A Review on Liquefaction Potential Assessment of Kashmir Valley

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ABSTRACT

The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893-2002] assigns four levels of seismicity for India in terms of zone factors (zone 2,3,4 and 5). Zone 5 expects the highest level of seismicity whereas zone 2 is associated with the lowest level of seismicity. According to the seismic zoning map of India, Kashmir valley lies in the seismic zone 5, where there is possibility of occurrence of high magnitude earthquakes. Moreover the presence of active seismogenic faults, soft alluvium and shallow groundwater levels in the basin of Kashmir valley signifies its determinental effects on the occurrence of earthquakes. One of the determinental effect of which there is a major possibility to occur in Kashmir valley is the liquefaction of soils located near the water bodies. The main aim of this present paper is to provide necessary data about the liquefaction potential values of soils in the valley from South Kashmir to North Kashmir. For this purpose detailed study was performed on the soils present near the water bodies. Two tests namely SPT (Standard Penetration Test) and Shake Table Test were used to obtain the liquefaction potential values of the soils. The Shake Table used in the study provided the necessary acceleration to saturated soil mass resembling the acceleration generated by the earthquakes of magnitude 7.6. To determine the dynamic properties of soil 7 SPT boreholes spread across the valley were used. The analysis shows that the southern part of Kashmir valley (Anantnag and Awantipora) is safe against liquefaction and there is gradual increase in the liquefaction potential index values towards the northern part of Kashmir valley, with Baramulla and Sopore having the highest possibility of liquefaction to occur.

Keywords: Liquefaction Potential (LP), Liquefaction Potential Index (LPI), Standard Penetration Test (SPT), Shake Table Test.

1. INTRODUCTION

Soil liquefaction is generally associated with major Earthquakes and related ground failures. In general liquefaction may be defined as the loss of strength of a saturated cohessionless soil mass due to the dynamic loads acting on it because of earthquakes. This loss of strength is mainly due to the build up of pore water pressure and thus making the effective stress equal to zero. The detailed description of the soil liquefaction provided by Sladenetl (1985) is: ‘soil mass will flow like a liquid until the shear stress acting on it are less or equal to the shear resistance. This liquid like flow is due to the loss of shear resistance of soil mass upon the application of monotonic, cyclic or shock loading’.

Speaking more specifically, liquefaction may be defined as "the transformation from a solid state to a liquefied state due to increased pore pressure and reduced effective stress." However the ground failures with less soil deformation and having no liquid-like flow attributed to soil liquefaction are ascribed more accurately to "cyclic mobility". Till now the proper and precise definition for soil liquefaction is the matter of ongoing discussion for geotechnical engineers. Although researchers have stated that the above two phenomenon should be properly separated.

Liquefaction has the possibility to occur when the soils are subjected to shearing stresses, resulting in the decrease of their volume. For loose and moist soils the soil grains will rearrange themselves into a denser packing having less room in the voids as water is pushed out of the pore spaces. When pore water drainage is stopped, pore water pressure rises slowly with the increase in shearing load. Due to this stresses from the soil skeleton are transferred to the water present in the pores which causes a decrease in the shear resistance and effective stress of the soil mass. When the soil's resistance to shear becomes lower than the driving shear stress, the soil will show significant deformations and is thus said to be liquefied. Under both monotonic and cyclic shear loads, liquefaction of loose, cohessionless soils can be observed.

The skeleton of the dense sands will compress first and then dilate when they are sheared monotonically and the particles of the sand travel up and over each other. Dense saturated sands dilate when they are loaded without pore water drainage. This dilation reduces the pore water pressure and increases the effective stress and shear strength of the soil sample. However due to the repeated cycles of loading, excess pore pressure may get developed in each load cycle as a result of which soil mass will become soft and deformations will be formed in it.

Objectives

Main aim of this project is to provide necessary data about the liquefaction potential values of the soils in the vicinity of the river Jhelum. Since Kashmir lies in the earthquake zone V, where the earthquakes of medium to high magnitude can occur due to which there is the possibility of liquefaction problem in the saturated soils. The problem of liquefaction damages the structures which are constructed near the river. In order to minimize the damage caused to these structures in future this project is going to provide the necessary preliminary data that will help the civil engineers to incorporate such methods of construction which will minimize the effect of liquefaction of soils.

2. LITERATURE REVIEW

Idrees and Boulanger (2006) Semi-empirical procedures for evaluating the liquefaction potential of saturated cohessionless soils during earthquakes are re-examined and revised relations for use in practice are recommended. The stress reduction factor (r_d), earthquake magnitude scaling factor for cyclic stress ratios (MSF), overburden correction factor for cyclic stress ratios (K_σ), and the overburden normalization factor for penetration resistances (C_N) are discussed and recently modified relations are presented. These modified relations are used in re-evaluations of the SPT and CPT case history databases. Based on these re-evaluations, revised SPT- and CPT-based liquefaction correlations are recommended for use in practice. In addition, shear wave velocity based procedures are briefly discussed.

Bishop C (2012) Determining the liquefaction potential of soil is important in earthquake engineering. This study proposes the use of the Relevance Vector Machine (RVM) to determine the liquefaction potential of soil by using actual cone penetration test (CPT) data. RVM is based on a Bayesian formulation of a linear model with an appropriate prior that results in a sparse representation. The results are compared with a widely used artificial neural network (ANN) model. Overall, the RVM shows good performance and is proven to be more accurate than the ANN model. It also provides probabilistic output. The model provides a viable tool for earthquake engineers to assess seismic conditions for sites that are susceptible to liquefaction.

Neelima Satyam Seshagiri K. Rao (2014). The seismic behaviour of a saturated soil depends on the potential for significant strains or strength loss that can contribute to ground deformations or instability during an earthquake. Historic large earthquakes throughout the world explain that the liquefaction related ground failure commonly causes extensive structural and lifeline damage in urban areas. Detailed assessment of liquefaction hazard is important for evaluating and reducing the risk through appropriate mitigation techniques. Soil liquefaction generally occurs in areas underlain by low density, saturated granular sediments. The liquefaction susceptibility can be mapped using specific, well established geologic and geotechnical criteria. Damages caused by liquefaction of saturated soil revealed that after liquefaction the ground failed, sand boiling occurred and the structure subsided unevenly causing tilting, cracking or even collapse. After the devastating 2001 Gujarat earthquake, the Government of India has paid serious attention to carry out the detailed site characterization and ground response studies which are very crucial in seismic microzonation and it is also accepted as a guiding tool in land use planning and safe construction practices to avoid the loss from the future earthquakes. Very preliminary process of reducing the effects of earthquake is by assessing the hazard itself. As part of the national level microzonation program, Department of Science and Technology, Govt. of India has initiated microzonation of 63 cities in India. In this research paper two urban centers Delhi and Vijayawada city which falls in seismic zones IV and III respectively are considered for liquefaction hazard assessment. Since these two cities are falling in the areas with high and moderate seismic probability, there is a great need for the assessment of liquefaction potential. An attempt has been made estimate the liquefaction hazard for these two cities considered using the measured shear wave velocities and SPT borehole data. From the detailed liquefaction assessment, it is observed that the possibility is severe in the north and north eastern side of Delhi and is very less in the western side of the city. In the south and central part of the area where shear wave velocities of the soil strata is ≥180 m/s the possibility of liquefaction is unlikely and in Vijayawada city, the occurrence of liquefaction is likely at several locations especially in Patamata, Autonagar and Kanuru

Javaid Amad Dar and R.K. Dubey(2015) Kashmir valley India is located in seismically active Himalayan-Hindukush belt, which has been witnessed by the number of high magnitude earthquakes during the past centuries. The presence of active seismogenic faults, soft alluvium and shallow groundwater levels in the basin of the Kashmir valley signifies its detrimental effect on the occurrences of future strong ground motions. In view of severe damaging attitudes and frequent occurrences of earthquakes in the region the present paper emphasizes attenuation model for seismic hazards zonation to ensure the safe and comfortable expansion of settlements and industrial establishments. For the purpose detailed study was performed on the seismically deformed beds, water-table conditions and past seismic activities of the area around the valley. The results of study reveal the peak ground acceleration (PGA) of 10, 5 and 2 % probabilities of event in 50-year lifetime with probability of 2 % for PGA = 0.652 (g), 5 % for PGA = 0.460 (g) and 10 % for PGA = 0.372 (g) which varies with the different surface and sub-surface conditions of the area.

(Hamid Sana) and Sankar Kumar Nath(2016) We present the liquefaction potential analysis of Kashmir valley alluvium in general with special emphasis to four benchmark localities. The synthetic ground motions from the site response analysis of the valley during the 8 October 2005 Kashmir earthquake of M_w 7.6 are used as input motions. To determine the dynamic properties of soil, 64 SPT (Standard Penetration Test) boreholes spread across the valley were used. The analysis shows that the north-western part of the Kashmir valley has very high, central part very high to high and south-eastern part low to very low liquefaction potential, as measured on the Liquefaction Potential Index (LPI) scale. These results are complemented by the field investigations carried out after the earthquake wherein liquefaction features were observed in the north-western part of the valley. At the benchmark sites, the soil profiles of Baramulla (Ahtishampora) and Kupwara are unsafe, showing a tendency to liquefy, while as in Anantnag (Khanabal) and Srinagar (Mehjoor Nagar) shallow layers are safe but the deeper layers are unsafe. As far as liquefaction potential is concerned, Baramulla (Ahtishampora) and Kupwara soil profiles show very high LPI values, Srinagar (Mehjoor Nagar) portrays high LPI, but Anantnag (Khanabal) exhibits low liquefaction potential.

Mohammad Mominul Hoque,Mehedi Ansary (2017) This paper presents evaluation and comparative analysis of liquefaction potential from Standard Penetration Test (SPT) and Cone Penetration Test (CPT) based deterministic relationships. Both methods have significant relative advantages, and can often be optimal when used in combinations. In this research, four pairs of SPT and CPT tests were carried out at the river bank of Jamuna, Bangladesh and each pair of test was conducted as close as possible. Particle size analysis on collected samples indicated that, fines content varied in the range of 3.5 to 39.2 percent. The recorded SPT N-values in different boreholes varied from 1 to 42 and maximum CPT resistance was approximately 20 MPa. It was observed that the recorded SPT N-value and CPT resistance considerably varied at some depths in certain locations. These result in some inconsistency in the safety factors against liquefaction calculated on the basis of SPT and CPT data. So, it is emphasized that quality test data is required to obtain consistent and reliable results when both methods are used in combinations for liquefaction analysis.

A.Kayabasi and C.Gokceoglu (2018) Eskişehir is a city in Turkey that is located primarily on the Porsuk river alluvium deposits. Hence, the probability of liquefaction is a geotechnical problem in this city. In this study, the liquefaction potential was investigated using a standard penetration test (SPT) and down hole geophysical test. Menard pressure meter tests were also performed in order to modify liquefaction analysis methods with this test. Laboratory tests were performed on standard penetration split sampler samples collected from the boreholes. Liquefaction analysis was performed considering different scenarios. The first peak horizontal acceleration value was determined from the earthquake that occurred in 1956, which was 6.4 Mw. The second peak horizontal acceleration value was determined from Çukurhisar-Sultandere fault, which is approximately 40 km long and may create a 6.94 Mw earthquake with a peak horizontal acceleration of a_{max} = 0.48 g. There are some differences between SPT-N method and Vs method but both the SPT-N method and the Vs method are harmonious with each other in general for determination of the liquefiable soils. The Vs method particularly results in a continuous profile for the liquefaction determination. There is no regional liquefaction potential in the study region, but locally liquefiable silty sand layers were determined. The liquefiable layer thickness increases with increasing peak horizontal acceleration. A liquefaction analysis method using the Menard pressure meter test is suggested in this study. Both the cyclic resistance ratio (CRR) chart and the equation are modified for liquefaction analysis using the Menard pressure meter test.

3. CONCLUSION

Considering the substantial seismic risk in the Kashmir valley, this study tries to evaluate the factors of safety for liquefaction (FOS) and their corresponding liquefaction potential indices (LPI) for the worst seismic conditions of the valley using SPT-based semi-empirical procedures.

These erstwhile tests were conducted at different depths at various locations within the valley. The results varied from location to location. Our endeavour was limited by the depth that could manually be achieved for the aforementioned procedures. Generally the region of south Kashmir was found to be safe against soil liquefaction. This could possibly be attributed to sand deposition in the middle and late phases of the Jhelum River and its various tributaries. The central part of Kashmir especially Srinagar was found to be unsafe. North Kashmir particularly the town of Baramulla and its vicinities were found to be unsafe despite being better than Srinagar in several target variables. Liquefaction in the vicinity of Baramulla due to earthquake of 2005 also confirms these results. Our tests were conducted for shallow depths which in turn limited our insight into the liquefaction phenomenon. The liquefaction process apparently shows significant variation with the depth at which the study is concerned. Due to the omnipresent threat of a large earthquake, several places within the valley need a comprehensive study to determine the damage that could in all its probability occur in the foreseeable time.

4. REFRENCES

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