International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 10 ǁ October 2023 ǁ PP. 334-340

Analysis of Liquefaction Potential of Paneki River, Sigi Regency

Astrid Dwijayanthi [1] , Hendra Setiawan [2] , Sriyati Ramadhani [3]
1 Department of Civil Engineering, University of Tadulako, Indonesia
Corresponding Author: astriddwijayantthi82@gmail.com

Abstract
Liquefaction that occurred due to the earthquake on September 28, 2018 which claimed many lives, left drastic landscape changes, especially in Sigi Regency, including the Paneki River. One of the changes that occurred in the location of the Paneki River was caused by liquefaction. Liquefaction that occurred in the upper reaches of the Paneki River, precisely in JonoOge Village, is still a threat at this time, whether liquefaction will occur again in the middle stream area of the Paneki River which is the location of this research. The potential for liquefaction is analyzed based on the value of N SPT issued by dee corporate .ltd and Jica Team Project. The results of this study showed the magnitude of the safety factor value showed <1. So it can be concluded that in the middle stream the Panaki River still has the potential for liquefaction.
Keywords:Consolidation of DAM, Likuefaksi, Middle stream, Sigi Regency, Paneki River.

Date of Submission: 14-10-2023 Date of acceptance: 29-10-2023

I. INTRODUCTION

1.1 Background of The Research

Liquefaction that occurred due to the earthquake on September 28, 2018 which claimed many lives, left drastic landscape changes, especially in Sigi Regency, including the Paneki River. One of the changes that occur in the location of the Paneki River is caused by liquefaction, where if there is rainfall with high enough intensity, the remnants of liquefaction sediments are carried away with the current.
The Government under the ministry of public works and public housingcontinues to carry out development in all fields after liquefaction occurs at the location, one of which is the construction of a consolidation dam in the middle stream of the Paneki River which serves to control the flow of debris that carries the remaining sediment due to liquefaction. However, the construction of consolidation dam and development must certainly consider many aspects, one of which is vulnerability to liquefaction.

Remind that liquefaction has occurred in the upper reaches of the Paneki River, precisely in JonoOge Village, further research is needed whether the Paneki River area still has liquefaction potential or not potential, especially at the dam consolidation construction site precisely in the middle stream of the Paneki River, Kabobona Village.

The purpose of this research was to determine the liquefaction potential in the middle stream of the Paneki River. Based on the results of observations at the research site, it was obtained that the type of soil along the Paneki River is soil with a low to medium density level. So the author feels the need to conduct in-depth research related to "Analysis of the Liquefaction Potential of the Paneki River, Sigi Regency"**.**

1.2 Research References

1.2.1 Definition nofLiquefaction

Liquefaction is a phenomenon that occurs due to an earthquake that hits an area. Liquefaction is an event where the soil loses shear strength due to increased pore water tension as a result of cyclic loads (earthquake loads) that are very fast and in a moment.*(Idriss Baker, 2008)*

1.2.2 Determining Liquefaction Potential

To find out an area of potential liquefaction, several tests must be carried out and then processed into CSR Value (Cyclic Stress Ratio) and CRR Value (Cyclic Resistance Ratio) then based on these values can be produced Safety Factor (Safety Factor) which is described as follows.

a) Cyclic Stress Ratio (CSR)

The value of Cyclic Stress Ratio (CSR) is a comparison between cyclic stress caused by an earthquake and effective vertical stress of the ground. In determining the value of this Cyclic Stress Ratio (CSR), an equation written by Youd and Idriss (1997) is used, as follows,

$$\mathbf{CSR = 0,65.\frac{\alpha max}{g}.\frac{\sigma v}{\sigma' v}.rd}$$

where;

CSR = *Cyclic Stress Ratio*

αmax = Maximum horizontal acceleration due to earthquakes on the earth's surface (m/s^2)

g = Earth's gravitational acceleration (9,81 m/s^2)

σv = Total vertical tension of the ground at depth z (kN/m2)

σ'v = Effective vertical tension of the soil at depth z (kN/m2)

rd = Voltage reduction factor

As for the comparison between the total vertical stress of the soil with the effective vertical stress of the soil, it can be calculated using a simple equation contained in the theory of Soil Mechanics (Hardiyatmo, 2002)

$\sigma v = \gamma \cdot z$

$\sigma' v = (\gamma - \gamma w) \cdot z$

Reduction factor, rd is a value that can affect the voltage in the soil. The farther the depth of the soil, the smaller the reduction factor ((S.S.C. Liao, 1986)) as shown in the reduction factor equation, rd is a value that can affect the stress in the soil, as shown in the following equation.

Rd $= 1,00 - 0,00765z$; (for$z \leq 9,15\ m$)

Rd $= 1,174 - 0,0267z$; (for $9,15 \leq z \leq 23m$)

Rd $= 0,744 - 0,008z$; (for $23 \leq z \leq 30m$)

Rd $= 0,5z$; (for$z \geq 23m$)

Where;

Z = depth of soil layer under review.

b) Correction Factors (N1)60cs

Liquefaction is influenced by soil plasticity, determining the correction factor (N1)60cs as follows,

(N1)60cs = $\alpha + \beta$(N1)60

The values of α and β are influenced by the percentage of FC content fines,

α = 0, β = 1, FC ≤ 5%,

α = exp[1,76-(190/FC2)] 5% < FC < 35%,

β = [0, 99-(FC1,5/1000)] 5% < FC < 35%,

α = 5,0 β = 1,2 FC ≥ 35%

c) Determining the CRR Value

Determining the CRR value on the magnitude of the earthquake scale (Mw) that has been corrected based on the value of (N1)60cs, (Boulanger, 2006)cited in Tsai et al. (2009), gives the equation as shown in the equation below.

$$CRR^{7,5} = \exp \frac{(N1)60cs}{14,1} + (\frac{(N1)60cs}{126})^2 - (\frac{(N1)60cs}{23,6})^3 + (\frac{(N1)60cs}{25,4})^4 - 2,8$$

d) Determining*Magnitude Scalling Factors* (MSF)

The value of Magnitude Scalling Factors (MSF) is used to balance the CRR value to the general value of Moment Magnitude (Mw) = 7.5 where the CRR value obtained from the evaluation of this liquefaction potential is based on an earthquake of 7.5 Mw. Seed and Idriss (1982) quoted in Youd and Idriss (2001), provide an equation regarding the MSF value for magnitudes greater than 7.5 Mw and smaller than 7.5 Mw. The equation can be shown as follows,

$$Mw < 7,5 ; MSF = \frac{10^{2,24}}{Mw^{2,56}}$$

e) DeterminingOverburden Voltage Correction Factor Value (Kσ)

Seed (1983), introduced the overburden voltage correction factor (Kσ). This overburden voltage correction factor (Kσ) is taken into account because it is useful for adjusting the CRR value to the effective voltage value. For the overburden voltage correction factor equation (Kσ), as quoted in Youd and Idriss(2001).

$$K\sigma = (\frac{\sigma' vo}{pa})^{(f-1)}$$

To get the value of f (relative density of the soil), the following equation can be used.

$$f = 0,831 - \frac{N1(60)cs}{60}$$

Where:

Kσ = Effective overburden voltage correction factor

σ'vo = Effective voltage overburden (kN/m2)

Pα = Pressure on 1 atm (101 kN/m2)

f = Soil relative density factor

f) Determining CRR_{Mw}

In determining the CRR value with a magnitude different from 7.5 Mw, the value of Magnitude Scalling Factors (MSF) is used as the correction factor as quoted in Youd and Idriss (2001), with the equation as shown below.

$$CRRMw = CRR7{,}5 \cdot MSF \cdot K\sigma$$

g) Determining *Factor of Safety* (FS)

In evaluating soil resistance to liquefaction, a guideline is needed to determine the reference value / boundary value whether a land evaluated has the potential to become liquefaction or not potentially liquefaction. The reference value or security factor value is the comparison between the CRR value and the CSR value. In full, the equation for the safety factor (FS) can be seen as follows,

$$\mathbf{FS} = \frac{CRRMw}{CSR}$$

Provided that:

If FS < 1 (Liquefaction occurs)

If FS = 1 (Critical condition)

If FS > 1 (No liquefaction occurs)

1.3 METHODOLOGY

1.3.1 Research Location

Administratively, the research location is in the Middle Stream of the Paneki River, Kabobona Village, South Dolo District, Sigi Regency, Central Sulawesi Province. Geographically, Paneki River is located between 05°08'34"S 119°53'23"E. While the topographic condition of this research location is at an elevation of ±22.901, with coordinates X = 821672.873 and Y = 9891962.258. The slope of the river bed (i) 0.4%. (JICA Team Project, Yachiyo Engineering Co., 2019)

Figure 1. Research Location

1.3.2 Types of Research

This research uses case study methodology using quantitative approach.

1.3.3 Data Sources

The data used is in the form of primary data, namely disturbed soil sample data obtained directly from the research site. While the Secondary Data are data in the form of topographic data, soil investigation data which includes N-SPT data at the DB-2 drilling point obtained from Dee Corporate Ltd., and paneki river technical planning data obtained from the JICA TeamProject.

1.3.4 Research Flow Chart

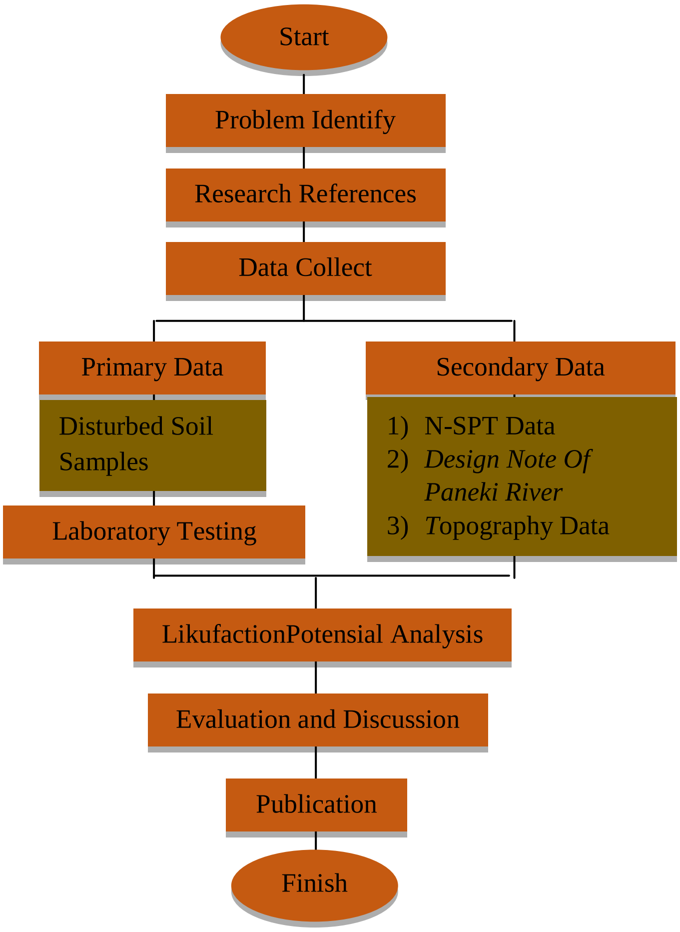

Figure 2. Research Flow Chart

II. RESULT AND DISCUSSION

The results obtained are as discussed below;

2.1 Laboratory Test Results

The tests carried out are Direct Shear testing and Sieve Analysis. This test was carried out at the Soil Imaging Laboratory of Tadulako University. The sampling rate is the same as the DB-2 drill point previously implemented by Dee Corporate Ltd. The results of the two tests are as follows.

Table 1. Direct Shear Test Results

P - Normal		P	3	Kg	P	6	Kg	P	9	Kg
σ - Normal		σn	0,079	Kg/cm²	σn	0,157	Kg/cm²	σn	0,236	Kg/cm²
Time	Transfer	Dial Load	P (shear)	τ (shear stress) Kg/cm²	Dial Load	P (shear)	τ (shear stress) Kg/cm²	Dial Load	P (shear)	τ (shear stress) Kg/cm²
	0,600	20	1,52	0,040	48	3,648	0,096	35	2,66	0,070
	1,200	36	2,736	0,072	60	4,560	0,120	45	3,42	0,090
	1,800	45	3,42	0,090	92	6,992	0,183	52	3,952	0,104
	2,400	52	3,952	0,104	110	8,360	0,219	63	4,788	0,126
	3,000	73	5,548	0,145	112	8,512	0,223	78	5,928	0,155
	3,600	86	6,536	0,171	116	8,816	0,231	86	6,536	0,171
	4,200	92	6,992	0,183	120	9,120	0,239	95	7,22	0,189
	4,800	101	7,676	0,201	122	9,272	0,243	110	8,36	0,219
	5,400	107	8,132	0,213	124	9,424	0,247	116	8,816	0,231
	6,000	110	8,36	0,219	125	9,500	0,249	125	9,5	0,249
	6,600	113	8,588	0,225	125	9,5	0,249	130	9,88	0,259
	7,200	114	8,664	0,227	122	9,272	0,24312981	132	10,032	0,263
	7,800	114	8,664	0,227	120	9,12	0,239144075	131	9,956	0,261
	8,400	112	8,512	0,223	118	8,968	0,23515834	130	9,88	0,259

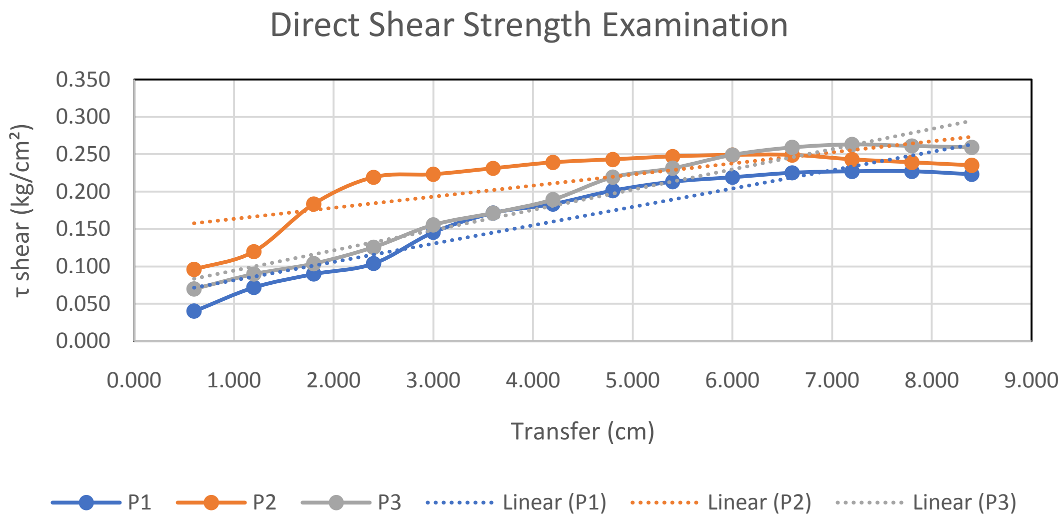

Figure 3. Graph of the Relationship between Shear and Shift Stress

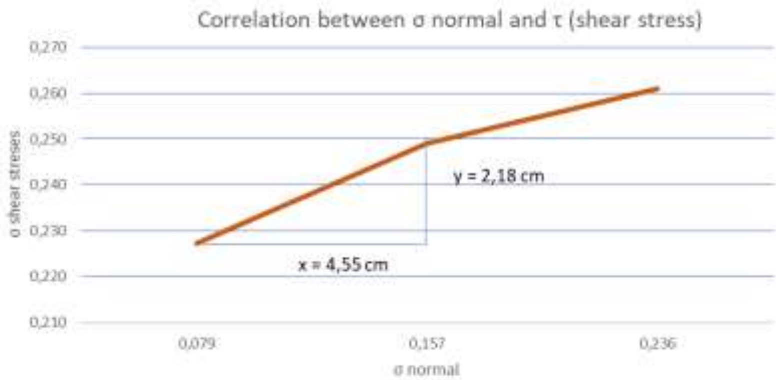

Figure 4. Graph of the relationship between shear stress and normal voltage

Table 2. Sieve Analysis Results Table

SIEVE ANALYSIS

Dry soil sample weight before sieved : 1500,00 gr

Sieve No.	Sieve Size (mm)	Soil Retained, gr	Total Suspended, gr	% Retained	% finer
1 1/4	31,5	0	0	0	100
1/2	12,7	230,74	230,74	15,38	84,62
1/4	6,35	290,18	520,92	34,73	65,27
4	4,750	74,84	595,76	39,72	60,28
10	2,000	174,20	769,96	51,33	48,67
40	0,450	405,05	1175,01	78,33	21,67
80	0,180	225,06	1400,07	93,34	6,66
100	0,150	31,41	1431,48	95,43	4,57
200	0,075	46,02	1477,5	98,50	1,50
PAN	0,000	22,50	**1500**	100,00	0,00

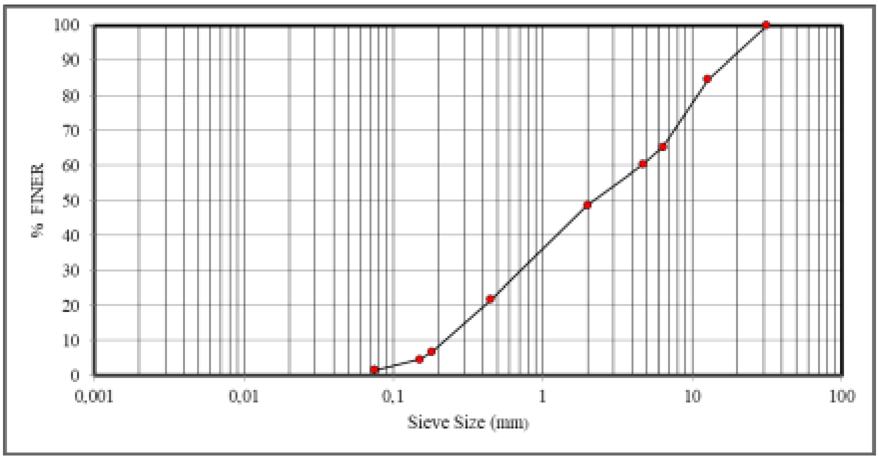

Figure 5. Graph of percentage of granules passing sieve 200

From the removal of soil samples at the research site, a γsat value of 2.0571 gr/cm3 was obtained. For cohesion value (c) 0.227 obtained from the direct shear test (see table 1). From the graph of the relationship between shear stress and normal voltage (see figure 4) obtained the value of φ^0 as follows:

$$\varphi^0 = \arctan \frac{4,55}{2,18}$$

$= 25,66°$

Meanwhile, from the results of the sieve analysis test (see table 2) it can be concluded that the type of aggregate located at the DB – 2 point is a type of fine aggregate dominated by sand.

2.2 Soil Research Outcomes

Land investigation data is secondary data obtained from dee corporate ltd. in collaboration with JICA Team Project and the Ministry of Public Works and Public Housing. The results of the land investigation can be seen in the following table.

Table 3. Summary of N-SPT

Depth (m)	N160
1.0	18
2.0	8
3.0	13
4.0	18
4.5	14.5
5.0	23
6.0	21
7.0	25

8.0	36
9.0	40
10.0	29
11.0	29
12.0	36
13.0	29
14.0	31
15.0	31
16.0	32
17.0	31
18.0	31
19.0	40
20.0	34

source :(Corporation Dee. ltd, 2020)

2.3 Results of Liquefaction Analysis

The peak acceleration map in bedrock for each Indonesian earthquake region published by the National Earthquake Study Center in 2017 shows that the Palu City area is in the earthquake acceleration zone between 0.7 – 0.8 g. However, in the results of research conducted by the National Earthquake Study Center Team on the Study of the Palu Earthquake of Central Sulawesi Province on September 28, 2018 (M7.4) obtained a horizontal value of 333 gals and a vertical value of 335 gals, when converted into units of m/s2 to 3.33 m/s2 for horizontal vectors (1 gals equals 0.01 m/s2) or equivalent to 0.33 gal (1g = 9.81 m/s2).(Tim Pusat Studi, 2017)
Meanwhile, to complete the analysis of liquefaction potential in this research, the results of laboratory tests that have been carried out are taken needed to determine the potential for liquefaction are obtained, the following are the results of the liquefaction potential analysis.The results of the analysis can be seen in the following table.

Table 4. Results of Liquefaction Potential Analysis

Depth (m)	(NI60)	Ysat	Yw	Pa	rd	amax	σv	σ'v	CSR	CN	α	β	N160cs	CRR7,5	MSF	f	Kσ	CRR_{Mw}	FS	Annotation
1	18	2,0571	1,00	101	0,992	0,33	2,057	1,057	0,042	1,817	0	1	18	0,2179	1,035	0,719	0,008	0,002	0,040	Potential for liquefaction
2	8	2,0571	1,00	101	0,985	0,33	4,114	2,114	0,042	1,802	0	1	8	0,1072	1,035	0,781	0,016	0,002	0,043	Potential for liquefaction
3	13	2,0571	1,00	101	0,977	0,33	6,171	3,171	0,042	1,787	0	1	13	0,1529	1,035	0,750	0,024	0,004	0,090	Potential for liquefaction
4	18	2,0571	1,00	101	0,969	0,33	8,228	4,228	0,041	1,772	0	1	18	0,2179	1,035	0,719	0,030	0,007	0,164	Potential for liquefaction
5	23	2,0571	1,00	101	0,962	0,33	10,285	5,285	0,041	1,757	0	1	23	0,3107	1,035	0,687	0,036	0,012	0,282	Potential for liquefaction
6	21	2,0571	1,00	101	0,954	0,33	12,343	6,343	0,041	1,742	0	1	21	0,2696	1,035	0,700	0,044	0,012	0,302	Potential for liquefaction
7	25	2,0571	1,00	101	0,946	0,33	14,400	7,400	0,040	1,728	0	1	25	0,3580	1,035	0,675	0,049	0,018	0,455	Potential for liquefaction
8	36	2,0571	1,00	101	0,939	0,33	16,457	8,457	0,040	1,714	0	1	36	0,7810	1,035	0,606	0,051	0,041	1,026	Not Potential for liquefaction
9	40	2,0571	1,00	101	0,931	0,33	18,514	9,514	0,040	1,700	0	1	40	1,0371	1,035	0,581	0,055	0,059	1,482	Not Potential for liquefaction
10	29	2,0571	1,00	101	11,473	0,33	20,571	10,571	0,488	1,686	0	1	29	0,4754	1,035	0,650	0,068	0,033	0,069	Potential for liquefaction
11	29	2,0571	1,00	101	12,620	0,33	22,628	11,628	0,537	1,673	0	1	29	0,4754	1,035	0,650	0,075	0,037	0,069	Potential for liquefaction
12	36	2,0571	1,00	101	13,768	0,33	24,685	12,685	0,586	1,660	0	1	36	0,7810	1,035	0,606	0,076	0,061	0,105	Potential for liquefaction
13	29	2,0571	1,00	101	14,915	0,33	26,742	13,742	0,635	1,647	0	1	29	0,4754	1,035	0,650	0,088	0,043	0,069	Potential for liquefaction
14	31	2,0571	1,00	101	16,062	0,33	28,799	14,799	0,683	1,634	0	1	31	0,5479	1,035	0,637	0,093	0,053	0,077	Potential for liquefaction
15	31	2,0571	1,00	101	17,210	0,33	30,856	15,856	0,732	1,621	0	1	31	0,5479	1,035	0,637	0,100	0,057	0,077	Potential for liquefaction
16	32	2,0571	1,00	101	18,357	0,33	32,913	16,913	0,781	1,609	0	1	32	0,5881	1,035	0,631	0,106	0,064	0,082	Potential for liquefaction
17	31	2,0571	1,00	101	19,504	0,33	34,970	17,970	0,830	1,597	0	1	31	0,5479	1,035	0,637	0,113	0,064	0,077	Potential for liquefaction
18	31	2,0571	1,00	101	20,651	0,33	37,028	19,028	0,879	1,585	0	1	31	0,5479	1,035	0,637	0,120	0,068	0,077	Potential for liquefaction
19	40	2,0571	1,00	101	21,799	0,33	39,085	20,085	0,928	1,573	0	1	40	1,0371	1,035	0,581	0,116	0,124	0,134	Potential for liquefaction
20	34	2,0571	1,00	101	22,946	0,33	41,142	21,142	0,976	1,561	0	1	34	0,6777	1,035	0,619	0,129	0,091	0,093	Potential for liquefaction
4.5	14.5	2.0571	1.00	101	0.966	0.33	9.257	4.757	0.041	1.764	0	1	14.5	0.1700	1.035	0.740	0.035	0.006	0.149	Potential for liquefaction

From Table 4. It is found that the middle stream of the paneki river still has the potential for liquefaction. This is shown by the Safety Factor value which is dominated by <1. While for a depth of 8-9 meters there is no potential for liquefaction.

III. CONCLUSION

From the results of liquefaction analysis, it was obtained that the middle stream of the Panaki River still has the potential for liquefaction. This is shown by the Safety Factor value which is dominated by <1. While for a depth of 8-9 meters there is no potential for liquefaction.

REFERENCES

[1]. Boulanger, I. M. (2006). Soil Dynamics and Earthquake Engineering. 26(2):115-130
[2]. Corporation Dee. ltd. (2020). Geotechnical Report Of River Improvement And Sediment Control In Paneki River, Central Sulawesi. 23

[3]. Hardiyatmo, ChristiadyHary. (2002). Mekanika Tanah I. [book auth.] Mekanika Tanah I. 2002.
[4]. M.-Idriss-and-Ross-W.-Boulanger. 2008. Soil-Liquefaction-During-Earthquakes-. United States, America.
[5]. Project, J. T. (2019). Consolidation Design ForPaneki River.
[6]. Seed, H. B. (1982). ‘‘Ground motions and soil liquefaction during earthquakes.’’ Earthquake Engineering Research Institute Monograph, Oakland, Calif.
[7]. S.S.C. Liao, R. W. (1986). Overburden correction factors for SPT in sand.
[8]. Tim PusatStudi, G. (2017). PetaSumberdanBahayaGempaTahun 2017. Bandung: KemnterianPekerjaanUmumdanPerumahan Rakyat.