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LABORATORY TESTS ON FAILURE BY OVERTOPPING OF EARTH DAMS. IMAGING TECHNIQUES USED FOR EXTRACTION OF EXPERIMENTAL DATA

Sílvia Amaral[1(*)], Teresa Viseu[1], Rui M. L. Ferreira[2]
[1]Laboratório Nacional de Engenharia Civil (LNEC), Lisboa, Portugal
[2]Instituto Superior Técnico (IST), Lisboa, Portugal
(*)Email: samaral@lnec.pt

ABSTRACT

A set of tests on failure by overtopping of earth dams were performed under hydraulic and geotechnical controlled conditions in a medium-scale facility located at the Portuguese National Laboratory of Civil Engineering. The flow originated by a dam failure is a complex 3D flow where detailed aspects of the breaching process can only be studied from non-intrusive measurements. This work presents a set of image post-processing methods developed for results extraction from the data gathered in the failure experiments and evaluates the suitability of the methods in achieving these results.

Keywords: experimental modelling, breaching process, imaging techniques, PIV and PTV.

INTRODUCTION

The experimental tests campaign on failure by overtopping of earth dams performed in a medium-scale facility located at the Portuguese National Laboratory of Civil Engineering was designed to: 1) estimate breach effluent hydrographs; and to 2) deepen the knowledge about the breach hydrodynamics during the failure process. Both of these goals were based on proximity measurements (data acquired near or at the breach section).

To respond to the study's' goals several parameters had to be extracted from the acquired data as it is: i) the breach area; ii) the surface velocity maps; iii) 3D surface of the failed earth dams. All these parameters were obtained through image post-processing analysis gathered with a digital monitoring system specially designed for this purpose. Its layout was composed by two CCD video cameras, complemented by other three video records, including two digital HD video cameras and the use of one motion sensor that allows the reconstruction of the 3D embankment surfaces, previous and after the failure (Kinect Sensor). A mechanical dispenser of seeding particles (styrofoam beads), 3 floodlights and a high power laser were also part of the monitoring system layout. This digital monitoring system was fixed to be redundant, and therefore the five cameras were strategically placed to obtain overlay images so that all digital data could be related.

Further details on the layout of the digital monitoring system and of its components, as well as on the image post-processing analysis used in the data treatment from the experiments on failure by overtopping of earth dams can be found in Amaral (2017).

This paper presents all the optical techniques used in image analysis for the extraction of the breach area, the surface velocity maps near and at the breach section and for the 3D surface reconstruction of the failed earth dams. The adequacy of these optical techniques in extracting the referred parameters is also assessed.

RESULTS AND CONCLUSIONS

The breach area was determined by two different approaches (transversal and radial). Both methodologies revealed good estimates of the breach area and they are an absolute novelty in this type of studies - Bento *et al.* (2017). Even so, some difficulties were encountered in the application of this method, as the limited reach of the laser sheet inside the flow (for water heights above the breach bottom higher than 6cm, the trace of the laser is no longer seen by the CCD video camera).

Surface velocity maps near and at the breach section were determined by both *Particle Image Velocimetry* (PIV) and *Particle Tracking Velocimetry* (PTV) methods. PIV revealed to be useful in identifying flow tendencies, but insufficient to understand the relation between local variations of velocity vectors and the occurrence of sudden mass detachments from the earth dam body. In general, the PTV method revealed greater accuracy for this particular application allowing to relate flow hydrodynamics with the breach geotechnics. In fact, this had already been seen by Orendorff, *et al.* (2011), who refer that PTV techniques greatly enhance the amount of information that can be determined in the embankment breach tests.

Kinect sensor was successfully used in the 3D reconstruction of the earth dam (Figure 1).

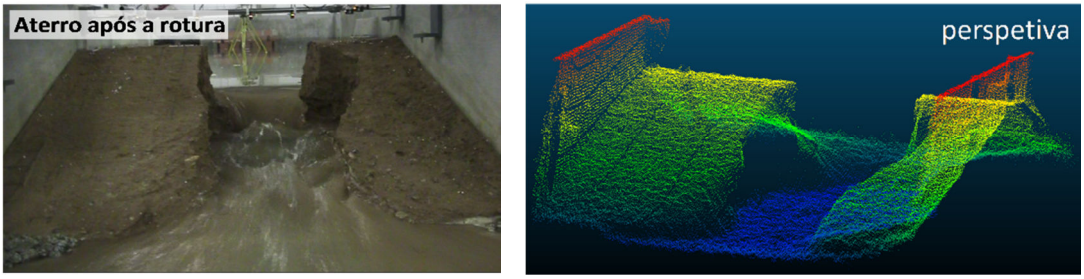

Fig. 1 - Reconstruction of the surface of the failed earth dam. Left - failed dam; right - point cloud of the reconstructed dam morphology

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