A PhD scholarship is available at Politecnico di Torino, Italy, under the guidance of Prof. Marina Pirulli. The project aims at developing a multi-scale modeling strategy for debris-flow through the integration of 2D and 3D numerical approaches. The scholarship has a length of 36 months and prescribes an 18-month mobility period at the Hong Kong University of Science and Technology.

The ideal candidate has a strong background in hydraulic or geotechnical engineering, especially in constitutive and numerical modeling. Basics of continuum mechanics are required. A strong interest in computational methods and any previous experience of C++ and/or Fortran is highly appreciated.

In order to take part to the selection procedures, applicants are required to hold before 31/10/2018:

- A master degree in environmental/civil engineering or a related field (for Italian candidates minimum graduation mark is 100/110). For international applicants, a GRE general test certificate must be held prior to applying.
- An internationally recognized certificate of English language knowledge.

For information contact: marina.pirulli@polito.it

PhD in Civil and Environmental Engineering

Research Title: Multi-scale modeling strategies for debris-flow: a new technique for hazard assessment combining numerical modeling and physical experiments

Funded by	Politecnico di Torino – Joint Research Projects with Top Universities

Supervisor	Marina Pirulli, Politecnico di Torino (marina.pirulli@polito.it) Clarence Edward Choi, Hong Kong University of Science and Technology (ceclarence@ust.hk) Alessandro Leonardi, Politecnico di Torino (alessandro.leonardi@polito.it)

Contact	Marina Pirulli, Politecnico di Torino (marina.pirulli@polito.it) http://www.diseg.polito.it/en/

Context of the research activity	Debris flows are flow-like landslides composed of a mixture of loose sediments and water, constituting one of the major threats to mountain settlement. To limit the loss of lives and of strategic infrastructures, often barriers are designed, with the target of stopping the flow, reducing its energy, or filtering out the largest boulders. The rational design of these countermeasures nowadays still relies on highly simplified techniques, which assume load patterns on the barrier. This has proven to be unreliable, as the complex composition of debris flow eludes the concepts of classical hydraulics. Therefore the need of new numerical models, able to give a reliable contribution for the design of structural countermeasures. However, a general tool for the realistic simulation of the flow-structure interaction problem is still missing. This is also due to the lack of validation data, as field measurement is often impractical.

	This project proposes a novel simulation strategy, which merges two existing numerical approaches. A simplified 2D model will track the evolution of the flow, from its initiation through the whole transport phase. The output is then converted into a full 3D simulation before the flow reaches the barrier, thus providing an optimized and affordable strategy to tackle the whole flow process. The code will be tested using the large-scale experimental facility at Hong Kong University of Science and Technology (HKUST). The teams at HKUST will design a set of experiments, reproducing debris flow as a mixture of a granular material and of a liquid. The mass will be discharged in a long instrumented channel, at the end of which barriers are set. This will provide a data source for validating an in-house numerical model under development at POLITO, which will be in turn used to extend and generalize the results on more realistic topographies, also leading to the development of new guidelines for practitioners.

Objectives	This PHD project aims at developing a new approach: simulating debris flow events, from initiation to stoppage against a barrier, with a combined strategy. In the initial-stage the flow is simulated by a traditional approach based on a 2D Depth Averaged Method (DAM). Before the material reaches the barrier, information about flow height, composition and velocity are converted from 2D to 3D and given as input for a second-stage Lattice-Boltzmann Method (LBM) simulation, which will deal with the flow-barrier interaction problem. This require the development of an appropriate coupling strategy, to be validated by comparison with the large-scale experiments carried out at HKUST. The main goal of Politecnico di Torino (POLITO) PHD student is to develop and validate a novel numerical method for the simulation of debris flow. The method will be based on two different (and, so far, only alternative) approaches: 1. DAM: the Depth-Averaged Method is an optimal tool for characterizing a geophysical flow on real topographies. POLITO has an in-house code, already validated and routinely used for the assessment of natural events. 2. LBM: the Lattice-Boltzmann Method can be effectively used to simulate the interaction between flow

	and barrier, but is limited to a small domain (the immediate neighborhood of the barrier) POLITO PHD student will receive training on both methods at POLITO by Prof. Pirulli, who is an expert in DAM, and her collaborator Dr. Leonardi, an LBM developer. POLITO PHD student will be tasked with the development of an adequate coupling strategy. A new inlet boundary condition need to be designed in the LBM code, where inflow velocity and shape are extrapolated from the information coming from DAM: flow level and depth-averaged velocity. This, together with the literature review and general training, is expected to be carried out in the first year at POLITO. The validation of the coupling strategy needs field data that is not readily available, as debris flow are unpredictable and highly destructive, with field measurement often impractical. At the same time, the information coming from small-scale physical modeling is of little use, as small models are known to suffer from unresolved scaling issues. During the outgoing phase at HKUST, POLITO PHD student will be tasked with interfacing with HKUST PHD student, who will be at the time carrying out experiments at the large-scale flume at the University of Hong Kong Kadoorie Centre. The flume can reproduce in a highly controlled environment both run-out stages. In the 18 months at HKUST, POLITO PHD student will use the experiments as a benchmark for validating the novel code. Finally, in the return phase POLITO PHD student will use the validated model for reproducing a real-case, by implementation of the expertise. The candidate is expected to spend the first year at POLITO to fulfill formal requirements for the doctoral school (compulsory credits, soft-skill training). In this timeframe, training in DAM and LBM will be provided. The outgoing phase will begin at month 13, and will last around 18 months, containing the development of the coupling strategy and its validation through the large-scale flume experiments at HKUST. Additional 6 months are expected at POLITO for exploitation of the results and for drafting the PHD thesis.

Skills and competencies for the development of the activity	The ideal candidate has a strong background in hydraulic or geotechnical engineering, especially in constitutive and numerical modeling. Basics of continuum mechanics are

	required. A strong interest in computational methods and any previous experience of C++ and/or Fortran is highly appreciated. The availability to spend 18 months in Hong Kong is an important requirement for all the applicants. Proficiency in written and spoken English.