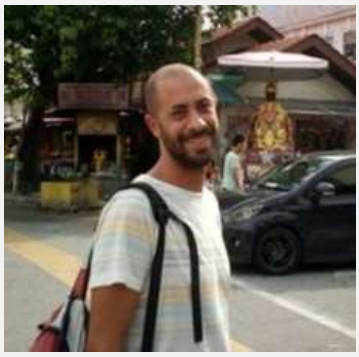
CERIS Civil Engineering Research and Innovation for Sustainability

Experimental and numerical study of the failure of fluvial dikes



PhD student
Ricardo Jorge Lourenço Jónatas

PhD program
Civil Engineering (IST, University of Lisbon)

Supervisor
Rui Ferreira (CERIS, IST, University of Lisbon)

Co-supervisors
Sílvia Amaral (LNEC) and
Enrique Nieto (University of Seville)

Period
2022-2026

Funding
FCT scholarship (SFRH/BD/2021.07337)

Summary

Dikes are typically built to protect populations from extreme floods at the intersection of urban areas and floodplains. Thus, any accident that can lead to potential failure of the dikes can have a major socioeconomic impact. There are far more failure studies on dams than on dikes. Yet, the latter are more frequent and can still induce catastrophic scenarios in protected areas, if no flood risk management tools or prevention practices are implemented. Take as example the failure of the New Orleans dikes system in 2005 in which about 85% of the metropolitan area was flooded, causing about $75 billion losses, and directly killing hundreds of persons. In addition, in Portugal, on December the 22nd of 2019, two dikes from the Mondego dikes system failed causing remarkable floodplain and urban inundations in Coimbra city. Hence, it is of paramount importance to be able to obtain accurate estimates of dike outflow discharges.

As dyke failure phenomena brings the extra complexity of dealing with the effects of longitudinal flow (parallel to the dike) along the dike and the upstream boundary, the results from dam failure studies cannot be directly transferred to the dykes. Several laboratory studies that were developed for dikes failure were performed on facilities with no longitudinal flow and assuming breach symmetry, being both assumptions is unsuited for fluvial dikes studies. Dike slopes are often protected by hard or soft materials or simply by naturally grown vegetation. However, the studies on the effect of surface protections need updating and are yet to be included in tools to forecast breach evolution.

To improve the general knowledge on breaching processes of fluvial dikes during an induced failure and to incorporate this knowledge into hydrodynamic and morphodynamic simulation tools this PhD work will incorporate:

I. a systematic program of dyke breach experiments, including both failure modes, by overtopping and by internal erosion, different affluent flows and the variation of the slopes protection - results will be based on the characterization of the breach morphology, breach effluent flow (outflow hydrograph) and surface velocity fields;
II. a theoretical approach based on the experimental data for the development of erosion closure models compatible with data assimilation strategies to be included in the 3D numerical tool;
III. the 3D numerical model validation with laboratory data.

Keywords

Fluvial dike failure, experimental modelling, numerical model calibration.