Special Guest Lectures

Flow Penetration into Porous Hydraulic Structures: A New Computational Approach for an Old Multi-scale Problem

Xiaofeng Liu, University of Texas at San Antonio

Assistant Professor, Department of Civil and Environmental Engineering

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Abstract:

In many water resources and coastal infrastructure projects, hydraulic structures are designed to have some porous parts. For example, some river training dykes and scour protections are made of loosely packed rocks. Many river banks are protected by layers of ripraps. Typically, these structures are composed of coarser outer layers and finer inner layers, which introduce multiple length scales. Due to the porous nature of these structures, turbulent flows can penetrate inside with significant magnitude. This penetration has the potential to stir up the sediment underneath these structures which they are supposed to protect. It is an old problem recognized by the hydraulics community long time ago. To prevent the failure of these structures and make better design, it is important, though extremely difficult, to visualize and evaluate the turbulent flow field inside. A hybrid computational approach for this multiscale problem has been developed. In our hybrid model, large outer layer stones are resolved using immersed boundary method and inner filter layers with finer particles are modeled by adding extra drag terms in momentum equations. Large outer stones are digitized using a 3D laser scanner. They are put into the computational domain using the collision detection and rigid body dynamics algorithms which guarantees realistic and physically-correct spatial arrangement. Example simulations in rivers (unidirectional flow) and coastal environment (wave and combined flows) will be shown.

We have also used this new computational tool in other research areas. Examples are gravity current over rough and uneven surfaces, coherent structures and drag forces in gravel rivers, etc.

Speaker's Bio:

Xiaofeng Liu got his bachelor's degree in Hydraulic Engineering from Tsinghua University, China and master's degree in Environmental Science from Peking University, China. In 2003, he moved to US and did his doctoral research at University of Illinois at Urbana-Champaign (UIUC) on the topic of the flow and sediment scour around structures such as bridge piers and offshore foundations. He got his second master degree in Applied Mathematics in 2007 and Ph.D. in Civil Engineering in 2008 from UIUC. He then worked for two years as a postdoctoral researcher and visiting research assistant professor at UIUC. Since 2010, he has been an assistant professor at the University of Texas at San Antonio. His research area is water resources engineering in general. He specializes in computational hydraulics and environmental flows.

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2003 Digital Media Center • Telephone: +1 225/578-5890 • Fax: +1 225/578-8957