Closure to "Application of Godunov-type schemes to transient mixed flows"

by Arturo S. Leon, Mohamed S. Ghidaoui, Arthur R. Schmidt, and Marcel H. Garcia Volume 47, No. 2 (2009), pp. 147-156

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The authors would like to thank the discusser for raising certain points, the clarifications to which are given below.

With regard to the shape of the Preissmann slot, we agree with the discusser that his exponential slot is more general that that proposed by the authors. As pointed out by the discusser, his exponential slot has the ability to produce a slot transition similar to that proposed by the authors and that can be easily adjusted for other applications.

As of the discrepancy suggested by the discusser with regard to the velocity of the interface in the experiment of Cardle, this is not actually a discrepancy. Right after the gate is closed, the water piles up in front of the gate and it takes time for the positive interface to form and then start to propagate. Also the positive interface just formed is weaker and it takes time for its speed of propagation to fully develop. The latter is confirmed by the experiments and our simulations (See Figure 5 in our paper).

The discusser also questions whether our model would have advantage in applied stormwater applications with respect to implicit methods. We agree with the discusser that implicit models might be superior when transient flows are of no interest, however as stated in our paper, the aim of our model is for transient flow conditions. For transient flow conditions, the Method of Characteristics (MOC) and Finite Volume (FV) methods, which are explicit methods, are the most popular (e.g., Ghidaoui and Karney 1994; Leon et al. 2006). As pointed out by the discusser, implicit methods are stable for large time steps. However, implicit schemes increase both the execution time and the storage requirement and require a delicate matrix inversion solver (e.g., Zhao and Ghidaoui 2004). In addition, for most problems, iterative schemes must be used. Also, as pointed out by Ghidaoui and Karney (1994), physically, implicit methods entirely distort the path of propagation of waves and their region of influence and domain of dependence. Hence, in transient conditions, the use of explicit formulations over implicit methods are preferred.

It is pointed out that the model presented in the discussed paper (Leon et al. 2009) was implemented in an earlier version of the Illinois Transient Model (ITM) and it has been applied for the transient analysis of three existing large combined storm-sewer systems in the Unites States. The discussed paper uses the Preissmann slot approach for simulating pressurized flows. As is well known, the Preissmann approach has the inability to simulate negative pressures and may compromise the accuracy of the simulation and may produce mass and momentum balance problems if wide slots are used.

Because of the limitations of our Preissmann-based model (and other Preissmann slot models) for simulating transient mixed flows, the current version of the Illinois Transient Model (V. 1.2) replaced the Preissmann slot formulation with the compressible water hammer equations for simulating pressurized flows (Leon et al. 2010). In the current version of the ITM, the free surface region is simulated using the modified 1D Saint-Venant equations, the pressurized region is simulated using the classical 1D compressible waterhammer equations and open channel-pressurized flow interfaces are simulated by enforcing mass, momentum and energy relations across open channel-pressurized flow interfaces. The separate simulation of free surface and pressurized flows is more complex; however, this model is able to simulate sub-atmospheric pressures in the pressurized flow regime and can simulate pressure transients in mixed flow conditions when large pressure wave celerities of the order of 1000 m/s are used (Leon et al. 2010).

References

Ghidaoui, M.S., and Karney, B.W. (1994) ‘‘Equivalent differential equations in fixed-grid characteristics method.’’ J. Hydraul. Engng., 120(10), 1159-1175.

Leon, A.S., Ghidaoui, M.S., Schmidt, A.R., García, M.H. (2006). Godunov-type solutions for transient flows in sewers. J. Hydraul. Engng. 132(8), 800-813.

Leon, A.S., Ghidaoui, M.S., Schmidt, A.R. and Garcia, M.H. (2009) “Application of Godunov-type schemes to transient mixed flows.” Journal of Hydraulic Research, 47(2), 147-156.

Leon, A.S., Ghidaoui, M.S., Schmidt, A.R. and Garcia, M.H. (2010) “A robust two-equation model for transient mixed flows.” Journal of Hydraulic Research, 48(1), 44-56.

Zhao, M., Ghidaoui, M.S. (2004). Godunov-type solutions for water hammer flows. J. Hydraul. Engng. 130(4), 341-348.