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Analysis of Liquefaction Potential in The Youtefa Bay Area, Jayapura City

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ABSTRACT

The distribution of soil in Jayapura City, especially the Youtefa Bay area, consists of three dominant soil types that then form the stratigraphy of the local soil layer, namely allifial deposits, silt silt/silt clay, and fine, uniformly grained sand. Soil conditions like this have great potential for liquefaction, especially since this area is mostly passed by fault lines that have the potential to cause earthquakes. The groundwater table factor that is very close to the surface soil is also an important factor in the occurrence of liquifaction. There are 2 ways to analyze the potential for liquifaction, namely by *laboratory test* and from field test data. The approach to calculating field test data is CPT (*Cone Penetration Test*) testing. The results obtained were the *Cyclic Stress Ratio (CSR) value and the Cyclic Resistance Ratio* (CRR) value obtained by simulating seismic data using an earthquake strength of 6.5 on the riter scale and *a pic ground acceleration* value (0.3), then based on the results of *the cone penetration test* (CPT)/Sondir showed a maximum value of CRR 2.88, a minimum value of 0.21, a maximum CSR value of 3.70, a minimum value of 2.25. The maximum value of FS is 0.97, the minimum value is 0.07. There are 6 points at the research location that have the potential for liquefaction (Very High), namely points S1, S2, S5, S7, S8, S10, while 3 points with medium potential (*High*), namely points S3, S4, S9 for those with low potential (*Low*) S6.

Introduction

The Jayapura City area often experiences earthquake disasters, this is because the structure of the tectonic order is in tune with the tectonic structure of the Papua region as a whole.

The vulnerability of the Jayapura City area to earthquakes with a risk level of small to large risk can cause a failure due to loss of soil stability (failure of the lower structure) (Kumar et al., 2023). The failure of this soil structure is caused by the amount of energy released by the epicenter (*hypocenter*) in the form of vibrations that propagate on the earth's surface. One of the damages to the soil structure due to the earthquake is liquefaction.

Liquefaction is more likely to occur in unconsolidated water-saturated soils with low porosity, such as sandy loam or fine sand and gravel. During an earthquake, the unconsolidated sand layer will tend to shrink in volume. At the same time, there is an increase in water pressure in the pores of the rock and causes a decrease in the shear strength of the rock, namely a reduction in *effective stress.* Liquefaction results in the collapse of bearing capacity, lateral soil movement, and different subductions in buildings.

In general, the distribution of soil in Jayapura City, especially the Youtefa Bay area, consists of three dominant soil types that then form the stratigraphy of the local soil layer. These three types of layers include (alluvial deposits, silt clay/silt clay, fine sand with uniform grains). Soil conditions like this have great potential for liquefaction, then based on the geological distribution map of the location of Jayapura City, Keerom Regency and Sarmi Regency are often passed by fault lines that have the potential to cause earthquakes so that it has the potential to cause liquefaction. The groundwater table factor that is very close to the surface soil is also an important factor that can result in the potential for liquifaction. However, it is necessary to conduct research to prove the potential for liquefaction in Jayapura City, especially the Youtefa Bay area, (Holtekamp).

Method

This study uses a quantitative approach with field survey methods and laboratory testing. Primary data was obtained through Cone Penetration Test (CPT) testing at 10 test points in the Youtefa Bay area, Jayapura City. This test was carried out to obtain the value of conus tip resistance (qc), the number of adhesive resistance (JHP), and the value of Fraction Ratio (FR). This data is then used to calculate key parameters such as Cyclic Resistance Ratio (CRR), Cyclic Stress Ratio (CSR), and Safety Factor (FS).

1. Research Design

This study uses a field experimental design to evaluate liquefaction potential based on seismic data simulations with a magnitude of 6.5 on the Richter scale and a peak soil acceleration (PGA) value of 0.3g. This simulation was carried out to calculate seismic parameters and soil resistance to cyclic pressure due to earthquakes.

2. Data Collection Techniques,

Data collected through:

- Field Testing: CPT testing is carried out at each test point to obtain soil parameter data.
- Seismic Data Simulation: Using geotechnical data processing software to calculate CRR, CSR, FS, and liquefaction potential index (LPI) values.

3. Data Analysis

Data analysis is carried out in the following stages:

- CPT Data Processing: The data from the CPT test results is analyzed to determine the qc, FR, and soil content weight values.
- CRR and CSR calculations: The calculations were performed using a formula from Seed & Idriss (1971) which was updated by Idriss & Boulanger (2008).

- Safety Factor Determination (FS): The FS value is calculated as the ratio between CRR and CSR. If the FS value is < 1, then the liquefaction potential is declared high.
- Evaluation of the Liquefaction Potential Index (LPI): The calculation of the LPI is carried out by considering the depth and severity of the liquefaction potential at each test point.

4. Result Validation

The results of the tests and calculations are compared with international standards and related geotechnical literature to validate their level of accuracy and reliability.

With this research method, the liquefaction potential in the Youtefa Bay area can be comprehensively analyzed based on seismic parameters and local geotechnical conditions obtained through field surveys and seismic data simulations.

Results and Discussion

The results of the CPT/Sondir test provide the value of the conus end resistance (qc) and the number of adhesive resistance (JHP), the difference in the reading results shows the value of "*Fraction Ratio*" (FR). This result, after plotting into a graph, will provide information on the Soil Type and Contents Weight Value, which can then be used to calculate the CRR value which represents the value of soil resistance to repeated loads due to earthquakes (CSR).

The Liquifaction Potential Index can be calculated and funded using sondir/CPT data. According to Iwasaki et al. in 1982, it was divided into several categories. Starting from *Very Low* to *Very High*. The LPI calculation itself uses a formulation where z is the depth of the midpoint of the soil layer (0-20 m) and dz is the difference in depth increase. Weight factor w(z), and severity factor F (z).

For the calculation of the potential liquidation index, it can be calculated with the formula above and can be formulated using *Microsoft Exel Software* as seen in the table

Data

- z : 1 m
- SF : 0.83

a. Calculating the value of F (z))

- F(z) = 1-SF

= 1-0,83

= 0,17

b. Calculating the value of w (z)

- w(z) = 10-(0,5.z)

=10-(0,5.1)

= 9.5

c. Calculating the LPI value

- ∑LPI = LPI depth 0 to depth 20 m

= 67,95 *(Very High)*

The results of the calculation of CRR, CSR, FS, and Liquifaction Potential Weighting values that have been carried out with the number of tests of 10 CPT/Sondir test points are then expressed in the form of tables and maps of liquifaction potential.

Table 1. Table Recapitulation Results of Calculation of CRR, CSR, FS, LPI Sondir 10

CPT/SON DIR 1-10	NL	Soil Behaviour Type	Depth		tebal lapisan	qc/pa	FR	NILAI CRR, CSR, FS			Keterangan	Liquifaksi Potensial Index (LP!)	
			h_a	h				CRR	CSR	FS			
			m	m	m							LPI	ket
CPT/S1	L4	Sand	4.00	7.80	3.80	655.45	0.85	2.88	3.46	0.83	Likuifaksi	67.95	Very High
	L5	Sand	7.80	8.80	1.00	441.27	0.81	2.88	3.42	0.84	Likuifaksi		
	L6	Sand to silty sand	8.80	10.40	1.60	1097.05	0.56	2.88	3.35	0.86	Likuifaksi		
	L10	Sand to silty sand	12.80	14.80	2.00	759.97	0.65	2.88	2.98	0.97	Likuifaksi		
CPT/S2	L5	Sand	4.80	5.80	1.00	431.46	0.70	2.88	3.76	0.77	Likuifaksi	20.64	Very High
	L7	Sand	6.60	7.80	1.20	433.10	0.76	2.88	3.60	0.80	Likuifaksi		
	L8	Silty Clay to Clay	7.80	9.00	1.20	702.76	0.74	2.88	3.70	0.78	Likuifaksi		
	L9	Sand to silty sand	9.00	9.60	0.60	1568.96	0.42	2.88	3.69	0.78	Likuifaksi		
	L10	Sand	9.60	10.00	0.40	2108.29	0.42	2.88	3.63	0.79	Likuifaksi		
	L11	Sand to silty sand	10.00	10.80	0.80	1311.55	0.63	2.88	3.55	0.81	Likuifaksi		
CPT/S3	L3	Clayey silt to silty clay	5.40	8.40	3.00	751.79	0.73	2.88	3.25	0.89	Likuifaksi	7.37	High
	L6	Sand	11.00	11.80	0.80	1961.20	0.34	2.88	3.12	0.92	Likuifaksi		
CPT/S4	L8	Sand	9.80	10.40	0.60	2157.32	0.51	2.88	3.32	0.87	Likuifaksi	4.96	High
	L9	Sand	10.40	11.00	0.60	849.85	0.91	2.88	3.19	0.90	Likuifaksi		
	L10	Sand	11.00	11.40	0.40	2108.29	0.31	2.88	3.16	0.91	Likuifaksi		
CPT/S5	L5	Sand	3.80	7.00	3.20	441.27	0.91	2.74	3.04	0.90	Likuifaksi	108.79	Very High
	L6	Sand	7.00	7.60	0.60	2190.01	0.60	2.88	3.06	0.94	Likuifaksi		
	L7	Sand	7.60	9.80	2.20	695.33	0.90	0.55	3.04	0.18	Likuifaksi		
	L8	Sand	9.80	10.40	0.60	2190.01	0.50	2.88	2.99	0.96	Likuifaksi		
CPT/S6	L6	Sand to silty sand	9.60	10.20	0.60	1225.75	1.08	2.88	2.99	0.96	Likuifaksi	3.27	Low
	L7	Sand	10.20	10.80	0.60	2255.38	0.58	2.88	2.96	0.97	Likuifaksi		
	L10	Sand to silty sand	16.40	17.00	0.60	1078.66	1.12	2.08	2.49	0.83	Likuifaksi		
	L13	Sand to silty sand	19.60	20.00	0.40	1299.30	1.02	0.28	2.25	0.12	Likuifaksi		
CPT/S7	L5	Sand	8.00	9.60	1.60	968.34	0.85	2.88	3.53	0.82	Likuifaksi	15.93	Very High
	L6	Sand to silty sand	9.60	10.80	1.20	1315.64	0.50	2.88	3.42	0.84	Likuifaksi		
	L7	Sand	10.80	12.80	2.00	995.31	1.17	1.27	3.13	0.40	Likuifaksi		
	L9	Sand to silty sand	14.60	16.40	1.80	1182.17	1.05	0.21	2.77	0.07	Likuifaksi		
CPT/S8	L4	Sand	9.60	10.20	0.60	980.60	1.35	2.27	2.91	0.78	Likuifaksi	15.98	Very High
	L5	Sand	10.20	10.60	0.40	1088.47	0.39	2.88	2.89	1.00	Likuifaksi		
	L6	Silty sand to sandy silt	10.60	12.00	1.40	553.34	0.77	1.96	2.81	0.70	Likuifaksi		
CPT/S9	L4	Sand to clayey sand	7.00	9.00	2.00	416.76	0.84	2.88	3.14	0.92	Likuifaksi	6.42	High
	L5	Sand	9.00	10.00	1.00	1784.69	0.42	2.88	3.16	0.91	Likuifaksi		
	L6	Sand	10.00	11.60	1.60	784.48	1.31	2.88	2.98	0.97	Likuifaksi		
CPT/S10	L3	Sand	5.80	7.40	1.60	784.48	0.84	2.88	3.53	0.82	Likuifaksi	21.21	Very High
	L4	Sand	7.40	9.20	1.80	1329.26	0.66	2.88	3.51	0.82	Likuifaksi		
	L5	Sand to silty sand	9.20	11.80	2.60	475.21	0.75	1.48	3.52	0.42	Likuifaksi		
	L8	Sand	17.00	20.00	3.00	666.81	0.84	2.39	3.14	0.76	Likuifaksi		

The Cyclic *Stress Ratio (CSR) value and Cyclic Resistance Ratio* (CRR) values obtained by simulating seismic data using an earthquake strength of 6.5 on the riter scale and a pic ground acceleration value (0.3), based on the results of the cone penetration test (CPT)/Sondir test, the maximum CRR value is 2.88, the minimum value is 0.21, the maximum CSR value is 3.70, and the minimum value is 2.25. The Cyclic *Stress Ratio (CSR) value and Cyclic Resistance Ratio* (CRR) value were obtained based on the results of the cone penetration test (CPT)/sondir and earthquake zoning to obtain *the "Pic Ground Acceleration"* (PGA) value. Sondir testing is carried out to obtain the conus tip resistance value (qc) and "*fraction ratio"* (FR) which will be used to obtain the type of soil, the weight value of soil content and the value of "n" based on the soil type per depth of 0.00-20 m, the results of this analysis are then used to calculate the behavior of total soil stress, pore water pressure and effective stress due to the influence of pore water pressure that occurs below the groundwater surface due to the influence of earthquakes which result in The total tension of the soil has the potential to experience a reduction in its strength value. By combining several other variables such as the normalization value of conus resistance (qcIN), cyclic voltage reduction (RD), CRR and CSR values can be calculated.

The "Factor Savety" (FS) value obtained based on the results of the cone penetration test (CPT)/Sondir showed a maximum value of FS 0.97, a minimum value of 0.07. The value of the "*Safety Factor"* (FR) is obtained from the quotient of CRR and CSR values. If the CRR value is less than the CSR value, it can be assumed that liquifaction has the potential to occur.

The evaluation results of the "*Liquifaction Potential Index*" (LPI) were obtained from the calculation of the FS value and the depth of the CPT test, where the calculation results showed that the liquifaction potential consisted of *very high, high, low* (high, medium). Low). The results of the LPI analysis from each test point showed that the research location was dominated by a very high potential for liquifaction. The results of the calculation show that there are 6 points at the research location that have a very high potential for liquifaction (Very High), namely points S1, S2, S5, S7, S8, S10, while 3 points with medium potential (*High*), namely points S3, S4, S9 for those with low potential (*Low*) S6

Conclusion

The results obtained were the Cyclic Stress Ratio (CSR) value and the Cyclic Resistance Ratio (CRR) value obtained by simulating seismic data using an earthquake strength of 6.5 on the riter scale and a pic ground acceleration value (0.3), then based on the results of the cone penetration test (CPT)/Sondir showed a maximum value of CRR 2.88, a minimum value of 0.21, a maximum CSR value of 3.70, a minimum value of 2.25. The maximum value of FS is 0.97, the minimum value is 0.07. There are 6 points at the research location that have the potential for liquifaction (Very High), namely points S1, S2, S5, S7, S8, S10, while 3 points with medium potential (High), namely points S3, S4, S9 for those with low potential (Low) S6.

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