PRELIMINARY LIQUEFACTION POTENTIAL ANALYSIS OF VIJAYAWADA REGION

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Abstract: Experience from past earthquakes has demonstrated the vulnerability of structures to seismically induced ground deformation. During earthquake, soil can fail due to liquefaction with devastating effect such as landslides, lateral spreading, or large ground settlement. The phenomenon of liquefaction of soil had been observed for many years, but was brought to the attention of engineers after Niigata (1964) Alaska earthquakes (1964). Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction and related phenomena have been responsible for tremendous amounts of damage in historical earthquakes around the world (Borcherdt R.D 1991; Dobry R, 1981). During the Bhuj earthquake, India on 26th January 2001 (M=7.7) lot of damages had been occurred due to liquefaction and other ground failures (Rao and Mohanty, 2001). In this paper, a preliminary liquefaction hazard assessment was carried out using the available SPT data. From these investigations it was observed that a vast majority of liquefaction occurrences were associated with sandy soils and silty clays of low plasticity.

***Keywords**: Liquefaction potential, seismic hazard assessment*

Introduction

The city Vijayawada occupies an area of 119.8 square kilometers. The population of the whole city (along with Vijayawada Sub-Urban and Vijayawada Rural) is more than 2.5 Million. Vijayawada is bounded by the Indrakiladri Hills on the east and west and the Budameru River on the north. The Northern, North-Western, and South-Western parts of the city are covered by a low range of hills, while the Central, South-Western and North-Western parts are covered by rich and fertile agriculture lands with three major irrigation canals. The topography of Vijayawada is flat.

A large number of investigations have been carried out for understanding the phenomenon of soil liquefaction in the last four decades. From these investigations it was observed that a vast majority of liquefaction occurrences were associated with sandy soils and silty sands of low plasticity.

Mechanism

Liquefaction of soil is a process by which sediments below water table temporarily lose shear strength and behave more as a viscous liquid than as a solid. The water in the soil voids exerts pressure upon the soil particles. If the pressure is low enough, the soil stays stable. However, once the water pressure exceeds a certain level, it forces the soil particles to move relative to each other, thus causing the strength of the soil to decrease and failure of the soil follows. During earthquake when the shear wave passes through saturated soil layers, it causes the granular soil structure to

deform and the weak part of the soil begins to collapse.
The collapsed soil fills the lower layer and forces the pore water pressure in this layer to increase. If increased water pressure cannot be released, it will continue to build up and after a certain limit effective stress of the soil becomes zero. If this situation occurs then the soil layer losses its shear strength and it cannot certain the total weight of the soil layer above, thus the upper layer soils are ready to move down and behave as a viscous liquid.

Methodology

Ground response analysis is an important factor that is to be taken into consideration for evaluation and remediation of geotechnical as well as structural seismic hazards. For site specific ground response analysis three basic input parameters that are essential are, (i) Input ground motion (ii) Shear wave velocity profile and (iii) Dynamic soil characteristics (e.g., strain dependent modulus reduction and damping behaviour and cyclic strength curves).
Linear analysis using DEEPSOIL (Youssef M.A.H, 2009) in frequency domain was used to compute free field response, which is very popular with practitioners.
Analyses were carried out for the stochastically simulated acceleration time histories from local sources using in-situ measured shear wave velocities. Shear wave velocity (Vs) is one of the most important input parameter to represent the stiffness of the soil layers. It is preferable to measure Vs by in situ wave propagation tests, however it is often not economically feasible to perform the tests at all locations. Hence, a reliable correlation between Vs and standard penetration test blow counts (SPT) would be a considerable advantage. Shear wave velocity was measured using an attenuation relation developed for Delhi region (Neelima Satyam D, 2006)

$$V_S = 61 \text{ X } N^{0.5} \quad (1)$$

Where, N = corrected SPT value.

In the current study, Chamba earthquake from long distance of magnitude 4.9 was considered (Fig.1). Fast Fourier transform was applied. Analysis is performed for 5% damping. Thickness (m), unit weight (kN/m^3) and shear velocity (m/sec) for each layer are given as input as shown in Table 1. Borehole data including corrected SPT values were consired in the analysis. Figure 3 shows the soil profiles of boreholes of 10m deep along with SPT value. After obtaining the Surface PGA from DEEPSOIL as shown in Fig. 3, Matlab is used to generate the liquefaction factor of safety at the locations.
Two methods have been adopted for accuracy. They are Seed and Idriss method and Seed and Peacock method

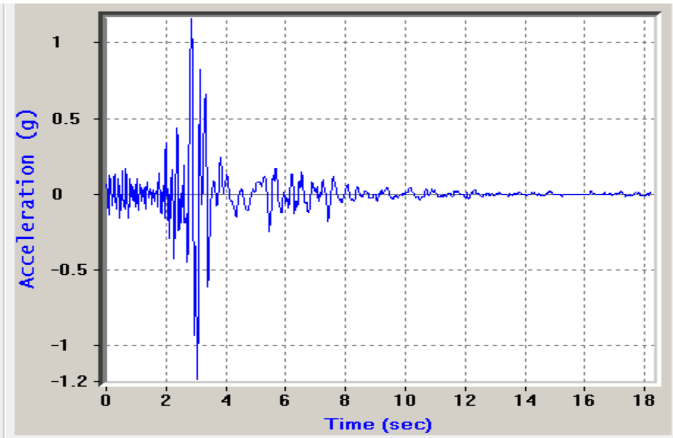
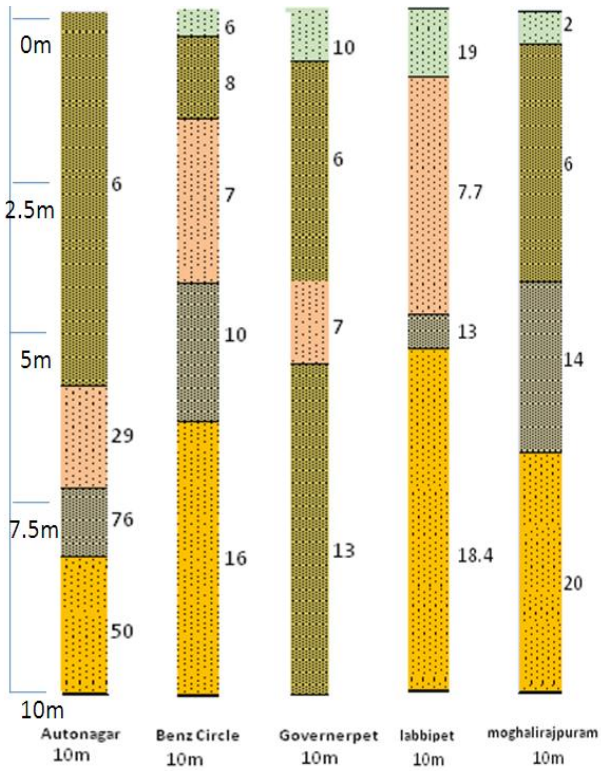


Fig 1. Acceleration time history of 1995 Chamba Earthquake

Table 1. Details of soil profiles given in Deepsoil

Layer no	Thickness (m)	Unit Weight (kN/m^3)	Vs (m/s)	Damping Ratio (%)
1	1.5	14.8	86.26	5
2	6.55	15.3	158.13	5
3	0.95	15.4	192.89	5
4	1	15.5	192.89	5



IS Classification	legend
SM-SP	
SC-CI	
SC-CP	
SP	
SM	

Fig 2. Details of SPT data consider for analysis (few locations are shown here)

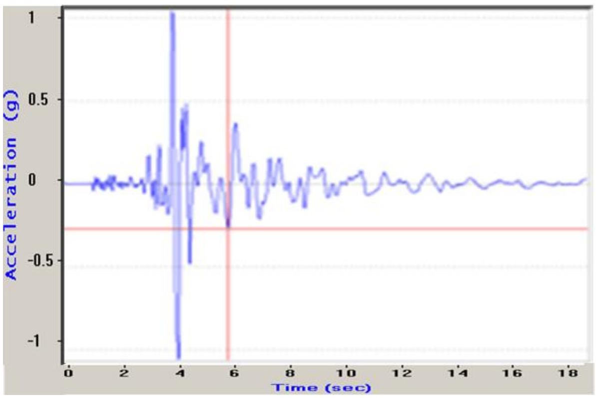


Fig 3. Acceleration time history at the surface

The shear stress developed at any point in a soil strata during an earthquake appear to be primarily due to the vertical propagation of shear waves in the deposit. This leads to a simplified procedure developed by Seed and Idriss (1971) for evaluating the induced shear stress. The

simplified procedure was evolved initially based on extensive laboratory studies of the behaviour of soils subjected to cyclic loading and later confirmed and supplemented with field case histories. This procedure is based on the relationship between the SPT N′ value and the intensity of cyclic loading, expressed as magnitude weighted equivalent uniform cyclic stress ratio. Figure explains the steps involved in the analysis procedure in the simplified Seed and Idriss (1971) method.

In Seed and Peacock (1971) method the induced average cyclic shear stress (τav) due to a given earthquake can be computed. Using corrected SPT 'N' value the resistance for the soil liquefaction was estimated for the boreholes.

Results

Profiles for each borehole data has been drawn based on the IS Classification of soils and indicating the water table level at each borehole. Chamba earthquake data with a maximum PGA 0f 0.118g and magnitude of 4.9 is given as input. The results obtained from the DEEPSOIL as shown in Table 2 by assuming the engineering bedrock at a depth of 200m from ground surface. And the inputs given were Thickness of layers, Unit weight, Shear wave velocity as described earlier. Shear wave velocity for the engineering bed rock was considered as 760m/s and unit weight as 18.5 kN/m^3 with a damping of 5%. The water table at each borehole data which has a significant effect on the liquefaction potential at a point is also considered. Rock Property is considered as Rigid Half Space. Number iterations used for fast Fourier transform is 15. Complex shear modulus is taken as Frequency independent. Using the matlab, a code has been developed for calculating the factor of safety using the two methods mentioned are carried out. Peak Ground Acceleration (PGA) obtained above, unit weights of layers, thickness, shear wave velocity and water table level are given as inputs.

Conclusions

- Borehole data at 10 locations have been considered based on the existence of important buildings like hospitals, colleges and important buildings in the locality, Population etc. and Preliminary liquefaction potential assessment has been carried out at the study areas.
- The preliminary Liquefaction potential analysis at all these locations has been carried out and estimated the liquefaction potential.
- By Seed and Idriss (1971) Method, at the locations like patamata, Autonagar and kanuru liquefaction can occur.
- In Seed and Peacock (1971) Method, at the locations like Autonagar and kanuru liquefaction is likely to occur.
- Required precautions have to be taken into consideration. As the Preliminary assessment shows the possibility of occurrence, so a detailed liquefaction potential analysis of the area has to be carried out.

References

[1] Borcherdt R.D. (1994), Estimates of Site Dependent Response Spectra for Design (Methodology and Justification) *Earthquake Spectra*, (10) 4, 617-653.

[2] Dobry R. (1981), Liquefaction Susceptibility from S Wave Velocity, Insitu Testing to Evaluate Liquefaction Susceptibility, *J. Geotechincal Engg., ASCE*.

[3] D.Neelima Satyam, (2006), Seismic Microzonation of Delhi Region, Ph.D Thesis, IIT Delhi

[4] Rao K.S. and Mohanthy W.K. (2001), The Bhuj Earthquake and Lessons for the Damages, IGS Newsletter, 33, 3-10.

[5] Steven L. Kramer (1996), Geotechnical Earthquake Engineering, Third Edition.

[6] Seed H.B and Idriss I.M. (1971) Simplified Procedure for Evaluating Soil Liquefaction Potential, J. Soil Mechanics and Foundations*, ASCE*, (97) SM9, 1249-1273.

[7] Seed H.B. and Peacock W.H. (1971) Test Procedures for Measuring Soil Liquefaction Characteristics, J. Soil Mechanics and Foundations Div., ASCE*,* 152-167.

[8] Youssef M.A.H (2009), DEEPSOIL, http://www.geoengineer.org/software/applications-deepsoil.htm

Table 2 Estimated surface PGA from DEEPSOIL

Location	Latitude	Longitude	Water table(m)	Max. PGA (g)
Auto Nagar	16^0 20' 31.31''	80 41'38.01''	9.5	0.2
Benz Circle	16° 49' 65"	80°65'89.00"	4.0	0.13
GovernerPet	16° 51' 42"	80°63'11.00"	5.0	0.12
Kanuru	16^0 28' 16.72''	80 43'12.67''	2.4	0.11
Labbipet	16° 50' 29"	80°63'60.00"	9.7	0.13
Moghalrajpuram	16° 50' 87"	80°64'54.00"	9.5	0.14
Patamata	16° 49' 50"	80°66'70.00"	8.6	0.14
Stella College	16° 50' 80”	80°66'06.00"	5.5	0.09
Sub collector Office(bunder road)	16° 50' 65"	80°63'29.00"	6.0	0.13
Surya raopet	16° 49' 16"	80°66'95.00"	7.4	0.11