

# Soil Liquefaction and Mitigation

Pratibha Yadav<sup>1</sup> and Sana Zafar<sup>2</sup>

<sup>1</sup>P.G. Student, Department of Civil Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, India

<sup>2</sup>Department of Civil Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, India

E-mail: <sup>1</sup>pratibhayadav96@gmail.com, <sup>2</sup>zsana06@gmail.com

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**Abstract**—Soil liquefaction is a phenomenon in which the strength and stiffness of soil is reduced and transformation takes place from solid state to liquid state that increases the pore water pressure by earthquake shaking or other rapid loadings, various risks and problem are associated like a sand boils, flow failures, lateral spreading, loss of bearing capacity causes of the foundation failure, ground settlement and failure of retaining wall. This problem may be solved by the various mitigation techniques which may include vibro-compaction, soil replacement, dynamic compaction and stone column. The main aim of this paper is to improve the liquefiable soil with the help of stone column, to examine the effects of stone column. Which help to improve the different problem like the soil densification, and reduced the settlements and identify the general use of stone column as liquefaction countermeasures. This paper identifies areas where more research is needed and includes recommendation for future research and development.

**Keywords:** Soil liquefaction, Mitigation, Stone column.

## 1. INTRODUCTION

Soil liquefaction has been causes the many problems, which may be ground failures, failures of structures, lifelines, building foundation .In which ground failures is a major problem associated due to past earthquake. In general terms, liquefaction refer to the loss of strength and loss of stiffness is occurred in saturated, Cohesion less soils unit (sand and silts) and sensitive clay due to the build-up pressures during dynamic loading. Evidence of liquefaction is based on considering the mechanisms of ground failure, on the past earthquake (e.g., Alaska earthquake in USA ,1964; Niigata earthquake in Japan,1964; Loma Prieta earthquake,1989; Kope earthquake in Japan,1965; Kobe,1995; Kocaeil,1999; Chi-Chi,1999; Bhuj in India,2001; Pakistan,2005; and Wenchuan in China,2008;) . Earthquake continues to show the destructive effects of liquefaction and causes the lots of problem. In general soil liquefaction occurs so often during earthquake by which sediments below the water table soil loss their strengths. Soil behaves like a liquid. If water pressure exceeds a certain level, then it forces the soil particles to move relative each other, thus cause the loss of strengths and also affects the failure of soil. In case of earthquake occurrence of shear waves passes through soil layers and effects on the granular soil structure to deform and weak part of soil begins to disturbed.

## 2. FACTORES AFFECTING THE LIQUEFACTION SUSCEPTIBILITY

Liquefaction susceptibility is a function of the geotechnical properties ant topographic position of region ,factors affecting liquefaction susceptibility may includes:-

1. Grain Size
2. Relative density
3. Depth of water table
4. Depth to thickness of strata
5. Previous liquefaction
6. Age of deposit
7. Sedimentation process
8. Geology history
9. Ground slope
10. Permeability
11. Shape of soil

## 3. TYPE OF SOIL LIQUEFACTION

Robertson (1994) and Robertson et al.(1994) suggested a classification system to explain the “soil -liquefaction” . Latest it’s given by Robertson and Fear (1996), can be explained as:

### 3.1. FLOW LIQUIFACTION

1. It is occurs in contractive soil and saturated soil.
2. It’s happen when static shear stress is more than the residual strength of soil.
3. Flow liquefaction failures are define by the sudden nature of their origin.



**Fig. 1 (a): Flow liquefaction**



**Fig. 1 (b): Flow liquefaction**

### 3.2. CYCLIC SOFTENING

1. It occurs during large deformation produced during cyclic shear. It is further divided as:

- (a) Cyclic liquefaction (stress is reversal)
- (b) Cyclic mobility (cyclic load does not yield a shear stress reversal)



**Fig. 2 (a): Cyclic Softening**



**Fig. 2 (b): Cyclic softening**

### 4. EFFECTS OF SOIL LIQUIFACTION

Soil liquefaction related ground failure due to past earthquake and related hazard has caused extensive structural and lifeline damage in both rural and urbanised areas around the world. The problems associated by liquefaction leave the very painful effects of the living things. A lot of property and lives are lost due to the liquefaction problem. When ground surface is liquefied in an earthquake then soils saturate and behave like a liquid. Different problems are associated like causing pipes to leak, roads and airports runway to buckle, and buildings' foundations to be displaced. Many other effects are:

1. Loss of bearing strength.
2. Lateral spreading.
3. Sand boils.
4. Flow failures.
5. Ground oscillation.
6. Flotation.
7. Settlement.

Different diagrams are mention below:



**Fig. 3: Sand Boiling**



**Fig. 4: Lateral Spreading**



**Fig. 5: Settlement**



**Fig. 6: Flow Failure**

## 5. MITIGATION OF SOIL LIQUEFACTION

Soil liquefaction and the associates the failure have the resulted improvement method:- in civil infrastructure . For solving the problem of soil liquefaction various ground improvement technique are involved.

### 5.1. Soil improvement method:-

1. Dewatering.
2. Relief well (to reduced the pore water pressur ).
3. Stone column (vibro replacement).
4. Excivation of poor soil and replacement with compacted fill grout injection.
5. In situ densification (e.g. ,vibro flotation, terraprobe, impact densification , dynamic compaction, compaction piles, etc;).
6. Wet soil mixing.
7. Placement of additional fill( to increased the overburden pressure and soil strength).
8. Cement grouting.
9. Chemical grouting.



## 5.2. Structural fortification:-

1. Strength structural connection add grade beam and tie beams.
2. Extend pile support into deeper stable soils.

Various type of above mention technique are used nowadays . Using the above technique which considering the component that comprise the liquefaction problem, and this method also help to improve the susceptibility of liquefaction from soil. The structural fortification method does not help to reduce the hazards due to earthquake but rather they help to reduce the vulnerability of civil infrastructure. Among the various ground improvement method stone column nowadays use as a mitigation of soil liquefaction. Stone column mitigation are used in past earthquake (Englehardt and Golding,1975; Dobson,1975; Mitchell and Wentz,1991; Mitchell et al., 1995; Sumer et al. ,2011).

Previous studies have shows that the effect of stone column for liquefaction mitigation help to improve the density of soil, reduce the excess pore water pressure and also improve the settlement problem in infra structural .

## 6. STONE COLUMN

Stone column are nowadays frequently used for purpose of ground improvement with order to reduce the bearing capacity, settlement, and other risks also. The stone column are subjected to group loading . Using the stone column depends up on the grain size distribution , before using the stone column technique we ensure that for testing of well graded soil are used. Soil should have to know that the index property such as specific gravity ,maximum and minimum dry density, and void ratio.Column is important in Soil improvement and structural fortification technique, to reduce the vulnerability of civil infra structure.Stone columns nowadays use as more frequent.An improved understanding of liquefaction problem mitigation effects of stone column.

Authors have different views regarding the stone column. Whilst Gruber (1994), reports no significant increases of the horizontal stress after the installation of stone column.

Watts et al. (2002), shows an increase of up to 60Kpa of the horizontal stress during column installation. The result of pore water pressure measurement during the installation of stone column may be in two ways. It may be square pattern or triangular grid pattern. The degree of densification is directly related to soil type, fines content, soil plasticity, Pre-densification relative density, vibrator type, stone shape and durability, stone column. Brown (1997), Lope and Hayden (1992), Baez (1997) discuss the design of vibro –replacement method and construction.



Fig. 7: Stone Column

## 7. SUMMARY AND CONCLUSION

A comprehensive review of the stone column is an application for soil liquefaction mitigation and also associates the ground deformation. It's also help to find the problem and how to overcome the problem with different ground improve technique.

Also help to sources of useful information.

SOME OF MAZOR CANCLUSION :-

1. Increased the bearing capacity of the soil.
2. Increased the settlement of soil.
3. Attention to the option available to mitigation against the hazard (soil liquefaction).

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