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Auteur : Wylock, Grégoire
Promoteur(s) : Dewals, Benjamin
Faculté : Faculté des Sciences appliquées
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Efficient prediction of the fluvial dike failure dynamics: *hydraulic prediction of breach discharge*

Author: Grégoire Wylock
Supervisor: Benjamin Dewals
Grade: Master's degree in civil engineering
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Abstract

Fluvial dike breaches are a recurrent and major worldwide issue. Indeed, many recent events have shown the disastrous impacts that can occur as a result of dike failure. Therefore, it is essential to be able to obtain information on the hydraulic variables related to this type of event. The emergence of numerical methods enables the creation and the use of different models allowing the prediction of these variables. Complex models (2D/3D) already exist in literature. However, the need for simpler models is increasing. These provide a higher number of simulations because the computation time is very low. This is one of the advantages of this kind of model. The present work has enabled the development of two simpler numerical models (0D/1D) based exclusively on hydraulic principles. The numerical models used allow obtaining hydraulic variables such as lateral discharge. However, the first steps in the development of the models were focused on obtaining lateral discharge coefficients. For this purpose, formulations of the lateral discharge coefficient had to be sought. Some empirical formulae coming from literature were used.

The models development was first based on simpler hydraulic configuration cases. The configurations used are characterized by a fixed breach geometry with zero or non-zero lateral crest height. These basic cases enabled the comparison of the results obtained with the different models and the experimental results. In addition to the creation of numerical models, this work allowed the different empirical formulae for the discharge coefficient to be tested. For each test performed, the results obtained with these formulae were analyzed in order to identify relevant and irrelevant formulations. Once the base cases were analyzed, the models were redeveloped to suit dynamic breach evolutions. The results obtained in these more complex configurations were analyzed according to the model used and the formulation employed.

A sensitivity analysis was also conducted to identify how uncertainties in the input parameters influence the results. This analysis was conducted on the dynamic breach tests. It was found that the uncertainties do not significantly influence the results. This conclusion is only valid in the experimental context.

The overall synthesis of the empirical formulae accuracy was not straightforward to obtain. Formulations which work for one specific test do not necessarily correspond to those which work best for the other tests. Nevertheless, this work has highlighted the most effective formulations for each test performed. Subramanya and Awasthy (1972) formula provides the best breach discharge results for fixed lateral opening with zero crest height. Singh et al. (1994) expression must be used with non-zero crest height configuration. For dynamic breach opening cases, Hager (1987) formulation gives the most accurate results.

In addition, a comparison of the results from the two models was also conducted. This enabled the identification of the appropriate use of one model rather than the other. The lumped model combined with the accurate formulations gives better breach discharge results than the spatially-discretized model for experiments with fixed breach geometry. For this type of tests, the water depths are more accurately estimated by the 1D model. For the dynamic breach opening, the 0D model provides an accurate average water depth. However, the spatially-discretized provides the most accurate peak breach discharges.