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. EXPERIMENTAL WORK

The experimental work consists of following steps:

1. Digging of boreholes of various depths at different sites.
2. Determination of N-value of soils at different sites by SPT.
3. Correcting this N-value using different corrections to give $(N_1)_{60CS}$.
4. Determination of depth of water table at the site.
5. Collection of sample from the sites for Shake Table testing and calculation of soil parameters.
6. Determination of initial stresses.
7. Determination of stress reduction factor r_d.
8. Calculation of CSR (Cyclic Stress Ratio) and CRR (Cyclic Resistance Ratio) from $(N_1)_{60CS}$ and FC.
9. Calculation of factor of safety against liquefaction.
10. Calculation of liquefaction potential.
11. Calculation of liquefaction potential index.

3. RESULTS AND DISCUSSION

Two tests were conducted to determine the values of Liquefaction potential and Liquefaction potential index of the soils at different sites. One of the tests was Standard Penetration Test which was done at the site to obtain the standard penetration number 'N' of the soil mass and the second one was the Shake Table Test which was done in the laboratory. From the results of these tests and from other soil characteristics, the following values of factor of safety, liquefaction potential and liquefaction potential index were obtained.

FOS, LP and LPI values of different sites for frequency of vibration equal to 1.5Hz

S.No.	Site location	FOS	LP	LPI	Possibility for liquefaction
1	Anantnag	>1	8318.45	0	No
2	Awantipora	>1	7967.3	0	No
3	Pampore	>1	11237.32	0	No
4	Srinagar	<1	2123.135	8.28	Yes
5	Shadipora	<1	9975.18	3.439	Yes
6	Sopore	<1	1035.47	7.56	Yes
7	Baramulla	<1	862.87	5.814	Yes

FOS, LP and LPI values of different sites for frequency of vibration equal to 1.73Hz

S.No.	Site location	FOS	LP	LPI	Possibility for liquefaction
1	Anantnag	>1	7335.59	0	No
2	Awantipora	>1	7794.743	0	No
3	Pampore	<1	11230.86	4.437	Yes
4	Srinagar	<1	1748.83	10.71	Yes
5	Shadipora	<1	8819.125	4.94	Yes
6	Sopore	<1	895.6	10.188	Yes
7	Baramulla	<1	796.04	7.825	Yes

4. 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.

5. REFRENCES

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