Alternative Technologies as a Toolkit for Management for Less Know Disaster Soil Liquefaction at Machilipatnam Town

Dr. P. Pavan Kumar
Assistant Professor
Department of Architecture
Jnanabharathi Campus, Bangalore University, Bangalore, Karnataka, India

Abstract:
This paper is an attempt to cite the necessity of water sensitive urban planning incorporation into the masterplan while designing/sculpting/molding the urban geography by urban planners to alleviate natural disasters with affective and efficient use of alternate technologies. The researcher studied various locations and found a uniquely located town and this paper predicts of a disaster waiting to happen, which can never be gauged or read by the local citizens or Governing ULB’s. The disaster caused by “Soil Liquefaction” is little known, the research so far conducted by the author has shown that there is a very high probability of soil liquefaction in this town. Machilipatnam class-I town located at costal area of Andhrapradesh is studied and findings of the research so far, shows that there is a danger of soil liquefaction in future for this town, because of its unique topographic feature and a manmade canal called “Shivan Samudra”, which surrounds the town. On an average earthquake of magnitude 5 hits machilipatnam town once in every 5 years. Studies were conducted during the times when the town was totally flooded due to storms and overflow of both manmade and natural canals, which lead to stagnation of water throughout the town.

Keywords: Urban Planning, Master plan, Soil Liquefaction, Water Sensitive Planning, Alternate Technologies, Earthquake, Mean Sea Level.

I. INTRODUCTION

Definition of soil liquefaction is given by Sladen et.al. 1985. Liquefaction of soil is a process where the soil loses its resistance towards shear while bearing loads of certain types including cyclic loads, monotonic loads and acquire fluid property till the shear stresses reduce to match its shear resistance.

1.1 HAZARDS OF SOIL LIQUEFACTION

Soil liquefaction is unseen and least study format of hazard waiting to happen at certain locations, for this hazard not only the location, geographic, geological changers are important but timing is very crucial and its effects on societies and dwelling units is unimaginable. Structures designed always rest on ground and when the ground losses its quality and behaves like liquid, the buildings will collapse or tilt. These structural failures will be irreversible and when mega projects like bridges and dams get effected causing damage at an alarming rate Methods to mitigate liquefaction hazards include to masterplans prepared avoiding and marking danger zones, build liquefaction withstanding structures and improve soils conditions to avoid liquefaction by compacting, solid nailing, dynamic compaction, grouting and various other ground modification techniques Soil liquefaction causes both life and property lose as the ground becomes too unstable, its difficult for the structures to retain their designed functionality - a bridge, a building, a runway, a nuclear power plant, an earth dam will lean or tip over, split open, or sink adversely creating a havoc. Water logging, loose soil and earthquake are instrumental combination for liquefaction. It has been learned that solid ground can turn into mush under conditions that are not so rare. Soil that had supported structures before could suddenly become fluid, anything on it can slip or sink. The soil loses its strength and the soil transfers from solid state to liquefied state. Liquefaction is categorized into two broad categories:

- Liquefaction due to flow
- Liquefaction due to chemical processes an example is dispersive clay soils.

Liquefaction occurs when the pore water pressure increases to a higher degree which effects the saturated soil at a granular level, fast stocking, and earthquakes. Liquefaction due to chemical process is as the result of the nature of cations in the pore water of the soil mass in this case dispersive soils are as a result of liquefaction due to a chemical process.

II. CONTEXT

Dispersive clays have a preponderance of sodium cations, whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water (Sherard et al., 1976).

The presence of water will overcome and eliminate the inter-particle forces and would move even with an existing slow water flow. Soil liquefaction was not taken seriously till 1964 where significant damage was caused by niigata and Alaska earthquakes, More than 250 bridges were destroyed by this phenomenon during the 1964 Alaskan earthquake, same phenomenon destroyed san Francisco’s marina during Prieta disaster 1989 and recently satellite township at Christchurch during Canterbury earthquake suffered extensively in 2010. The importance of the dispersive soils that are as a result of soil liquefaction due to chemical process, in civil engineering practice was not recognized until the early 1960's, research project about failure of service infrastructure especially underground supply lines in and around dams due to uneven clay movement was initiated in Australia because of many failures of small clay dams (Aitchison and Wood, 1965).
Investigations have been performed for identifying dispersive clays because they cannot be identified by the conventional laboratory index tests such as visual classification, gradation, specific gravity, or Waterberg limits.

There are three vital parameters that cause Soil Liquefaction:

1. Water logging resulting in heavy saturation of soil with water
2. Loose soil / Granular soil
3. Disturbance in soil crust for any reason like earthquake, construction activities etc. Where z is depth in m, amax refers to peak ground acceleration, according to IS 1893:2002 our region of interest falls under zone III corresponding PGA is 0.16g. From the technical report by National Disaster Management Authority “Probabilistic Seismic hazard map of India” (2011) constituted by Raghukanth and Iyenger the PGA values for return periods of 500,2500 and 5000 years

III. METHODOLOGY

3.1. Source of data for this project secondary data was used, this type of data is has been already collected and recorded by other user and is readily available from other sources. Advantages of the Secondary data analysis is it gives the perspective of another co research/project manager who has already worked in the same lines its saves time as the data is readily available, this is kept to best use while doing quantitative analysis, its data base is larger and of high quality.

However, the main disadvantage of secondary data is that the accuracy is not known and the data maybe outdated. Internet, books, thesis, journal articles, conference proceedings, reports and newspaper articles played as a source for the data collection in this project.

3.2. Design and Construction Measures Almost all of the failures due to dispersive clay have occurred in homogeneous earth embankments without filters and all piping failures were caused by an initial concentrated seepage path through the embankment.

Seepage paths through embankments can be caused by cracking due to desiccation, differential settlement, saturation settlement, or hydraulic fracturing. Additionally, areas of potentially high soil permeability such as around conduits through the embankment, concrete structures, and at the foundation interface all require special treatment and attention during construction. If piping due to defloucating is to be avoided, permeability should be less than $10^{-5}$ cm/s. Careful control of compaction and water content during construction are thus necessary to minimize these conditions.

Sand filters can effectively and safely control leaks in embankments whether they are constructed of dispersive or non-dispersive clay. During the process of sealing and filtering a leak, dispersive clay does not have enough strength to stop the colloidal particles in suspension from passing through, but the silt-size particles carried by the flow cannot enter the sand filter and are retained in the leakage channel upstream of the filter, and gradually seal the leak. With non-dispersive soils the filter is designed to prevent all fine particles from a protected zone from entering the filter.

### Table 1. Types of Liquefaction- Structural Instability Caused (National Research Council, 1985)

<table>
<thead>
<tr>
<th>Infrastructure Most Affected</th>
<th>Types of Instability</th>
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<tbody>
<tr>
<td>BUILDINGS BUILT ON A SLOPE</td>
<td>SLOPE INSTABILITY</td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>UNDRAINED</td>
</tr>
<tr>
<td>DAM EMBANKMENT &amp; FOUNDATION</td>
<td>SLOPE INSTABILITY</td>
</tr>
<tr>
<td>BRIDGE PIER</td>
<td>FLUIDITY OF SOIL</td>
</tr>
<tr>
<td>RAILWAY LINE</td>
<td>LATERAL SPREADING</td>
</tr>
<tr>
<td>HIGHWAYS</td>
<td></td>
</tr>
<tr>
<td>UTILITY LINE</td>
<td></td>
</tr>
<tr>
<td>STRUCTURES, ESPECIALLY</td>
<td></td>
</tr>
<tr>
<td>THOSE WITH SLABS ON GRADE</td>
<td></td>
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<tr>
<td>UTILITY LINES</td>
<td></td>
</tr>
<tr>
<td>HIGHWAY</td>
<td></td>
</tr>
<tr>
<td>RAILWAY</td>
<td></td>
</tr>
<tr>
<td>BURIED TANK</td>
<td></td>
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<tr>
<td>UTILITY POLE</td>
<td></td>
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<tr>
<td>STRUCTURES BUILT ON GRADE</td>
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<tr>
<td>RETAINING WALL</td>
<td></td>
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<tr>
<td>PORT STRUCTURE</td>
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<tr>
<td></td>
<td>INCREASE OF LATERAL STRESS IN LIQUEFIED SOIL</td>
</tr>
</tbody>
</table>

Based on the above, Sherard et al. (1984b) state that sand or gravelly sand filters with $D_{15}=0.5$ mm or smaller will safely control and seal concentrated leaks through most dispersive clays with $d_{55}$ larger than about 0.03 rom. Sand filters with $D_{15}=0.2$ mm or smaller are conservative for the very finest dispersive clays. For clays having similar particle size distribution, whether dispersive or non-dispersive, the required filters are the same, where; $D_{15}$ = particle size in the filter of which 15 percent are smaller, by dry mass of soil $d_{55} =$ particle size of the base soil of which 85 percent are smaller, by dry mass of soil. The filter should be non-cohesive to be effective when cracks form.

If it is not, the filter could sustain an open crack and fail to protect the cracked core. Similar design criteria can be used if a geotextile is used for the filter element. Dams with dispersive cores on rock foundations should be given special consideration to prevent the clay from penetrating small rock cracks.

This can be done by cleaning the cracks to a minimum depth of three times their width and by filling the cracks with cement mortar before slush grouting the core-rock contact. Dispersive clay modified with hydrated lime (Haliburton et al., 1975, Knodel, 1987) or non-dispersive clay of medium to high plasticity can also be utilized for this important embankment-foundation interface, depending upon the circumstance (Forbes et al., 1980; Logani, 1979; McDaniel and Decker, 1979; Sherard and Decker, 1977).

Great care should be taken during compacting soil adjacent to rigid structures such as conduits. In some cases, lime-modified dispersive clay has been used for portions of this interface. Lime modification of dispersive clay may be necessary for slope protection where other means such as gravel with the necessary filter layers are not economically feasible.

5.3.2. Selection of Materials for Economic Construction

Although dispersive soils require special provisions when used in earth embankments, these materials may represent the most economic choice of materials for a specific situation. Concern for the limitations of these materials and the serious problems...
they may cause should not be reason to avoid their use where alternate materials would be more expensive.

In the view of geologic time frame at present earth is in Holocene Epoch era, it is also called as Anthropocene Epoch, as its states the environmental impact caused by anthropological evolution. But it is a must of a researcher to remember that contemporary man was existing way before the epoch began, the time represent Holocene Epoch is 12000 to 11500 year ago. It Started after Paleolithic Ice Age and still continuing.

![Machilipatnam Town Surround by natural/manmade canals](http://ijesc.org/)  
**Figure.1.** Machilipatnam Town Surround by natural/manmade canals (Geographical Terrain is Molded Using Google Earth Image and 3D Max Software by Author)

![Stagnated Water for 7days around a Dwelling Unit in Madulagudem, Machilipatnam](http://ijesc.org/)  
**Figure.2.** Stagnated Water for 7days around a Dwelling Unit in Madulagudem, Machilipatnam (Picture Taken By Author)

### IV. RESULTS

Figure 1 is graphical representation showing after 10 minutes of rain, storm water gets collected and starts to flows in to Shivanasamudra through main storm water drains resulting in raising the level of water in the drain during monsoons. Figure 1 clearly shows the spillage over from the storm water drain into the low-lying areas due to back flow from Shivanasamudra when the water level in the drain reaches equivalent level of discharge from the storm water drain from Machilipatnam town. Water logging happens for weeks together causing heavy saturation of water in the soil. Figure 2 shows fungus formation on the stagnated water around the dwelling unit clearly indicates the water logging is there for more that 7 days in Mandulagudem. It is very clear that storm water drains are not effective in the town. The change in levels of stagnation can be clearly understood by studying damages caused to the plinth of the dwelling unit in its entire span of life which is 10 years.

### Table.2. Comparison of Flow Liquefaction and Cyclic Softening

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>FLOW LIQUEFACTION</th>
<th>CYCLIC SOFTENING</th>
<th>CYCLIC MOBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOIL STRESS RESPONSES</td>
<td>SUITABLE STRESS</td>
<td>STRESS SOFTENING</td>
<td>EFFECTIVE STRESS</td>
</tr>
<tr>
<td></td>
<td>UN-DRAINED SHEAR</td>
<td>STRAIN SOFTENING</td>
<td>STATE REACHES</td>
</tr>
<tr>
<td></td>
<td>NON-DRAINED SHEAR</td>
<td>STRAIN SOFTENING</td>
<td>ESSENTIALLY</td>
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<td></td>
<td>STRAIN HARDENING</td>
<td></td>
<td>ZERO</td>
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<tr>
<td></td>
<td>EFFECTIVE STRESS</td>
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<td></td>
<td>STATE REACHES</td>
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<tr>
<td></td>
<td>ESSENTIALLY ZERO</td>
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</tbody>
</table>

![Google Earth Image and 3D Max Software by Author](http://ijesc.org/)  
**Figure.3.** Graphical Representation of After 10 minutes

### V. CONCLUSION

Soil Liquefaction is a hazard which can weaken the soil causing unforeseen damage to property and life.

### VI. RECOMMENDATIONS

Soil liquefaction has serious damaging effects. Structural damage due to liquefaction-induced ground failure is a very costly phenomenon leading to significant economic losses and life losses therefore:

- **Areas that have liquefied soils or soils susceptible to liquefaction should be avoided or necessary mitigation against liquefaction hazards should be applied.**
- **The various tests to evaluate liquefaction should always be performed in areas susceptible to liquefaction before any development is planned.**
All testing and inspection records of construction activities in liquefaction zones should be kept for future reference and easier analysis.

Finally liquefaction of soil is an area in Geotechnical engineering that requires extensive research so as to be well understood and properly dealt with as the mitigation procedures available are either very expensive or require extensive ground disturbance to implement.

VII. REFERENCES

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