Reviewer: Ezio Todini

Review of

CFD modelling approach for Dam break flow studies

by Biscarini C., Di Francesco S. and Manciola P.

According to the authors, scope of their paper is to compare two different approaches to the solution of a dam-break problem. The first approach, preferred by the authors, is based upon a full 3-D solution of the complete set of Reynolds-Averaged Navier-Stokes (RANS) equations coupled to the Volume of Fluid (VOF) method, while the second one is the classical 2-D model based on the shallow water equations approximation.

The comparison is made on two dam-break test cases: the first one over a frictionless flat terrain and the second one with the presence of a triangular obstacle.

From the analysis of the reported results, the authors conclude, *that the shallow water approach loses some three-dimensional phenomena, which may have a great impact when evaluating the downstream wave propagation.*

Needless to say that the authors must be complimented for their numerical analysis coherence and the capability of implementing such a complex 3-D model, which in my view can be proficiently used for scouring analysis around piers and in many other interesting cases. But, I have serious doubts that the authors are really aware of the dam-break problems and how these problems can be effectively approached.

A clarification is here required. Although called dam-break, from its originator Danny L. Fread of the US-NWS (unfortunately not quoted by the authors), who developed a 1-D full Saint Venant model, the approach has been used for two similar but distinct problems.
The first one is a real dam failure problem, particularly referred to arch dams as in the case of Malpasset (France), which implies that water will mainly follow a deep valley, expanding or contracting according to its geomorphologic characteristics. This problem was originally studied as a one-dimensional problem and successively studied with 2-D dimensional models in order to more accurately describe the effects of the lateral expansions.
The second one, more realistically called a dam-breach problem, which studies the failure of a dyke or of an earth-dam. In both cases the terrain is generally rather flat and a 2-D model is absolutely needed because the integration domain immediately expands laterally.

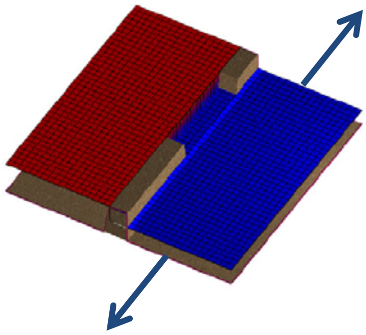
From the original studies in 1-D it already emerged that the dynamical and inertial terms, which are essential to correctly represent the near field (close to the breach or the dam failure), have scant effect in the far field (in reality not that far from the dam, most of the time less than 1 km). When one goes from 1-D to 2-D this effect is even enhanced by the larger importance of the volumetrical replenishment of the domain.
Taking into account the extremely large computational effort already required to represent the flooding in 2-D, in a real dam failure case the basic question to be answered must be: what is the benefit of a using a 3-D representation of the routing phenomenon, as opposed to a 2-D, if the interest lays not in the proximity of the dam where it is hard to believe that there will be inhabitants and properties at stake, but downstream, where the flooding risk

can be extremely large? While in the case of the dyke failure, the question is what is the improvement that a 3-D model can provide when the phenomenon is fundamentally ruled by a 180° expansion?

I must admit that I could not find this discussion in the paper, and, moreover, I am strongly convinced that the interpretation given by the authors is not supported by the displayed results.

Let me discuss in detail this last statement.

1) In both test cases the integration domain is practically one dimensional. In particular in the first example, a real 2-D problem must be solved by allowing the water also to expand in the direction of the arrows. Therefore the effect of the inertial terms is amplified and even if the interpretation of results was correct (which is not in my opinion) one could not really assess if a 3-D model may produce improved results.



2) Moreover, in the first test case there is no comparison of the results with actual observations or with a theoretical solution. How do the differences between the two approaches compare with the inevitable errors induced by the geomorphologic representation of the ground and its discretisation combined to the effects of the assumed friction factors and the hypothesis on the dam or dyke collapse?

3) There is no mention of the computational requirements of a 3-D model (or a discussion) when the simulation inevitably must extend for many kilometres (probably tenths of kilometres) downstream the breach or the dam failure point.

Going more in detail. With reference to the first example, the comparison produced in Figure 4, 5, 8 and 9 relates to the near field which implies the representation of a real 3-D field. It is obvious that the 2-D solution will differ from the 3-D's. I must admit that from what I see in Figs. 4 and 5 the 2-D shows astonishing good performances, since the differences are quite small. Then the authors point out that the 2-D model at a distance of 600 m has a delay in the front transfer time of about 4 seconds and a peak attenuation of 20% with respect to the 3-D model, and they state "It is important to note that this shift time assumes a very important role in a real basin scale, as an incorrect prediction of the lead time may yield relevant errors in the emergency planning and risk mitigation activity". I believe this statement to be meaningless due to the fact that 4 s at 600 m will be only a

few minutes several tenths of kilometers downstream, and that emergency plans are based on hours not on minutes.
Another intriguing question is the second peak in Fig. 9 relevant to the 2-D solution in terms of discharge, which does not appear in Fig. 8 in terms of water depth. Do the authors have an explanation for it? It is very strange and may induce to think to an effect of the downstream boundary conditions. And why it does not appear in the 3-D results?

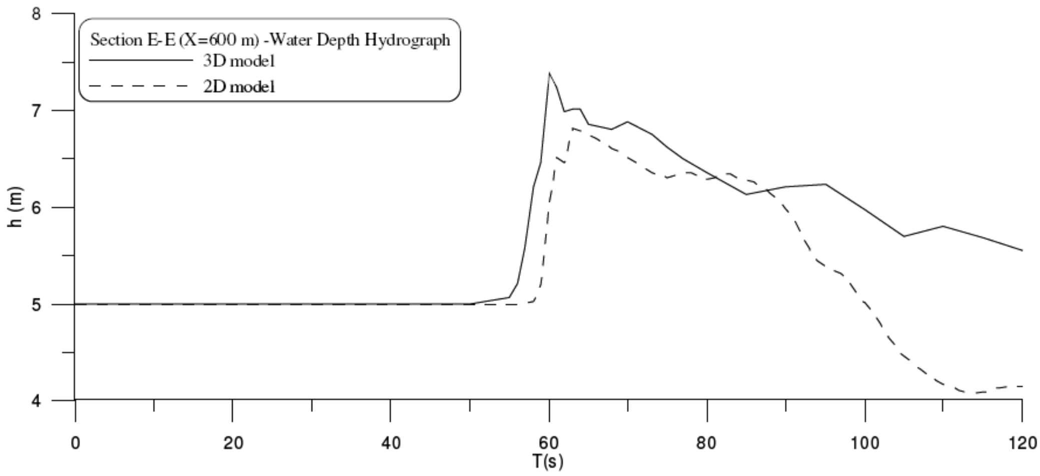


Figure 8. Water Depth hydrograph at E-E section (x=600).

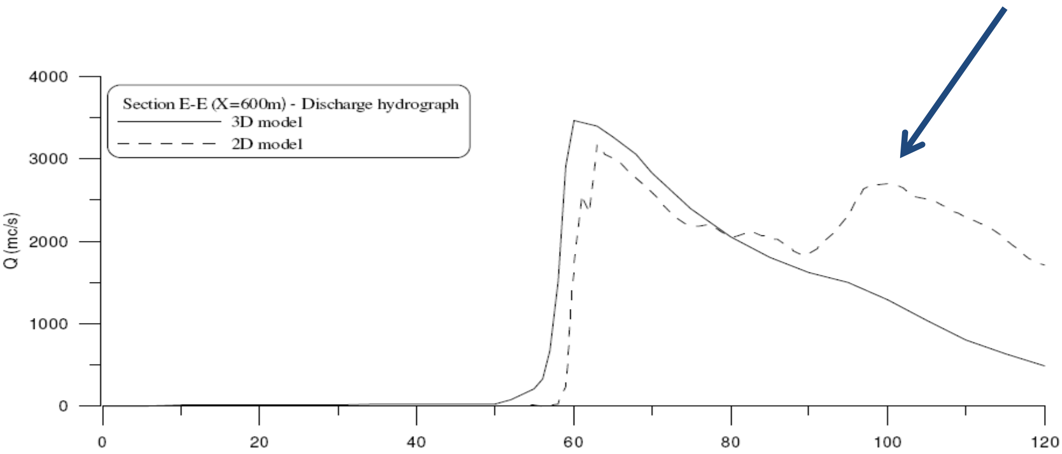


Figure 9. Discharge hydrograph at E-E section (x=600).

Finally in the description of the second test case results, the authors say that the 3-D model has a globally better behavior. But this is not fully substantiated by the displayed results. For instance at t = 8.4 s the free surface profile is better reproduced by the 3-D model upstream the obstacle, but is better reproduced by the 2-D mode downstream. Additionally Fig. 13 is almost unreadable due to the scale.

Therefore my conclusions are:
1) the 3-D model developed by the authors may be an extremely valuable piece of work.
2) the authors, for all the above discussed reasons, in my view failed at demonstrating the superiority of the 3-D approach for the solution of the dam break or dam breach problems.
3) the authors must:
    3.1) either, following the above provided comments, prove the improvements obtainable on a real case for which actual observations are available but also

considering the relevant costs to pay in terms of computational efforts and time consumption; or

3.2) prove the validity of the approach for the solution of other problems more relevant to the near field.