SLOPE ANALYSIS WITH FELLENIUS METHOD IN HYDROELECTRIC POWERPLANT X, SOUTHEAST SULAWESI PROVINCE

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Abstract

Geology is a very vast knowledge, then among of it consist infrastructure determination (including hydroelectric powerplant development). Geological engineering has important role that can be used to analyze disaster management based on some factors. One of factors is a slope analysis with Fellenius method which uses cohesion, unit weight, and internal friction. This research is located in hydroelectric powerplant, Southeast Sulawesi Province. This location has 3 lithologies: phyllite, schist, and alluvial sedimentation with range value of cohesion 9,74-11,41 kPa, unit weight 16,53-17,05 kN/m3, and internal friction 10,91-14,02. All of those factors are calculated in Fellenius formula. The result is a 1,132 value in Safety Factors which is below in 1,5 safety limit value. In order to increase the Safety Factors, we may change the slope geometry.

Keywords: Geological Engineering, Slope Analysis, Southeast Sulawesi Province.

1. INTRODUCTION

Slope stability in mathematically is a function force that push for a landslide (driving force) and force that resist landslide (resisting force) (Cheng & Lau, 2008). The stability of a slope is expressed in Safety Factor (SF). The force which is discussed in this research is not separated from the level of cohesion, normal stress, and internal angle. However, there are other factors that may affect the slope stability such as: rock and soil condition, slope angle, and ground water level. These things become a consideration in analyzing the occurrence of landslide and determine the type of it. Those things can be used to determine the most propotional and efficient to minimize the disaster less likely. Along with the growing demand for electrical energy, PLN (national powerplant) aims to build the Konawe Hydroelectric Powerplant. It is located in Southeast Sulawesi Province.

2. LITERATURE REVIEW

Literature review is done by looking for knowledge source that support the reseach. Some Progresses on this part are: Determining points and observation boundary location, keeping the research to not out of context, determining data which can be utilized effectively.

Slope is an aslant surface and forms a certain angle against a horizontal plane. Place where there are two different altitude ground surfaces will be having a force that push from higher ground position tends to move downward which is called the gravitational potentional force causing the landslide. Landslide can occur on any kind of slope, due to the weight of material itself, coupled with great influence of groundwater seepage, as well as other force outside slope. Slope landslide is the movement of rock or soil mass from it`s original position as a result of inability of the slope to resist the shear force from boundary between driving force and resisting force.

Data acquisition

The act to retrieve data in order to develop the research:
a. Cohesion
b. Unit Weight
c. Internal friction angle
d. Groundwater condition
e. Geological data (Rock condition, stratigraphy, and geological structure)

Cohesion is a attraction force between particles in a material (unit weight per unit area). Cohesion from material will be greater as long as shear strength increases. Cohesion in this research is tested with triaxial test.

The unit weight value of a material will determine how large the force that taken on a landslide plane (weight per volume). Unit weight also affected by how large the amount of water content from material. The greater unit weight in a slope, the greater driving force which cause landslide.

Internal friction angle is an angle which formed from the relation between normal stress and shear stress inside material. Internal friction angle is a fracture angle that formed when a material is given a stress or force on it exceed shear stress. The greater internal friction angle, the greater material itself to resist external force.

Slope with high angle tend to easier to slide if compared with slope with low angle. That thing can occur because slope with high angle receive a bigger downward force.

A swallow groundwater level makes most of slope moist and also the rock or soil will have more water inside of it. This condition creates material compacticity become low and material will receive additional water load so that the slope becomes easily landslide.

3. METHODOLOGY

There are few methods to analyze slope stability. The most common is slice method that found by Fellenius. This Method is usually used to analyze slope stability which arranged by a material and it`s slide plane. Slope calculation with Fellenius method is done by separating slide mass into vertical slices.
Fellenius method can be used in slope with layered condition. Width from a slice is not the same as the original so that arch bow in base slice is considered as a linear line. Safety Factor (SF) is a comparison between driving force and resisting force.

$$Fk = \frac{\Sigma \left[c' b + (W_t \cos \alpha - u b) \tan \phi' \right]}{\Sigma W_t \sin \alpha}$$

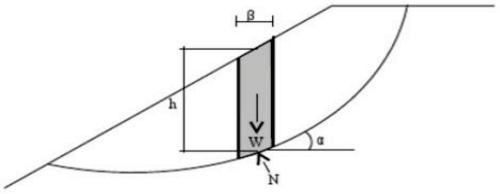

Figure 3.1. Fellenius method image

Legend:
W = Slice weight
N = Normal Stress
α = Slice angle against slide plain
β (b)= Slice Width
H = Slice Height
c = cohesion
u = Pore water pressure
ϕ = Sudut geser dalam
Fk = Safety Factor

Based on parameters which explained before, those parameters is used in Fellenius formula where numerator explains the resisting force and denominator explains driving force.

4. RESULT AND DISCUSSION

Research area has homocline structure between schist and phyllite. Based on regional scale of Sulawesi island by Hamilton (1979), research area is not exposed to a major horizontal fault that cross with northwest-southeast direction in Southeast Sulawesi.

Research area has 3 different lithologies based on field survey: schist, phyllite, and alluvial deposition.

Aluvial deposition

Aluvial deposition consist of gravel, sand, clay, and mud which formed from river or even swamp deposit. It also spreads on the location around the estuary of large river. Generally, from the result of surface mapping proves that research location is filled with many alluvial deposits. Those depositions are formed by loose material such as gravel and sand.

Phyllite

Phyllite is one of regional metamorphic rock (pressure and temperature effect). It is colored by light purple in geology map and cross section. Based on data from PLN investigation, the outcrop condition on this rock is usually found in loose condition from Konawe Eha river. This metamorphic rock has characteristics: gray-colored, medium-hard in hardness, foliated, phyllitic, lepidoblastic texture. Phyllite on this research area has slide parameters: 9,74 kPa cohesion, 17,05 kN/m3 unit weight, 14,02 internal friction angle.

Schist

Schist is also one of regional metamorphic rock (pressure and temperature effect). It is colored by dark purple in geology map and cross section. Based on data from PLN investigation, the outcrop condition on this rock has a fresh condition but some of it also has weathering grade from high to low. This metamorphic rock has characteristics: gray-colored, medium-high in hardness, foliated, phyllitic, granoblastic texture. Schist on this research area has slide parameters: 11,41 kPa cohesion, 16,53 kN/m3 unit weight, 10,91 internal friction angle.

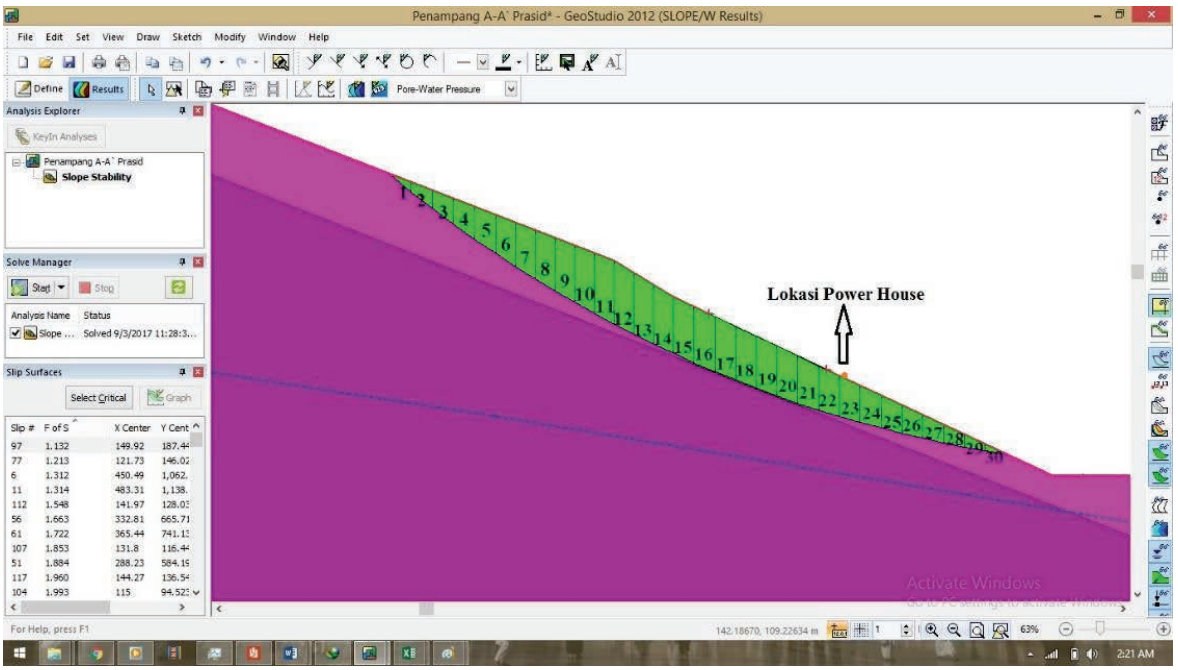

Figure 4.1. Research area slide model with SLOPE/W

Slice number	Cohesion (c)°	Slice width (b) kPa	Slice weight (W) kN	Slice angle against slide plane(α)°	Pore water pressure (u) kPa	Internal friction angle (ϕ)°	[c.b + (W.cosα-u.b)tanϕ]	W.sinα
1	11,41	1,77	11,05	38	38	10,96	5	3
2	11,41	1,77	32,25	38	38	10,96	22	20
3	11,41	1,77	51,71	37	39	10,96	40	33
4	11,41	1,77	69,51	35	40	10,96	32	30
5	11,41	1,77	85,73	34	41	10,96	49	45
6	11,41	1,66	93,82	33	42	10,96	103	94
7	11,41	1,66	105,54	32	44	10,96	77	58
8	11,41	1,66	116,1	31	46	10,96	54	47
9	11,41	1,66	125,52	30	48	10,96	134	124
10	11,41	1,66	133,85	29	51	10,96	97	89
11	11,41	1,66	141,13	28	54	10,96	40	38
12	11,41	1,66	142,45	27	57	10,96	139	136
13	11,41	1,66	137,86	26	60	10,96	107	105
14	11,41	1,66	132,3	25	64	10,96	19	18
15	11,41	1,76	135,67	24	69	10,96	127	123
16	11,41	1,76	134,02	23	73	10,96	118	113
17	11,41	1,76	131,31	22	78	10,96	2	1
18	11,41	1,76	127,56	21	83	10,96	109	107
19	11,41	1,76	122,79	20	89	10,96	118	112
20	11,41	1,76	117,02	19	95	10,96	21	18
21	11,41	1,76	110,27	18	101	10,96	86	83
22	11,41	1,76	102,55	17	107	10,96	101	99
23	11,41	1,76	93,88	16	114	10,96	29	27
24	11,41	1,76	84,28	15	122	10,96	58	55
25	11,41	1,76	73,76	14	130	10,96	75	73
26	11,41	1,76	62,32	13	138	10,96	27	26
27	11,41	1,76	49,99	12	148	10,96	28	27
28	11,41	1,76	36,77	11	158	10,96	42	37
29	11,41	1,76	22,67	10	168	10,96	15	12
30	11,41	1,76	7,7	9	179	10,96	4	3
Result							1989	1756

$$Fk = \frac{\Sigma \left[c' b + (W_t \cos \alpha - u\, b) \tan \phi' \right]}{\Sigma W_t \sin \alpha}$$

$$Fk = \frac{1989\ N}{1756 kN} = 1{,}132$$

5. CONCLUSION

Parameters are calculated in SLOPE/W program so that resulting the safety factor value of 1,132 (below safety limit: 1,5 based on Minister of Public Work Inonesia Regulation No: 22/PRT/M/2007). With that value proves that research area is prone to slide and need to be solved with slope geometry change.

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