers of dry soil or the concrete floors of buildings. The liquefied soil under that weight is forced into any cracks and crevasses it can find, including those in the dry soil above, or the cracks between concrete slabs. It flows out onto the surface as boils, sand volcanoes and rivers of silt. In some cases the liquefied soil flowing up a crack can erode and widen the crack to a size big enough to accommodate a car.

Some other consequences of the soil liquefying are:

- Settlement of the ground surface due to the loss of soil from underground. • Loss of support to building foundations.
- Floating of manholes, buried tanks and pipes in the liquefied soil - but only if the tanks and pipes are mostly empty.
- Near streams and rivers, the dry surface soil layers can slide sideways on the liquefied soil towards the streams. This is called lateral spreading and can severely damage a building. It typically results in long tears and rips in the ground surface that look like a classic fault line. Not all of a building's foundations might be affected by liquefaction. The affected part may subside (settle) or be pulled sideways by lateral spreading, which can severely damage the building. Buried services such as sewer pipes can be damaged as they are warped by lateral spreading, ground settlement or floatation.

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