# Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

| Supervisor information | |
|---|---|
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| **University name** | Université Clermont Auvergne |
| **Country** | France |

| PhD information | |
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| **Title** | **Probabilistic Reliability Analysis of earth dams or dikes concerning internal erosion risk** |
| **Main topics regards to CSC list (3 topics at maximum)** | VI-2.Prévention des pannes graves d'ingénierie et sûreté des systèmes |
| **Required skills in science and engineering** | Civil or hydraulic engineering, geomechanical modeling, stochastic modelling, geostatistics, reliability |

# Subject description (two pages maximum)

OBJECTIVES AND DESCRIPTION OF THE WORK

Hydraulic works – dams and dikes – are risky civil engineering structures. Dramatic consequences in terms of human and material losses may be induced by their failure. Embankment dams represent the majority of dams worldwide, without considering the important lengths of fluvial and coastal dikes. Statistics on failures of large earthfill dams show that almost 50% of ruptures are due to internal erosion (the rest is mainly attributed to overtopping and a small fraction to the sliding mechanism).

The structural safety of such structures is traditionally evaluated with limit-state deterministic or semi-probabilistic methods. More recently, probabilistic approaches (based on reliability analysis) have been developed considerably for carrying out dam risk analysis studies.

The evaluation of the internal erosion mechanism of embankment dams is a major challenge in the face of the uncertainties associated with the evaluation of hydraulic stresses due to seepage, on the one hand, and the evaluation of the soils strength properties to internal erosion, on the other hand.

In this purpose, the principal objective of this thesis work is to develop a probabilistic approach to evaluate earth dam reliability concerning internal erosion mechanism.

The following scientific issues have to be treated for developing such approach:

1) Elaboration of an hydro-mechanical model for the dam deterministic evaluation towards internal erosion mechanism.
2) Analysis of the spatial variability of internal flows and their impact on the assessment of internal erosion mechanisms in an embankment dam. Analysis of the propagation of uncertainties in the evaluation of the soils strength properties to internal erosion.
3) The use of monitoring measurements for the analysis of uncertainty reductions in the analysis of internal erosion mechanisms (Machine learning, Bayesian approaches…).
4) Probabilistic modelling of scenarios leading to failure by internal erosion of an earth dam, considering the initiation and propagation (non-filtration) mechanisms of internal erosion processes.

Several research works have been carried out in recent years to model the internal erosion mechanism. However, very few studies have been conducted to assess the propagation of uncertainties and to analyze the reliability of internal erosion of embankment dams.

This research project proposes a global methodological approach taking into account all the scientific issues mentioned above and applying hydraulic and mechanical modelling approaches based on real data available in an earth dam. The approach developed will be applied to several case studies of existing dams and dikes for which a large amount of data is available (soil properties, monitoring data, etc.).

Hydro-mechanical model uses finite-difference method and/or finite-element method and is developed with the Flac2D/3D and/or Cast3M codes which are compatible for a research use. The spatial variability of embankment properties is represented with random fields based on a geostatistical analysis of construction controls data. These random fields are then integrated into the numerical model using Monte-Carlo simulations. This approach finally makes it possible to analyze the propagation of uncertainties and to carry out a reliability analysis of the internal erosion of an earthfill dam.

In operational terms, this research project will allow to assess the uncertainties in internal-erosion stability analyses for dam projects as well as for the diagnosis of existing dams. It will also quantify the uncertainties associated with assessing the probability of failure due to internal erosion in dam risk analysis studies.

This study will be applied to a real case of dam and realized in association with the RECOVER research unit of the French National Research Institute Irstea (http://www.irstea.fr/linstitut/nos-centres/aix-en-provence) which will supply its scientific expertise as well as the set of the real data on the case study and the tests of characterization.

KEY WORDS: internal erosion, embankment dams, reliability analysis, stochastic finite elements, geostatistics, random fields, monitoring, numerical model

BIBLIOGRAPHIC REFERENCES:

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- X. Guo, D. Dias, C. Carvajal, L. Peyras, P. Breul, 2018. Reliability analysis of embankment dam sliding stability using the sparse polynomial chaos expansion. Engineering Structures, Vol.174, pp.295-307.
- Bonelli S. (edt), Erosion in Geomechanics Applied to Dams and Levees, Wiley/ISTE , 388 p., 2013.
- Schweckendiek T., Vrouwenvelder , A.C.W.M., Calle , E.O.F., Updating piping reliability with field performance observations, Structural Safety (2013);47:13–23.

COLLABORATIONS – SCIENTIFIC SUPERVISION

- Clermont-Auvergne university. Institut Pascal. Polytech' Clermont-Ferrand : Pr. Pierre Breul, Dr. Claude Bacconnet.
- Irstea – French National Research Institute of Science and Technology for Environment and Agriculture. RECOVER research unit : Pr. Laurent Peyras, Dr. Claudio Carvajal.