

出國報告（出國類別：其他-出席國際會議）

出席 35th IGC 國際學術研討會
學術口頭發表心得

服務機關：國立嘉義大學

姓名職稱：陳建元 教授

派赴國家：南非開普敦

出國期間：2016.08.26-2016.09.06

報告日期：2016.09.09

摘要

參加本次國際研討會之目的為研究論文口頭發表。本次出席發表學術口頭報告題目為「Landslide volume estimation by landslide area-frequency distribution」。近年來全球氣候異常，颱風豪雨過後各地災情頻傳，而過度的開發山坡地使台灣的邊坡災害頻繁，危害人民生命財產安全，所以山坡地的使用及保護為重要課題之一。崩塌體積的估計在目前仍無法有效精確的評估，難以作為集水區土砂量的評估依據與土砂災害的防治規劃。本研究建立崩塌面積與體積的關係，讓工程師能從衛星影像判釋崩塌地後即可利用此關係式推估崩塌體積，並以石門水庫流域作為研究區域，目的為估計流入水庫的土砂量，作為水庫集水區土砂量評估的依據。

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- 二、參加國際會議之過程.....p2
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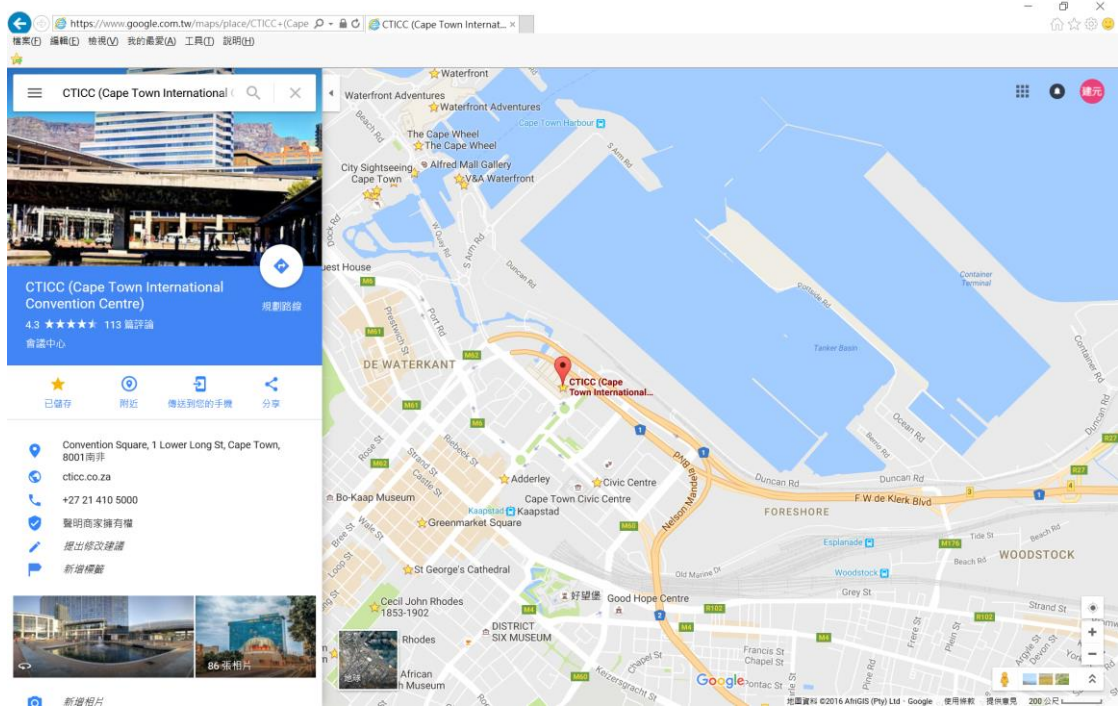
一、參加國際會議之目的

參加本次國際研討會之目的為研究論文口頭發表。本次出席發表學術口頭報告題目為「Landslide volume estimation by landslide area-frequency distribution」。近年來全球氣候異常，颱風豪雨過後各地災情頻傳，而過度的開發山坡地使台灣的邊坡災害頻繁，危害人民生命財產安全，所以山坡地的使用及保護為重要課題之一。崩塌體積的估計在目前仍無法有效精確的評估，難以作為集水區土砂量的評估依據與土砂災害的防治規劃。本研究建立崩塌面積與體積的關係，讓工程師能從衛星影像判釋崩塌地後即可利用此關係式推估崩塌體積，並以石門水庫流域作為研究區域，目的為估計流入水庫的土砂量，作為水庫集水區土砂量評估的依據。

二、參加國際會議之過程

會議時間與地點

本會議於 2016 年 8 月 27-9 月 4 日於南非開普敦國際會議中心(Cape Town International Convention Center, CTICC)舉行(圖一)，並辦理多日的現地參觀活動。研討會場位於開普敦市中心，距離開普敦機場約 20 公里，到達機場後轉搭市區公車約需 40 分鐘可到達市區的 Civic Centre，再由市區步行數十分鐘可至研討會地點。圖二為研討會報到櫃台，圖三為研討會會場。



圖一、研討會場南洋執行中心位置圖(摘自 Google Map)



圖二、研討會報到櫃台



圖三、研討會會場外觀

會議議程

本次會議議程如下(表一)，表二為研討會本人口頭發表場次議程表：

表一、研討會議程表



35TH INTERNATIONAL GEOLOGICAL CONGRESS
 27 AUGUST - 2 SEPTEMBER 2016 | CAPE TOWN, SOUTH AFRICA

VENUE: CAPE TOWN INTERNATIONAL CONVENTION CENTRE (CTICC)																	
	MONDAY 29 AUGUST		TUESDAY 30 AUGUST				WEDNESDAY 31 AUGUST				THURSDAY 01 SEPTEMBER			FRIDAY 02 SEPTEMBER			
	SESSION 1	SESSION 2	SESSION 3	SESSION 4	SESSION 5	SESSION 6	SESSION 7	SESSION 8	SESSION 9	SESSION 10	SESSION 11	SESSION 12	SESSION 13	SESSION 14	SESSION 15	SESSION 16	SESSION 17
	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30
Hall 481	T15 - Engineering Geology and Geomechanics																
Hall 482	T8 - Geohazards																
Hall 483	T29 - Basin Formation and Continental Margins								T31 - The Deep Earth								
Hall 484	T4 - Climate Change Studies								T32 - The Hadean and Archaean Earth								
Reg Foyer 1	T47 - Phanerozoic Earth History, Stratigraphy and the Geologic Time Scale																
Reg Foyer 2	T44 - Palaeontology and Palaeo-anthropology								T4 - Climate Change Studies								
Audi 1	T30 - A Dynamic Earth																
Audi 2	T17 - Mineral Exploration														T29 - Basin Formation and Continental Margins		
Ballroom East	T18 - Mineral Deposits and Ore Forming Processes (Incl. Mining Geology and Earth Resource Engineering)																
Ballroom West	T40 - Marine Geosciences and Oceanography								T18.A - Mineral Deposits and Ore Forming Processes (Incl. Mining Geology and Earth Resource Engineering)								
Roof Terrace	T8.A - Geohazards				T8.A - Geohazards				IUGS					T44 - Palaeontology and Palaeo-anthropology			
1.41 & 1.42	T36 - Magmatism - Settings, Compositions and Processes				T28 - Sedimentary Processes - ancient to modern				T27 - Gold Mineralizing Systems (jointly sponsored by SEG and SGA)								
1.43 & 1.44	T20 - Petroleum Systems and Exploration								T28 - Sedimentary Processes - ancient to modern								
1.61	T26 - Resourcing Future Generations				T16 - Mineral Resources Evaluation, Geostatistics and Mathematical Geoscience				T21 - Unconventional Hydrocarbons and Emerging Fuels								
1.62	T1 - Geohazards and Conservation (Incl. PanAfrica launch)								T33 - The Proterozoic Earth								
1.63	T3 - Public Sector Geoscience and Geological Surveys										T12 - Global Geoscience Professionalism and Geoethics			T3 - GMIS Special Symposium			
1.64	T10 - History of the Geosciences						T2 - Geoscience Education and Public Communication						T2 - Geoscience Education and Public Communication / EAGE VP session		T2 - Geoscience Education and Public Communication		
2.41 & 2.42 & 2.43	T12 - Global Geoscience Professionalism and Geoethics										T7 - Geoscience Data and Information Systems (Africa One Geology)						
2.44 & 2.45 & 2.46	T7 - Geoscience Data and Information Systems								T9 - Proximal and Remote Sensing Technologies								
2.61 & 2.62 & 2.63	T14 - Environmental Geosciences																
2.64 & 2.65 & 2.66	T5 - Groundwater and Hydrogeology						T41 - Arctic and Antarctic Geoscience										
1.52	T2 (Text book launch)																

VENUE: THE WESTIN HOTEL (ACROSS FROM THE CTICC)																	
	MONDAY 29 AUGUST		TUESDAY 30 AUGUST				WEDNESDAY 31 AUGUST				THURSDAY 01 SEPTEMBER			FRIDAY 02 SEPTEMBER			
	SESSION 1	SESSION 2	SESSION 3	SESSION 4	SESSION 5	SESSION 6	SESSION 7	SESSION 8	SESSION 9	SESSION 10	SESSION 11	SESSION 12	SESSION 13	SESSION 14	SESSION 15	SESSION 16	SESSION 17
	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30	16:00-17:45	08:00-10:00	10:30-12:00	14:00-15:30
Bartholomew Dick & Vasco De Gama	T38 - Metamorphic Processes						T36 - Magmatism - Settings, Compositions and Processes				T38 - Metamorphic Processes						
Ballroom East	T16 - IAMG AWARDS CEREMONY & KEYNOTE		T30.A - A Dynamic Earth				T30.A - A Dynamic Earth				T30.A - A Dynamic Earth			T30.A - A Dynamic Earth			
Ballroom West	T30.B - A Dynamic Earth		T30.B - A Dynamic Earth				T30.B - A Dynamic Earth										
Prince Edward / Schappien	T34 - Geochronology				T45 - Instrumental, experimental and laboratory-based developments in the Geosciences						T42 - Surficial Processes and Landscape Evolution						
Seal/Robben	T37 - Mineralogy						T40 - Marine Geosciences and Oceanography						T46 - Volcanology				
Sir Francis Drake	T48 - Planetary Sciences and Meteorite Impacts				T35 - Isotope Geoscience		T39 - Evolution of the Biosphere and Biogeoscience		T43 - Rock Deformation and Structural Geology								
Marco Polo	T19 - Coal						T22 - Energy in a Carbon Constrained World		T20 - Petroleum Systems and Exploration		T23 - Applied Mineralogy and Geometallurgy				T30.C - A Dynamic Earth		T30.C - A Dynamic Earth
Victoria and Alfred	T6 - Soil Science				T25 - Critical metals - a global perspective		T11 - Medical Geology				T13 - Geosciences for Benefitting Low-income Countries						

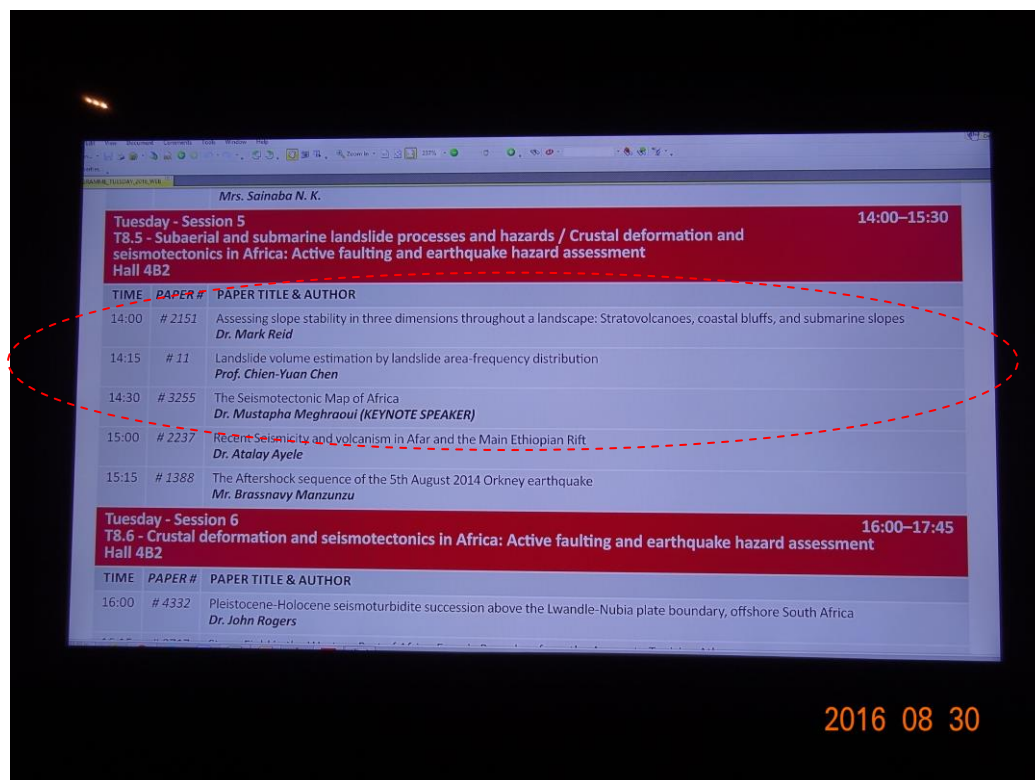
Correct at time of going to print. Programme changes will be communicated via the App and venue screens.

表二、研討會部分議程表

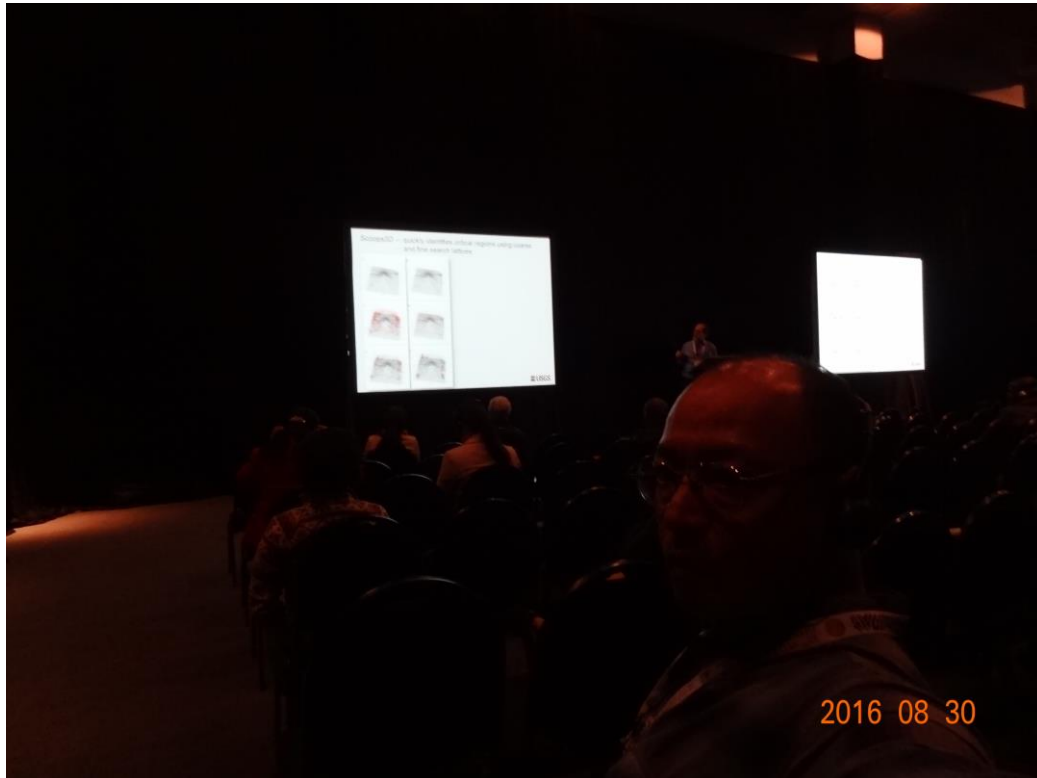
			Tuesday 30 August	
11:15	# 5319	Landslide Monitoring through Spatial Sensor Network <i>Dr. Ping Lu</i>		
11:30	# 2390	Sedimentary processes associated to a late Miocene large-scale submarine landslide (Sierra de Gádor, Almería, SE Spain) <i>Dr. Ángel Puga-Bernabéu</i>		
11:45	# 828	Submarine landslides and related geohazards around Indian Subcontinent and Islands <i>Mrs. Sainaba N. K.</i>		
Tuesday - Session 5			14:00–15:30	
T8.5 - Subaerial and submarine landslide processes and hazards / Crustal deformation and seismotectonics in Africa: Active faulting and earthquake hazard assessment				
Hall 4B2				
TIME	PAPER #	PAPER TITLE & AUTHOR		
14:00	# 2152	Assessing slope stability in three dimensions throughout a landscape: Stratovolcanoes, coastal bluffs, and submarine slopes <i>Dr. Mark Reid</i>		
14:15	# 11	Landslide volume estimation by landslide area-frequency distribution <i>Prof. Chien-Yuan Chen</i>		
14:30	# 3255	The Seismotectonic Map of Africa <i>Dr. Mustapha Meghraoui (KEYNOTE SPEAKER)</i>		
15:00	# 2237	Recent Seismicity and volcanism in Afar and the Main Ethiopian Rift <i>Dr. Atalay Ayele</i>		
15:15	# 1388	The Aftershock sequence of the 5th August 2014 Orkney earthquake <i>Mr. Brassnavy Manzunu</i>		
Tuesday - Session 6			16:00–17:45	
T8.6 - Crustal deformation and seismotectonics in Africa: Active faulting and earthquake hazard assessment				
Hall 4B2				
TIME	PAPER #	PAPER TITLE & AUTHOR		
16:00	# 4332	Pleistocene-Holocene seismoturbidite succession above the Lwandle-Nubia plate boundary, offshore South Africa <i>Dr. John Rogers</i>		
16:15	# 3717	Stress Field in the Western Part of Africa-Eurasia Boundary from the Azores to Tunisian Atlas <i>Dr. Farida Ousadou</i>		
16:30	# 3259	Stress change and fault interaction from a two century-long earthquake sequence in the central Tell Atlas (Algeria) <i>Prof. Mustapha Meghraoui</i>		
16:45	# 3202	Stress field in the African Plate <i>Dr. Damien Delvaux</i>		
17:00	# 1169	Neotectonic stress mapping in Southern Africa solves the puzzling M5.5 Orkney Earthquake of 5 August 2014, North West Province, South Africa <i>Dr. Marco Andreoli</i>		
17:15	# 3254	Neotectonic stress orientation in the Kaapvaal Craton, South Africa derived by the Dihedra method <i>Prof. Adam Bumby</i>		
17:30	# 3256	Investigating Seismic Source Zones in Cameroon: A preliminary step for Seismic Hazard Assessment <i>Dr. Bekoa Ateba</i>		
Tuesday - Session 6			16:00–17:45	
T8.6a - Challenges in Identifying and Characterising Seismogenic Faults in Non-Plate Boundary Settings / Geohazards and societal benefits: coping with reality				
Roof Terrace				
TIME	PAPER #	PAPER TITLE & AUTHOR		
16:00	# 4192	Cosmogenically dated marine terraces in South Africa reveal low long-term rates of uplift and no evidence for localized faulting <i>Dr. Paul Bierman</i>		
16:15	# 911	Differences in geological hazards from liquefaction–fluidization and ground waves in the areas facing Tokyo Bay and San Francisco Bay <i>Prof. Hisashi Nirei</i>		
16:30	# 5562	The use of downhole geophysical logging in assessing subsidence from abandoned coal mines <i>Mr. David L Knott</i>		
16:45	# 3077	Present Permafrost Degradation in NE Siberia: Environmental Implications <i>Dr. Jiri Chlachula</i>		
17:00	# 3635	Artificial neural network based geohazard potential mapping for sustainable land use planning: approaches and examples from Germany and Namibia <i>Dr. Andreas Barth</i>		
17:15	# 3844	Variations in the morphology of reactivated fault scarps in the UK <i>Dr. Laurance Donnelly</i>		

與會過程

本研討會由於參加人數超過千人，因此主要會議期間共有八天，論文發表期間則有數場次的現地參觀行程。除專題演講外，論文發表共分成數十個場次 (session)。本人發表的文章則被安排在 8 月 30 日下午 14:00 場次的第二位，[圖四](#)及[圖五](#)為研討會口頭發表情形。



圖四、研討會作者口頭發表會場(一)




圖五、研討會作者口頭發表會場(二)

本場次共有 5 篇文章發表，本人已有甚多次口頭發表經驗，但由於參加人數眾多，因此在發表上顯得有些緊張，英文也因不常使用，部分單字發音不正確。由於每位簡報時間僅 15 分鐘，加上緊張因此結語尚未報告完時間即結束了。本人簡報檔資料如下(圖六)。

35th INTERNATIONAL GEOLOGICAL CONGRESS (35th IGC, 2016)

Landslide volume estimation by landslide area-frequency distribution




Dept. of Civil & Water Resources Engineering
National Chiayi U., Chiayi City, Taiwan R.O.C.

Speaker: Professor Chien-Yuan Chen
30 August 2016

Outline

- ④ BACKGROUND/ OBJECTIVES AND GOALS
- ④ STUDY AREA AND METHODOLOGY
- ④ RESULTS
- ④ SUMMARY

Background/ Objectives and Goals

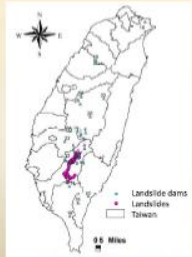


Background

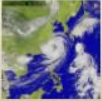
- Global climate change has caused increased natural disasters to occur worldwide in recent years.
- Taiwan has frequent earthquakes as it is situated at the juncture of the Eurasian and Philippine Sea Plates. Its geographical location causes Taiwan to be affected by typhoon-induced landslides frequently.
- Landslides reduce reservoir life as they produce large quantities sand and rock deposits.

Background

- Eighteen landslide dams formed during Typhoon Morakot when it hit Taiwan. The dammed-lakes were blocked as a result of landslides and debris flows (Forest Bureau 2009).



Site locations of the 18 historical landslide dams in Taiwan.

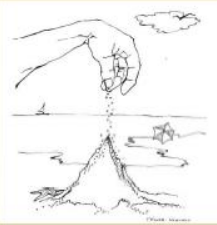


Typhoon Morakot in 2009

Background

Sandpile Model (Bak, 1987):

- If the pile is shaped so that the slope is less than the critical value, then the avalanches will consist of only small events; this is the sub-critical state, which will grow until it reaches the critical one.
- If, on the other hand, the slope is greater than the critical value, then a very large avalanche will result; this is the supercritical state, which will collapse until it attains the critical state. Irrespective of the initial conditions, the sandpile will evolve (self-organized) to a critical state.



(copy from Bak, How Nature Works)

圖六、作者口頭報告簡報檔

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Background

- The power-law distribution of landslide frequency and area in the Sandpile model can be expressed as (Bak, 1987):

$$-N_L = \gamma A_L^{-\alpha}$$
 where N_L is the cumulative number of landslide, A_L is the landslide area, and γ and α are constants.
- The formula was modified to compare the artificial Sandpile model and nature landslide into non-cumulative form as following (Crosta et al., 2003).

$$-N'_L = -\frac{dN_L}{dA_L} = \alpha \gamma A_L^{-(\alpha+1)}$$

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Background

- Landslide volume (V_L) and area (A_L) shows a power-law distribution in the log-log plot statistics analysis (Hovius et al., 1997; Brardinoni and Church, 2004; Guzzetti et al. 2009; Chen 2012; Tsai et al., 2013; Wood et al., 2015). Landslide volume and area scaling relationship can be explained as (Larsen et al., 2010):

$$V_L = \gamma A_L^v \quad (2)$$
 where γ = coefficient and v = scaling exponent. The coefficient γ is in the range of 1.09 to 1.40 for soil landslides (Larsen et al., 2010).

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- Landslide frequency-volume also shows a power-law distribution (Fujii 1969, Dai and Lee 2001, Hungr et al. 1999, Dussauge-Peisser et al. 2002, Brunetti et al. 2009; Tsai et al., 2013). The landslide frequency-volume relationship can be presented as (Malamud et al., 2004):

$$-N'_L = -\frac{dN_L}{dV_L} = \alpha \gamma V_L^{-(\alpha+1)} = C' V_L^{-\beta} = f(V_L)$$

$$= N_{tot} P(V_L)$$
 where N_L is the cumulative number for landslide volume large than V_L ; V_L is the landslide volume. In which, $C' = \gamma \alpha$ is the intercept of the curve, β is the exponent for the straight line part and $\beta = \alpha + 1$ (Guzzetti et al., 2002).

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Objectives and Goals

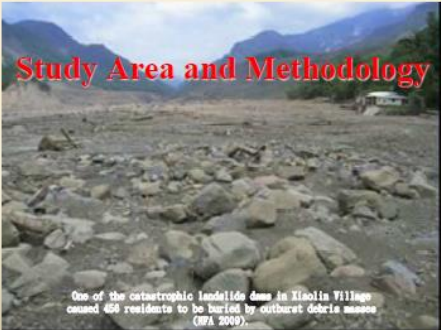
- The applications of landslide frequency-area distribution are limited at this stage.
- The conceptual of SOC has been used as an index to exhibit current state of a basin before and after landslides (Chen, 2009).
- The exponent of landslide frequency-area distribution could be an index to show landslide characteristics and stability state of a basin (Chen et al., 2007; Chen 2012).
- It is expected to use for landslide volume estimation for debris masses budget management in a basin.



A historical landslide dam in middle Taiwan

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Study Area and Methodology

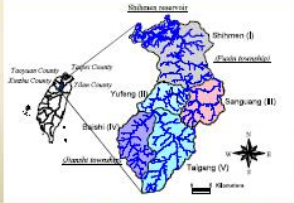


One of the catastrophic landslide dams in Xiaolin Village caused 450 residents to be buried by outburst debris masses (CWA 2009).

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Study Area

- The study area, Shihmen reservoir basin, is located in northern Taiwan. Two typhoons, Sinlaku and Jangmi in 2008, induced landslides in the study area were interpreting from remote sensing images.



Shihmen reservoir

Shihmen (I)

Shihmen (II)

Yungfeng (I)

Yungfeng (II)

Sangqiang (I)

Sangqiang (II)

Taiqiang (V)

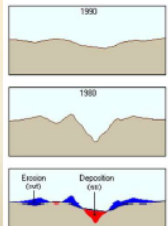
Site location of the study area in Shihmen basin area in Taiwan

圖六、作者口頭報告簡報檔(續)

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Methodology

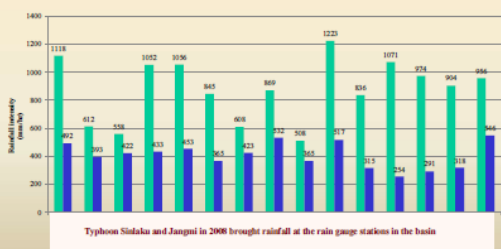
- We study the magnitude and frequency distributions of landslides at Shihmen Reservoir Watershed induced by typhoons Sinlaku and Jangmi in 2008.
- The methodologies include geomorphology analysis by DEMs before and after landslide events using ArcGIS spatial analysis.
- The paper formulates landslide regression equations for landslide area and volume from the landslide inventory.
- The landslide volume is estimated by using soil thickness in comparison with field tests.



Example of erosion and deposition areas by subtraction of DEMs

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Methodology



Typhoon Sinlaku and Jangmi in 2008 brought rainfall at the rain gauge stations in the basin

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Results



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Statistics of landslide area and volume

- The total landslide volume is 53,756,633 m³ by the DEM analysis.
- The volume of top 10% of the large landslides occupied 89.6% of the total landslide volume, and occupied 89.6% for the top 20% of large landslides.
- Most of the landslides are small in area, nevertheless, their summation of volume is solely less than 1% of the total volume in the study area.
- It explicit that large landslides affect the sediment budget strongly in a basin.

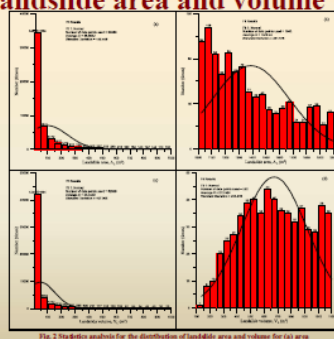


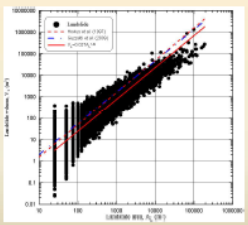
Fig. 2. Histogram analysis for the distribution of landslide area and volume for (a) area smaller than 1,000 m², (b) area bigger than 1,000 m², (c) volume smaller than 1,000 m³, and (d) volume bigger than 1,000 m³.

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Relationship of landslide volume and area

- The relationship of landslide volume V_L (m³) and area A_L (m²) is regressed as:

$$V_L = 0.027A_L^{1.48} \quad (r^2 = 0.73)$$
- An improvement of the relationship for better estimation of landslide volume by area is needed.



Relationship of landslide volume and area and comparisons with available approaches

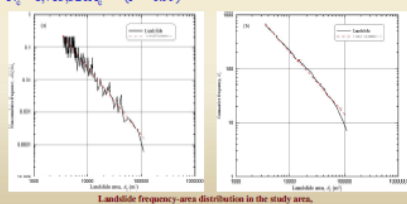
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Landslide frequency-area relationship

- The cumulative form (N_c-A_c) and non-cumulative form of landslide frequency density (dN_c/dA_c-A_c) and landslide area statistics distribution are shown in below. Their regressed equations can be presented as:

$$dN_c/dA_c = 6,070,966A_c^{-2.1} \quad (r^2 = 0.26)$$

$$N_c = 8,715,520A_c^{-1.16} \quad (r^2 = 0.99)$$



Landslide frequency-area distribution in the study area.
 (a) Non-cumulative form (dN_c/dA_c-A_c) distribution.
 (b) Cumulative form (N_c-A_c) distribution.

圖六、作者口頭報告簡報檔(續)

Landslide frequency-volume relationship

- The cumulative landslide frequency (N_c) and non-cumulative form of landslide frequency density (dN_c/dV_c) and landslide volume (V_c) statistics distribution are shown in below. Their regressed relationship can be presented as:

$$dN_c/dV_c = 2,526,737V_c^{-2.0} \quad (r^2 = 0.92) \quad (16)$$

$$N_c = 3,440,144V_c^{-1.0} \quad (r^2 = 0.99) \quad (17)$$

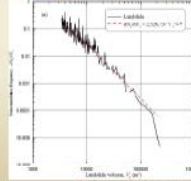
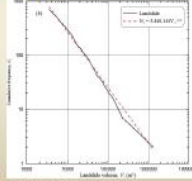



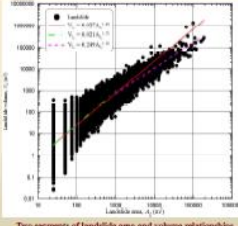
Fig. 5 Landslide frequency-volume relationship in the study area.
(a) Non-cumulative form (dN_c/dV_c) distribution, (b) Cumulative form (N_c-V_c) distribution

Two segments of landslide area and volume relationships

- The relationship of landslide volume and area is separated at 1,000 m² and corresponding to 1,000 m³ into two segments to improve the predictive precisions.
- The two segments of formulas are listed below:

$$V_L = 0.021A_L^{1.55} \quad (r^2 = 0.64, \text{ for } A_L \leq 1,000 \text{ m}^2)$$

$$V_L = 0.249A_L^{1.16} \quad (r^2 = 0.73, \text{ for } A_L > 1,000 \text{ m}^2)$$



Two segments of landslide area and volume relationships

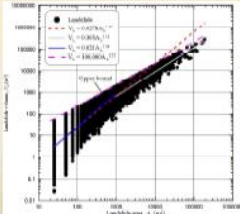
Landslide area and volume relationship for shallow landslides

- The shallow landslides are further separated into two parts for area large and small than 1,000 m² to improve the precision of estimation.
- The two segments of landslide area and volume relationship for shallow landslide (depth ≤ 2 m) can be expressed as:

$$V_L (\text{m}^3) = 0.305A_L^{1.12} \quad (r^2 = 0.78, \text{ for depth } \leq 2\text{m}, A_L \geq 1,000 \text{ m}^2)$$

$$V_L (\text{m}^3) = 0.021A_L^{1.54} \quad (r^2 = 0.64, \text{ for depth } \leq 2\text{m}, A_L < 1,000 \text{ m}^2)$$
- The data exhibited an upper bound that is attributed to the limited depth 2 m used for shallow landslides and its equation could be expressed as:

$$V_L (\text{m}^3) = 100,000A_L^{1.15}$$

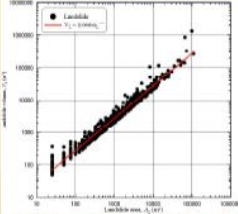


Landslide area and volume relationship for shallow landslides
(h ≤ 2 m)

Landslide area and volume relationship for deep seated landslide

- To improve the regression equation of landslide area and volume relationship, deep seated landslides (depth > 2 m) were separated from all landslides.
- The regressed equation for a deep seated landslides shows a high correlation as listed below:

$$V_L (\text{m}^3) = 2.808A_L^{1.0} \quad (r^2 = 0.98, \text{ for depth } > 2\text{m})$$



Landslide area and volume relationship for deep seated landslide (h > 2 m)

Results

• Error (%) = $\frac{\text{Volume by DEM} - \text{Estimated Volume by DEM}}{\text{Volume by DEM}} \times 100\%$

Slope and regolith thickness relationship in the study area

Slope (degrees)	Thickness (cm)
5-9	190
10-19	140
20-29	70
30-39	40


Comparisons of the landslide volume estimation by cumulative (Nc) and non-cumulative (dNc/dAc) forms

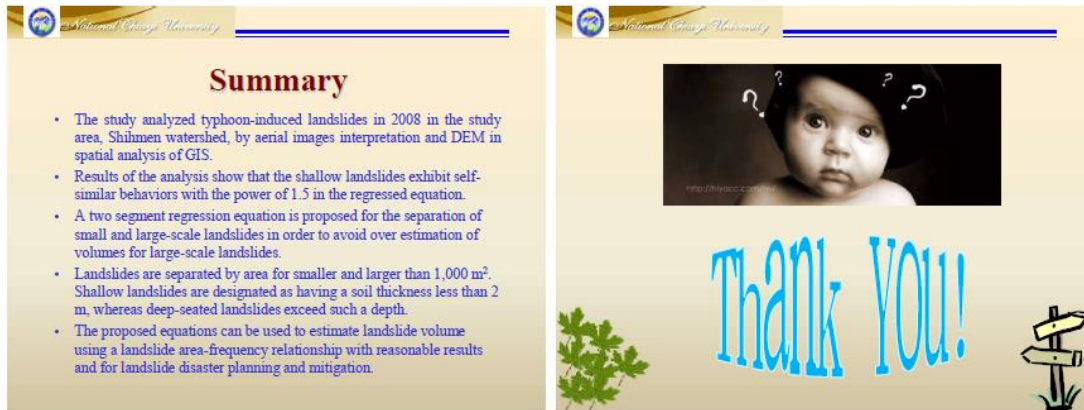
Method	Estimated volume (m ³)	Error (%)	Volume (DTM, m ³)
N_c	2,072,638	+12.9	
dN_c/dA_c	1,809,766	-12.5	1,825,800
average	1,841,202	+0.29	

Type of landslide	Fig.	Statistics	Estimated volume (m ³)	DTM (m ³)	Error (%)
Single size	3	$V_L = 0.021A_L^{1.54}$ ($r^2 = 0.64$)	30,894,542	19,226,574	-37.0
Two segments (regarded @ $A_L < 1,000$ m ²)	5	$V_L = 0.021A_L^{1.54}$ ($r^2 = 0.64$)	15,076,108	13,765,514	-8.7
	6	$V_L = 0.305A_L^{1.12}$ ($r^2 = 0.78$)	15,818,434	13,458,286	-13.3
Shallow landslides (h ≤ 2 m)	7	$V_L = 0.021A_L^{1.54}$ ($r^2 = 0.64$)	30,894,542	11,947,456	-61.6
Two segments of shallow landslides (regarded @ $A_L < 1,000$ m ²)	8	$V_L = 0.021A_L^{1.54}$ ($r^2 = 0.64$)	11,351,404	11,947,456	+5.2
	9	$V_L = 0.305A_L^{1.12}$ ($r^2 = 0.78$)	11,351,404	11,947,456	+5.2
Deep seated landslides (h > 2 m)	8	$V_L = 2.808A_L^{1.0}$ ($r^2 = 0.98$)	5,233,314	7,568,319	+44.8

- red estimated - blue measured

Summary





圖六、作者口頭報告簡報檔(續)

本次研討會攜回資料包括：

1. 研討會會議手冊，
2. 研討會手提包，
3. 研討會展覽場各國宣導資料與紀念品。

考察參觀活動

研討會於舉辦期間辦理多場地質現地參觀行程，本人主要參觀新世界七大奇蹟之一的-桌山(Table Mountain)行程，並於往來會議期間順便參訪開普敦市區。



圖七、研討會現地參觀-桌山

三、心得及建議

南非開普敦有非洲母城的稱謂，在研討會停留期間，本人觀察此次會議在國際間有下列幾點特點：

1. 研討會參加人數近千人，是國際上數一數二的重要地質相關研討會(每四年舉辦一次)。

2. 中國學者與會人數眾多，並有數個地質團體及學校設攤宣傳。台灣學者在國際上已經無法與中國大陸學者競爭。

3. 國際上各國地質團體皆積極爭取主辦權，下屆為印度及東南亞等五國共同辦理，下下屆為韓國，台灣則永遠不可能。

4. 市區規劃有觀光專車與路線，觀光交通便捷，是一個進步且開發的國際城市。

在市區的參觀讓人體驗到開普敦的繁華與進步，獨特的地理環境(桌山的屏障)，讓少雨缺水的非洲孕育出開普敦這顆綠鑽石，儼然是新世界的奇蹟之一。