

Home

Journal Rankings

Journal Search

Country Rankings

Country Search

Compare

Map Generator

Help

About Us

Show this information in  
your own website



Display journal title

Just copy the code below and paste within your html page:

<a href="http://www.scimagojr.com

### Journal Search

Search query

in Journal Title

Exact phrase

### International Journal of Earth Sciences and Engineering

Country: India

Subject Area: Earth and Planetary Sciences | Engineering | Environmental Science

Subject Category:

Category	Quartile (Q1 means highest values and Q4 lowest values)															
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Building and Construction													Q4	Q4	Q4	Q4
Civil and Structural Engineering													Q4	Q4	Q4	Q4
Earth and Planetary Sciences (miscellaneous)													Q4	Q3	Q3	Q3
Environmental Engineering													Q4	Q4	Q4	Q4
Ocean Engineering													Q4	Q3	Q3	Q3

Publisher: Cafet-Innova Technical Society. Publication type: Journals. ISSN: 09745904

Coverage: 2010-2014

H Index: 4

Charts

Data

### SJR indicator vs. Cites per Doc (2y)

### Related product



@scimago

SJR is developed by:



Powered by  
**Scopus**

The SJR indicator measures the scientific influence of the average article in a journal, it expresses how central to the global scientific discussion an average article of the journal is. Cites per Doc. (2y) measures the scientific impact of an average article published in the journal, it is computed using the same formula that journal impact factor™ (Thomson Reuters).

### Citation vs. Self-Citation

February 2016

Volume 09 No 01

ISSN 0974-5904

# INTERNATIONAL JOURNAL OF EARTH SCIENCES AND ENGINEERING

**Indexed in:** Scopus Compendex and Geobase (products hosted on Engineering Village)  
Elsevier, Amsterdam, Netherlands, Geo-Ref Information Services-USA, List B of Scientific  
Journals in Poland, Directory of Research Journals  
**SJR: 0.17 (2014); H-index: 4 (2014);**  
**CSIR-NISCAIR, INDIA Impact Factor 0.042 (2011)**

*EARTH SCIENCE FOR EVERYONE*

## SPECIAL ISSUE OF International Conference on Innovative Trends in Civil Engineering for Sustainability

(ICICES 2016) 8 - 9 January, 2016

Organized by

**Toc H Institute of Science and Technology (TIST), Ernakulam, Kerala, INDIA**

In Technical Collaboration with

**CAFET INNOVA Technical Society (CITS), Hyderabad, Telangana, INDIA**



Published by

**CAFET-INNOVA Technical Society**

**Hyderabad, INDIA**

<http://cafetinnova.org/>

**CAFET-INNOVA Technical Society**

1-2-18/103, Mohini Mansion, Gagan Mahal Road, Domalguda

Hyderabad – 500 029, Andhra Pradesh, INDIA

Website: <http://www.cafetinnova.org>

Mobile: +91-7411311091

Registered by Government of Andhra Pradesh

Under the AP Societies Act., 2001

**Regd. No.: 1575**

The papers published in this journal have been peer reviewed by experts. The authors are solely responsible for the content of the papers published in the journal.

Each volume, published in six bi-monthly issues, begins with February and ends with December issue. Annual subscription is on the calendar year basis and begins with the February issue every year.

*Note: Limited copies of back issues are available.*

Copyright © 2015 CAFET-INNOVA Technical Society

All rights reserved with CAFET-INNOVA Technical Society. No part of this journal should be translated or reproduced in any form, Electronic, Mechanical, Photocopy, Recording or any information storage and retrieval system without prior permission in writing, from CAFET-INNOVA Technical Society.

# INTERNATIONAL JOURNAL OF EARTH SCIENCES AND ENGINEERING

The International Journal of Earth Sciences and Engineering (IJEE) focus on Earth sciences and Engineering with emphasis on earth sciences and engineering. Applications of interdisciplinary topics such as engineering geology, geo-instrumentation, geotechnical and geo-environmental engineering, mining engineering, rock engineering, blasting engineering, petroleum engineering, off shore and marine geo-technology, geothermal energy, resource engineering, water resources and engineering, groundwater, geochemical engineering, environmental engineering, atmospheric Sciences, Climate Change, and oceanography. Specific topics covered include earth sciences and engineering applications, RS, GIS, GPS applications in earth sciences and engineering, geo-hazards such as earthquakes, landslides, tsunami, debris flows and subsidence, rock/soil improvements and development of models validations using field, laboratory measurements.

Professors / Academicians / Engineers / Researchers / Students can send their papers directly to: [chiefeditor\\_ijee@yahoo.com](mailto:chiefeditor_ijee@yahoo.com)

## CONTACT:

For all editorial queries:

**D. Venkat Reddy** (Editor-in-Chief)

Professor, Department of Civil Engg.

NIT-Karnataka, Surathkal, INDIA

☎ +91-9739536078

✉ [dvr1952@gmail.com](mailto:dvr1952@gmail.com)

All other enquiries:

**Hafeez Basha. R** (Managing Editor)

☎ +91-9866587053

✉ [hafeezbasha@gmail.com](mailto:hafeezbasha@gmail.com)

**Raju Aedla** (Editor)

☎ +91-7411311091

✉ [rajucits@gmail.com](mailto:rajucits@gmail.com)

**EDITORIAL COMMITTEE****D. Venkat Reddy***NITK, Surathkal, Karnataka, INDIA*

EDITOR-IN-CHIEF

**Trilok N. Singh***IIT-Bombay, Powai, INDIA*

EXECUTIVE EDITOR

**P. Ramachandra Reddy***Scientist G (Retd.), NGRI, INDIA*

EXECUTIVE EDITOR

**R. Pavanaguru***Professor (Retd.), OU, INDIA*

EXECUTIVE EDITOR

**Joanna Maria Dulinska***Cracow University of Tech., Poland*

EXECUTIVE EDITOR

**Hafeez Basha R***CAFET-INNOVA Technical Society*

MANAGING EDITOR

**Raju Aedla***CAFET-INNOVA Technical Society*

EDITOR

**INTERNATIONAL EDITORIAL ADVISORY BOARD****Zhuping Sheng***Texas A&M University System  
USA***Choonam Sunwoo***Korea Inst. of Geo-Sci & Mineral  
SOUTH KOREA***Hsin-Yu Shan***National Chio Tung University  
TAIWAN***Hyun Sik Yang***Chonnam National Univ Gwangu  
SOUTH KOREA***Krishna R. Reddy***University of Illinois, Chicago  
USA***L G Gwalani***NiPlats Australia Limited  
AUSTRALIA***Abdullah MS Al-Amri***King Saud University, Riyadh  
SAUDI ARABIA***Suzana Gueiros***Dra Engenharia de Produção  
BRAZIL***Shuichi TORII***Kumamoto University, Kumamoto  
JAPAN***Luigia Binda***DIS, Politecnico di Milano, Milan  
ITALY***Gonzalo M. Aiassa***Cordoba Universidad Nacional  
ARGENTINA***Nguyen Tan Phong***Ho Chi Minh City University of  
Technology, VIETNAM***Ganesh R. Joshi***University of the Rykyus, Okinawa  
JAPAN***Kyriakos G. Stathopoulos***DOMI S.A. Consulting Engineers Athens,  
GREECE***U Johnson Alengaram***University of Malaya, Kuala Lumpur,  
MALAYSIA***Robert Jankowski***Gdansk University of Technology  
POLAND***Paloma Pineda***University of de Sevilla, Seville  
SPAIN***Vahid Nourani***Tabriz University  
IRAN***Anil Cherian***United Arab Emirates  
DUBAI***P Hollis Watts***WASM School of Mines  
Curtin University, AUSTRALIA***Nicola Tarque***Department of Engineering  
Catholic University of Peru***S Neelamani***Kuwait Institute for Scientific  
Research, SAFAT, KUWAIT***Jaya naithani***Université catholique de Louvain  
Louvain-la-Neuve, BELGIUM***Mani Ram Saharan***National Geotechnical Facility  
DST, Dehradun, INDIA***G S Dwarakish***NITK- Surathkal  
Karnataka, INDIA***Subhasish Das***IIT- Kharagpur, Kharagpur  
West Bengal, INDIA***S Viswanathan***IIT- Bombay, Powai, Mumbai  
Maharashtra, INDIA***K U Maheshwar Rao***IIT- Kharagpur, Kharagpur  
West Bengal, INDIA***Ramana G V***IIT- Delhi, Hauz Khas  
New Delhi, INDIA***Usha Natesan***Centre for Water Resources  
Anna University, Chennai, INDIA***M R Madhav***JNTU- Kukatpally, Hyderabad  
Andhra Pradesh, INDIA***Kalachand Sain***National Geophysical Research Institute,  
Hyderabad, INDIA***R Sundaravadivelu***IIT- Madras  
Tamil Nadu, INDIA***M K Nagaraj***NITK- Surathkal  
Karnataka, INDIA***Arash Ebrahimabadi***Azad University, Qaemshahr  
IRAN***S M Ramasamy***Gandhigram Rural University  
Tamil Nadu, INDIA***Gholamreza Ghodrati Amiri***Iran University of Sci. & Tech.  
Narmak, Tehran, IRAN***Chachadi A G***Goa University, Taleigao Plateau  
Goa, INDIA***Girish Gopinath***Geomatics Division  
CWRDM, Kerala, INDIA***Shamsher B. Singh***BITS- Pilani, Rajasthan  
Rajasthan, INDIA***C Natarajan***NIT- Tiruchirapalli,  
Tamil Nadu, INDIA***N Ganesan***NIT- Calicut, Kerala  
Kerala, INDIA***Linhua Sun***Suzhou University  
CHINA***Pradeep Kumar R***IIT- Gachibowli, Hyderabad  
Andhra Pradesh, INDIA***Vladimir e Vigdergauz***ICEMR RAS, Moscow  
RUSSIA*

<b>D P Tripathy</b> National Institute of Technology Rourkela, INDIA	<b>E Saibaba Reddy</b> JNTU- Kukatpally, Hyderabad Andhra Pradesh, INDIA	<b>Chowdhury Quamruzzaman</b> Dhaka University Dhaka, BANGLADESH
<b>Parekh Anant kumar B</b> Indian Institute of Tropical Meteorology, Pune, INDIA	<b>Datta Shivane</b> Central Ground Water Board Hyderabad, INDIA	<b>Gopal Krishan</b> National Institute of Hydrology Roorkee, INDIA
<b>Karra Ram Chandar</b> NITK- Surathkal Karnataka, INDIA	<b>Prasoon Kumar Singh</b> Indian School of Mines, Dhanbad Jharkhand, INDIA	<b>A G S Reddy</b> Central Ground Water Board, Pune, Maharashtra, INDIA
<b>Rajendra Kumar Dubey</b> Indian School of Mines, Dhanbad Jharkhand, INDIA	<b>Subhasis Sen</b> Retired Scientist CSIR-Nagpur, INDIA	<b>M V Ramanamurthy</b> Geological Survey of India Bangalore, INDIA
<b>A Nallapa Reddy</b> Chief Geologist (Retd.) ONGC Ltd., INDIA	<b>Bijay Singh</b> Ranchi University, Ranchi Jharkhand, INDIA	<b>S Suresh Babu</b> Adhiyamaan college of Engineering Tamil Nadu, INDIA
<b>C Sivapragasam</b> Kalasalingam University, Tamil Nadu, INDIA	<b>Xiang Lian Zhou</b> ShangHai JiaoTong University ShangHai, CHINA	<b>Debadatta Swain</b> National Remote Sensing Centre Hyderabad, INDIA
<b>Kripamoy Sarkar</b> Assam University Silchar, INDIA	<b>Ranjith Pathegama Gamage</b> Monash University, Clayton AUSTRALIA	<b>B M Ravindra</b> Dept. of Mines & Geology, Govt. of Karnataka, Mangalore, INDIA
<b>Nandipati Subba Rao</b> Andhra University, Visakhapatnam Andhra Pradesh, INDIA	<b>M Suresh Gandhi</b> University of Madras, Tamil Nadu, INDIA	<b>Autar Krishen Raina</b> CSIR-CIMFR, Maharashtra, INDIA
<b>H K Sahoo</b> Utkal University, Bhubaneswar Odissa, INDIA	<b>R N Tiwari</b> Govt. P G Science College, Rewa Madhya Pradesh, INDIA	<b>Nuh Bilgin</b> Istanbul Technical University Maslak, ISTANBUL
<b>M V Ramana</b> CSIR NIO Goa, INDIA	<b>N Rajeshwara Rao</b> University of Madras Tamil Nadu, INDIA	<b>Manish Kumar</b> Tezpur University Sonitpur, Assam, INDIA
<b>Salih Muhammad Awadh</b> College of Science University of Baghdad, IRAQ	<b>Sonali Pati</b> Eastern Academy of Science and Technology, Bhubaneswar, INDIA	<b>Safdar Ali Shirazi</b> University of the Punjab, Quaid-i-Azam Campus, PAKISTAN
<b>Naveed Ahmad</b> University of Engg. & Technology, Peshawar, PAKISTAN	<b>Raj Reddy Kallu</b> University of Nevada 1665 N Virginia St, RENO	<b>Glenn T Thong</b> Nagaland University Meriema, Kohima, INDIA
<b>Raju Sarkar</b> Delhi Technological University Delhi, INDIA	<b>Jaya Kumar Seelam</b> National Institute of Oceanography Dona Paula, Goa, INDIA	<b>Samir Kumar Bera</b> Birbal sahani institute of palaeobotany, Lucknow, INDIA
<b>C N V Satyanarayana Reddy</b> Andhra University Visakhapatnam, INDIA	<b>S M Hussain</b> University of Madras Tamil Nadu, INDIA	<b>Vladimir Vigdergauz</b> ICEMR, Russian Academy of Sciences Moscow, RUSSIA
<b>T J Renuka Prasad</b> Bangalore University Karnataka, INDIA	<b>Deva Pratap</b> National Institute of Technology Warangal, INDIA	<b>K. Subramanian</b> Coimbatore Institute of Technology Tamil Nadu, INDIA
<b>Mohammed Sharif</b> Jamia University New Delhi, INDIA	<b>A M Vasumathi</b> K.L.N. College of Inf. Tech. Pottapalayam, Tamil Nadu, INDIA	<b>Deepak T J</b> INTI International University Kuala Lumpur, MALAYSIA
<b>C J Kumanan</b> Bharathidasan University Tamil Nadu, INDIA	<b>B R Manjunatha</b> Mangalore University Karnataka, INDIA	<b>M S Ravikumar</b> Noorul Islam University Kanyakumari, INDIA
<b>Ch. S. N. Murthy</b> NITK- Surathkal Karnataka, INDIA	<b>Jitendra Virmani</b> Jaypee Uni. of Information Tech. Himachal Pradesh, INDIA	<b>K Elangovan</b> PSG College of Technology Coimbatore, INDIA
<b>Vikram Vishal</b> Department of Earth Sciences IIT Roorkee, INDIA	<b>A K Verma</b> Indian School of Mines Dhanbad, Jharkhand, INDIA	<b>Saeed Khorram</b> Eastern Mediterranean University Famagusta, CYPRUS

**Zhuping Ping Sheng**

Texas AgriLife Research &  
Extension Center at El Paso, USA

**V Madhava Rao**

CGARD, NIRD & PR  
Hyderabad, INDIA

**Jayaprakash M C**

MITE, Moodabidri  
Karnataka, INDIA

---

# INDEX

Volume 09	February 2016	No.01
<b>RESEARCH PAPERS</b>		
<b>Effects of Moisture Content Variation on Shear Strength Properties of Flyash Samples</b>		01
<i>By ABEBE MEKONNEN AND JANENDRA MANDAL</i>		
<b>Development of Stability Criteria For Risk Reduction In the Sianok Canyon In Bukittinggi Indonesia</b>		02
<i>By BAMBANG ISTIJONO AND ABDUL HAKAM</i>		
<b>Heavy Metal Pollution In Surface Dust From Urban Squares In Suzhou, China: Total Concentrations, Speciation Analysis, and Health Risk</b>		03
<i>By QI LI AND YAFEN HAN</i>		
<b>Fresh and Hardened Properties of Glass Fiber Reinforced Self-Compacting Concrete with Flyash and Metakaolin Combination</b>		04
<i>By JITHIN DAVID AND VASUDEV R</i>		
<b>Trend Analysis of Rainfall in Southern Kerala based on Empirical Mode Decomposition</b>		05
<i>By PRIYA PHILIP AND ADARSH S</i>		
<b>Performace of eccentrically braced frames under the action of lateral load</b>		06
<i>By RAMYA A, MUTHUMANI K AND NAFEEZ AHMED L</i>		
<b>3D Reconstruction of Buildings from Classified LiDAR Point Cloud</b>		07
<i>By ARUN R NATH AND RAMIYA A M</i>		
<b>Leaching Characteristics of Fly Ash Generated From Suratgarh Thermal Power Plant</b>		08
<i>By RAHUL DANDAUTIYA, PRANAV MAYEKAR, MADHUR TOSHNIWAL, AJIT PRATAP SINGH AND SANGHAMITRA KUNDU</i>		
<b>Community Perceptions Towards The Causes of Flood In Air Pacah Area, Padang City, Indonesia</b>		09
<i>By BAMBANG ISTIJONO, TAUFIKA OPHIYANDRI AND ANNISA ANNISA</i>		
<b>Resistance To Wear, Durability And Micro Structural Properties of CBA As Sand Replacement In Mortar</b>		10
<i>By MADHAV KADAM AND YOGESH PATIL</i>		
<b>Adsorption of Pb<sup>2+</sup> in waste-water by Biochars Derived from Different Crop Residues</b>		11
<i>By YAFEN HAN AND QI LI</i>		
<b>Remotely Sensed Aster and SRTM Dems Performance Analysis on Bhopal Terrain</b>		12
<i>By RISHIKESHAN C A AND ARPITA BARONIA</i>		
<b>Finite Element Analysis of Composite Slab with Intermediate Stiffeners</b>		13
<i>By SHARDA SIDDH, YOGESH PATIL AND HEMANT PATIL</i>		



**Oedometer Based Study on Collapse Potential of Cement Admixed Loess Soil** 14  
*By NANDYALA DARGA KUMAR AND RAVIKANT R SINGH*

**Fluoride concentration in groundwater: A case study from Ramanagaram taluk,  
Karnataka, India** 15  
*By ATNI VENKATARAMAIAH GANESHA, C KRISHNAIAH AND L PRASANNA KUMAR*



www.cafetinnova.org

Indexed in  
Scopus Compendex and Geobase Elsevier, Geo-Ref  
Information Services-USA, List B of Scientific Journals,  
Poland,  
Directory of Research Journals

**International  
Journal  
of Earth  
Sciences  
and Engineering**

ISSN 0974-5904, Volume 09, No 01

February 2016, PP. 02

## DEVELOPMENT OF STABILITY CRITERIA FOR RISK REDUCTION IN THE SIANOK CANYON IN BUKITTINGGI INDONESIA

**BAMBANG ISTIJONO and ABDUL HAKAM**

*Civil Engineering of Andalas University, Padang 25163, Indonesia*

*Email: [bistijono1452@yahoo.co.id](mailto:bistijono1452@yahoo.co.id), [ahakam2008@yahoo.com](mailto:ahakam2008@yahoo.com)*

---

### Abstract:

The development of Sianok Canyon area as a tourist destination in Bukittinggi - Indonesia also needs a disaster risk reduction to be included in. The city already has land use plan that restricts the development around the upper part of the Canyon. This restriction is not equally effective because it has no consideration based on the actual thinking. The study that provide a scientific consideration is needed since the city has limited land. Then, the geological study and geotechnical investigation was done to obtain required data. It is followed by the potential landslide analyses of the Canyon area. Furthermore, based on the results of the analyses the safety factor and safe distance criteria are proposed for consideration in the development plan of the city as well as to reduce the disaster risk.

**Keywords:** landslide, land use, risk reduction

---

### 1. Introduction

Sianok canyon is one of the most popular tourism destination in Indonesia. There are two well known theories adopted 'why this canyon is exist'. First believe that this canyon is made by erosion of water flow along the river and second one say it is made by Sumatran fault. Both need advanced investigation to prove the theories. Whatever the nature made it, the Sianok Canyon can stand up to 90° which become a dramatically seen that attractive for tourists (Figure 1). The Canyon with length of 15 kilometer passes through Bukittinggi city which has more than 3,300 population per square kilometer.

In the past the Sianok Canyon area of plantations and rice fields. Since it has beautiful scenery, then it became very popular for tourist visits. The development of the Sianok Canyon then becomes quite rapid. However, with limited land this area is also developed to build tourism support facilities like culinary shop and stay houses. Later the residential houses also exist at both under and on the top of the Canyon wall (Figure 2 and 3). The development of



Figure 1. Sianok Canyon wall can stand up to 90°  
the township above the Sianok Canyon are now in a very dangerous situation where the distance between the building with the edge of top side of the Canyon wall just in a matter of less than 5 meters. The investigation on this area is needed to reduce the disaster risk as it has happen in the other place (Hakam et al, 2013).

## Development of Stability Criteria for Risk Reduction in the Sianok Canyon in Bukittinggi Indonesia

It is very concern that this development does not consider the danger in behind the Canyon wall. In fact, from the experience the earthquake in 2007, the Canyon walls suffered from landslide. This concerns about the danger seems has been defeated by the needs of everyday life. Then the people in the Sianok Canyon live in a very high risk especially due to landslide.

Even worse is the regional land use plan of Sianok Canyon can not be complied with. In the land used declares the area with a distance of 100m from the end of the Canyon must be free of construction development. This restriction is certainly a thing to devastate natural resources because it is not based on scientific judgment. The regulations to control the land use development also has not already exist (BAPPEDA, 2007). Then it should be a scientific consideration for safe development based on the knowledge as described in this paper.

In order to protect people and environment in industrial field it has been introduced a Safety Integrity Level (SIL) to include risk reduction action to a tolerable level. The SIL is proposed to help companies to specify both the risk assessment and the measures to be taken in the design of safety for emergency shutdown in hazardous conditions (Gathur, 2013). In this paper the landslide safety criteria are developed for risk assessment based on the hight and the distance from the canyon edge.

The geotechnical behavior of the Sianok Canyon initially must be explored from the field. A laboratory test series were included to have specific data that needed for slope stability analysis. The numerical simulations then were conducted to develop risk disaster criteria based on the hight and the distance.



Figure 2. Township on the edge of the canyon



Figure 3. Houses and business building development under the canyon

### 2. Geological and geotechnical overview

The Sianok Canyon is located in Bukittinggi - West Sumatra Province, Indonesia. This area is geographically located in the west-central side of the Sumatra Island (Figure 4). The Sianok Canyon is in the middle of hill area that lay from the north to the south as part of the Bukit Barisan hill. The Canyon may be geologically formed due to the existence of the Semangko fault which divides the Sumatra Island into two parts, east and west. Along the Semangko fault there are some active and non-active volcanoes which create soil deposit in surrounding areas.

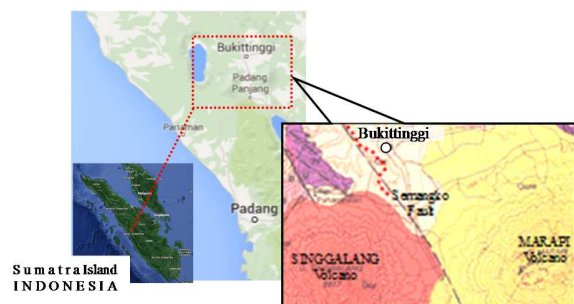


Figure 4. Geography and geology map of Sianok Canyon

Soil deposit that make up the Sianok Canyon is derived from ancient volcanic eruption in past. This deposit type is a Pumiceous Tuff with color of pinkish grey to slightly brown (Kastowo et al, 1996). The soil deposit then is compacted naturally that makes a layer of soil provides a cohesion like effect.

In order to investigate the geotechnical behavior of the Sianok Canyon walls then the soil sample is collected from the field. Soil samples were then tested in the laboratory to obtain physical and technical parameters. The laboratory experiment performed include grain

## Development of Stability Criteria for Risk Reduction in the Sianok Canyon in Bukittinggi Indonesia

gradation, unit weight, soil consistency, unconfined compression and direct shear tests.

The soil deposit is made of non-plastic particles with liquid limit water content of 27% and plastic-index of only 1.4%. The soil contains 50% of sand and the rest is the silt particle. Based on those data the soil then can be categorized into inorganic silty-sand (ASTM, 1985). The soil mechanical data from the laboratory tests are the unit weight of 16.7 kN/m<sup>3</sup>, the unconfined compression strength of 150 kN/m<sup>2</sup> with sensitivity of 18 (Figure 5) and the internal friction angle of 33° (Figure 6).

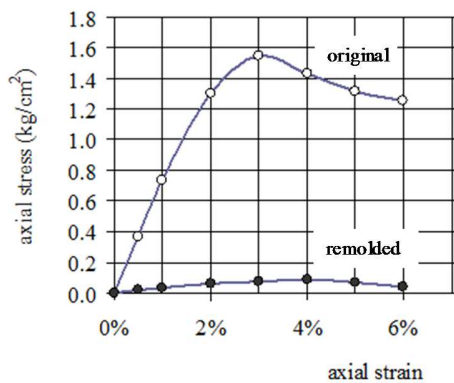


Figure 5. Unconfined compression test results

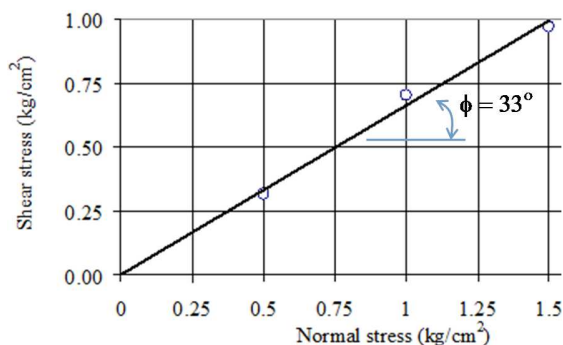


Figure 6. Direct shear test results

### 3. Landslide hazard simulation

Based on geotechnical data from the soil sample test results, then the landslide analyses of the Sianok Canyon were conducted. This landslide analyses were performed by numerical simulations with variations in height of the Canyon wall. The simulation results are in terms of the safety factor against sliding along the failure plane and the safe distance on the top of the Canyon as defined in Figure 7.

The landslide simulation is conducted in the Canyon height variations. The results in the term of safety factors shows that the Canyon wall can stand safely up to a height of 150m. The wall with 200m of vertical height is

in a very critical condition with the safety factor equal to one.

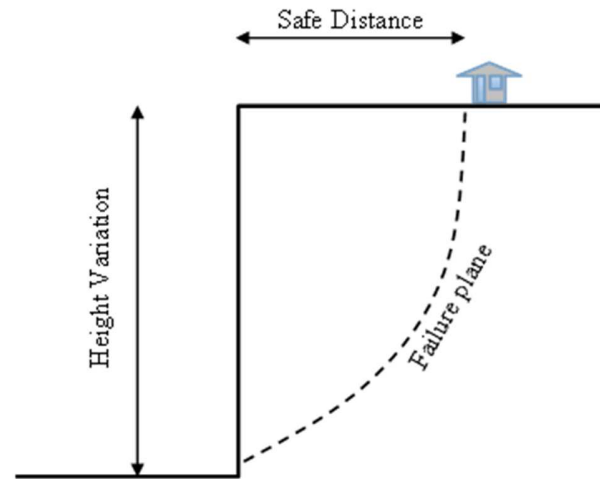


Figure 7. Definition of term in simulations

Based on the safety factor criteria for slope stability analyses (PU, 1987) as shown in Table 1, the safety factor of the Canyon wall around residential areas in case of an earthquake is at least 1.8. The height of the Canyon Wall to meet that criterion is about 90m. The height of the Canyon Wall to meet the criterion of moderate risk level is about 120m, that is for access road use. In addition the area around the Canyon with the height of 150m is safe enough for farm field (Figure 8).

Table 1. Safety Factor Criteria for Slope Stability for various risk level

Risk level	Analysis Type	Ultimate Shear strength of soil
High (residential)	earthquake	1.50
	<b>static</b>	<b>1.80</b>
Moderate (Access road)	earthquake	1.30
	<b>static</b>	<b>1.50</b>
Low (Farm)	earthquake	1.10
	<b>static</b>	<b>1.25</b>

## Development of Stability Criteria for Risk Reduction in the Sianok Canyon in Bukittinggi Indonesia

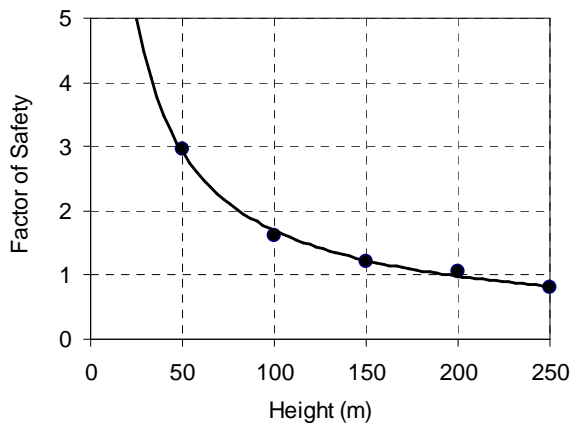


Figure 8. Simulation results in term of factor of safety

The area on the top of the Sianok Canyon that can be developed must also meet the safe distance from the edge as shown in Figure 9. The Canyon height of 90m or less seem to be safe to be developed for residential area, however the safe distance must also be met such as at least 70m for the edge of the Canyon wall. Then the existing residential areas that do not meet the criteria of safe height and distance are in very high risk condition.

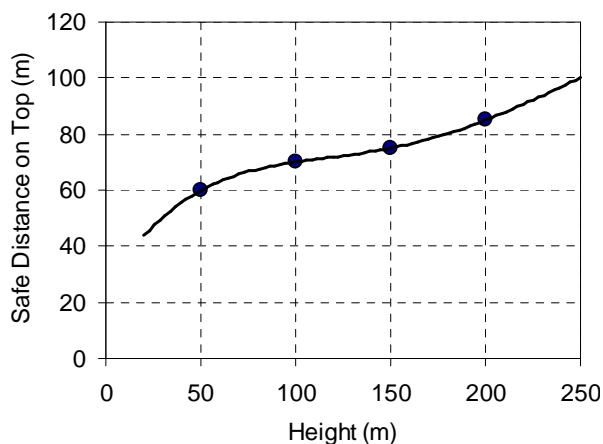


Figure 9. Simulation results in term of safe distance on top

### 4. Conclusions

The Sianok Canyon and surrounding area have beautiful scenery and also hide a very high risk against landslide. The factor of safety of the Canyon is vary according to the height of its canyon. The safety factor values from analysis results start from less than 1 for height of more than 200m to more than 3 for the height less than 50m. The Canyon area with a height of 150m to 200m which is categorized as critical level still can be used for agriculture development. While height of less than 120m

still to be developed safely for access roads. The area that safe for residence is the canyon with the height of less than 90m and it is at least 70m from the edge of the canyon.

Based on the development and designation of the Sianok Canyon area in the land use plan, it is recommended to socialize the risk reduction in development. The easiest way of that action is by providing warning signs in associate with the height of the Canyon wall. The residential houses on the dangerous area that do not meet safe criteria are suggested to be relocated slowly. The public roads that are under the Canyon wall of 125m or more also should be relocated to avoid casualties in future earthquake.

### REFERENCES

- [1] American Society for Testing and Materials, Classification of Soils for Engineering Purposes: Annual Book of ASTM Standards, D 2487-83, 04.08, 1985
- [2] Department of Public Work of Indonesia (PU), A guide for Landslides Prevention (in bahasa: Petunjuk Perencanaan Penanggulangan Longsor), Departemen Pekerjaan Umum, Jakarta, 1987
- [3] Development Planning Agency (BAPPEDA), Land Use Planning (RTRW) Bukittinggi, 2007
- [4] Gathur, M, Understanding Safety Integrity Levels (SIL) and its Effects for Field Instruments, ITT Corporation, 2013
- [5] Hakam A, Ismail F A, Fauzan, Istijono B and Arnaldo R, Slope stability analysis following Maninjau Landslide 2013, SIBE - Conference ITB, 2013
- [6] Kastowo, Leo W G, Gafoer S and Amin, T.C., *Geological Map of The Padang Quadrangle, Sumatra*, Indonesian Geological Research and Development Centre, 1996