LABORATORY TEST EFFECT OF THE SLOPE ANGLE AND THE LOADINC WITH PILE AS AN ALTERNATIVE TO SLIDING

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ABSTRACT

Increasing the pore water pressure effects the stability of the slope, this is caused by the sc shear strength depends on the presence of water in the soil itself. This experiment using tl slope model test with the angle 45o, 60o, 70o with load above slope and given pi reinforcement. Using the box of 40 cm x 160 cm, the height is 50 cm, slope model using cla The space distance between the pile is 10D by using the configuration honeycomb. The ma purpose of this experiment is to understand the behavior and to know the variable influen on the collapse of the slope. The variable observed are: knowing the relationship influen pore water pressure toward the safety factor, the relationship of the safety factor with tl loading, and also the relationship of the safety factor with the time duration needed collapse. Based on the results of data analysis testing that has been done, obtained the value pore water pressure inversely proportional to the value of the safety factor and the value the safety factor will be inversely proportional to the increase of loading. However, the valı of these safety factors is directly proportional to the time of the collapse.

Keywords: slope stability, shear strength, safety factor, pore water pressure

1. INTRODUCTION

Events that indicate that the presence of water in the soil due to increased pore water pressure greatly affects the slope. This is due to the shear strength of the soil depends largely on the presence of water in the soil itself. The saturated soil of water has a smaller shear strength in comparison with wet soil or with dry soil. Changes in water content can cause the shrinkage of soil that is the cause of the collapse of the slope. If the movement of the soil due to changes in this volume occurs on the soil that forms the slope, then there will be a slump that can cause damage.

Follow up the problem of how much increase in pore water pressure on the slopes when there is a load above the slopes during the rainy season that could cause landslides will be done a study of the loading on the slopes by making the test in the form of a load evenly and given a pile reinforcement with the installation of configuration form hexagons and clay soil media.

The main purpose of this experiment is to understand the behavior and to know the variable influence on the collapse of the slope. The variable observed are: knowing the relationship influence pore water pressure toward the safety factor, the relationship of the safety factor with the loading, and also the relationship of the safety factor with the time duration needed to collapse. Pile reinforcement with the installation of a hexagon configuration for slope.

Some researches have been done to researched the slope stability with anchored pile has been done. Koerner et al investigated the use of anchors for slope stabilization is accompanied by geotextile; Takemura investigated slope stabilization with pile reinforcement ; Sugiyama et al investigated the effect of increasing pore-water pressure on slope stability (by giving rainwater intensity); Irsyam et al investigated the stabilization of the slope with the use of anchored geosynthetic.
Anchoring with flexible piles is assumed to be a horizontal force resisting pile due to movement of soil above landslide surface. This is so because at the end of the anchor there is a concrete block that holds the movement of the slope soil during the landslide, so the anchor is considered to function as a flexible pile. In this study, it is necessary to take into account the forces acting on a flexible pile with predetermined dimensions. So as to get contribution of flexible pile to value of safety factor.

2.1. Slope Stability with Anchored Pile

2.1.1. Lateral Force on Pile

It is viewed on a pole that withstands lateral force, and lies in the soil having cohesion and friction (ground c- ϕ). The ground ultimate equilateral resistance equation in any depth z based on the lateral ground pressure theory is as follows:

$P_z = P_o K_q + c\, K_c$ (1)

The values of K_c *and* K_q relation to the value of d d given by Brinch Hansen. The passive lateral resistance of each horizontal element is $P_u\ d\ (\ l\ /\ n\ )$. By taking the moment point at which the horizontal load is working,

$$\sum M = \sum_{z=0}^{z=x} Pu\ d\ \left(\frac{L}{n}\right)(e+z) - \sum_{z=x}^{z=1} Pu\ d\ \left(\frac{L}{n}\right)(e+z) \qquad (2)$$

Rotation point located at depth x, determined $\sum M = 0$, that is when the ground resistance above this point is equal to the ground resistance below it. Thus, the point x can be determined by trial and error, in the absence of data. If the horizontal force in the head of the pile is replaced by the moment force M, this moment can be replaced by multiplication of force H by e, or M - He.
The amount of calculated pile resistance, intended to diminish the pile in order to withstand the working force. If the dimensions of the studied pile are not able to withstand the working force, then the pole needs to be redesigned. But in this study, dimensions and lengths have been determined. So the pile arrest is not taken into account.
The resistance of flexible pile pull out can be calculated,

$Tj = \pi \times d \times \tau \times L$ (4)

Where:

T_j = The resistance of flexible pile pull out
d = diameter of flexible pile
t = soil shear strength
L = the length of the flexible pile entered under the slip surface

In the diameter of the area of influence of 10D, it is expected that between the flexible pile can close each other, so that there is a unity, then the moving ground can be retained by piles. This is because the piles are not aligned but the movement of a moving ground can be retained by a flexible pile, see Figure 1.

The flexible pile model used in the form of a cylinder is made of steel or wire on the market with a diameter of 3 mm. At the upper end there is a pointless binding to block model blocks. Moderate block model used is made of zinc plate in the market with the size 2cm x 2cm.

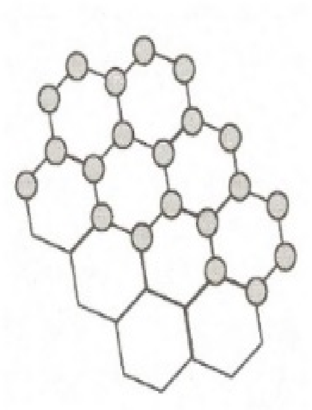


Figure 1. Configuration of pile installation with hexagon method (honeycomb)the test set-up

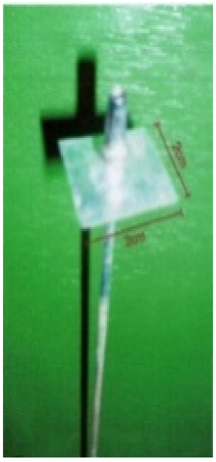


Figure 2. Model Flexible Pile Cap

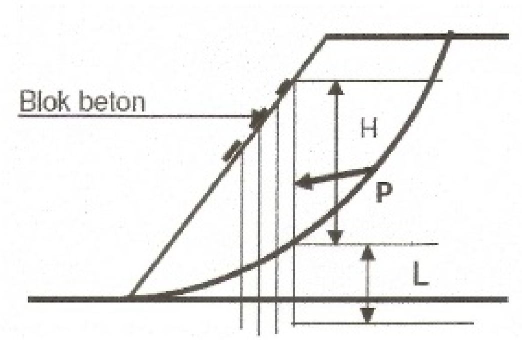
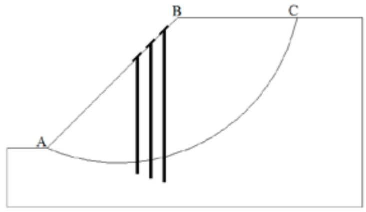


Figure 3. Anchoring model (Maugeri, M. and Motta, 1991)

2.2 Research Methods

Determining the F_i Value



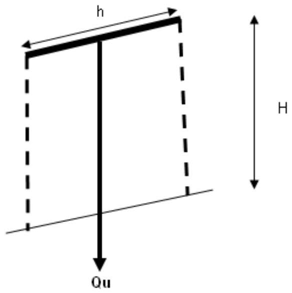


Figure 4. Contribution of Pile Cap

$$Q_u = \frac{\pi.H.h^2.\gamma}{4} + \frac{\pi}{2}\gamma.h.H^2.K_0.\tan\emptyset \quad (5)$$

With :

$Q_u = F_i$ = The amount of pressure due to anchor block

H = The length of the embedded flexible pole

h = Dimension of the anchor head

W = Soil weight

K_o = Koefesient of lateral earth presure

ϕ = Angle of internal shear

2.3 Safety Factor Analysis

Methods of research undertaken using the Simplified Bishop Method (Bishop Simplyfied).

Using modified Bishop way. So the formula for obtaining a secure factor can be written as follows:

$$FS = (1+f)\sum_{i=1}^{n}\frac{c.\Delta x_i + ((W_i + F_i.cos\beta_i - \mu_i.\Delta x_i))tan\varphi * \frac{1}{M_{i(\alpha)}}}{(W_i.\sin\alpha_i)} \quad (6)$$

With :

c = soil cohesion (gr/cm²)

Φ = angle of internal shear (°)

Wi = weight of slice (gr)

Δxi = slice width (cm)

αi = the angle formed between W and the center point of the slip O on slip fields. α is taken positively in the same quadrant with slopes or in the direction of the retaining force

u_i = pore water pressure= $\gamma_w Z_w$
γ_w = water content weight (1 kg/cm^3)
Z_w = the water level is measured from the slip plane (cm)
n = slice number
(1+f) = contribution of flexible pile
Fi cos βi = contribution due to head or block

$$M_{i(\alpha)} = \cos \alpha_i \left(1 + \frac{tan\alpha_i tan\emptyset}{FK}\right) \quad (7)$$

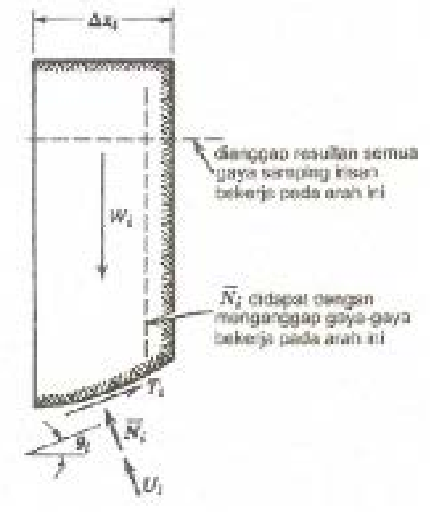


Figure 5. Review the forces on the base of the wedge according to modified Bishop's way,

(Lambe, Whitman, 1968)

2. MATERIAL AND METHODS

2.1. Laboratory Model Test

Model box size 50 cm x 160 cm, height 60 cm. The vessel model uses the Sugiyama model (1993), Takemura (1994), the method of supplying water. The pile used in the form of a cylinder made of steel or wire on the market with a diameter of 3 mm.

Soil media in wet conditions, saturated water then the box must be waterproof. In order for the box to hold the load when setting up the test media, the outside of the box is reinforced with a L-profile (L 60.60.6).

The bottom of the box is equipped with a C-100 mm steel, as shown in the vessel equipped with two water containers, a tub to the right of the box (see figure 3) serves as a water supply the second is located on the left side of the box (figure 3) which serves as a reservoir of water that has passed the slope model. In the second basin is equipped with a drying hole to make it easier to remove water.

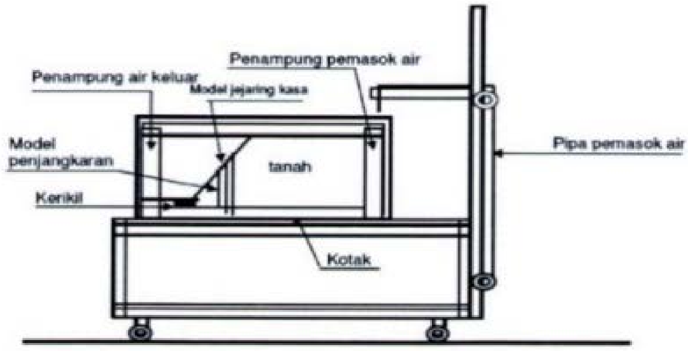


Figure 6. Schematic view of the test set-up

3. Experiment Set-Up and Test Programme

3.1. The Preparation Test Object

Before the ready-made soil is put into the box, the preparation is as follows:

1. Installation of gravel

Gravel is mounted at the bottom end of the box which serves as a retaining barrier of soil from within the slope model.

2. Installation of Piezometer Pipe

In actualization in the research, used plastic diameter tube as small as possible in the market. The hoses are mounted on a sloped furrow slope model body with a distance of 15 cm and 30 cm from the bottom of the box. The purpose of this installation is to find out how much pore water pressure occurs at the time of the test (collapse).

3. Land Filling

After the soil through the preparation process, the soil is wet enough to be put into a vessel that has been prepared for pre loading.

4. Pre-Loading Ground In The Box

After the soil is put into the box, it is then returned to its original state such as in the wild or undisturberd by means of Pre-Loading (Eko Ch. 2004). Pre-Loading is done as much as 3 stages or 1 / 3x height plan slope model plus high estimates due to depreciation. For pre-loading the first stage and the second stage is done for 60 minutes while for the third pre-loading done for 24 hours. It aims to restore the condition of the soil as its original condition.

Figure 7. Preloading Test

Figure 8. Installation of Anchored Pile with Honeycomb Configuration

3.2. Load Applied

After the slope model is formed, further flexible anchoring is done at the designated place and with the specified distance as well as the configuration according to the plan that is with the hexagon configuration with the distance between pile 10D and the loading of concrete plate above the slope.

The loading model used is an iron plate. According to Holtz and Kovacs (1981) for the burden of widespread union is estimated the weight of the building or house per floor of 10 Kpa (102 gr/cm²). The test is done in two series, namely the first series with the load from one floor (6.94 gr / cm²), then the second series with the load from three floor (20.83 gr/cm²) [8].

Figure 9. Landslides Model

4. RESULT AND DISCUSSION

Tabel 1 Resume Slope Modelling Test

N N	Parameter	Angle of the slope 45		Angle of the slope 6		Angle of the slope 75°		Unit
		The lo from o floor	The lo from thr floor	The lo from o floor	The lo from thr floor	The lo from o floor	The load fro three floor	
		6,94 gr/cr	20,83 gr/cm²	6,94 gr/cm²	20,83 gr/cm²	6,94 gr/cm	20,83 gr/cm²	
1	Safety facto	1,636	1,627	1,551	1,517	1,412	1,36	-
2	Time collapse	152	113	144	107	140	62	minute
3	Average water conte							
	Before t collapse	47,24%	47,24%	47,24%	47,24%	47,24%	47,24%	%
	After t collapse	71,278%	70,884%	71,72%	71,11%	72,34%	71,78%	%
4	γ_t	1,586	1,512	1,564	1,527	1,543	1,542	kg/cm²

Table 2. Pore Water Pressure Results

Number of segment	Angle of the slope 45	Angle of the slope 60	Angle of the slope 75
	Pore water pressu (kg/cm^2)	Pore water pressu (kg/cm^2)	Pore water pressu (kg/cm^2)
1	10834	11539	13364
2	23474	24559	25574
3	30208	31332	32208
4	29683	30491	30693
5	19743	20580	21750
6	8245	8510	8740

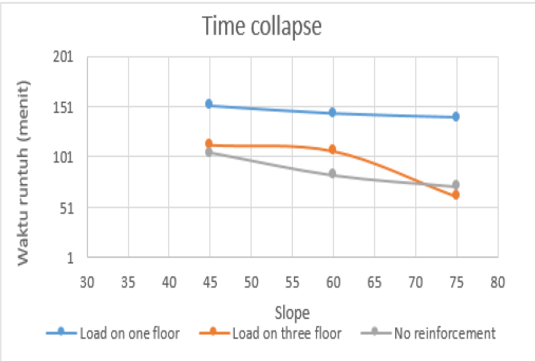


Figure 10. Relationship Time collapses with

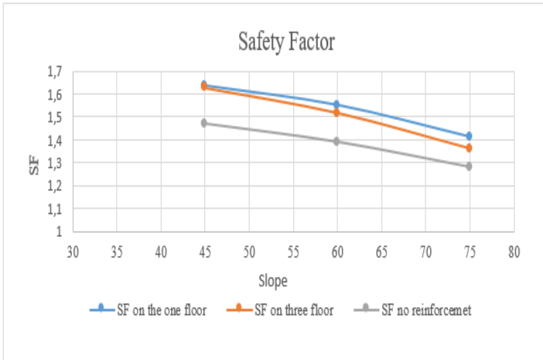


Figure 11. Relationship Safety Factor with loading

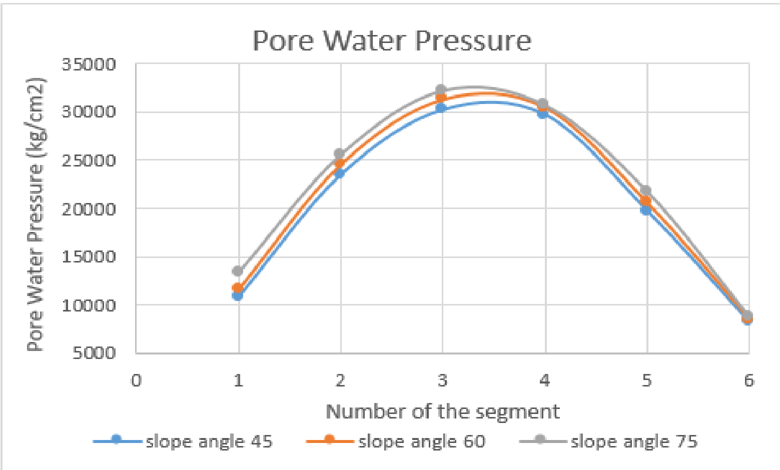


Figure 12. Relationship of Pore Water Pressure and the Slope Angle

Seen in Table 1, the value of safety factors decreases with the amount of loading. Visible on the parameters of the safety factor, the value in the first test is greater than the second test. In this case the loading affects the value of the security factor. The value of the safety factor will be inversely proportional to the amount of loading, that is the greater the loading the smaller value of the safety factor. However, the value of these safety factors is directly proportional to the time of

collapse, that is the greater the safety factor of a slope, the greater the duration required to collapse.
This is also seen in the slope angle will affect the time of collapse and value of its safety factor. From table 1 shows that the greater angle of the slope greater the angle of the slope causing the collapse time will be faster and the value of the safety factor has increased. While the influence of the load is as an accelerator of the time of collapse and will affect the declining value of the safety factor.
While from table 2, it can be seen that the amount of pore water pressure each segment will increase along with the increment of slope inclination. When associated with the magnitude of the security factor, the greater the safety factor, the more the pore water pressure decreases for each segment.

5. CONCLUSION

1. Slope reinforcement with anchored pile has a significant effect to increase safety factor of slope stability
2. The larger angle of the slope causing the collapse time will be faster and the value of safety factornya decreased.
3. The effect of the load is as an accelerator of the time of collapse and will affect the declining value of the safety factor. Or the greater the load the faster the duration it takes a slope to collapse, this causes the decreasing value of the safety factor.
4. The pore water pressure of each segment will increase along with the increment of slope inclination. When associated with the magnitude of the security factor, the greater the safety factor, the more pore water pressure decreases for each segment.

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