USE OF INTERFACE ELEMENT FOR SIMULATION OF BRECCIA RESLIDING ON CLAYSTONE

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1 INTRODUCTION

South Semarang is a hilly and mountainous area where a number of landslides or land movement occur almost yearly. The area is well known as Jatingaleh, which in Javanese means 'moving trees' since most of the trees are moving in certain direction mainly during rains.

In the project site where new road was to be constructed, an excavation of 4.0 m depth was conducted. This excavation was initially thought to be the cause of the landslides. Spring water appeared at the toe of the slope and the excavation shows the severely weathered breccia. However, this initial opinion cannot be justified due to the fact that the building on top of the excavation still remains in good condition. No significant damage was noticed and the steep slope looks very stable. Figure 1. shows this phenomenon.

Figure 1: Excavation in the breccia layer

2 RESEARCH OBJECTIVE

This research was intended to study the mechanism of the sliding that occurred and to recommend a solution for the landslide problem. The work was divided into a geological investigation, including the drilling and soil laboratory tests, and the geotechnical work, including analysis and recommendation for future development. The geological work was conducted by Wahjono, et al (2002) and the geotechnical analysis was done by the author and team. The use of interface elements is the main method for simulation of the sliding mechanism.

3 DAMAGES OF INFRASTRUCTURES

Based on information by the residence, the land movement occurred yearly but in small increment so that ordinary paste and rehabilitation is very common. In this particular slide, however, the damage was so severe and large soil movement destroyed the infrastructure as well as housing.

The movement started early in the morning when about 25 cm of sudden drop initialized the whole movement. Afterward, subsidence occurred systematically reaching 3.5 m in about 10 hours. A number of cracks appeared in this area and water sprang out through gaps in the cracking ground. This phenomenon caused several houses tilt and crack and by the end of the day the whole infrastructure was devastated.

The subsidence was localized in the fill area where a number of infrastructure including roads, drainage and electric towers were damaged. Since the subsidence caused 3.5 m difference in elevation, the connecting road tore out in certain patterns either laterally across the road or longitudinally. Figure 2 and Figure 3 shows severe damage of the infrastructure.

Figure 2: Damages due to subsidence

Figure 3: Road damage and gabion heaves

Figure 4: Ground cracking

Figure 4 shows ground cracking parallel to the road and Figure 5 shows how the land elevation moved downwards about 3.5 m in one day. The direction of the cracking indicated that the land experienced lateral spreading. However, at this point the real mechanism was not known until re-measurement of the contour was conducted.

Figure 5: Land subsidence causing different elevation

4 THOUGHT ON THE LANDLSIDES MECHANISM

It is of interest that this phenomena gives thought about a possible sliding mechanism which seems to be movement of the breccia over the impervious layer since a water level rise was detected the day after. Although in the east side, movement and cracks were seen, in the west side no cracking or damages were observed.

The fact that water level increase is so rapid in the breccia layer, means that water accumulated and was retained in this layer. Weathered breccia on the surface shows a lot of cracking that eases water seeping into the ground. Land development hinders water outflow which cause high lateral forces for the whole layer and subsequently moved it in a translational direction.

It was later known that the subsidence has been caused by this lateral spreading of the breccia. The subsiding ground consisted of fill material, which is well compacted in a valley located between 2 hills of breccia. According to the geologist, these valleys were formed by very old slides or volcanic activity.

5 SOIL CONDITION AND GEOLOGY

The geomorphology of the area consisted of a valley within 2 hills and was a low site where sediment was deposited. This area was then filled with local material to increase the elevation and to form a more or less plane area. The stratigraphy shows that 3 kinds of materials dominated the site. The lower one is claystone over the whole area and forming an impervious layer. The upper one is breccia with andesitic fragment and filled with secondary material. The average thickness of the breccia layer in this area is about 15 m and this layer formed two hills as shown in the cross section.

The other material is found as alluvium, which is the minority of the material type. This material was the result of ground erosion over time.

6 MECHANISM OF RE-SLIDING OF BRECCIA LAYER

After the landslides, a contour measurement was conducted as shown in Figure 6.

The topography shows a long steep slope over the whole area except the area where the sliding problem is being investigated. The difference in elevation over a distance of about 500 m is about 100 m, hence on the average the slope is about 20∞. The mechanism of re-sliding was known from visual observation verified by contour measurement. From site survey, the breccia layer is shown to have many cracks to facilitate water seeping into the layer and causing a ground water level increase.

The cross section of this area is shown on Figure 8 where it is clearly shown that the breccia layer is limited and sitting on top of the impervious layer. The fill and the land development area are also shown.

Figure 6: Topography of the study site

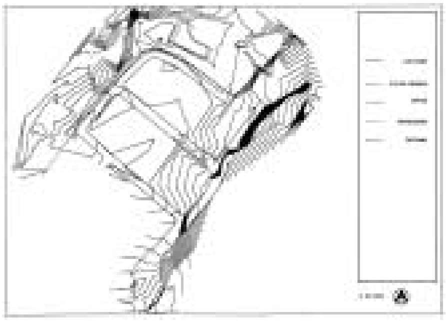

Figure 7: The re-measurement of contour

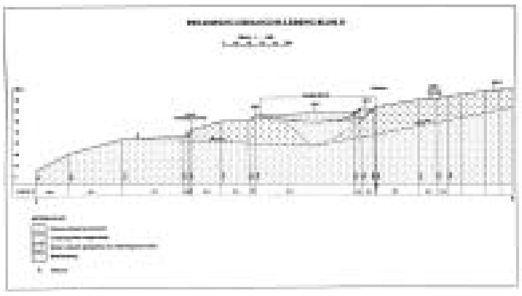

Figure 8: Cross section of the weathered breccia on claystone

7 SIMULATION OF RE-SLIDING

This research was facilitated by use of finite element analysis (computer program PLAX-IS) where stages of land changes are made possible. The analysis is limited to two-dimensional. The model started with initial conditions where the breccia layer was assumed to be stable and hence interface elements were used in the boundary between the breccia and the claystone. The value of the interface strength was exercise by changing the value of R-interface until movement started in the breccia.

The model was continued by placing fill material on top of the sliding area and infiltration of rainwater is made possible. The effect of rain water infiltration is modelled as an increase of the ground water in the breccia layer. Soil model is ordinary Mohr – Coulomb. The soil has low strength of 6 – 24 kPa and a friction angle about 8∞.

The soil system is discretized to clusters of material where geotechnical properties can be input. Modelling the excavation causes some movement of the breccia layer, which is insignificant. However, the main movement occurs when modelling the ground water level increase, which certainly gives lateral forces to the whole mass.

Figure 9 shows the discretization of the mass through the critical section where the boundary of the breccia and the claystone is characterized by a sliping plane having the potential to slip between each other.

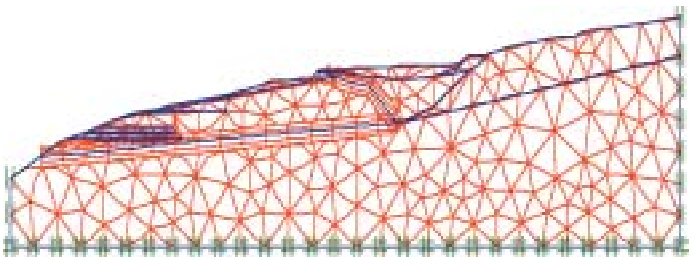

Figure 9: Discretization of the soil mass

Based on the result of the analysis, the effect of fill material is a compression of the sediment to about 27 cm, especially in the mid area. However, this analysis cannot be verified since no measurement was available. The mass failed with huge displacements when the ground water was raised to about ground surface.

Figure 10 shows the localized mass movement resulting from the finite element modelling.

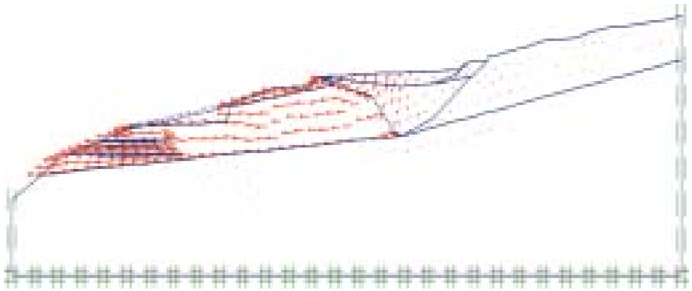

Figure 10: Result of computer simulation

The movement was predicted to reach about 1.3 m but this is lower than measured data, since after failure the computer simulation cannot be continued. Back analysis for the value of R-interface yields a friction coefficient as low as 0.25.

The recommendation, which resulted from this study, is a water level decrease by use of pumping in several areas. For the long term, several horizontal drains were installed. Rows of drilled shafts were installed to protect the rest of the building.

8 CONCLUSION SUMMARY

- The landslides, which occurred on February 8, 2002, were basically re-sliding in a big scale on the breccia layer on top of the claystone due to ground water rise.
- Fill placement and limited excavation was not the cause of the landslides, however, small movement were detected.
- Finite element modelling is very useful in simulating the mechanism of the slides and can also be used to back analyse the interface value between the breccia and the claystone.
- The fact that water level increase significantly affects the landslides tells the developer to be cautious and minimizing rain water seeping in into the breccia.
- Lesson learned from this landslide occurrence is that the landslide is transtational and in such rock stratification, landslide could occur as a sudden mechanism due to the increase of ground water level alone.

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