Journal of Advances and Scholarly Researches in Allied Education
Vol. 15, Issue No. 9, October-2018, ISSN 2230-7540

Liquefaction Potential Assessment from Shake Table Testing From Various Regions in Kashmir: A Study

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Abstract – 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.

Keywords: Soil, Liquification, Sheer Test, Cyclic Triaxial Test

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TEST METHOD:

The important laboratory tests used in study of soil liquefaction are cyclic triaxial test, cyclic simple shear test, cyclic torsional shear test and shake table test. Cyclic tri-axial test is one of the common tests done to measure the dynamic properties of the soil at higher strain levels.

The most effective test to determine the damping characteristics of soil over a wide range of strain levels is through cyclic torsional shear test.

In this method the shear modulus of soil was calculated from field calculations like standard penetration test SPT from the given set of equations.

$$Vs = 73\ N.33$$

$$G = \rho V\ 2\ s$$

Then the maximum or peak ground acceleration generated by the table or maximum velocity of vibration V_{max} used for testing is recorded at different frequencies and the duration time taken by each sample at those peak ground accelerations to get liquefied is also recorded. Also the effective overburden pressure at the site were sample was taken is calculated. Then the liquefaction potential is given by the equation.

Liquefaction potential assessment from shake table testing

1. Calculations of Anantnag Sample

The in-situ standard penetration value at the site (N value) was found to be 9. Depth selected for liquefaction potential assessment was 1.5m. Mass density at the site was calculated as 1330.27Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 19.575 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s=73N^{0.33}$$

Dikmen (2009)

$$Vs = 73 \times 90.33$$

$$V_s = 150.73 m/s.$$

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho\ (V_s)^2$$

$$G = 1330.27(150.73)^2$$

$$G = 30223.113\ KPa.$$

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016m/s and time taken by the sample to liquefied was -recorded as 17 sec. thus

$$LP = \frac{0.3016 \times 30223.113 \times 17}{19.575}$$

LP = 7916.2

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 13 sec. thus

$$LP = \frac{0.3478 \times 30223.113 \times 13}{19.575}$$

LP = 6980.88

2. Calculations of Awantipora Sample:

The in-situ standard penetration value at the site (N value) was found to be 6. Depth selected for liquefaction potential assessment was 2m. Mass density at the site was calculated as 1347.95Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 26.438 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s=73N^{0.33}$$

Dikmen (2009)

Vs = 73 × 60.33

V_s = 131.86 m/s.

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho (V_s)^2$$

$$G = 1347.95 (131.86)^2$$

G = 23436.89 KPa.

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016 m/s and time taken by the sample to liquefied was recorded as 18 sec. thus

$$LP = \frac{0.3016 \times 23436.89 \times 18}{26.438}$$

LP = 4812.55

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 16 sec. thus

$$LP = \frac{0.3478 \times 23436.89 \times 16}{26.438}$$

LP = 4933.11

3. Calculations of Pampore Sample:

The in-situ standard penetration value at the site (N value) was found to be 4. Depth selected for liquefaction potential assessment was 3m. Mass density at the site was calculated as 1317.54 Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 38.76 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s=73N^{0.33}$$

Dikmen (2009)

Vs = 73 × 40.33

V_s = 115.34 m/s.

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho (V_s)^2$$

$$G = 1317.54 (115.34)^2$$

G = 17527.65 KPa.

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016 m/s and time taken by the sample to liquefied was recorded as 45 sec. thus

$$LP = \frac{0.3016 \times 17527.65 \times 45}{38.76}$$

LP = 6137.4

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 39 sec. thus

$$LP = \frac{0.3478 \times 17527.65 \times 39}{38.76}$$

LP = 6133.86

4. Calculations of Srinagar Sample:

The in-situ standard penetration value at the site (N value) was found to be 2. Depth selected for liquefaction potential assessment was 2m. Mass density at the site was calculated as 1370.86 Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 21.014 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s = 73N^{0.33}$$

Dikmen (2009)

Vs = 73 × 20.33

V_s = 91.76 m/s.

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho\,(V_s)^2$$

$$G = 1370.86\,(91.76)^2$$

G = 11542.5 KPa.

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016 m/s and time taken by the sample to liquefied was recorded as 7 sec. thus

$$LP = \frac{0.3016 \times 11542.5 \times 7}{21.014}$$

LP = 1159.63

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 5 sec. thus

$$LP = \frac{0.3478 \times 11542.5 \times 5}{21.04}$$

LP = 954.01

5. Calculations of Sopore Sample:

The in-situ standard penetration value at the site (N value) was found to be 2. Depth selected for liquefaction potential assessment was 2m. Mass density at the site was calculated as 1311.9Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 25.74 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s = 73N^{0.33}$$

Dikmen (2009)

Vs = 73 × 20.33

V_s = 91.762m/s.

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho\,(V_s)^2$$

$$G = 1311.9\,(91.762)^2$$

G = 11046.54 KPa.

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016 m/s and time taken by the sample to liquefied was recorded as 8 sec. thus

$$LP = \frac{0.3016 \times 11046.54 \times 8}{25.74}$$

LP = 1035.47

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 6 sec. thus

$$LP = \frac{0.3478 \times 11046.54 \times 6}{25.74}$$

LP = 895.6

6. Calculations of Baramulla Sample:

The in-situ standard penetration value at the site (N value) was found to be 2. Depth selected for liquefaction potential assessment was 1.5m. Mass density at the site was calculated as 1235.47Kg/m^3.The effective overburden pressure at the point where liquefaction potential was to be calculated is 18.18 KN/m^2 Also the shear wave velocity of sample can be calculated as

$$V_s=73N^{0.33}$$

Dikmen (2009)

$$Vs = 73 \times 20.33$$

$$V_s = 91.762 m/s.$$

Then the maximum shear modulus of soil can be calculated by the following equation.

$$G = \rho (V_s)^2$$

$$G = 1235.47 (91.762)^2$$

$$G = 10402.53 KPa.$$

Now the two different samples from same site were tested at two different frequency (different velocities) of vibrations and the corresponding duration time required for the sample to get liquefied is noted. Then the liquefaction potential is calculated as

$$LP = \frac{[v_{max} * G_{max} * dur]}{\sigma_o}$$

where, 'vmax' is the horizontal strong motion velocity (m/sec), 'Gmax' is small strain shear modulus (KPa), 'dur' is duration of strong ground motion (sec), Ϭv' is initial effective overburden pressure (kPa).

(a) For frequency 1.5Hz, v_{max} = 0.3016 m/s and time taken by the sample to liquefied was recorded as 5 sec. thus

$$LP = \frac{0.3016 \times 10402.35 \times 5}{18.18}$$

LP = 862.87

(b) For frequency 1.73Hz, v_{max} = 0.3478 m/s and time taken by the sample to liquefied was recorded as 4 sec. thus

$$LP = \frac{0.3478 \times 10402.53 \times 4}{18.18}$$

LP = 796.04

CONCLUSION

Considering the substantial seismic risk in the Kashmir valley, this study attempts to evaluate the factors of safety against liquefaction (FOS) and corresponding liquefaction potential indices (LPI) for the worst seismic scenario for 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 early and middle phases of the Jhelum river and its various tributaries.

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