ADAPTIVE HYDRAULICS

A TWO-DIMENSIONAL MODELING SYSTEM
DEVELOPED BY THE COASTAL AND HYDRAULICS LABORATORY
ENGINEER RESEARCH AND DEVELOPMENT CENTER

A PRODUCT OF THE SYSTEM-WIDE WATER RESOURCES PROGRAM

COMPARISON TO RMA2 & HIVEL2D

Two dimensions defined.

ADAPTIVE HYDRAULICS PROVING ITS WORTH.

(From a paper presented by Thomas Gambucci, “ADH=Fast & Stable 2D Finite Element Model,” at the World Environmental and Water Resources Congress 2009

RMA2 is a two-dimensional depth averaged hydrodynamic numerical model that computes the water surface elevations and horizontal flow velocities at nodal points of a finite element mesh that represents the river. RMA2 can be used to analyze both steady and unsteady state problems. TABS-MD was the predecessor to the RMA2 program and the names are often used interchangeably. In the past RMA2 was sometimes (erroneously) referred to as SMS, the interface to display mesh/model input and output. To run a hydro analysis, the GFGEN program was typically run first to pre-process the geometry file (mesh), then RMA2 was run to compute the hydrodynamic field. Since the computations of this finite element model are an implicit scheme, they are performed simultaneously in a matrix form. Various RMA2 compilations were used to limit the matrix size to the number of nodes and elements in the model, which optimizes and improves computation speed. SMS (the Surface-Water Modeling System) is used to view/create the model mesh and display results. For 3D applications GMS (the Ground-Water Modeling System) is used. RMA2 was commonly used by MVR from 1995 to 2005. A common stability problem was the issue of wetting/drying elements. Modelers became experienced with troubleshooting techniques such as adding/refining elements, modifying eddy viscosities and using marsh porosity. RMA2 is being phased out due to the vast improvements in speed and stability seen with the AdH program.

HIVEL2D is a two-dimensional numerical model used to analyze high velocity flow, and it has been adapted for use with both supercritical and/or subcritical flow fields with either lined or natural channels. HIVEL2D is a linear solver so only linear elements are created (no middle/side nodes). Using the command of Linear <—> Quadratic in SMS, the RMA2 grid with quadratic elements can be easily converted to HIVEL2D grid with only linear elements. HIVEL2D was extended to include guard walls and was used to simulate the flow under and around the guard walls. Thus, HIVEL2D can be used to rapidly evaluate the navigation conditions in lock approaches for various guard wall configurations. HIVEL2D was the predecessor to AdH and it should now be considered obsolete.

Converting RMA2 to AdH grids using SMS

Given an RMA2 grid of quadrilaterals and triangles:

1. Split quadrilaterals such that the grid is now only triangular elements

2. Check mesh quality

3. Thin triangles: Often RMA2 rectangles have large aspect ratios which become thin triangles when split

4. Area changes: Often RMA2 elements increase in area quite rapidly. Avoid this.

5. Smooth transitions or add nodes to create a better representation of the bathymetry — the direction elements are drawn can create misrepresentations of bathymetry.

6. Try to form elements such that they provide smooth lines for material definitions — RMA2 grids usually include this, so it should still remain, but check just in case you have moved nodes around.

7. Create a scatter-set of elevations from the RMA2 mesh to be interpolated onto the new AdH mesh.

How to convert mesh From HIVEL2D to AdH

1. HIVEL2D and AdH are both linear basis functions, so neither has midside nodes.

2. AdH is all triangles. HIVEL2D can contain quadrilaterals as well. These need to be converted to triangles. Try to swap the direction of diagonals if they are all the same direction. Be sure to avoid dams when the swap doesn't conform to the bathymetric contours.

3. Check the mesh quality.

4. HIVEL2D is linear like AdH and a static grid, so it probably has more resolution in the initial mesh than AdH would need if you were starting from scratch.

8. This needs to be done after nodes are added or moved since the interpolation in SMS may not give elevation contours that are identical to the RMA2 grid.

9. Also, if nodes lie outside of the scatter set (will often happen if you add nodes on the mesh boundary), they will be given a value of zero. Look for these zeros after interpolating from scatter sets.

10. Perform a careful inspection of the bathymetry representation to ensure that the AdH grid includes all of the features of the RMA2 grid and that the elevation values match.

11. Remember to renumber the mesh once you are satisfied with the conversion.

12. You could take the material boundaries and create map polygons that can be meshed in different ways; however, you will probably lose all features of the RMA2 mesh, such as smooth material lines and refinement where needed to describe features in the domain. In other words, this should be a last resort.

1**3.** If you have solutions from RMA2 runs that you want to use to hotstart AdH, you can interpolate those to the AdH mesh as well. Perform the same checks to ensure that the interpolation does not generate any misrepresentations of the solutions. Once you have values at every node in the ADH grid, you can export the dataset to create your hotstart file.