Date of Submission	25 October 2019

IPL Project (IPL - 157) Annual Report Form 2018

1 January 2018 to 31 December 2018

1. Project Number (approved year) and Title,

   IPL-157(2010) Dynamics of large-scale subaerial landslides and submarine megaslides

2. Main Project Fields
   (1) Technology Development: Development of new high stress ring shear apparatus for 100-1000m deep megaslides; Monitoring and Early Warning, Vulnerability and Risk Assessment.
   (2) Targeted Landslides: Mechanisms and Impacts Catastrophic Landslides, Coastal and Marine Landslides

   (3) Mitigation, Preparedness and Recovery Preparedness and Mitigation

3. Name of Project leader
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   Core members of the Project:
   Kazuo Konagai, International Consortium on Landslides, Japan
   Khang Dang, International Consortium on Landslides, Japan
   Loi Doan Huy, International Consortium on Landslides, Japan

4. Objectives: (5 lines maximum)
   Mega landslides of 100-1000 m in depth, greater than 10 million m3 in volume causes a great effect either on land, coastal or under water. Magaslides may trigger Tsunami, landslide dams which may fail and cause great debris flows or floods as well as causing direct damages. Large-scale subaerial landslides may cause catastrophic landslides. This project will study the dynamics of large-scale subaerial landslides and submarine megaslides.

5. Study Area: Japan, Sri Lanka, Vietnam, Indonesia

6. Project Duration
   New duration by new core members is from March 2018 to March 2025

7. Report

1) Progress in the project: (30 lines maximum)

The project group has developed a new high stress ring shear apparatus (ICL-2) to simulate the initiation and motion of megaslides with more than 100 m depth in 2012-2013. The successful undrained capacity of ICL-2 is 3 MPa. This apparatus was applied to interpret the initiation and motion of the 1792 Unzen Mayuyama megaslide (volume is 3.4 x 108 m3, Maximum depth is 400 m) triggered by an earthquake. This landslide killed around 15,000 people by the landslide and the Tsunami wave induced by the landslide. Samples were taken from the source area for initiation and the moving area for motion. The hazard area was estimated by the undrained ring shear tests and the integrated computer simulation model (LS-RAPID, Sassa et al 2010) using parameters obtained from the tests data. The simulation result well matched the real motion of landslides.

The group has developed new software to simulate a landslide-induced tsunami (LS-Tsunami). The trigger of tsunami is the moving landslide simulated by LS-RAPID. Landslide mass on the sea floor upheaves sea water which cause tsunami wave. The LS-tsunami was applied to the tsunami induced by 1792 Unzen Mayuyama megaslide. The simulated tsunami heights were close to the historical records in the opposite bank of Ariake Sea. This paper was contributed to Landslides in 9 January 2016. It was published in December 2016 (Landslides Vol.13, No.6: 1405-1419).

This technology was applied to earthquake-induced landslides in Kumamoto Prefecture, Japan and susceptibility assessment of the precursor state of Haivan Station Landslide in Vietnam (Lam et al. 2018). Manuals of LS-RAPID and LS-Tsunami as well as manuals of the Undrained Dynamic-loading Ring-shear apparatus and its applications were created and published in Vol. 2 of ISDR-ICL Landslide Interactive Tools “Landslide Dynamics”. The group will support other ICL members to apply these methods to landslides and landslide induced tsunami in other countries.

2) Planned future activities or Statement of completion of the Project (15 lines maximum)

From 15-19 December 2018, a Japan-Indonesia Joint Field investigation was carried out on the earthquake-induced landslide and tsunami disasters in Palu, Sulawesi Island on 28 September 2018. Soil samples were taken and are being sent to ICL laboratory in Kyoto for testing with the new ring-shear apparatus then simulating with LS-Tsunami to analyze the mechanism of the event. The research result is expected to publish in Landslides or Full color book of the WLF5.

The Suruga Bay earthquake occurred on 11 August 2009 with a magnitude of 6.4 Mw caused a submarine mass movement. The landslide-induced tsunami simulation model and fault-induced tsunami simulation model are used to compare with the tsunami observations at 6 stations including Yaizu, Omaezaki, Shimizu-ko, Uchiura and Tago station. Reproduction of the 2009 earthquake-triggered submarine landslide-induced-tsunami in Surga bay, Japan is being examined.

The 5th of November was designated as World Tsunami Awareness Day (WTAD) by the 70th United Nations General Assembly in December 22, 2015. It was proposed by 142 countries following the Sendai Framework for Disaster Risk Reduction adopted at the Third UN World Conference on Disaster Risk Reduction (WCDRR) held in March 2015 in Sendai and the 2030 Agenda for Sustainable Development. Our group will organize a special event for World Tsunami Awareness Day on 5th November 2020 during the World Landslide Forum 5 which will be hold from 2-6 November 2020 in Kyoto, Japan. The special event includes sessions for tsunamis induced by coastal and submarine landslides and also multi-hazard risk analysis and modelling of various types of landslide disasters linked with other hazards.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

Megaslides either on land and submarine bed are posing a great risk because of its scale. Submarine landslides cause Tsunami. Global communities that are exposed to risk by subaerial and submarine megaslides, policy-makers, public administrators, researchers, scientists are beneficiaries of this project.

The development of the high stress ring shear apparatus and the computer simulation verified the possibility to assess mega submarine landslides triggered by mega earthquake. These achievements will be used as basic education materials for graduate students working on landslide-related research.

4) Results: (15 line maximum, e.g. publications)

1. Tien PV, Sassa K, Takara K, Fukuoka H, Dang K, Shibasaki T, Nguyen DH, Setiawan H, Doan HL (2018) Formation process of two massive dams following rainfall-induced deep-seated rapid landslide failures in the Kii Peninsula of Japan. Landslides, Volume 15, Issue 9, pp 1761–1778

2. Lam HQ, Doan HL, Sassa K, Takara K, Ochiai H, Dang K, Abe S, Asano S, Do NH (2018) Susceptibility assessment of the precursor stage of a landslide threatening Haivan Railway Station, Vietnam. Landslides, Vol. 15 (2): 309-325

3. Dang K, Sassa, Yanagisawa H, He B (2018) TXT-tool 3.081-1.2: Simulation of Landslide Induced Tsunami (LS-Tsunami) Based on the Landslide Motion Predicted by LS-RAPID. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing,

Risk Management and Country Practice (Kyoji Sassa, Binod Tiwari, Kofei Liu, Mauri McSaveney, Alexander Strom, Hendy Setiawan, eds): 111-130

4. Dang K, Sassa K, He B, Takara K, Inoue K, Nagai O (2018) TXT-tool 3.081-1.8: A New High-Stress Undrained Ring-Shear Apparatus and Its Application to the 1792 Unzen–Mayuyama Megaslide in Japan. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 371-391

5. Doan HL, Sassa K, Fukuoka H, Sato Y, Takara K, Setiawan H, Pham T, Dang K (2018) TXT-tool 3.081-1.4: Initiation Mechanism of Rapid and Long Run-Out Landslide and Simulation of Hiroshima Landslide Disasters Using the Integrated Simulation Model (LS-RAPID). Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 149-168

6. Pham VT, Sassa K, Dang K (2018) TXT-tool 3.081-1.1: An Integrated Model Simulating the Initiation and Motion of Earthquake and Rain-Induced Rapid Landslides and Its Application to the 2006 Leyte Landslide. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 83-100

7. Pham VT, Sassa K, Takara K, Fukuoka H, Dang K, Shibasaki T, Setiawan H, Nguyen DH (2018) TXT-tool 4.081-1.1: Mechanism of Large-Scale Deep-Seated Landslides Induced by Rainfall on Gravitationally Deformed Slopes: A Case Study of the Kuridaira Landslide in the Kii Peninsula, Japan. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 793-806

8. Sassa K, Dang K (2018) TXT-tool 0.081-1.1: Landslide Dynamics for Risk Assessment. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.1 Fundamental, Mapping and Monitoring (Kyoji Sassa, Fausto Guzzetti, Hiromitsu Yamagishi, Zeljko Arbanas, Nicola Casagli, Mauri McSaveney, Khang Dang, eds): pp 1-79

9. Sassa K, Setiawan H, He B, Gradiški K, Dang K (2018) TXT-tool 3.081-1.5: Manual for the LS-RAPID Software. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 191-224

10. Setiawan H, Sassa K, Dang K, Ostric M, Takara K, Vivoda M (2018) TXT-tool 3.081-1.6: Manual for the Undrained Dynamic-Loading Ring-Shear Apparatus. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice: 321-350