

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020

Study of Ground Fissures Generated by Liquefaction Following an Earthquake

SULAIMAN C.P.

Lecturer, Department of Civil Engineering, S. S. M. Polytechnic College, Thekkumuri, Tirur, Kerala, India

ABSTRACT: Seismically generated soil liquefaction hazard assessment and mitigation have made significant progress in the last decade, both in theory and in practise. Seismic soil liquefaction hazard assessment and mitigation is now a distinct sub-field of soil liquefaction engineering, with a growing body of research and practise devoted to the subject. Lessons and data provided by a series of big quakes over the previous 12 years, as well as the professional/political will that was generated by these major seismic occurrences, have led to this rapid evolution in liquefaction treatment. Now that soil liquefaction engineering has developed into a coherent and comprehensive framework, the many components are becoming increasingly interdependent. Although progress has been impressive, there is still a long way out there and a lot more to be done. Soil liquefaction engineering is becoming more and more complicated as we enter the "new millennium."

KEYWORDS: Liquefaction , earthquake , Fissures, soil liquefaction,

I. INTRODUCTION

Liquefaction-induced ground failure has been a major cause of earthquake damage and death in numerous historical earthquakes. Many of the 70-80 percent of the liquefied locations in the 2008 Wenchuan Ms8.0 Earthquake formed 100 meter to hundreds kilometer-long and 5 to 50 centimeter broad ground fissures, which intersected homes and fields and caused serious damage, as well. [1] Borehole drilling and Multi-Channels Electricity Resistance Test were used to determine the cause of the structure damage and ground cracks. It was observed that: (1) The building whose foundation was pierced by the liquefaction suffered more severe damage than its surrounding structures; (2) The plentiful ground fissures were formed by gravels liquefaction rather than the raptures or secondary faults; and (3) The fundamental requirements for the production of ground fissures by liquefaction are: flat ground surface (slop less than 3%), horizontal non uniform distribution of liquified soils. [2]

Cyclic stress ratios can be used to examine liquefaction-related phenomena in seismically active areas. The shear/cyclic stress ratios are affected by soil properties such as stiffness, elasticity, void ratio, and soil stress (CSR or SSR). The metrics used to estimate soil liquefaction include earthquake-induced cyclic loads and soil liquefaction resistance. It is the continuous initial stress, rather than cyclic stresses, that triggers liquefaction-triggered risks. The shear/cycle resistance ratio (SRR or CRR), cyclic stress ratio, and soil thickness are all factors in liquefaction analysis [3]. Shear wave velocity (V_s), soil and seismic data are used to calculate cyclic loads. Small strain shear waves can be used to determine cyclic stress ratios, which has the advantage of being applicable to all types of soils while also having the disadvantage of not being able to distinguish between different types of soil and thinner layers. Cemented soils and silty soils above the ground water table are best suited to small shear strain waves because of their high water content. Following liquefaction in the field, there are three frequent ground collapse conditions. (1) Flow landslides are widespread when water flow is unrestricted. (2) A lateral-spreading landslide is typical in areas where there is a lack of water movement. While a single episode of limited flow may be insignificant, a succession of episodes, such as those that occur during an earthquake, often results in significant ground movement. Many earthquake-related events labelled

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020

as lurching or land spreading are actually lateral-spreading landslides triggered by liquefaction. (3) The third category of ground failures caused by liquefaction are quick-condition failures, such as the loss of bearing capacity. [4]

The simple empirical technique requires three parameters to determine liquefaction potential: the cycle stress ratio (CSR), the shear velocity V_s , and the soil's ability to resist the liquefaction of the soil, given as the cyclic resistance ratio (CRR). It is necessary to account for overburden stress in the simplified technique because shear wave velocity is proportional to soil stiffness ($V_s \propto \sigma_v$). Our original method's expression: where is the cyclic stress ratio we're interested in. [5]

$$\frac{\tau_c}{\sigma'_v} \approx 0.65 \frac{a_{\max}}{g} \frac{\sigma_v}{\sigma'_v} r_d$$

(1)

A_{\max} is the greatest horizontal acceleration at the surface of the soil, and the acceleration of gravity; σ_v and r_d are the total and effective vertical stresses, respectively; r_d is the coefficient of reducing the efforts. In order to estimate the average value of r_d , apply the following formulae. [6]

II. REVIEW OF LITERATURE

Microtremor Analysis Method (MAM) and Multichannel Analysis of Surface Waves (MASW) are used in this paper to derive shear wave velocity profiles (MASW). A deeper penetration depth was achieved by combining MAM with MASW. It's possible to combine the higher frequency sledgehammer hits with the lower frequency tremors created by microtremors that travel deeper into the earth. In addition, the method reveals any modal patterns that may exist (Park et al., 2007). [7]

Recently, liquefaction has been highlighted in earthquakes in Chile (Bray et al. 2012)[8], New Zealand (Cubrinovski et al. 2011)[9], and Japan (Tokimatsu et al. 2012)[10]. Because the problem is so complex and there are so few well-documented field cases, liquefaction-induced building settlements are frequently approximated using empirical correlations derived for free-field locations on level ground that solely take into account postliquefaction volumetric strains. Because of the presence of a structure, these processes do not take into consideration extra impacts. Researchers can study liquefaction-induced building movement by conducting centrifuge studies.

Furthermore, the computational approaches proposed by Andrianopoulos et al. (2010)[11] were shown to be in good agreement with the results of geotechnical centrifuge tests. A non-liquefiable surface layer was explored by Karamitros et al. (2013a, b) [12-13] using numerical simulations, and a method for estimating liquefaction-induced building settlement was devised based on these numerical processes.

During recent earthquakes, liquefaction-induced settlements caused severe damage to structures. Building settlements caused by liquefaction can be studied using geotechnical centrifuge tests, and a number of recent research have examined the impacts of liquefaction on isolated structures (e.g., Dashti et al. 2010a,b; [14-15] Allmond and Kutter 2012; [16] da Silva Marques et al. 2014 [17]).

Objectives

- For the purpose of drawing a diagram of the volcano's internal structure.
- To learn about several kinds of liquefaction-induced structural instability.
- Examining the evaluation process for "Liquefiable" soil types
- To investigate the shear wave velocity profiles.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020

III. RESEARCH METHODOLOGY

Methodology in research refers to a discussion of the procedures utilised in a research study. Theories that support the selection and use of methods are included in this debate as well. Data for this research was gathered from a variety of published sources and is considered secondary in nature. The information used to prepare this paper was gleaned from a variety of reliable online sources.

IV. RESULT AND DISCUSSION

Figure 9 shows shear wave velocity (V) profiles at depths ranging from 1.8 to 30 m. At depths more than 30 metres, the procedure is no longer accurate. [18]

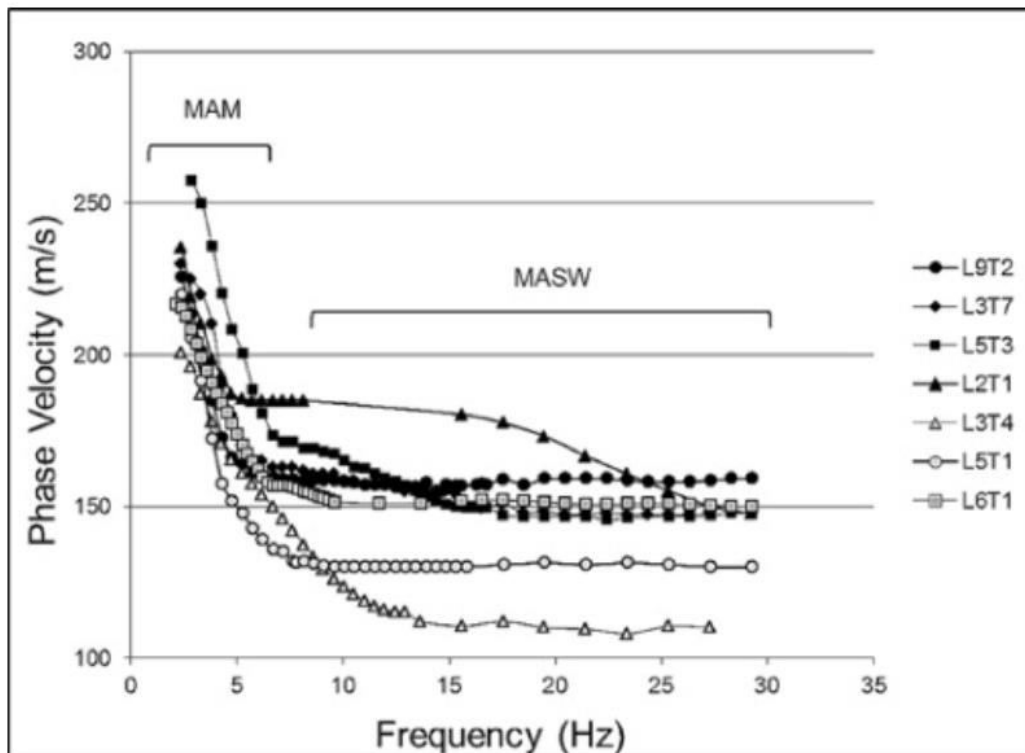


Figure 1: Velocity profiles of shear waves

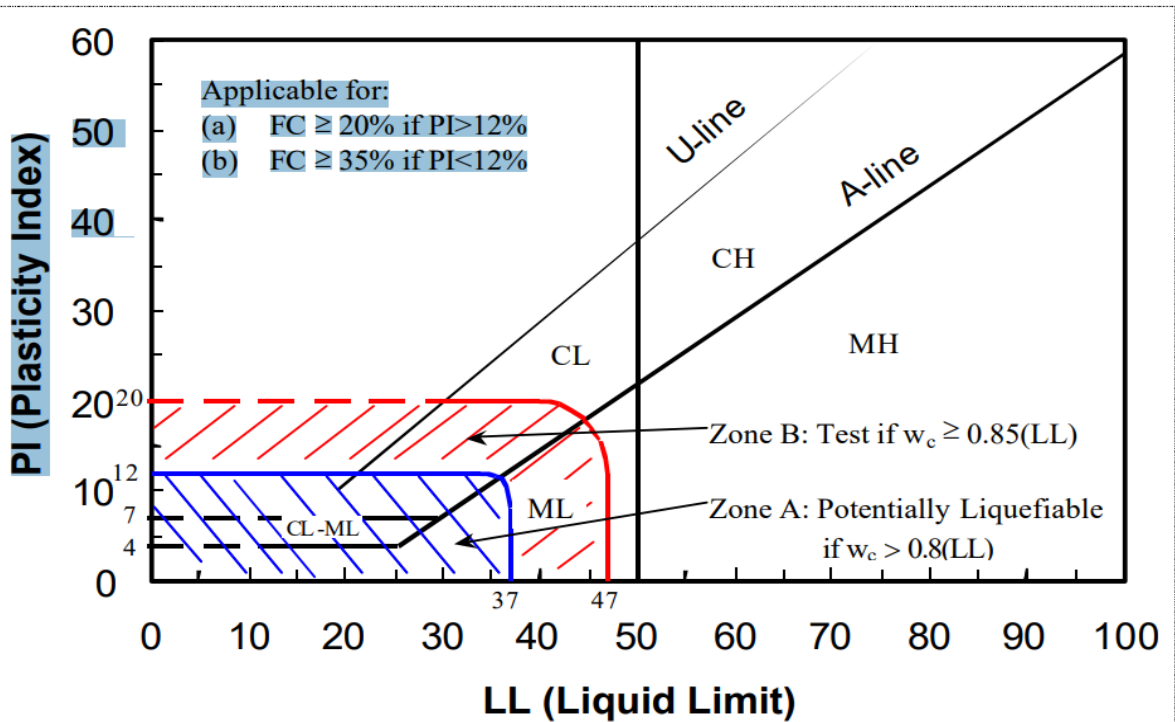
"Liquifiable of soils with Applicable for: 50 (a) $FC \pm 20\%$ in cases where $PI > 12\%$ (b) $FC \pm 35\%$ in cases where $PI < 12\%$, indicates interim suggestions in Fig. 2. This may change in the future, but it provides a solid overview of PI (Plasticity Index) 40 thus far. [19]

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020



The Fig. 2 Recommendations Regarding the Assessment of "Liquefiable" Soil types

Table 1: Structural instability caused by liquefaction (National Research Council, 1985)

Structures Most Often Affected	Types of Structural Instability
Buried and surface structures	Loss of foundation bearing capacity
Structures built on or at the base of a slope	Slope instability slides
Dam embankments and foundations	Slope instability slides
Bridge piers Railway lines Highways Utility lines	Movement of liquefied soil adjacent to topographic depressions
Structures, especially those with slabs on grade Utility lines Highways Railways	Lateral spreading on horizontal ground
Buried tanks Utility poles	Excess structural buoyancy caused by high subsurface pore pressure
Structures built on grade	Formation of sink holes from sand blows
Retaining walls Port structures	Increase of lateral stress in liquefied soil

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020

Table 1 offers a list of structures sensitive to liquefaction and the type of instability to which each structure is most exposed.

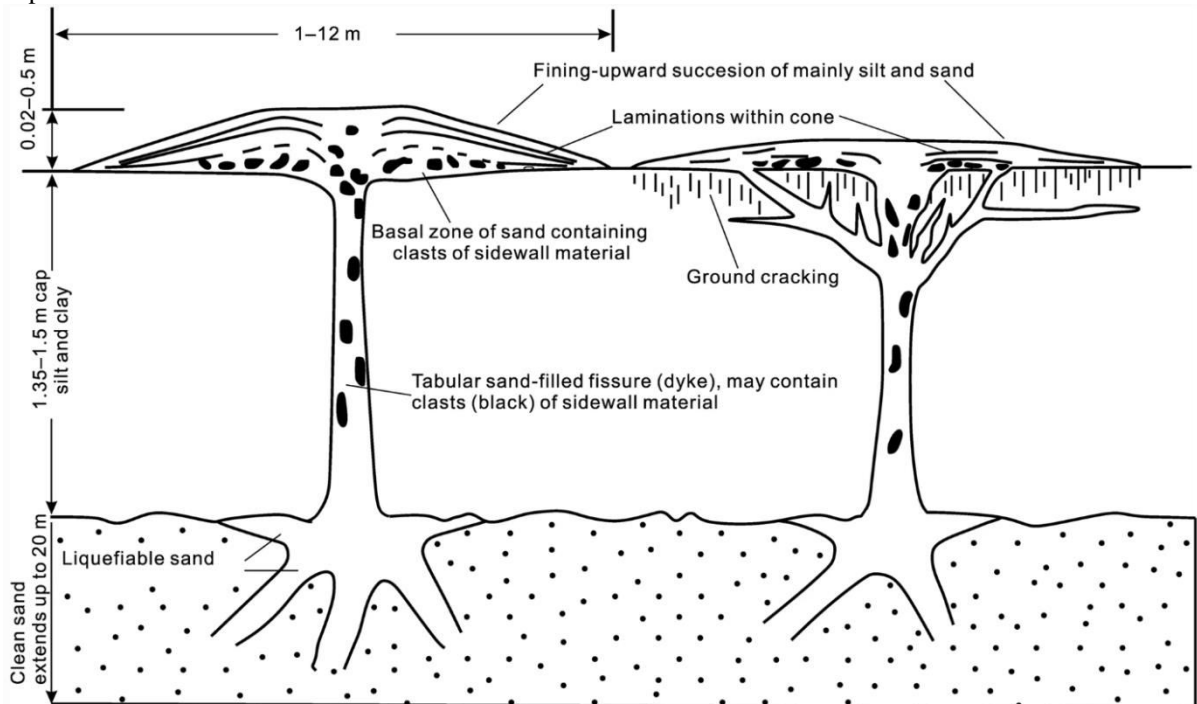


Figure 3 shows a rough sketch of a sand volcano's internal structure.

Sand volcanoes also erupt on a regular basis as a result of the periodic seismic waves they are influenced by. It is illustrated in Figure 3 that after the eruption, the sand moves laterally to produce incline laminations. As with the sand volcanic deposit, inclined lamination has an overall shape that points away from the crater's centre toward its distal end[20]. A gully and draw-in structures are formed at the inner margin of the crater by the refluxing influence of eruption in the interior of the sand volcanic channel.

V. CONCLUSION

Liquefaction in and of itself is not dangerous. An isolator could be formed during seismic shaking by a liquid layer at depth, preventing vibrational energy from the deeper layers from reaching structures at the surface. Liquefaction in the field can lead to an infinite flow if the conditions are right. Earth materials can travel long distances in liquid flows or chunks of intact materials riding atop liquefied flows if the mobilised soil is unconstrained. Slope decrease can cause flow to stop, but only if the driving shear forces fall below the viscous shear resistance of flowing material. Settlement of the structure and walls occurs once some liquefaction reaches the base of the containment wall. Because of the increased depth of the liquefaction caused by high shaking intensity, structures and the containment walls themselves sink into the softened soil. Small earthquakes that cause liquefaction only up to a depth below the containment walls can benefit from partial depth containment walls. Even in large earthquakes, full-depth containment walls can reduce structural settlements. It was shown that solid containment walls are particularly successful in minimising the risk of liquefaction because they prevent the spread of soil and reduce the volume of soil that changes.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 1, January 2020

REFERENCES

1. Acosta Chang et al., 2010 Acosta Chang J.G., Vásquez S., Mendoza L.H., Hernández F., Salas J., Ruiz e., Arellano g., R. Reyes R., Granados O., 2010, Estudiogeofísico y geológico en la colonia Solidaridad Social, Mexicali Baja California. Informe técnico para el Ayuntamiento de Mexicali. pp. 107 (Registro CICESE PA: 101086).
2. Alsop, G.I., and S. Marco. 2011. Soft-sediment deformation within seismogenic slumps of the Dead Sea Basin. *Journal of Structural Geology* 33 (4): 433–457.
3. Bhattacharya, S., M. Hyodo, K. Goda, T. Tazoh, and C.A. Taylor. 2011. Liquefaction of soil in the Tokyo Bay area from the 2011 Tohoku (Japan) earthquake. *Soil Dynamics and Earthquake Engineering* 31 (11): 1618–1628.
4. Chen, J., and H.S. Lee. 2013. Soft-sediment deformation structures in Cambrian siliciclastic and carbonate storm deposits (Shandong Province, China): Differential liquefaction and fluidization triggered by storm-wave loading. *Sedimentary Geology* 288: 81–94.
5. Olivia Chen Consultants, Inc. (2003). “Report on the Seismic Stability of Calaveras Dam”, report prepared for the San Francisco Public Utilities Commission, Utilities Engineering Bureau.
6. Rauch, A.F. and Martin II, J.R. (2001). “Prediction the Maximum and Distribution of Displacements on Liquefaction Induced Lateral Spreads.” Proceedings: Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, San Diego, California.
7. Park et al., 2007 C.B. Park, R.D. Miller, J. Xia, J. Ivanov Multichannel analysis of surface waves (MASW)-active and passive methods *The Leading Edge (TLE)*, 26 (1) (2007), pp. 60–64’
8. Bray, J., Rollins, K., Hutchinson, T., Verdugo, R., Ledezma, C., Mylonakis, G., Assimaki, D., Montalva, G., Arduino, P., Olson, S. M., Kayen, R., Hashash, Y. M. A., and Candia, G. (2012). “Effects of Ground Failure on Buildings, Ports, and Industrial Facilities.” *Earthquake Spectra*, 28(S1), S97–S118.
9. Cubrinovski, M., Bray, J. D., Taylor, M., Giorgini, S., Bradley, B., Wotherspoon, L., and Zupan, J. (2011). “Soil liquefaction effects in the central business district during the February 2011 Christchurch earthquake.” *Seismol. Res. Lett.*, 82(6), 893–904.
10. Tokimatsu, K., Tamura, S., Suzuki, H., and Katsumata, K. (2012). “Building damage associated with geotechnical problems in the 2011 Tohoku Pacific Earthquake.” *Soils Found.*, 52(5), 956–974.
11. Andrianopoulos, K. I., Papadimitriou, A. G., and Bouckovalas, G. D. (2010). “Bounding surface plasticity model for the seismic liquefaction analysis of geostructures.” *Soil Dyn. Earthquake Eng.*, 30(10), 895–911.
12. Karamitros, D., Bouckovalas, G., and Chaloulos, Y. (2013a). “Insight into the Seismic Liquefaction Performance of Shallow Foundations.” *J. of Geotech. Geoenviron. Eng.*, 139(4), 599–607.
13. Karamitros, D. K., Bouckovalas, G. D., and Chaloulos, Y. K. (2013b). “Seismic settlements of shallow foundations on liquefiable soil with a clay crust.” *Soil Dyn. Earthquake Eng.*, 46, 64–76
14. Dashti, S., Bray, J., Pestana, J., Riemer, M., and Wilson, D. (2010a). “Mechanisms of Seismically Induced Settlement of Buildings with Shallow Foundations on Liquefiable Soil.” *J. of Geotech. Geoenviron. Eng.*, 136(1), 151–164.
15. Dashti, S., Bray, J., Pestana, J., Riemer, M., and Wilson, D. (2010b). “Centrifuge Testing to Evaluate and Mitigate Liquefaction-Induced Building Settlement Mechanisms.” *J. of Geotech. Geoenviron. Eng.*, 136(7), 918–929
16. Allmond, J., and Kutter, B. (2012). “Centrifuge Testing of Rocking Foundations on Saturated Sand and Unconnected Piles: The Fluid Response.” *GeoCongress 2012, ASCE*, 1760–1769
17. Da Silva Marques, A. S. P., de Figueiredo Coelho, P. A. L., Haigh, S., and Madabhushi, G. (2014). “Centrifuge Modeling of Liquefaction Effects on Shallow Foundations.” *Seismic Evaluation and Rehabilitation of Structures*, Springer, 425–440.
18. Manual design of civil works, 2008 Manual design of civil works, 2008, Design by earthquake. Recommendations and Comments, Federal Electricity Commission (CFE), Distrito Federal, Mexico.
19. Marchetti et al., 2001 Marchetti S., Monaco P., Totani G., Calbrese M., 2001, The flat dilatometer test (DMT) in soil investigations”, A report by the ISSMGE committee TC16, Proceedings IN SITU 2001, International Conference on in situ measurement of soil properties, 44, Bali, Indonesia.
20. Ge, R.F., Q.L. Zhang, L.S. Wang, G.A. Xie, S.Y. Xu, J. Chen, and X.Y. Wang. 2010. Tectonic evolution of Songliao Basin and the prominent tectonic regime transition in eastern China. *Geological Review* 56 (2): 180–195.