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The Effect of Season on the Slope Stability Analysis: Case Study at UNNES Building, Semarang - Indonesia

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Abstract. A slope assessment to predict the probability of landslide occurrence and the safety factor of landslide at E9 building, Home Economics Department, Universitas Negeri Semarang was conducted to obtain a safety factor index of slope and structures in study area. A rupture of soil surface appeared in some parts of the study area. It indicated an initial destruction of structure and infrastructure. Differential settlements occurred in north side of building. Therefore, a downward movement of soil, rock mass and debris to the slope direction was identified as an initial hypotheses. The influence of season was analyzed in this paper. A combination of LHZ method and numerical analysis by Plaxis version 9.2 was utilized for the predicted behavior of soil movement and the safety factor. The results of analysis revealed that the safety factor in the wet season reached 1.0635 and in the dry season reached 1.075. From this results, it can be concluded that the influence of season parameter of the season did not affect for the possibility of landslide in this area.

INTRODUCTION

Problems in soft soil type, such as low bearing capacity and settlement when load subjected to soil were frequently found in the civil construction. Some previous research defined that it was caused by the process of soil consolidation. Consolidation can be defined as an event of soil compression when load was subjected continuously by a construction. As a consequence, it affected water discharge from the soil pores. A settlement phenomenon which is induced a building subsidence was caused by compression and deformation of the subsoil beneath the construction. Previous research revealed that soil subsidence in lowland of Semarang area ranged from 0 up to approximately 3 cm / year during twelve year observation (2001-2013). In addition, a slope stability is one of the main problems for structure in highland area of Semarang. Some landslides phenomenon in Semarang were caused some failures in structure function. Furthermore, it caused some losses such as deceased and injured casualties, also economic losses (Jotisankasa, 2015). In tropical country, the parameter which trigger a landslide phenomenon is heavy rainfall. Then, it results in a loss of stability and equilibrium between residual soil and weathered rock (Thanakrit, 2015). Evaluation of soil movement which triggered a landslide phenomenon is very important for this area. Development of city drives a human mobility to highland area for housing purposes. Landslides can be defined as a displacement of slope forming material which moves down or out the slopes. In principle, landslides occur when the driving force on a slope is greater than the resisting force. The resisting force is generally influenced by the resistance of rock and soil density, while the other parameter was increased the possibility of landslide are the slope angle, water, load, and the density of soil / rock. A slope has been stabilized in the long time because of consolidation process. Otherwise, the slope can

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become unstable due to several factors such as the type and state of the soil layers / slope forming rock, the addition of water content in the soil (eg, water seepage or rain infiltration), as well as the weight and load distribution (Pangemanan, 2008). Therefore, the consolidation process becomes one of the factors affecting the stability of slopes and landslide susceptibility. As a consequence, an analysis of the stability of the slope with the consolidation of input parameters using numerical applications is required. Two phenomenon above consolidation and landslide was considered as the aim of this research in order find the trigger of failure in Home Economics Department, Universitas Negeri Semarang.

FIGURE 1. Some failure of beam and wall in Home Economics Department, Universitas Negeri Semarang

METHODOLOGY

Location of study

The study was conducted on a slope on the side of the E9 Building, Domestic Welfare Science Department, Universitas Negeri Semarang, Semarang. The location is situated at 7 ° 3'9,31 " South and 110 ° 4'13,15 " East and at an altitude of ± 300 m. The topography and the slope in study area can be seen in Fig. 3 and average of slope angle is 56 °. The type of soil is predominantly clay and precipitation based on the data from Indonesian Agency for Meteorology, Climatology, and Geophysisics (BMKG) is 101-150 cm/h. The area which was used as the object of research was 400 $m^{2.}$

FIGURE 2. The location of landslide study on Universitas Negeri Semarang area

FIGURE 3. The inclination of the slope from the study site

Field Investigation

In this study, a Dutch Cone Penetration Test (DCPT) and Standard Penetration Test (SPT) were conducted. The results of the test are presented on Table 1 below.

TABLE 1. Identification of soil stratigraphy on the study site

No.	Depth (m)	Identification	N-SPT
1	0-1	Clay with high plasticity	5
2	1-2	Clay with high plasticity	25
3	2-3	Clay solid (cemented) padas mixed rock and sand (non-plastic) brown whitish	33
4	3-20	Clay solid (cemented) padas mixed rock and sand (non-plastic) brown whitish	> 60

Numerical Analysis

The investigation analysis was conducted by using numerical simulation software Plaxis to find the landslide potential in the research area. Plaxis is a numerical program based on the finite element method which used to solve many problems in geotechnical area. The results could be used to identify the deformation of soil, effective stress, behaviour of pore water pressure in relation with safety factor of construction. A problem could be analyzed using axisymmetric and plane strain model. For this research, the problem was modelled by plane strain, then soil data were inserted for next calculation process. Furthermore, determination for suitable process analysis during calculation must be considered. Slope stability analysis was conducted to determine safety factor from potential landslides area by looking at the value of the safety factor from the output of Plaxis application which is the value of slope stability expressed in numbers (Al-Taee, 2015; Aseeja, 2016).

RESULTS AND DISCUSSION

Input Parameter

In this analysis which was described above, plane strain assumption was used for the structure model which considered the deformation was observed per 1 meter and perpendicular to the surface. Some variables which

had to be considered were topograhy of the research area, soil properties, structure loading, rainfall intensity during dry and wet season. Parameters as input materials for calculation process were summarized in some table below. In this paper, intensity of rainfall during the different seasons, wet and dry, was modelled due to the fluctuation of groundwater surface

TABLE 2. Summarized slope in the study area

Point	Distance (m)	Height (m)	Slop angle (°)
1	29.6	4	56 773
2	82.4	15	56 349
3	117	23	56 192
4	149	31	56 060

TABLE 3. Physical properties of soil parameters

Properties	Layer	medium Clay	Very Stiff Clay	Extremely Stiff Clay	Extremely Stiff Clay
Depth	-	0-2 m	2-3 m	3-4 m	> 4 m
Material models	Model	Mohr Coloumb	Mohr Coloumb	Mohr Coloumb	Mohr Coloumb
Type of soil material	Type	drained	drained	drained	drained
Soil unit weight above phreatic level	γ_{unsat} (kN / m ^{3})	14	17	19	21
Below phreatic level Soil unit	γ_{sat} (kN / m $^{3)}$	16	19	20	22
Permeability in the horizontal direction	k_x (m / d)	1, E-15	1, E-15	1, E-11	1, E-11
Permeability in vertical direction	k_y (m / d)	1, E-15	1, E-15	1, E-15	1, E-15
Young's Modulus (constant)	E Reff (kN / m2)	15000	30000	35000	50000
Poisson ratio	v	0.35	0.3	0.25	0.2
Cohesion (constant)	c_{ref} (kN / m2)	20	80	120	250
friction angle	φ	20	20	25	25

Results Analysis

In this analysis which was described above, plane strain assumption was used for the structure model which considered the deformation was observed per 1 meter and perpendicular to the surface. Some variables have to considered such as topograhy a research area, soil properties, structure loading, rainfall intensity during dry and wet season. Parameters as a input material for calculation process were summarized in some table below. In this paper, intensity of rainfall during the different seasons, wet and dry, was modelled due to the fluctuation of groundwater surface. The trend of landslide safety factor during the dry season with the time on the slope are compared with the rainy season obtained reached 1.0635 and in the dry season reached 1.075. For consolidaton analysis, the safety factor was 1,0804.

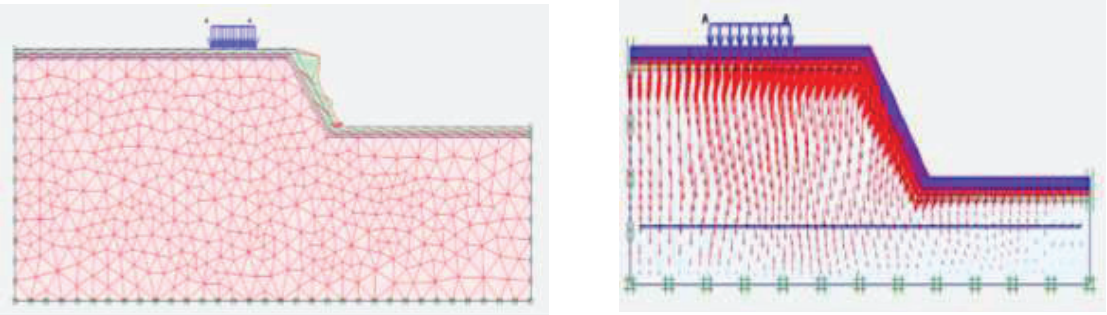

FIGURE 4. Soil deformation of the research area according to slope stability (a) and soil consolidation (b)

CONCLUSION

From the analysis, it revealed that consolidation process are working during the time. The longer process of consolidation resulted in the denser soil as the pressure of water pores decreased until it reached its minimum level. It was shown by the increasing safety factor index. The safety factor ranging 1,07 – 1,25 showed that the slope has undergone landslide which meant that it was not safe or in critical condition.

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