

# Application Form for World Centre of Excellence on Landslide Risk Reduction 2020-2023

## 1. Name of Organization

University of Ljubljana, Faculty of Civil and Geodetic Engineering (UL FGG)

## 2. Name of Leader: Professor Matjaž Mikoš

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## 3. Date of Submission of Application: August 13, 2019

## 4. Activity scale and targeted region: Global: heterogeneous sedimentary rock masses & Regional: Adriatic-Balkan region (flysch formations)

## 5. Short Title characterizing past and planned activities: Landslides in Weathered Heterogeneous Sedimentary Rock Masses such as Flysch

## 6. Objectives for the initial 3 years

- (i) The main scientific aim will be to study weathering processes of heterogeneous sedimentary rock masses such as flysch bedrock both in laboratory (using standard tests) and on site (using remote sensing techniques on different landslides in flysch).
- (ii) Enhancement of landslide science in the Adriatic-Balkan Region through capacity development at the regional level as an outcome of regional scientific and high-education projects and cooperation.

## 7. Background Justification

Landslides in weak and complex rock masses need more research due to the problem of adequate estimation of geotechnical properties of such masses (Marinos & Hoek, 2001; Marinos, 2019) to be used in assessing landslide hazard in weathered heterogeneous sedimentary rock masses such as flysch. In Vipava valley (W Slovenia) rock slopes are made of flysch mudstones and sandstones, which are susceptible to weathering. On these slopes there are periodically reactivated landslides that have been observed in the last 250 years. Among them are two deep-seated large landslides, Slano Blato and Stogovce landslide, reactivated in 2000 and 2010. The previous studies shown that not only extreme weather (i.e. rainfall), but also flysch formations weathering/softening is needed for landslide reactivation and later their retrogressive widening (Maček et al., 2016). The retrogressive widening follows the period of apparently dormant behavior when exposed flysch bedrock on the main scarp deteriorates. The weathered flysch bedrock is mainly made of smaller blocks of mudstone and sandstone, which after the landslide reactivation changes in clayey gravel. Thus, it is important to improve our knowledge about mechanisms that influence weathering/softening of flysch bedrock and its disintegration into clayey gravel.

## 8. Resources available for WCoE activities

Altogether 10 researchers are active in the Research Institute for Geo and Hydro Threats (RIGHT), coming from the following faculty chairs: Geotechnics, Hydrology and Hydraulic Engineering, Fluid Mechanics, and Cartography, Photogrammetry & Remote Sensing. The available facilities comprise of soil mechanics lab & fluid mechanics lab & aggregates lab, field installations on the Slano Blato

landslide; including photogrammetric and remote sensing equipment (e.g. TLS, UAVs). The research budget will be mainly covered through the national 4-year research program “Geoinformation infrastructure and sustainable spatial development of Slovenia” & 5-year research program “Water Science and Technology, and Geotechnics”. Furthermore, research co-operation within INTERPRAEVENT (Europe, Taiwan, Japan) and ICL (active ICL member since 2009, taking parts in ICL symposia and WLF), as well as the newly established UNESCO Chair on Water-Related Disaster Risk Reduction will contribute to the 2020 Kyoto Commitment for Landslide Risk Reduction.

## **9. Description of past activities related to risk reduction of landslides and other related earth system disasters (since 2012)**

The WCoE was active in the past four periods 2008-2011, 2011-2014, 2014-2017 & 2017-2020 in the field of landslides in flysch formations. The field experimentations were done on one of the largest landslides in Slovenia, i.e. the Slano Blato Landslides that was firstly mentioned 230 years ago and was activated again in autumn 2000. It is one of the best documented landslides in the Balkan Peninsula (2 profiles with suction probes; on-line monitoring of suction; field meteorological station; on-line CCTV observation of the landslide surface). The field experimentations in the past were combined with comprehensive laboratory tests (mineralogy, chemistry of pore water, physical properties) performed on samples from the bore-holes and investigation pits, especially to understand triggering mechanisms and rheological properties to be used in advanced numerical models of triggering of landslides (e.g. LS-RAPID) and for debris-flow routing (e.g. Flo-2D & RAMMS). We were also investigating triggering of rainfall-induced shallow landslides through statistical analyses of IDF curves.

In 2012, the WCoE was active in preparation of ICL regional and thematic networks. As initiator we took over as coordinator the ICL Landslide monitoring and warning thematic network and we are active ICL member in the newly established ICL Adriatic-Balkan network.

In 2012-13, we worked on a 2-year bilateral project with Serbia (University of Belgrade, Faculty of Mining and Geology, coordinator Prof. Biljana Abolmasov) titled “Adriatic-Balkan Regional Network: Landslide Risk Mitigation for Society and Environment”.

In 2014-15, we worked on a 2-year bilateral research project with Croatia (University of Rijeka, Faculty of Civil Engineering, coordinator Prof. Željko Arbanas) titled SoLiFlyD “Study of landslides in flysch deposits: sliding mechanisms and geotechnical properties for landslide modeling and landslide mitigation”.

In 2016-17, we worked on a 2-year bilateral research project with Croatia (University of Rijeka, Faculty of Civil Engineering, coordinator Prof. Željko Arbanas) titled “Laboratory investigations and numerical modelling of landslides in flysch deposits in Croatia and Slovenia”.

In 2017, we successfully organized the WLF4 in Ljubljana, Slovenia, offering a post-forum study tour titled “Living with slope mass movements in Slovenia and its surroundings”, showing also problems with landslides in flysch in Slovenia. In 2017 we also co-organized the 3<sup>rd</sup> Regional Symposium on Landslides in the Adriatic-Balkan Region (3<sup>rd</sup> ReSyLAB) in Ljubljana, Slovenia, together with the Geological Survey of Slovenia. The 4<sup>th</sup> ReSyLAB will be held in Sarajevo, Bosnia & Hercegovina in October 2019.

From 2016 on, we were actively involved into 3 on-going IPL projects (216, 225, 226).

## **10. Planned future activities /Expected Results**

There would be two research activities: i) temporal observation of main scarps on selected landslides in weathered flysch formations for the estimation of flysch weathering intensity, and ii) observation of flysch durability/weathering in laboratory by conducting series of laboratory tests.

- i) The observation of the Slano Blato landslide main scarp and rock cliffs in flysch formations (marine cliffs along the Slovenian coast, riverine cliffs along the Dragonja River) using terrestrial and UAV

laser scanning and photogrammetric techniques will be conducted regularly (annually) in order to determine volumetric and topographic changes (e.g. rock wall retreat for cliffs) in time. The idea is that these changes can indicate in-situ flysch formations degradation and indicate future slope instabilities due to loss of shear strength. The changes will be presented using different cartographic visualization tools.

- ii) Sampling of smaller sandstone and mudstone blocks and surface soil material from the main scarp and cliffs to be used in laboratory tests. In the laboratory a series of tests will be performed to observe further weathering/disintegration due to wetting-drying process: a) some rock samples will be exposed to natural weathering (e.g. exposed to rainfall and natural drying) and using harsh environmental conditions in a climatic chamber - these samples will indicate how flysch disintegrates without any movement; b) jar slake test (testing flysch disintegration without any movement), and slake durability test (disintegration during movement) - for both tests, a different number and length of cycles will be used, and c) micro Deval test will be used to study disintegration due movement of flysch mass.
- iii) The results of disintegration/weathering tests will be compared to chemical and mineralogical composition (carbonate content) and pore water chemistry of sampled rock and soil material.

## 11. Beneficiaries of WCoE

The beneficiaries will be different institutions supporting the 2020 Kyoto Commitment and other regional/national stakeholders (e.g. Slovenian Administration for Civil Protection and Disaster Relief and their counterparts in the Adriatic-Balkan region) interested in the proposed WCoE main topics – through open access publication model of research results in the journal *Landslides* and in other international journals (e.g. SCOPUS journal *Acta hydrotechnica*), in new editions of ICL Teaching Tools & WLF5.

## 12. References

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