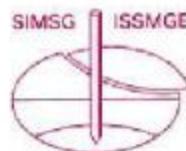




**HIMPUNAN AHLI TEKNIK TANAH INDONESIA**  
INDONESIAN SOCIETY FOR GEOTECHNICAL ENGINEERING (ISGE)  
MEMBER SOCIETY OF INTERNATIONAL SOCIETY FOR SOIL MECHANICS  
AND GEOTECHNICAL ENGINEERING (ISSMGE)



# Proceedings

## *18<sup>th</sup> Annual National Conference on Geotechnical Engineering*

*“Geotechnical Engineering  
for Future Infrastructure Development in Indonesia”*

Bidakara Hotel - Jakarta, 11-12 November 2014

Support by :



Departemen Pekerjaan Umum  
dan Pemukiman Rakyat  
Republik Indonesia



Lembaga Pengembangan  
Jasa Konstruksi  
Nasional



Proceeding 18<sup>th</sup> Annual National Conference on Geotechnical Engineering  
Jakarta - INDONESIA, 11-12 November 2014

## **“Geotechnical Engineering for Future Infrastructure Development in Indonesia”**

Editor : *Widjojo A. Prakoso*  
*Hasbullah Nawir*  
*Bigman M. Hutapea*  
*Hendra Jitno*  
*Nurly Gofar*  
*Agus Setyo Muntohar*  
*Munirwansyah*

**HIMPUNAN AHLI TEKNIK TANAH INDONESIA**  
**INDONESIAN SOCIETY FOR GEOTECHNICAL ENGINEERING (ISGE)**  
Basement Aldeveco Octagon, Jl. Warung Jati Barat Raya No. 75  
Jakarta Selatan 12740 - INDONESIA

## TABLE OF CONTENTS

Preface Committee Chairman .....	i
Message from President of Indonesian Society for Geotechnical Engineering (ISGE) .....	ii
Organizing Committee .....	iii
Table of Contents .....	v
<b>Keynote Speakers :</b>	
1 General Presentation of Eurocode 7 on Geotechnical Design <i>Prof. Roger Frank (President of International Society for Soil Mechanics and Geotechnical Engineering – France)</i> .....	1-10
2 Cyclic Performance of Loose Sandy Ground with Nonplastic Silt and its Application to Seismic Performance-based Design <i>Prof. Ikuo Towhata (Vice President ISSMGE for Asia – Japan)</i> .....	11-22
3 Forensic Geotechnical Engineering Practice in Indonesia <i>Prof. Ir. Chaidir Anwar Makarim, MSE, Ph.D (UNTAR - Ketua Umum HATTI 1999-2003)</i> .....	23-46
4 Low improvement ratio deep soil mixing method and its case histories of reducing long term settlement <i>Mitsuo NOZU, Dr. Eng., P.E. (FUDO Construction - Japan)</i> .....	47-54
<b>Session I :</b>	
1. Underwater Excavations and Underwater Concretings for Remedialing A Critical Instable Excavation and for Solving an Excavation with Excessive Inflowing Debit <i>Endra Susila, Andika Yudha Prayitno, Abdurrachman Husein, Suhermanto, Wirman Hidayat, Susilarto, Sahala Radjaguguk</i> .....	55-64
2. Construction of Kim Chuan Depot <i>Tiong Guan Ng, Indrayogan Yogarajah</i> .....	65-72

3. Analisis Deformasi Tanah Pada Struktur Dermaga Pile Supported Wharf Akibat Gempa Menggunakan Program Finite Difference Flac 2d (Studi Kasus: Dermaga 1b Kalibaru, Jakarta)  
*Yumar Imarrazan Basarah* ..... 73-80
4. Study of Building Structure Behavior on Acceleration Seismic Loading Using Soil Structure Interaction  
*Taufik Hidayat Linggadjaja* ..... 81-88
5. Studi Kasus Analisis Struktur Penahan Tanah Dengan Support Ground Anchor Pada Tanah Lunak : Plaxis-2D vs FREW Oasys  
*Budiantari Herdianti Laksita, Yuman Halim* ..... 89-96

#### Session II

6. Analisis Pengaruh Injeksi Mikroorganisme Potensial Pada Parameter Kompresibilitas Tanah Gambut Kayu Agung Sumatera Selatan  
*Wiwik Rahayu, Puspita Lisdiyanti, Albert Wilson Pardamean* ..... 97-104
7. Konsep Desain Jalan Tambang  
*D. Djarwadi* ..... 105-112
8. Usulan Pedoman Perencanaan dan Pelaksanaan Perbaikan Tanah dengan Menggunakan Vertikal Drain  
*GOUWTjie-Liong* ..... 113-128

#### Session III

9. Instrumented Bored Pile Socket Into Mudstone  
*Sindhu Rudijanto* ..... 129-134
10. Kajian Efek Desakan Tiang Pancang Terhadap Gerakan Turap Pada Tanah Lunak  
*Maryono, Paulus Pramono Rahardjo* ..... 135-140
11. Uji Beban Lateral Kelompok Tiang Beton Dengan *PileCap* Tipis Pada Tanah Lempung Lunak  
*Muhammad Firdaus, Hary Christady Hardiyatmo, Agus Darmawan Adi* ..... 141-148
12. Kasus Kegagalan Konstruksi Dinding Penahan Tanah Rumah Mewah Di Atas Tanah Lunak  
*Idrus Muhammad A, Djoko Soepriyono, Helmy Darjanto* ..... 149-156
13. Lateral Load Analysis of Suction Anchor in Marine Soft Clay Using 2D Plane Strain and Axisymmetric-Asymmetric FE Model  
*Andri Mulia, Reza Ismaniar, Paulinus Sitanggang* ..... 157-164

Session IV

14. Vibro Replacement for Tank Storages at Karimun Island, Indonesia  
*Muhammad Dwi Pamudji, HendyWiyono, Leong Kam Weng*..... 165-172
15. A Deformation Model of the Embankment dams of the Lusi Mud Volcano  
in Sidoarjo, East Java: A Case Study of Ground Subsidence Problems  
*Didi S. Agustawijaya, Sukandi, Buan Anshari* ..... 173-176
16. Rockfall Hazard Analysis on Sorowako – Malili Public Road KM. 020+200  
to KM. 021+700 at East Luwu Regency, Province of South Sulawesi,  
Indonesia  
*Wiyatno Haryanto, Indra Thamrun* ..... 177-186
17. Resiko Hukum Yang Timbul Bagi Tenaga Ahli Jasa Konstruksi Terkait  
Perbuatan Melanggar Hukum di Tinjau Dari Aspek Hukum Perdata dan  
Aspek Hukum Pidana Umum/Korupsi  
*Djoko Soepriyono* ..... 187-192

Other Session

18. Perbedaan Viskositas Menggunakan Alat Uji Geser Baling-Baling dan Flow  
Box Test untuk Transportasi Mudflow  
*Budijanto Widjaja, David Wibisono Setiabudi, Ivan Octora*..... 193-198
19. Perubahan Nilai CBR Pada Kadar Air Optimum-Basah Campuran Tanah  
Lempung Dan Abu Terbang  
*Muhardi, Soewigno Agus Nugroho, Puspa Ningrum* ..... 199-206
20. Karakteristik Kimia, Fisik dan Mekanik Abu Batu Bara (Abu Terbang dan  
Abu Dasar)  
*Muhardi, Syawal Satibi* ..... 207-216
21. Analisa Potensi Likuifaksi Berdasarkan Hasil Pengujian Piezocone  
*Erza Rismantojo* ..... 217-222
22. Application of Wavelet Spectrogram Analysis of Surface Waves for Long-  
term Settlement Prediction  
*Sri Atmaja P. Rosyidi, Colin Peter Abbiss* ..... 223-230
23. Effect of Rainfall Intensity and Initial Matric Suction on the Stability of  
Residuals Soils Slope  
*Agus Setyo Muntohar, Muhammad Suradi, Andy Fourie* ..... 231-236
24. Regional and National Government Databases of Geotechnical Data  
and the Importance of a Standard Electronic Interchange Format  
*Philip M. Wade* ..... 237-242

# Effect of Rainfall Intensity and Initial Matric Suction on the Stability of Residuals Soils Slope

Agus Setyo Muntohar

*Department of Civil Engineering, Universitas Muhammadiyah Yogyakarta, Indonesia*

Muhammad Suradi

*School of Civil and Resources Engineering, University of Western Australia, Perth, Australia*

*Politeknik Negeri Ujungpandang, Makassar, Indonesia*

Andy Fourie

*School of Civil and Resources Engineering, University of Western Australia, Perth, Australia*

**ABSTRACT:** Seepage and slope stability issues concerning infiltration in unsaturated slopes are investigated and presented. A two dimensional transient finite element analyses are used to study the effects of the rainfall intensity and initial matric suction on the stability of slope in tropical region in Northern Territory, Australia. The Jabiru landslide occurred in March 2007 after severe rainstorm with rainfall amount of 0.8 m in 3 days. This landslide occurred at a soil slope with height of 23 m and angle of 19°. Field and laboratory investigations were carried out to determine soil parameters required in slope stability analysis. Parametric study was performed to find out which cases with respect to rainfall intensity and initial matric suction triggering the landslide occurrence. The results indicates that if the rainfall intensity is greater or equal to the saturated hydraulic conductivity of the soil ( $I \geq k_{sat}$ ), the slope stability is controlled by the saturated hydraulic conductivity of the soil. In general, the results conclude that the slope stability is highly dependent on the initial matric suction.

**Keywords:** rainfall, infiltration, matric suction, slope stability, residual soil

## 1 INTRODUCTION

Shallow slopes failure have been identified while extreme rainfall throughout the entire Magela Creek catchment occurred at late February to early March 2007 (Moliere et al., 2007) at Northern Territory, Australia. The location and typical of landslide is shown in Figure 1 and 2 respectively. During a week period between 23 February and 16:30 h 2 March, 945 mm of rain was recorded from closest rainfall station at Jabiru Airport. Within a three-day period between 27 February and 2 March, 784 mm of rain fell at Jabiru Airport. As a result of this intense rainfall, landslides were initiated where the sandstone has been removed to expose Oenpelli Dolerite. This landslide occurred at a soil slope with a height of 23 m and angle of 19° (Erskine et al., 2012; Saynor et al., 2012). The intense rainfall may have a significant impact on the stability of a rehabilitated mine. Figure 2 illustrates the typical of slope failure. Study need to be performed to find out which cases with respect hydraulic parameter to triggering the landslide occurrence. Effect of

rainfall pattern and distribution has been investigated by Suradi and Fourie (2013), Muntohar et al. (2014), Suradi et al. (2014). The main objective of this research was to investigate the effect of rainfall intensities and initial matric suction on stability of the slope.

## 2 NUMERICAL MODELING

### 2.1 Seepage analysis

In this study, analyses for transient seepage conditions were conducted on a 23 m high slope inclined at 19°. The slope was composed of a homogenous, isotropic soil. The thickness of soil was relatively shallow about 2 m (assigned as R2). An impermeable soil and rock layers (assigned as R1) was found below the soil layer. The finite element seepage analysis software Seep/W 2004 for saturated–unsaturated soil systems was used in this study. The finite element mesh, along with the boundary conditions, is shown in Figure 3a. At the left and right edges were modeled as infinite element. Along the left and right boundaries beneath the soil layer (R2), a



Figure 1 Location of the studied area

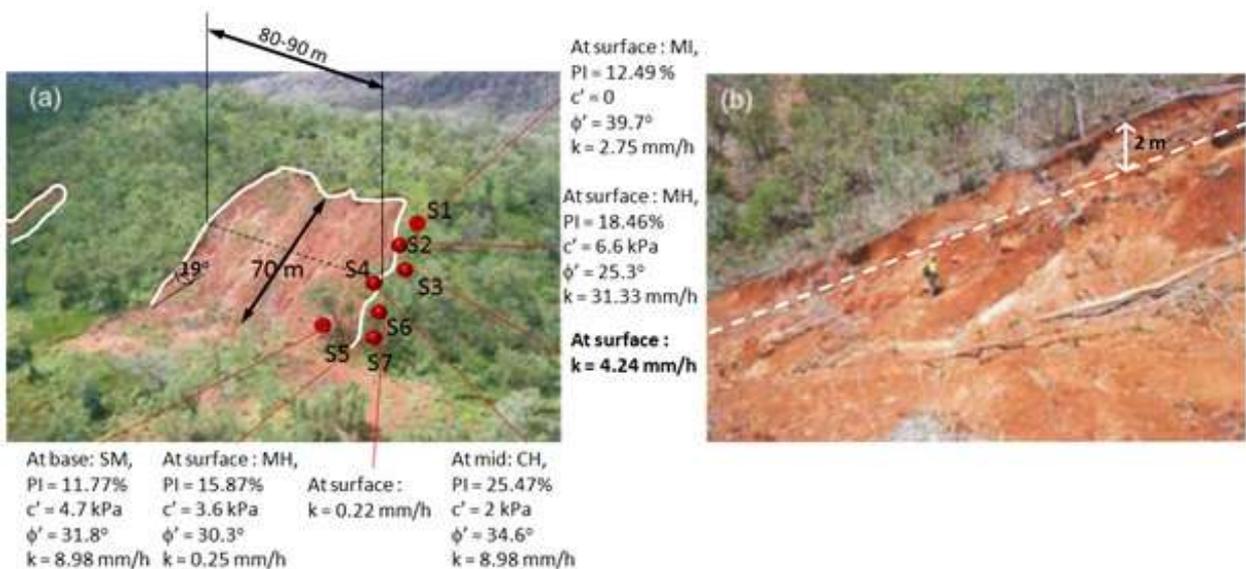


Figure 2 Typical of the landslides (a) landslide area and soil properties, (b) longitudinal section of failure plane

constant head was applied. A zero flux boundary was applied along the left and right boundaries of R2 layer. The rainfall intensity was modeled by applying unit flux boundary ( $q$ ) to the surface of the slope for 120 hours. Three rainfall intensity,  $I = 0.006$  m/h,  $I = 0.008$  m/h,  $I = 0.012$  m/h, were applied to investigate their effect on the slope stability. The pore-water pressure distributions above the water table were plotted for all time steps at selected sections; top, mid, and toe section, as shown in Figure 3a.

A hydrostatic initial condition was established at the beginning of the transient seepage analysis. Initial pore water pressure was generated from initial suction by applying nodes pressure in R2 layers (Figure 3b). A limiting negative pore-water pressure was

imposed as an initial condition would ensure that the pore-water pressure distributions were more realistic and represented a steady state condition. Three matric suction conditions were applied on slope surfaces, 10 kPa, 33 kPa, and 75 kPa, to evaluate the effect of initial matric suction on the slope stability.

## 2.2 Slope stability analysis

For the slope stability analysis, the Bishop method of slices was used to compute the factor of safety within the soil. The field observation confirmed that a shallow slope failure occurred with planar planes. The fully specified failure planes as illustrated in Figure 4 were used in the analyses. The depth of slip plane was determined at 2 m below the slope

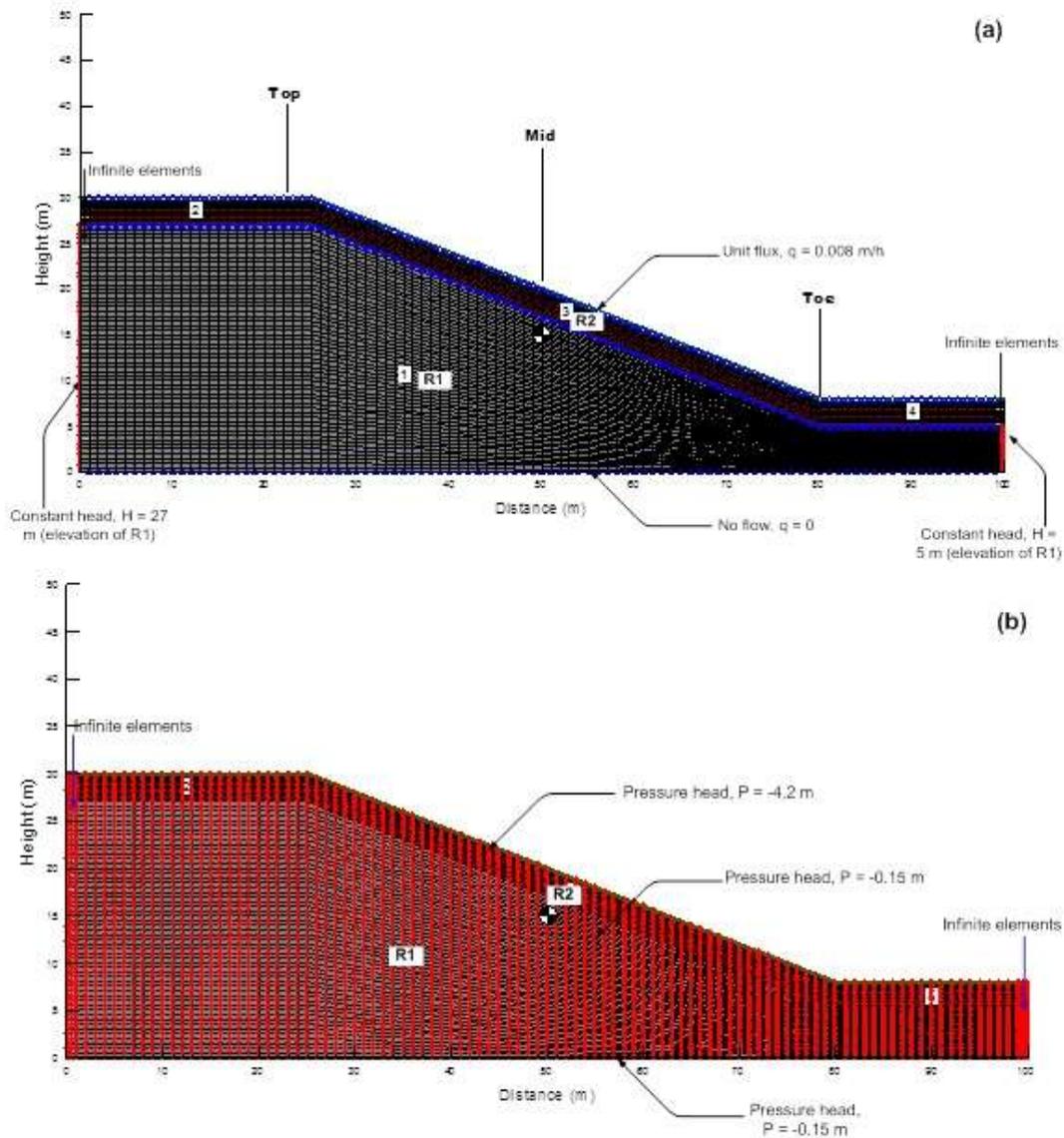


Figure 3 (a) Slope geometry and boundary conditions of the slope for transient analysis (b) Boundary conditions for generating initial pore-water pressure

surface. The pore-water pressures that were determined in the seepage analysis by Seep/W 2004 were used as input data for the slope stability analysis. Slope/W 2004 determines the elements that lie closest to the centre of each slice base and computes the pore-water pressure at each location from the nodal pore-water pressure conditions of the element nodes.

#### Soil properties

Laboratory tests were conducted to estimate the hydraulic shear strength and properties of the slopes. The location of soil samples and its properties was shown in Figure 2a. Figure 5 shows the soil water characteristic curve (SWCC) and unsaturated permeability which was obtained from pressure plate test (Suradi

and Fourie, 2013). The saturated hydraulic conductivity ( $k_{sat}$ ) of R1 and R2 layers were  $1 \times 10^{-10}$  m/h and 0.008 m/h for region R1 and region R2 respectively. The shear strength parameter for region R1 were  $c' = 0$  kPa,  $\phi' = 40^\circ$ ,  $\phi^b = 20^\circ$ , and  $\gamma = 23$  kN/m<sup>3</sup>, while for region R2 were  $c' = 3$  kPa,  $\phi' = 16^\circ$ ,  $\phi^b = 20^\circ$ , and  $\gamma = 18$  kN/m<sup>3</sup>.

### 3 RESULTS AND DISCUSSION

Figure 6 presents the results of numerical simulation on the effect of rainfall intensity and initial matric suction on the slope stability. For the rainfall intensity,  $I = 0.008$  m/h and 0.012 m/h, the change of  $FS$  is relatively the

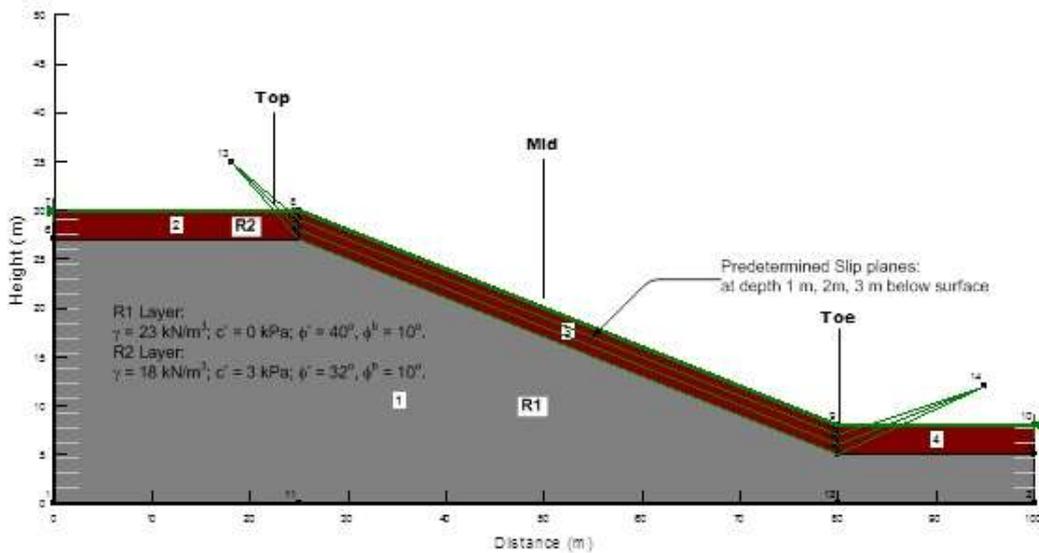


Figure 4 Range of possible critical slip surfaces used for the slope stability analysis

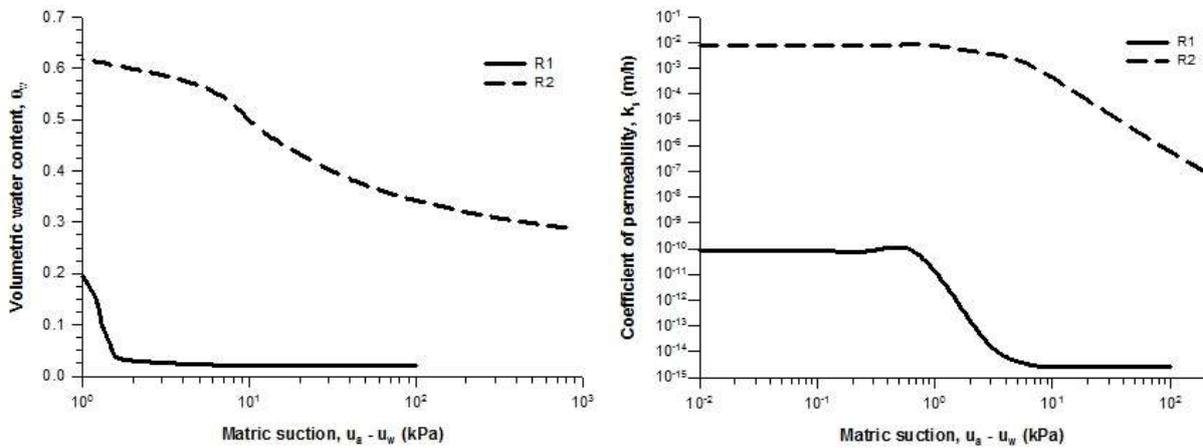


Figure 5 Soil-water characteristic curves and permeability functions with varying values for the soils used in the study

same for all initial matric suction condition. The result indicates that if the rainfall intensity is greater or equal to the saturated hydraulic conductivity of the soil ( $I \geq k_{sat}$ ), the slope stability is controlled by the saturated hydraulic conductivity of the soil. In contrast for a low-intensity rainfall,  $I = 0.006 \text{ m/h}$  ( $I < k_{sat}$ ), the soil in the unsaturated zone remains unsaturated as the wetting front moves through it and results in delay slope failure or the slope remains stable. Mahmood et al. (2011) show the similar characteristics with for anisotropic hydraulic conductivity. Tsaparas et al. (2002) explained that if the ratio  $I/k_{sat}$  is low, then more water will infiltrate the ground and less amount of the rainfall will disappear as runoff. If the ratio is too small then negative pore-water pressures may not even be affected by the infiltration.

In general, change in matric suction due to climate decreases with the depth. Slope failure is dependent on the initial matric suction condition of soil at the surface and subsurface. Figure 6 show clearly that the slope remains stable at a higher initial matric suction of 75 kPa although a high rainfall intensity of 0.012 m/h is applied on the slope. At a low initial matric suction of 10 kPa and 33 kPa, the slope is likely to fail which is indicated by the  $FS < 1$  for all applied rainfall intensities. From the trial of initial matric suction, the uncertainty of slope failure due to initial matric suction is high. Then, field monitoring should be carried out to observe the appropriate value of matric suction and to have a better slope stability analysis. Using the field observation, Lim et al. (1996) mentioned that the change of matric suction is a function of the initial matric suction in the slope.

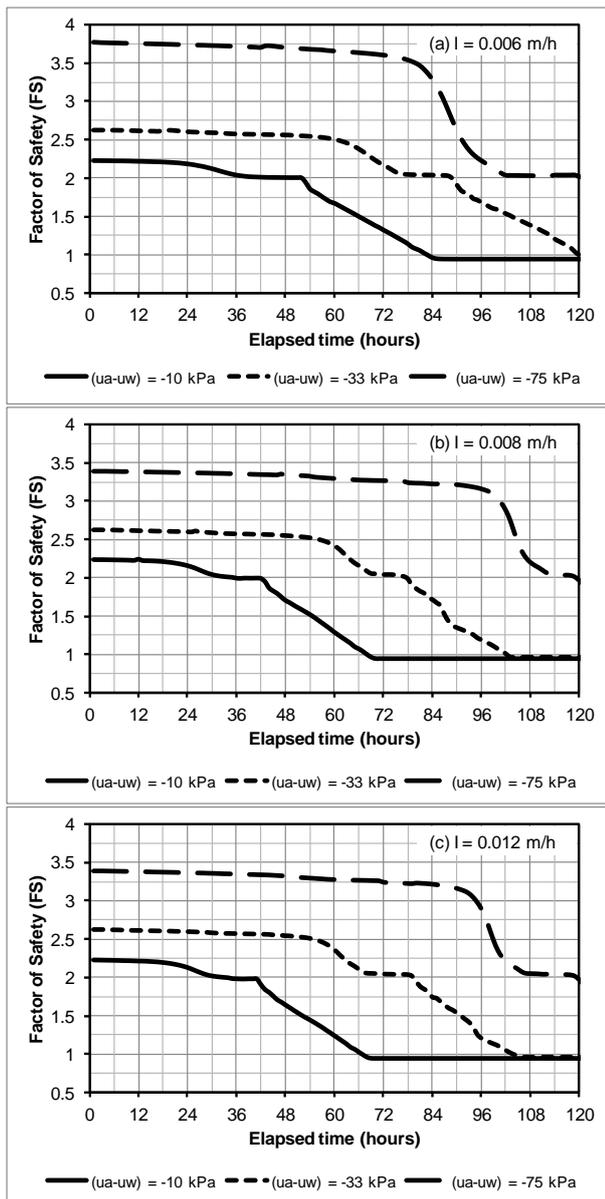


Figure 6 Variation of slope stability with various initial suction condition for (a)  $I = 0.006$  m/h, (b)  $I = 0.008$  m/h, and (c)  $I = 0.012$  m/h.

#### 4 CONCLUSIONS

The numerical study and a case study were used successfully to study rainfall intensity and initial matric suction and its effect on slope stability. The ratio between rainfall intensity and saturated hydraulic conductivity of the soil ( $I/k_{sat}$ ) controlled the change of slope stability. The results of the numerical study show that in general, the slope stability is more affected by the change of initial matric suction than the rainfall intensity. The strong interaction between the initial matric suction and slope stability, the parameters need for proper and realistic choices when performing transient analysis.

#### ACKNOWLEDGEMENTS

The first author thanks for the financial support from Ministry of Education and Culture, the Republic of Indonesia under fundamental research grant scheme in 2010-2012 entitled “Numerical and Experimental Studies of Rainfall Infiltration Induced Slope Stability”. Support from Mr. M. Suradi and Prof. Andi Fourie, School of Civil and Resources Engineering, University of Western Australia is acknowledged.

#### REFERENCES

- Erskine, W., Saynor, M., Jones, D., Tayler, K., and Lowry, J., 2012. *Managing for extremes: potential impacts of large geophysical events on Ranger Uranium Mine, N.T.*, in Grove, J.R & Rutherford, I.D (eds.), Proceedings of the 6<sup>th</sup> Australian Stream Management Conference, Managing for Extremes, River Basin Management Society, 6 – 8 February, 2012, Canberra, Australia, pp.1 – 7.
- Lim, T.T., Rahardjo, H., Chang, M.F, Fredlund, D.G., 1996. Effect of rainfall on matric suctions in a residual soil slope, *Canadian Geotechnical Journal*, Vol. 33, pp. 618–28
- Mahmood, K., Ryu, J., and Kim, J., 2011. Effect of anisotropic conductivity on suction and reliability index of unsaturated slope exposed to uniform antecedent rainfall, *Landslides*, Vol. 10, pp. 15-22
- Moliere, D.R., Evans, K.G., and Saynor, M.J., 2007. *Hydrology and suspended sediment transport in the Gulungul Creek catchment, Northern Territory: 2006-2007 wet season monitoring*. Internal Report 531, Supervising Scientist, Darwin, (Unpublished paper).
- Muntohar, A.S., Suradi, M., and Forie, A., 2014. *Development A Boundary of Rainfall-Induces the Stability of A Residuals Soils Slope in Northern Territory, Australia*, Proceeding Seminar Nasional Geoteknik, Yogyakarta, 10-11 Juni 2014, pp. 133-137.
- Saynor, M. J., Erksine, W. D., Staben, G., and Lowry, J., 2012. *A rare occurrence of landslides initiated by an extreme event in March 2007, in the Alligator Rivers Region, Australia*. In Erosion and Sediment Yields in the Changing Environment, Proceedings of the ICEE Symposium held at Institute of Mountain Hazard and Environment, Chengdu, China, IAHS Publication, Vol.356, pp. 303–310.
- Suradi, M., and Fourie, A., 2013. The Effect of Rainfall Patterns on the Mechanisms of Shallow Slope Failure, *Aceh International Journal of Science and Technology*, Vol. 3(1), pp. 1-18.
- Suradi, M., Fourie, A., Beckett, C., and Buzzi, O . 2014, *Rainfall-induced landslides: Development of a simple screening tool based on rainfall data and unsaturated soil mechanics principles*, in N . Khalili,

A.R. Russell, & A . Khoshghalb (Eds.), *Unsaturated Soils: Research & Applications*, pp. 1459–1465.  
Tsaparas, I., Rahardjo, H., Toll, D.G., and Leong, E.C.,  
2002, Controlling parameters for rainfall-induced

landslides. *Computers and Geotechnics*, Vol. 29, pp.  
1–27.