Date of Submission	03 March 2018

IPL Project (IPL - 157) Annual Report Form 2017

1 January 2017 to 31 December 2017

1. Project Number (approved year) and Title: IPL-157 (2010) Dynamics of subaerial 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:
   Kyoji SASSA
   Affiliation: Director, IPL World Centre, Kyoto, Japan
   Contact: ICL Headquarters, The Association for Disaster Prevention Research, 138-1 Tanaka Asukai-cho, Sakyo-ku, Kyoto 606-8226, Japan,
   Tel: +81(75)7230640, Fax:+81(75) 9500910
   Email: sassa@iclhq.org

   Core members of the Project:
   Kazuo Konagai, Yokohama National University, Japan
   Ikuo Towhata, University of Tokyo, Faculty of Engineering, Japan
   Toyohiko Miyagi, Tohoku Gakuin University, Japan
   Farrokh Nadim, NGI, Norway
   Alexander Strom, Institute of Geospheres Dynamics of Russian Academy of Sciences
   Roger Urgeles, Institute of Marine Sciences, Spanish National Research Council, Spain.

4. Objectives: 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. So far dynamics of such megaslides has not been studied. This project will develop a

super high stress ring shear apparatus of 10 MPa for 100-1000 m deep landslides. The ring shear test results are combined to the Mutibeam Swath Bathymetry, InSAR, GPS on-land and sea floor investigation, combined to 50 Centrifuge model experiment for landslide triggered tsunami, and computer simulation. It aims to establish Dynamics of Subaerial and Submarine megaslides which may provide reliable risk analysis of ongoing and also potential megaslides over the world.

5. Study Area: Japan, Pakistan, Uzbekistan, Norway, Italy, Central Asia, Mediterranean Sea, Viet Nam

6. Project Duration: 10 years, from March 2010 to March 2020

7. Report

1) Progress in the project:

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.

In 2015, the group has developed a 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 the Haivan Station Landslide which is in the precursor stage in Vietnam and also an earthquake-induced landslide in Kumamoto Prefecture.

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 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)

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 causes 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)

Dang K, Sassa K, Fukuoka H, Sakai N, Sato Y, Takara K, Lam H Q, Doan H L, Pham V T, Nguyen D H (2016) Mechanism of two rapid and long runout landslides in the 16 April 2016 Kumamoto earthquake using a ring-shear apparatus and computer simulation (LS-RAPID). Landslides Vol.13 (6): 1525-1534.

Dang K, Sassa K (2018) 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, pp 111-130

Dang K, Sassa K, He B, Takara K, Inoue K, Nagai O (2018) A new high-stress undrained ring-shear apparatus and its application to the 1972 Unzen-Mayuyama megaslide in Japan. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice, pp 371-391

Lam HQ, Doan HL, Sassa K, Takara K, Ochiai H, Dang K, Abe S, Asano S, Do NH (2017) Susceptibility assessment of the precursor stage of a landslide threatening Haivan Railway Station, Vietnam. Landslides Vol. 15 (2), pp 309-325.

Pham VT, Sassa K (2018) Dynamic Properties of Earthquake-Induced Large-Scale Rapid Landslides Within Past Landslide Masses. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice, pp 403-412

Pham VT, Sassa K, Takara K, Dang K, Le HL, Nguyen DH (2017) Simulating the Formation Process of the Akatani Landslide Dam Induced by Rainfall in Kii Peninsula, Japan. Advancing Culture of Living with Landslides (Mikoš M., Vilímek V., Yin Y., Sassa K., eds), Vol.5, pp 497-506. https://doi.org/10.1007/978-3-319-53483-1_59

Pham VT, Sassa K, Dang K (2018) 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, pp 793-806

Pham VT, Sassa K, Takara K, Fukuoka H, Dang K, Shibasaki T, Setiawan H, Nguyen DH (2018) Mechanism of large-scale deep-seated landslides induced by rainfall in gravitationally deformed slopes: A case study of the Kuridaira landslide in Kii Peninsula. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice (to be published in February 2018)

Sassa K, He B, Dang KQ, Nagai O (2014) Plenary: Progress in Landslide Dynamics. Landslide Science for a Safer Geoenvironment, Proc. The Third World Landslide Forum, Springer, Vol. 1: 37-67

Sassa K (2014) Landslide Risk Assessment at Cultural Heritage. Keynote for XII International IAEG Congress, Torino, Engineering Geology for Society and Territory (eds: Giorgio Lollino etc) , Vol.2 Landslide Process :79-103

Sassa K, Khang Dang, Bin He, Kaoru Takara, Kimio Inoue, Osamu Nagai (2014): Development of a new high-stress undrained ring shear apparatus and its application to the 1792 Unzen-Mayuyama megaslide in Japan. Landslides, Vol.11, No.5: 827-842

Sassa K, Dang K, Yanagisawa H, He B (2016) A new landslide-induced tsunami simulation model and its application to the 1792 Unzen-Mayuyama landslide-and-tsunami disaster, Landslides Vol.13, No.6: 1405-1419

Sassa K, Setiawan H, He B, Gradiški K, Dang K (2018) Manual for the LS-RAPID software. Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice, pp 191-224

Setiawan H, Sassa K, Dang K, Ostric M, Takara K, Vivoda M (2018) Manual for undrained dynamic-loading ring shear apparatus. Landslide Dynamics: ISDR-ICL Landslide interactive Teaching Tools. Springer, Vol.2 Testing, Risk Management and Country Practice, pp 321-350