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Progress in Landslides Dynamics to Protect Human Life and Cultural Heritage Sites

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Landslide Dynamics includes a process such as initiation of a landslide and its dynamics while in motion until it stops. A reliable scientific information, such as landslide hazard area, velocity of landslide and sliding surface depth, is essential to assess the motion of landslides and potential damage due to those landslides, which ultimately help in reducing human and property loss from landslides. However, predicting the initiation and motion of landslides is very complex and require quantitative evaluation of pore-pressure generation and the resulting continuous change in shear resistance mobilized on the sliding surface. A ring shear apparatus developed at Disaster Prevention Research Institute (DPRI) in 1984 (DPRI-1) and its periodically modified versions until the development of DPRI-6, ICL-1 (2011) and ICL-2 (2013), also globally known and used as landslide ring-shear simulators, are designed to physically simulate the formation of sliding surfaces as well as the post-failure motion of the involved soils under realistic stress ranges. These apparatuses also have capabilities to monitor pore-pressure generation under the undrained condition and mobilized shearing resistance together with shear displacement. A few examples of landslides dynamics simulations performed using these apparatuses include the 2006 Leyte Landslide that killed over 1,000 people, the 1792 Unzen Mayuyama Landslide that killed 15,000 people, a hypothetical Senoumi (Stone flower sea) submarine Megaslide where ring shear tests were conducted on a cored sample collected from 190 m below the sea floor, and 2014 Hiroshima urban disaster caused by a swarm of small-scale shallow landslides killing 74 people. Moreover, development of a new integrated computer model - LS-RAPID, which has a capability to simulate the initiation and motion of landslides using soil parameters obtained from the landslide ring-shear simulator, has significantly enhanced our capacity to evaluate landslides dynamics. LS-RAPID was successfully used to simulate landslides dynamics of landslide cases mentioned above. Many cultural heritage sites such as castles, palaces, and other important buildings have also been constructed on or close to slopes prone to landslides. Cultural heritage sites are usually stable areas for some hundred years or more. However, they can be affected by landslides because of long weathering, neotectonic process, river erosion, ground water pumping and other human activities. A series of long-span extensometers and other monitoring equipment together with drilling and tunneling presented the landslide risk at the precursor stage of deformation. Detailed slope monitoring, the landslide ring-shear simulators and LS-RAPID were successfully used for landslide risk assessments at a cultural heritage site in China (Lishan, Xian), a World Heritage site in Peru (Machu Picchu), a Global Geopark in Japan (Unzen Volcano) since 1991, as a part of the International Decade for Natural Disaster Reduction (IDNDR), the International Geoscience Programme (IGCP) and the International Programme on Landslides (IPL). This Medal Lecture includes the landslide dynamics evaluation case studies for earthquake induced landslides and cultural heritage sites presented above, which were successfully completed using the simulation tools such as Landslide ring-shear simulation and LS-RAPID.