



EARTHQUAKE INDUCED LIQUEFACTION AROUND THE WORLD

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Abstract: In this paper we have briefly studied effects of liquefaction on different locations around the world, specifically those places where earthquakes are the major reason for liquefaction to occur, as liquefaction is a major determining factor in longevity and stability of the entire structure during various situations that lead to liquefaction.

Keywords: liquefaction, effects of liquefaction, earthquake

1. Introduction

Liquefaction occurs when vibrations or water pressure within a mass of soil cause the soil particles to lose contact with one another.

Liquefaction also takes place when loosely packed, water-logged sediments at or near the ground surface lose their strength in response to strong ground shaking. Liquefaction occurring beneath buildings and other structures can cause major damage during earthquakes or other seismic events.

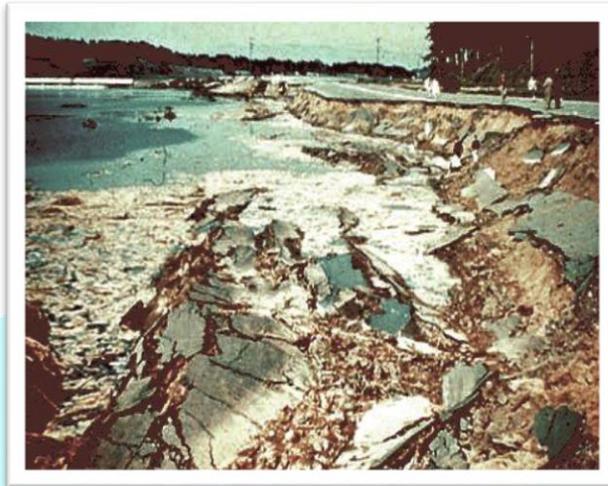
2. Historical occurrences

Liquefaction is an uncommon occurrence and has affected some parts of the world, some locations have been affected so bad that restoration has been hindered, following are certain examples that are more common.

Because liquefaction only occurs in saturated soil, its effects are most commonly observed in low-lying areas near bodies of water such as rivers, lakes, bays, and oceans.

Liquefaction has been observed in earthquakes for a long time. Written records dating back hundreds and even thousands of years describe earthquake effects that we know now to be associated with liquefaction. Liquefaction has been a common factor in a number of recent earthquakes, so it is often associated with them. Some of those earthquakes are mentioned below.

- i. The effects of liquefaction may include major sliding of soil toward the body slumping and sliding of water, as was the case of 1957 Lake Merced slide
- ii. In case of banks of Motagua, the tension cracks were introduced in the aftermath of the Guatemala earthquake back in 1976. The earthquake hit with a of 7.5 on Richter scale causing more than ten thousand landslides in total.



Lake Merced, road slid down due to SF earthquake in 1957



Highway blocked by landslide in Guatemala Earthquake

- iii. Liquefaction caused major damage to port facilities in Kobe, Japan in the 1995 Hyogo-ken Nanbu earthquake. It is also referred to as The Great Hanshin earthquake



Lateral displacement of a quay wall, Kobe 1995



1.2-2m drop in paved surface and flooding

Liquefaction also frequently causes damage to bridges that cross rivers and other bodies of water. Such damage can have drastic results. Liquefaction-induced soil movements can push foundations out of place to the point where bridge spans loose support or are compressed to the point of buckling.



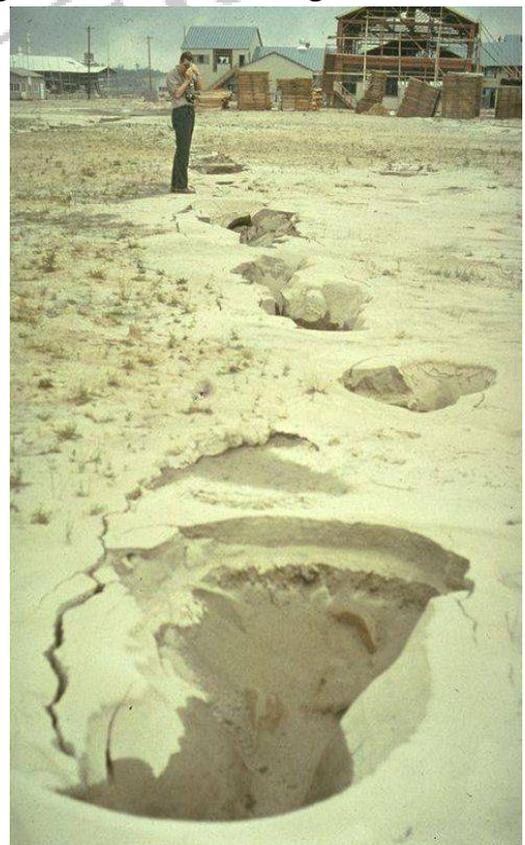
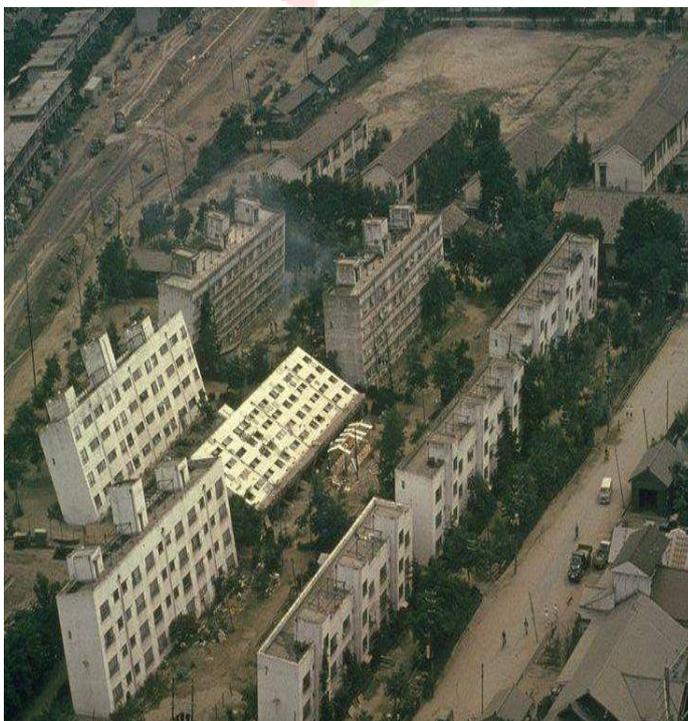
Loss of support due to sliding of soil during earthquake



Buckling of bridge due to compression induced by earthquake

- iv. The Niigata earthquake that hit on June 16, 1964 had a magnitude of 7.5 on Richter scale caused severe damage to many structures in Niigata. The destruction was observed to be largely limited to buildings that were built on top of loose, saturated soil deposits prone to liquefaction. Even though about 2000 houses were destroyed, only 28 lives were lost. A tsunami, caused by movement of the sea floor associated with the fault rupture, completely the port of Niigata.

A significant ground failure occurred near the Shinano river bank where the Kawagishi-cho apartment buildings suffered bearing capacity failures and tilted severely (left image below). Considering the extreme tilting, the buildings

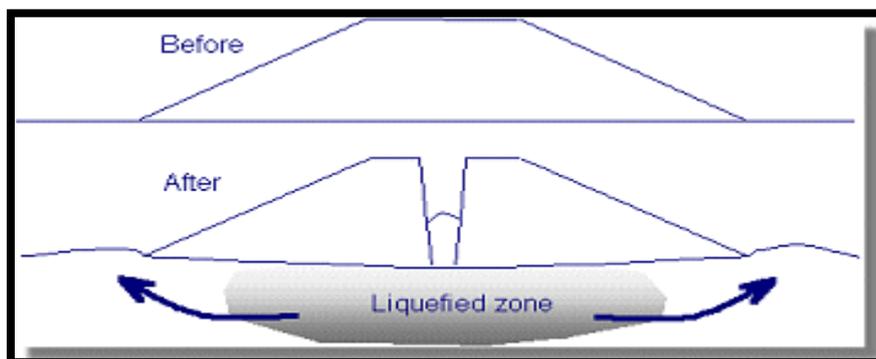


themselves suffered relatively less damage. Sand boils and ground fissures were observed at various sites in Niigata (right image below).

- v. Being a part of the Pacific Ring, the southern coast area of Alaska experiences many earthquakes. On March 27, 1964, a great earthquake of magnitude 9.2 struck Prince William Sound and caused severe damage in the form of landslides and liquefaction (image to the right). This seismic event is the second largest ever to have been recorded and it lasted for over 3 minutes. It was felt over an area of 500,000 square miles. A tsunami, heavily increased the amount of damage to wharf and waterfront facilities.



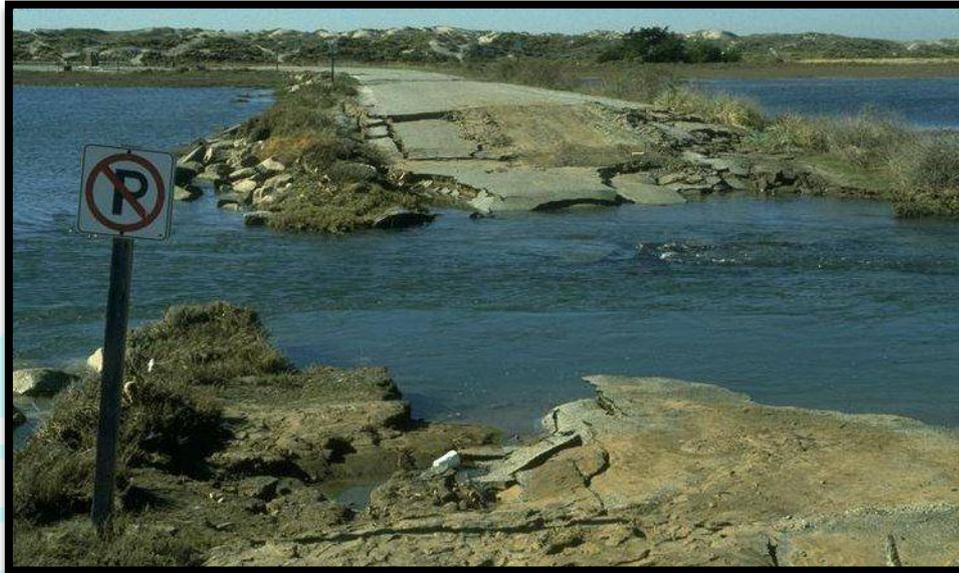
Liquefaction in sand layers, and in sand and silt seams in the clayey soils beneath Anchorage, caused many of the destructive landslides that occurred during the earthquake.



Lateral spreading in the soil beneath the roadway embankment caused the embankment to be pulled apart, producing the large crack down the center of the road.

- vi. On October 17 1989, Loma Prieta earthquake of magnitude 7.1 hit California's Central coast.

Soil liquefaction caused major damage to waterfront facilities, structures, and buried pipelines at locations in the Bay Area where loose saturated, sandy soils were susceptible to liquefaction. The numerous sandboils that were observed provided indisputable evidence of the occurrence of liquefaction. Liquefaction was observed at a number of sites, including the Oakland airport, sites along the Salinas River, and Moss Landing Marine Station.



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