The Use Of Hydrostatic Pressure As Lateral Pressure Of Counterfort Wall Design And Soil Stability

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Abstract – Land subsidence in North Jakarta is dangerous enough and can become a hazard to the people which live around there. The hazard come in two ways, such as a rob from the sea area and a slope in onshore area. Both of them need a comprehensive treatment, one of best solution is through the make of counterfort walls as a way to hold water from the offshore to the ground area in onshore. The Height of wall is around 3.7 meters with a strengthening wall around 3 meters. Another problem is the lateral pressure of water and a weight of counterfort will be a load to the soil in area. It need to be analysed to determine the strength that needed by counterfort wall.

Keywords – Countefort, Soil Stability, Hydrostatic Pressure

1. Introduction

Several area in Northern Jakarta have a big problem, especially in Mutiara Beach. Land in Mutiara Beach is experiencing land subsidence. In another case, global warming increase the sea water level in around the world.

The location is in North Jakarta in reclamation area, the exact location can be seen below :

2. Methodology

Based on SNI 1726 2012 about the soil characteristic classification[1], to analyses the strength of soil, we need to determine the class site of location based on the comparison of soil thickness of SPT Value.

Site Class	
Soil Characterisric	N
SE (Soft Soil)	<15
SD (Medium Soil)	15-50
SC (Hard Soil)	>50

Source : SNI 1726 2012

Based on the Bore hole in location, here are the site class table :

Site Class Bore Hole 3

depth (m)	□h	Nspt	□h/N
0 - 2	2	16	0.13
2 - 4	2	4	0.50
4 - 6	2	4	0.50
6 - 8	2	3	0.67
8 - 10	2	4	0.50
10 - 12	2	4	0.50
12 - 14	2	18	0.11
14 - 16	2	26	0.08
16 - 18	2	30	0.07
18 - 20	2	52	0.04
20 - 22	2	61	0.03
22 - 24	2	67	0.03
□□□h	24	□□□□h/N)	3.15

□□□□h/ □□□□h / N)	7.63
Soil Type	Soft Soil

Soil Stratification

In order to determine soil stratification, here are the soil correlation based on Handbook Of Geotecnical Investigation and Design Tables[2].

a. Soil Weight (γ)

- Clay

SPT	γn (kN/m3)
0-2	16
2-4	16.5
4-8	17
8-15	17.5
15-30	18
30-50	18

- Sand

SPT	γn (kN/m3)
0-4	15.5
4-10	17
10-30	17.5
30-50	18
>50	19

b. Elasticity Modulus

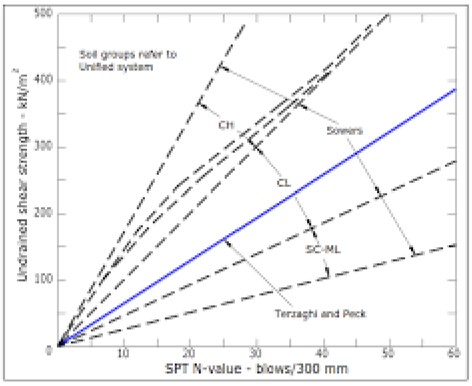
Eu = K x Cu

c. Poisson Ratio

Based on Braja M Das (2002)[3] v value which is suitable to design is around 0.35

d. Shear Strength (Cu)

To determine Cu value in several untested layer, we need to determine it with Sowers Diagram(Meyer & Keyser, 2019).



e. OCR (Overconsolidation Ratio)

Ocr calculation only analyzed in first layer, it based on assumption that the lower layer is intact and won' consolidate.

f. Internal Friction Angle (φ)

There are several way to determine friction angle through correlation method, here there are :

- Hatanaka and Uchida Method

$\varphi = [15{,}4.\ (N)]^{0{,}5} + 20°$

- Peck Method

φ = [0,3. (N)]0,5 + 27°

- JRA Method

φ = [15. (N)]0,5 + 15° ≤ 45°

- Ohsaki Method

φ= [20. (N)]0,5 + 15°

Based on correlation above, here are the soil design :

Lapisan	JenisTanah	Kedalaman			N_{SPT}	$\gamma_{n\ Desain}$ (kN/m³)
1	Lempung Sangat Kaku	0	-	2	16	14.7
2	Lempung Sedang	2	-	6	4	12.7
3	Lempung Lunak	6	-	8	3	12.5
4	Lempung Sedang	8	-	12	4	12.7
5	Lempung Sangat Kaku	12	-	16	18	15.0
6	Lempung Keras	16	-	18	30	17.0
7	Pasir Sangat Padat	18	-	24	52	18.0

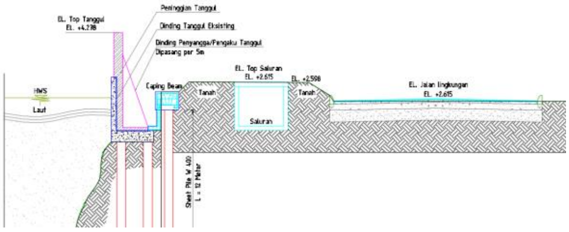
Lapisan	JenisTanah	$\gamma_{sat\ Desaim}$ (kN/m³)	γ' (kN/m³)	σ_v' (kN/m²)	Cu Desain (kN/m²)	ϕ Desain (◦)
1	Lempung Sangat Kaku	16.1	6.1	6.1	60	-
2	Lempung Sedang	14.0	4.0	20.2	18	-
3	Lempung Lunak	13.8	3.8	31.9	13.5	-
4	Lempung Sedang	14.0	4.0	43.6	18	-
5	Lempung Sangat Kaku	16.5	6.5	64.5	80	-
6	Lempung Keras	18.7	8.7	86.2	135	-
7	Pasir Sangat Padat	19.8	9.8	124.5	-	45.00

Lapisan	JenisTanah	Kedalaman			N_{SPT}	ϕ ' Desain (◦)
1	Lempung Sangat Kaku	0	-	2	16	0.00
2	Lempung Sedang	2	-	6	4	0.00
3	Lempung Lunak	6	-	8	3	0.00
4	Lempung Sedang	8	-	12	4	0.00
5	Lempung Sangat Kaku	12	-	16	18	0.00
6	Lempung Keras	16	-	18	30	0.00
7	Pasir Sangat Padat	18	-	24	52	45.00

Lapisan	JenisTanah	C' Desain (kN/m^2)	OCR Desain	Eu Desain (kN/m^2)	E' Desain (kN/m^2)	ν	Cc Desain	e_0 Desain
1	Lempung Sangat Kaku	10	1	60000	36000	0.3	0.05	0.313478
2	Lempung Sedang	10	1	7200	4320	0.3	0.2	0.443913
3	Lempung Lunak	10	1	4050	2430	0.3	0.35	0.574348
4	Lempung Sedang	10	1	7200	4320	0.3	0.2	0.443913
5	Lempung Sangat Kaku	10	1	48000	28800	0.3	0.05	0.313478
6	Lempung Keras	10	1	81000	48600	0.3	0.05	0.313478
7	Pasir Sangat Padat	-	-	-	39832	0.35	-	-

3. **Analysis and Discussion**

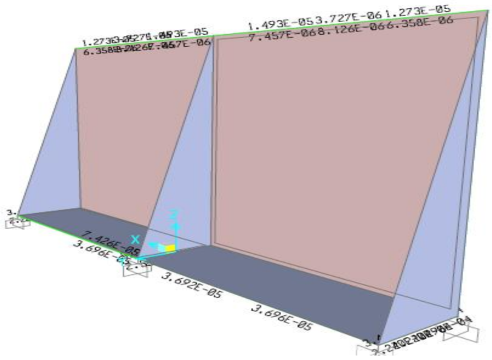
To determine a weight of load in model, we need to determine each load first. Here is the model :



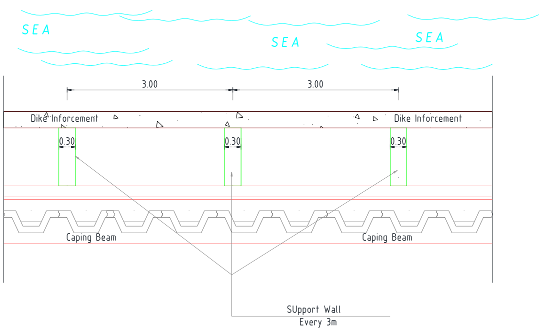
Picture III.1 Cross Section Of Model

g. Kantilever Load
The load which happened in kantilever wall is :
Model 1. Full 37.385kN/m2
Model 2. h 2.95m 29.807 kN/m2
Model 3. h 2.2m 22.22 kN/m2

Dead Load =10kN/m3x 0.5 =5kN/m2
Live Load =25kN/m2
Load Design = 1.6DL +1.2 LL = 46 kN/m2

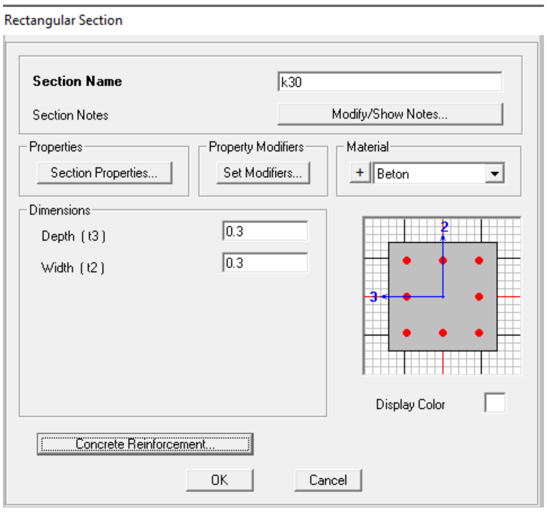


Picture III.2 Counterfort Model



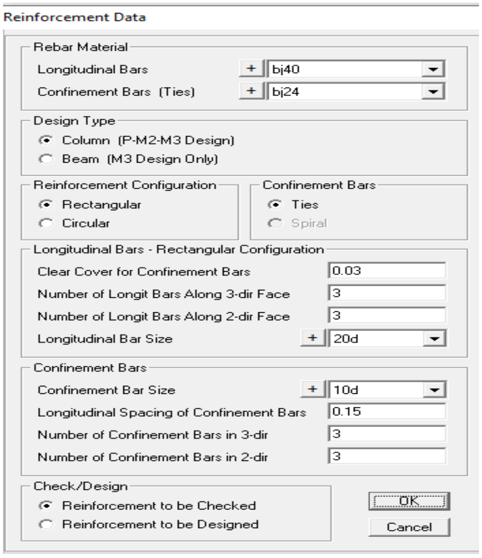
h. Column Design

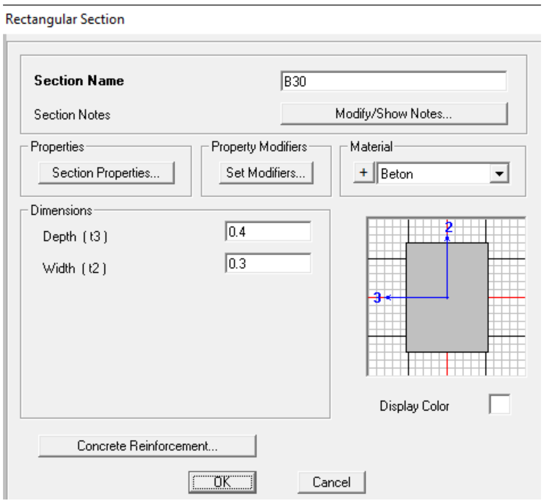
Column design in counterfort is shown below :

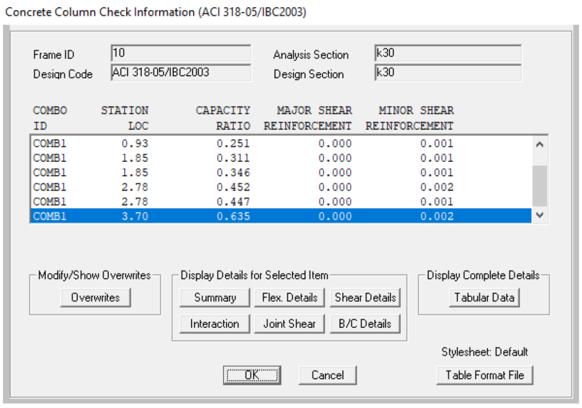


i. Beam Design

Beam design in counterfort is shown below :



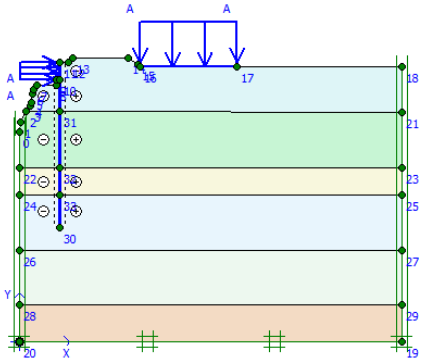




Based on model above, the capacity ratio is in a good condition such as 0.635.

j. Soil Stability Analysis

In Order to analyses soil stability in onshore area, the lateral pressure of water become lateral pressure to the soil. Load model of soil stability can be seen below :



Based on data above we can see the results is shown below :

Condition	SF Normal	SF Critical	SF Earthquake
Full Load	1.89	1.75	1.35
Load Of 2.95h	1.84	1.70	1.31
Load Of 2.2h	1.78	1.65	1.28

4. Results

Based on the research above, the model is safe enough to hold the pressure that caused by water level. From table above, we can see that in all condition the safety factor is decrease from normal condition, critical condition and earthquake condition. The smallest Safety Factor is in an earthquake condition while the water height is 2.2 meters from the base of plate. It can be happened because the lateral pressure from the water is help the structure keep intact while it get the axial pressure from an onshore area.

5. Conclusion

The various of safety factor decreasing is determined by water table and earthquake. It show that the lateral pressure from the offshore didn't give much trouble, it caused by axial load from an onshore area.

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