

INTERNATIONAL CONFERENCE



The Second International Conference on
Engineering and Technology Development

2nd ICETD 2013

27, 28, 29 August 2013, Bandar Lampung, Indonesia



PROCEEDINGS



In
Cooperations
With :



الجامعة الإسلامية العالمية
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
بوتنيونينى الشارقة انتنار نظرا ماليسيا



Hosted by :

Faculty of Engineering and Faculty of Computer Science,
Bandar Lampung University (UBL), Indonesia

2nd ICETD 2013

THE SECOND INTERNATIONAL CONFERENCE
ON ENGINEERING AND TECHNOLOGY DEVELOPMENT

28 -30 January 2013
Bandar Lampung University (UBL)
Lampung, Indonesia

PROCEEDINGS

Organized by:



Faculty of Computer Science and Faculty of Engineering
Bandar Lampung University (UBL)
Jl. Zainal Abidin Pagar Alam No.89 Labuhan Ratu, Bandar Lampung, Indonesia
Phone: +62 721 36 666 25, Fax: +62 721 701 467
website : www.ubl.ac.id

PREFACE

The Activities of the International Conference is in line and very appropriate with the vision and mission of Bandar Lampung University (UBL) to promote training and education as well as research in these areas.

On behalf of the Second International Conference on Engineering and Technology Development (2nd ICETD 2013) organizing committee, we are very pleased with the very good response especially from the keynote speaker and from the participans. It is noteworthy to point out that about 80 technical papers were received for this conference.

The participants of the conference come from many well known universities, among others : University Kebangsaan Malaysia – Malaysia, APTIKOM – Indonesia, Institut Teknologi sepuluh November – Indonesia, Surya Institute – Indonesia, International Islamic University – Malaysia, STMIK Mitra Lampung – lampung, Bandung Institut of Technology – Bandung, Lecture of The Malahayati University, B2TP – BPPT Researcher – lampung, Starch Technology Center – Lampung, Universitas Islam Indonesia – Indonesia, Politeknik Negeri Malang – Malang, University of Kitakyushu – Japan, Gadjah Mada University – Indonesia, Universitas Malahayati – Lampung, Lampung University – lampung, Starch Technology Center – Lampung, Universitas Riau – Riau, Hasanuddin University – Indonesia, Diponegoro University – Indonesia, King Abdulaziz University – Saudi Arabia, Parahyangan Catholic University – Indonesia , National Taiwan University–Taiwan, Surakarta Christian University – Indonesia, Sugijapranata Catholic University – Indonesia, Semarang University – Indonesia, University of Brawijaya – Indonesia, PPKIA Tarakanita Rahmawati – Indonesia, Kyushu University, Fukuoka – Japan, Science and Technology Beijing – China, Institut Teknologi Sepuluh Nopember – Surabaya, Researcher of Starch Technology Center, Universitas Muhammadiyah Metro – Metro, National University of Malaysia – Malaysia.

I would like to express my deepest gratitude to the International Advisory Board members, sponsor and also to all keynote speakers and all participants. I am also gratefull to all organizing committee and all of the reviewers who contribute to the high standard of the conference. Also I would like to express my deepest gratitude to the Rector of Bandar Lampung University (UBL) who give us endless support to these activities, so that the conference can be administrated on time

Bandar Lampung, 29 August 2013-08-26

Mustofa Usman, Ph.D
2nd ICETD Chairman

PROCEEDINGS

2nd ICETD 2013

The Second International Conference
On Engineering And Technology Development

28 -30 January 2013

INTERNATIONAL ADVISORY BOARD

Y. M Barusman, Indonesia
Ahmad F. Ismail, Malaysia
Mustofa Usman, Indonesia
Moses L. Singgih, Indonesia
Andreas Dress, Germany
Faiz A.M Elfaki, Malaysia
Warsono, Indonesia
Raihan Othman, Malaysia
Zeng Bing Zen, China
Tjin Swee Chuan, Singapore
Khomsahrial R, Indonesia
Rony Purba, Indonesia
Alex Tribuana S, Indonesia
Hon Wei Leong, Singapore
Imad Khamis, USA
Rozlan Alias, Malaysia
Rudi Irawan, Indonesia
Gusri Ibrahim, Indonesia
Jamal I Daoud, Malaysia
Riza Muhida, Indonesia
Heri Riyanto, Indonesia
Agus Wahyudi, Indonesia
Lilies Widojoko, Indonesia

PROCEEDINGS

2nd ICETD 2013

The Second International Conference
On Engineering And Technology Development

28 -30 January 2013

STEERING COMMITTEE

Executive Advisors

Dr. M. Yusuf S. Barusman
Andala R. P. Barusman, MA.Ec

Chairman

Mustofa Usman, Ph.D

Co-Chairman

Dr. Ir. Hery Riyanto, MT
Ahmad Cucus, S.Kom., M.Kom

Secretary

Marzuki, S.Kom., M.Kom
Maria Shusanti Febrianti, S.Kom., M.Kom

Technical Committee

Indyah Kumoro, ST. IAI
Ardiansyah, ST., MT
Sofiah Islamiah, ST. MT
Taqwan Thamrin, ST., MSc
Dina Ika Wahyuningsih, S.Kom
Agus Sukoco, M.Kom
Hj. Susilowati, ST. MT
Haris Murwadi, ST, MT
Robby Yuli Endra, S.Kom., M.Kom
Fenty Ariani, S.Kom., M.Kom

Treasure

Samsul Bahri, SE
Dian Agustina, SE

PROCEEDINGS

2nd ICETD 2013

The Second International Conference
On Engineering And Technology Development

28 -30 January 2013

ORGANIZING COMMITTEE

Chair Person

Dr. Ir. Hery Riyanto, MT

Vice Chair Person

Yuthsi Aprilinda, S.Kom., M.Kom

Treasure

Dian Agustina, S.E

Secretary

Aprizal, ST. MT

Ir. Tjejeng Sofyan, MM

Ir. Muhammad Zein, MT

Ir. Bambang Pratowo, MT

Special Events

Ir. Juniardi, MT

Ir. Indra Surya, MT

Ir. Sugito, MT

DR. Baginda Simaibang, M.Ed

Berry Salatar, S.Pd

Yanuar Dwi Prasetyo, S.Pd.I., M.A

Receptionist

Ir. Najamudin, MT

Kunarto, ST. MT

IB. Ilham Malik, ST. MT

Ir.A Ikhsan Karim, MT

Ir. Asikin, MT

Usman Rizal, ST., M.MSi

Transportation and Acomodation

Irawati, SE

Desi Puspita Sari, S.E

Tanto Lailam, S.H

Ilyas Sadad, S.T., M.T

Publication and Documentation

Ir. Indriati Agustina Gultom, M.M

Noning Verawati, S.Sos

Hesti, S.H

Rifandi Ritonga, SH

Violita, S.I.Kom

Cosumption

Dra. Yulfriwini, M.T

Wiwin Susanty, S.Kom., M.Kom

Fenty Ariani, S.Kom., M.Kom

Reni Nursyanti, S.Kom., M.Kom

Erlangga, S.Kom

Arnes Yuli Vandika, S.Kom

Facility and Decoration

Siti Rahma Wati,SE

Dina Ika Wahyuningsih, S.Kom

Zainal Abidin, SE

Ahyar Saleh, SE

Eko Suhardiyanto

Wagino

Sugimin

Table Of Content

Organizing Committee	i
Table Of Content.....	v
Keynote Speaker	
1. Recent Advances in Biofuel Cell and Emerging Hybrid System Abdul Aziz Ahmad and Raihan Othman	1
2. Waste Utilization Study Tailing Gold Mine in Way Linggo-Lampung, as Fine Aggregate Materials for Producing Mortar Materials based on concept of Green Technology Lilies Widodojoko & Susilawati	8
3. Infrastructure Health Monitoring System (SHM) Development, a Necessity for Maintance and Investigation Prof. Dr. Priyo Suprobo, Faimun, Arie Febry	17
4. Four Phases Quality Function Deployment (Qfd) By Considering Kano Concept, Time And Manufacturing Cost Prof. Dr. Moses L Singgih, Dyah L. Trenggonowati, Putu D. Karningsih	22

Speaker

1. Comparative Analysis for The Multi Period Degree Minimum Spanning Tree Problem
Wamiliana, Amanto, and Mustofa Usman..... 39
2. Choosing The Right Software In Supporting The Successful of Enterprise ERP Implementation
Yodhie Yuniarthe, Idris Asmuni..... 44
3. Climate Adaptive Technology In Maintaining Vernacularism Of Urban Kampong Case study: Kampung Adat (Indiginous) Mahmud, Bandung District, West Java
Marcus Gartiwa..... 50
4. The Prospect Of Diesohol In Facing Fossil Fuel Crissis
M.C. Tri Atmodjo..... 63
5. The Potential Of Agriculture And Forestry Biomass Wastes As Source Of Bioenergy
Hardoyo..... 66
6. The Importance of Education Facility as Sustainable Urban Generation Tool
Fritz Akhmad Nuzir, Haris Murwadi and Bart Julien Dewancker 71
7. The implementation of Secton Method for Solving Systems of Non Linear Equations
Nur Rokhman 80
8. Quality Control Analysis Into Decrease The Level Defects On Coffee Product
Heri Wibowo, Sulastri and Emy Khikmawati 85
9. Public Transpotion Crisis In Bandar Lampung
Ida Bagus Ilham Malik 89
10. Geospatial Analysis of Land Use Change in Way Kuripan Watershed, Bandar Lampung City
Candra Hakim Van Rafi'1., Dyah Indriana Kusumastuti2., Dwi Jokowinarno..... 99
11. Material Utilization Technology Of Agriculture And Forestry Waste
Hardoyo..... 105
12. The Supply Chain System Of Cassava On The Tapioca Industry
Hardoyo..... 108
13. Glass Technology In Natural Light Glasses On Aperture Element In The Architecture World
Muhammad Rija & MT Pedia Aldy 113

14. An Eksperimental Permeable Asphalt Pavement Using Local Material Domato Stone On Quality Of Porous Asphalt
Firdaus Chairuddin, Wihardi Tjaronge, Muhammad Ramli, Johannes Patanduk 117
15. Coordination Of Architectural Concepts And Construction Systems
Eddy Hermanto. 129
16. Seismic Assessment of RC Building Using Pushover Analysis
Riza Ainul Hakim...... 136
17. Viscosity and Liquidity Index Relation for Elucidating Mudflow Behavior
Budijanto Widjaja and Shannon Hsien-Heng Lee...... 143
18. The Use of Pozzolanic Material for Improving Quality of Strontium Liquid Waste Cementation in Saline Environment during Nuclear Waste Immobilization Process
Muhammad Yusuf, HayuTyasUtami, Tri SulistiyoHariNugroho, SusetyoHarioPutero 148
19. Geospatial Analysis Of Land Use And Land Cover Changes For Discharge At Way Kualagaruntang Watershed In Bandar Lampung
Fieni Yuniarti, Dyah Indriana K, Dwi Joko Winarno...... 153
20. Wifi Network Design For High Performance
Heru Nurwarsito, KasyfulAmron,BektiWidyaningsih 161
21. Studi on The Efficiency Using Nature Materials in The Structural Elements of Reinforced Concrete Beam
Yasser, Herman Parung, M. Wihardi Tjaronge, Rudy Djamaluddin...... 167
22. The Research Of Slow Release Nitrogen Fertilizer Applied In Sugarcane (Saccharum Officinarum) For Green Energy Bioethanol
M.C. Tri Atmodjo, Agus Eko T. Nurul Rusdi, Sigit Setiadi, and Rina...... 179
23. Energy Utilization Technology Of Agriculture And Forestry Waste
Hardoyo...... 185
24. Implementation Of Fuzzy Inference System With Tsukamoto Method For Study Programme Selection
Fenty Ariani and Robby Yuli Endra. 189
25. The Analysis of Video Conference With ITU Standarization (International Telecommunication Union) That Joining in Inherent At Bandar Lampung University
Maria Shusanti F, Happy Reksa 201

26. The E-internal audit iso 9001:2008 based on accreditation form assessment matrix in study program for effectiveness of monitoring accreditation Marzuki, Maria Shusanti F.	207
27. The Developing Of e-Consultations For Effectiveness of Mentoring Academy Ahmad Cucus, Endang K	214
28. The Evaluation of information system performance in higher education case study with EUCS model at bandar lampung university Reni Nursyanti, Erlangga.	221
29. The Analysis Of History Collection System Based On AndroidSmartphone With Qr Code Using Qr CodeCase Study: Museum Lampung Usman Rizal, Wiwin Susanty, Sutrisno.	230
30. Application of Complaint Handling by Approach Model of ISO 10002 : 2004 to Increase Complaint Services Agus Sukoco and Yuthsi Aprilinda.	235
31. Towards Indonesian Cloud Campus Taqwan Thamrin, Iing Lukman, Dina Ika Wahyuningsih	252
32. Bridging Router to ADSL Modem for Stability Network Connection Arnes Yuli Vandika and Ruri Koesliandana.	257
33. The Effect of Use Styrofoam for Flexural Characteristics of Reinforced Concrete Beams Yasser , Herman Parung, M. Wihardi Tjaronge, Rudy Djamaluddin	261
34. The Estimation Of Bioethanol Yield From Some Cassava Variety M.C. Tri Atmodjo	273
35. Effect of Superficial Velocity of Pressure Difference on The Separation of Oil And Water by Using The T-Pipe Junctionl Kms. Ridhuan and Indarto.	277
36. The use of CRM for Customer Management at Cellular Telecommunications Industry Ayu Kartika Puspa.	293
37. Indonesian Puslit (Centre Of IT Solution) Website Analysis Using Webqual For Measuring Website Quality Maria Shusanti Febrianti and Nurhayati.	297
38. The E-internal audit iso 9001:2008 based on accreditation form assessment matrix in study program for effectiveness of monitoring accreditation Marzuki, Maria Shusanti F.	307

39. Enhancing Quality Software Through CMMI-ISO 9001:2008 and ISO 9126 Agus Sukoco	320
40. Value Analysis Of Passenger Car Equivalent Motorcycle (Case Study Kartini Road Bandar Lampung) Juniardi, Aflah Efendi	337
41. Alternative Analysis Of Flood Control Downstream Of Way Sekampung River Sugito, Maulana Febramsyah.	347
42. Analysis Of Fitness Facilities And Effective Use Of Crossing Road Juniardi, Edi Haryanto.	353
43. Study On Regional Development Work Environment Panjang Port Lands In Support Bandar Lampung City As A Service And Trade Ir. A. Karim Iksan, MT, Yohn Ferry.	359
44. Analytical And Experimental Study Bamboo Beam Concrete Hery Riyanto, Sugito, Juli	370
45. Comparative Analysis Of Load Factor Method Static And Dynamic Method (Case Study Akdp Bus Route Rajabasa - Bakauheni) A. Ikhsan Karim, MT., Ahmad Zulkily.	378
46. Optimization Utilization Of Water Resources dam Batutegei Using Method Of Linear Program Aprizal, Hery Fitriyansyah	386
47. Characteristics Generation Traffic Patterns And Movement In Residential Area (Case Study Way Kandis Residential Bandar Lampung) Fery Hendi Jaya, Juniardi,	392
48. Use Study On Slight Beam Reinforced Concrete Floor Plate in Lieu Of Secondary Beam Hery Riyanto, Sugito, Lilies Widodjoko, Sjamsu Iskandar	399
49. Observation Of The Effect Of Static Magnetic Field 0.1 Mt On A-Amylase Activity In Legume Germination Rochmah Agustrina, Tundjung T. Handayani, and Sumardi.	405
50. Effectiveness Analysis Of Applications Netsupport School 10 Based Iso / Iec 9126-4 Metrics Effectiveness Ahmad Cucus, Nelcy Novelia	413
51. Comparative Performance Analysis Of Banking For Implementing Internet Banking Reza Kurniawan	418

Viscosity and Liquidity Index Relation for Elucidating Mudflow Behavior

Budijanto Widjaja¹ and Shannon Hsien-Heng Lee²

¹Department of Civil Engineering, Parahyangan Catholic University
No. 94 Ciumbuleuit Rd., Bandung 40141, Indonesia

²Department of Construction Engineering, National Taiwan University of Science and
Technology
No. 43 Keelung Rd, Section 4, Taipei 106, Taiwan ROC

Abstract: *The mechanism of mudflow, which is a type of mass movement, is different from that of landslide. A landslide has a discrete failure surface, whereas a mudflow has flow characteristics. Hence, the conventional approach of explaining the characteristics of landslide is not applicable in mudflow. The adaptation of rheological models, such as the Bingham and Herschel–Bulkley models, is required to explain the characteristics of mudflow. Qualitative classifications of mudflow based on water content are also available. The mass movement of mudflow is initiated when the water content of the mudflow is equal to or higher than its liquid limit. Thus, the mass movement of mudflow occurs when the mud is in a viscous liquid state. However, up to now, a detailed explanation on how mudflow is initiated by using a rheological approach is nonexistent. In this study, a flow box test is developed to determine the rheological parameters of mud, including yield stress and viscosity. This test is established to overcome the lack of conventional viscometers, which can only measure the rheological properties of mud in a viscous liquid state. The flow box test utilized the Bingham model and a couple of trap door mechanisms. Results are then interpreted using a method similar to the Herschel–Bulkley model. The flow box test provides reliable results for both plastic and viscous liquid states. Results show that the mudflow characteristics can be explained based on the changes in viscosity. Sudden changes in viscosity occur when the mud reaches its liquid limit, implying that mudflow is possibly triggered when the soil water content of the mud is equal to its liquid limit. The results of this study provide a detailed explanation of mudflow initiation.*

Keywords: ·Flow box test · mudflow · viscosity · viscous liquid state

1. INTRODUCTION

Mudflow can be initiated by landslides triggered by rainfall. Many researchers suggest that mudflow occurs because of changes in water content. Hungr et al. [5] denoted that water content is equal to or higher than the liquid limit (LL), and the flow velocity is higher than 5 cm/s.

Slano Blato in Slovenia was an example of a landslide. During this landslide, Petkovsek et al. [13] placed several instruments (i.e., tensiometer) to measure suction changes. They determined that suction was about 6 kPa with a cohesion of about 2 kPa. The

sudden change in water content, which reduces shear strength, is the main reason behind the initiation of the landslide. The flow velocity of Slano Blato ranged from 0.07 cm/s to 0.12 cm/s; thus, Slano Blato is classified as a landslide using the velocity criterion.

Mudflow exhibits instantaneous velocity at initiation. Measuring flow velocity can be dangerous when a landslide changes to mudflow. Considering its sudden occurrence, mudflow is a more dangerous type of mass movement compared with a landslide.

The Achacolla mudflow in Bolivia was the largest mudflow in the

world, which traveled a distance of approximately 25 km as in Hunt [6]. In Indonesia, Karanganyar in Central Java in 2007 and Ciwidey in West Java in 2010 were examples of mudflow, in which the former traveled a distance of about 260 m and the latter a distance of about 3300 m. The Maokong mudflow in Taiwan traveled a distance of approximately 200 m.

No technical explanation exists on how and why mudflow is initiated (Hung et al. [5]; Lee and Widjaja [14]). The only feasible qualitative method is using geological classifications. Hence, this paper aims to describe behavior of mudflow as one of mass movement type in a quantitative way using a rheological approach based on a relationship between viscosity and liquidity index.

2. MATERIALS AND METHODS

7.1 Classification of Mudflow

Several criteria that can be used to categorize mass movement as mudflow are as follows:

- a. Soil type
Mudflow comprises more than 50% fine soil.
- b. Viscous liquid state
Mudflow material is saturated and has water content equal to or higher than LL. Mudflow soil occurs in a viscous liquid state.
- c. Ratio of width and length
This criterion is recommended by Liu and Mason [8]. Width refers to the average width of mudflow, and length refers to the transportation length from the source area to the end of deposition area. The width-to-length ratio should range from 0.05 to 0.3.
- d. Solid concentration by volume
O'Brien and Julien [12] proposed utilizing solid concentration by volume (C_v) in determining mudflow. C_v is defined as

$$C_v = \frac{V_s}{V_w + V_s} \quad (1)$$

$$C_v = \frac{1}{1 + w \cdot G_s} \quad (2)$$

where V_w is the volume of the water part, V_s is the volume of the solid part, w is water content, and G_s is the specific gravity. C_v ranges from 0.45 to 0.55 in mudflow. C_v is higher than 0.55 in landslides.

- e. Flow velocity
Hung et al. [5] identified the flow velocity of mudflow as higher than 5 cm/s. However, obtaining C_v and flow velocity (v) is difficult. Back analysis is recommended in categorizing mudflow. Mudflow can be triggered by changes in water content, for example, infiltration of water into soil due to heavy rainfall. However, weather prediction is difficult, and mudflow prediction is more difficult because mudflow is a function of weather. Back analysis can be used after mudflow by numerical analysis such as Flo2d software. The results obtained are compared with that of mudflow simulation.

7.2 Landslide Versus Mudflow

The first criterion of mass movement classification is flow velocity. The flow velocity of the landslide is less than 5 cm/s. The water content of landslide is lesser than LL or is in plastic state as in Abbot [1]. By contrast, mudflow material exists in a viscous liquid state (Fig. 1).

Landslide has a discrete failure surface, whereas mudflow is a type of flow with fine material without a clear failure surface. Mudflow moves around gullies and can hit anything in instantaneous way, thus making this flow dangerous.

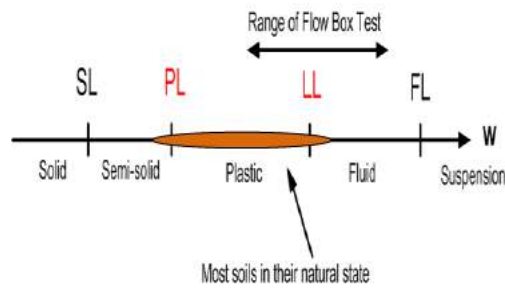


Fig. 1 Atterberg limits as boundary of material condition

(after Germaine and Germaine [4]).

7.3 Rheology

In geotechnical engineering, a landslide can be presented by a safety factor. The soil mass is assumed to be a solid material using a limit equilibrium method, such as Ordinary Method of Slices and Bishop in Bishop [2]. The soil strength model used for the plastic state is the Mohr–Coulomb model.

Mudflow is in a viscous liquid state. Rheology, which can be used to define flows, is the science dealing with flow characteristics of a material. Mudflow is categorized as non-Newtonian flow. The shear strength of mudflow is called yield stress (τ_y). When shear stress (τ) is lower than τ_y , the material is not in flow mode (Fig. 2). However, when shear stress is higher than τ_y , the material is in flow mode. Flow is governed by another parameter called viscosity (η).

The Bingham model can be applied to simplify mudflow behavior. This model uses a straight line in shear stress and a shear strain rate ($\dot{\gamma}$) plane. The intersection in the shear stress line is τ_y , and the positive gradient of the line is η . The Bingham model can be presented as

$$\tau = \tau_y + \eta\dot{\gamma} \quad (3)$$

Laboratory conventional viscometer is used to obtain the rheology parameters, yield stress and viscosity. However, this test can be applied only in viscous liquid state as in Dinger [3].

Herschel–Bulkley (or pseudoplastic) model is another type of rheology model. The Herschel–Bulkley model derives the rheology parameters using a graphical procedure of matching curves.

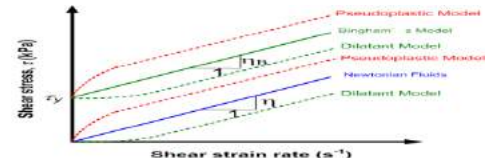


Fig. 2 Comparison among Newtonian, dilatant, Herschel-Bulkley, and Bingham models (modified from Lorenzini and Mazza [11])

7.4 Flow Box Test

Soil can change from plastic to viscous liquid state because of increased water content. Hence, the Flow Box Test (FBT) is proposed as a new laboratory test which couples Terzaghi's trap door and the Bingham model (Fig. 3). A detailed explanation of FBT such as governing equation was provided by Widjaja and Lee [14]. FBT utilizes displacement-time data using linear variable differential transformer (LVDT) and transforms the data into a relationship between viscosity and the liquidity index (LI). LI is defined as

$$LI = \frac{w - PL}{LL - PL}$$

(4)

LL can be treated as a limit for determining mudflow based on water content. However, the conventional viscometer cannot be applied for soil around its LL. Moreover, a conceptual, qualitative geological classification of mudflow is applied when LL is used as the indicator of mudflow limit. No quantitative explanation is available to elucidate mudflow behavior.

FBT can determine the viscosity for both plastic and viscous liquid states (Fig. 1). Real mudflow cases were used to validate the FBT results (Maokong in

Taiwan and Karanganyar and Ciwidey in Indonesia).

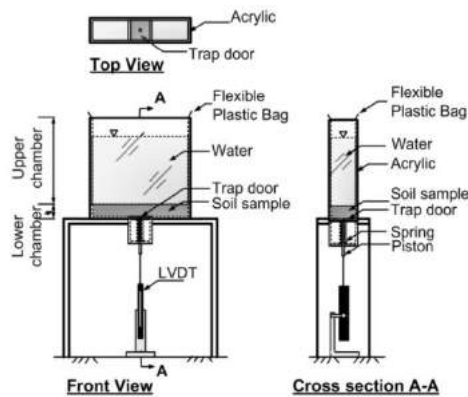


Fig. 3 Setup of flow box test (after Widjaja and Lee, 2013 [14])

3. RESULT AND DISCUSSION

Kaolin soil (circle number 8) was used as a pilot project; the Maokong mudflow case (circle number 11) was also utilized, and the Karanganyar and Ciwidey mudflow were applied to validate FBT results.

Compared with the results of other studies, the FBT results are reliable (Fig. 4). The lower value of mudflow was 0.0076 Pa·s by using a conventional viscometer as in Locat and Demers [10], which is lower than the FBT results for viscous liquid state. For comparison, water has viscosity of 0.001 Pa·s at room temperature.

The general mudflow behavior can be described as in Widjaja and Lee [14]. When soil changes from the solid state to the plastic state, the soil starts to move slowly due to high viscosity. When the water content increases progressively, the soil may enter the viscous liquid state gradually, leading to faster movement. At this point, mudflow may occur. The results confirm that viscosity is affected by increased water content as in Kooistra et al. [7]. Thus, LL (or LI = 1) is the lower limit for mudflow.

FBT uncovered the reason behind the in viscous liquid state of mudflow. The results thus prove that LL can be considered as the lower limit of mudflow.

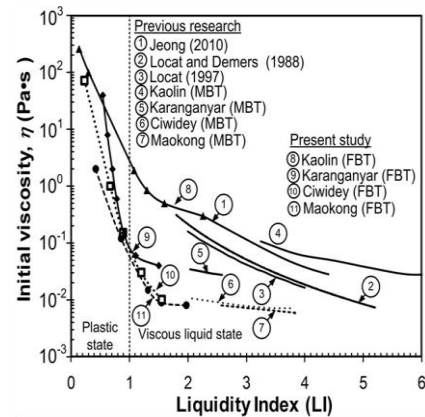


Fig. 4 Viscosity for Maokong, Karanganyar, and Ciwidey using FBT

4. CONCLUSIONS

In this paper, mudflow boundary is elucidated from the FBT results. FBT is reliable in determining the relationship between viscosity and LI for both plastic and viscous liquid states. Laboratory viscometers cannot provide data around LL. The general characteristics of this relationship have been described based on changes in water content. Increased water content results in decreased viscosity. Based on the rheological approach, mudflow may occur when water content reaches its LL. The results prove that using theology approach, LL can be considered as the lower limit of mudflows. Thus, FBT is successful in quantitatively describing the boundary of mudflow initiation.

5. ACKNOWLEDGEMENT

The authors greatly appreciate the financial support from the Ministry of Financial of Japan's government, the World Bank, the Japan Indonesia Presidential Scholarship, and Taiwan Tech in the production of this research.

6. REFERENCES

1. P.L., Abbot, 2004, *Natural Disasters*, 4th ed., New York, USA: Mc-Graw Hill.
2. A.W., Bishop, 1955, "The use of the slip circle in the stability analysis of

- slopes,” *Geotechnique*, vol. V(1), pp. 7-17.
3. D.R., Dinger, 2002, *Rheology for Ceramists*, Kearney, USA: Morris Publishing.
 4. J.T., Germaine and A.V., Germaine, 2009, *Geotechnical Laboratory Measurements for Engineers*, New Jersey, USA: John Wiley and Sons.
 5. O., Hungr, S.G., Evans, M.J., Bovis and J.N., Hutchinson, 2001, “A review of the classification of landslides of the flow type,” *Environ. and Eng. Geoscience*, vol. VII(3), pp. 221-238
 6. R.E., Hunt, 2007, *Geologic Hazards – A Field Guide for Geotechnical Engineers*, Boca Rotan, USA: Taylor & Francis.
 7. A., Kooistra, P.N.W., Verhoef, W., Broere, D.J.M., Ngan-Tillard and A.F., van Tol, 1998, “Appraisal of stickiness of natural clays from laboratory tests,” in *Proc. National Symposium of Eng. Geol. and Infrastructure*, p. 101-113.
 8. S.H.H., Lee and B., Widjaja, 2013, “Phase concept for mudflow based on the influence of viscosity,” *Soils and Foundations*, vol. 53(1), pp. 77-90.
 9. J.G., Liu and P.J., Mason, 2009, *Essential Image Processing and GIS for Remotes Sensing*, West Sussex, UK: Wiley-Blackwell.
 10. J., Locat and D., Demers, 1988, “Viscosity, yield stress, remolded strength, and liquidity index relationships for sensitive clays,” *Canadian Geotech. J.*, vol. 25(4), pp. 799-806.
 11. G., Lorenzini and N., Mazza, 2004, *Debris Flow Phenomology and Rheological Modeling*. Southampton, UK: WIT Press.
 12. J.S., O’Brien and P.Y., Julien, 1988, “Laboratory analysis of mudflow properties,” *J. Hydraul. Eng.*, vol. 114(8), pp. 877-887.
 13. A., Petkovsek, M., Macek, M., Kocevar, I., Benko and B., Majes, 2009, “Soil matric suction as an indicator of the mud flow occurrence,” in *Proc. 17th Int. Conf. on Soil Mechanics and Geotech. Eng.*, pp. 1855-1860.
 14. B., Widjaja and S.H.H., Lee, 2013, “Flow box test for the viscosity of soil in plastic and viscous liquid states,” *Soils and Foundations*, vol. 53(1), pp. 35-46.



**universitas
bandar lampung**

Jl. Z.A. Pagar Alam No.26 Labuhan Ratu
Bandar Lampung 35142 Phone: +62 721 701463
www.ubl.ac.id
Lampung - Indonesia

copyright © 2013