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SeaFEM - Validation case 2

Wigley hull

SeaFEM

Version
15.1.0

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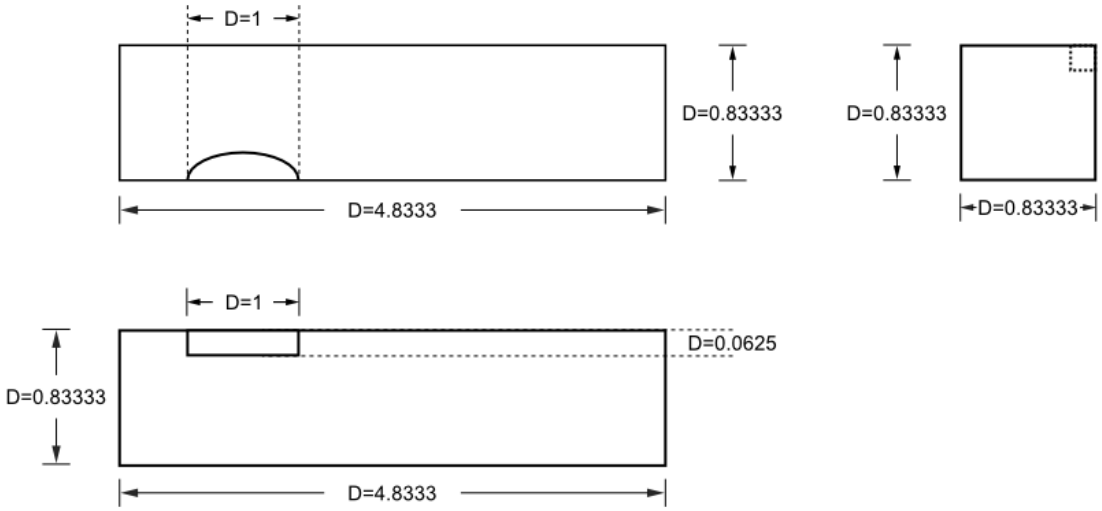
1 Validation Case 2 - Wigley hull

This test case analyses the wave pattern and wave resistance of a Wigley hull at a Froude number Fr=0.3. The model consists of a wigley hull one meter in length, its beam being 0.05 meters and its draft 0.0625 meters. The following figures show the control volume under analysis and the detailed geometry of the hull respectively (length units in meters). Experiments and numerical results obtained by CFD simulations in [1] are referred for the sake of verification.



Problem description

- Geometry

Wigley hull one meter length. The beam of the hull is 0.05 meters and its draft is 0.0625 meters.

- Domain

Seakeeping analysis dealing with currents.

- Fluid Properties

Seakeeping analysis undertaken using SeaFEM always consider that the fluid medium is sea water. Nevertheless, water density can be adjusted to match the actual fluid properties variation. For the present analsyis, water density was taken to be $\rho = 1025\ kg/m^3$.

- Fluid Models

Seakeeping analysis undertaken using SeaFEM always deal with incompressible fluids.

- Boundary Conditions and seakeeping environment

Current velocity: 0.939467136 m/s

Current direction: 0.0 deg

- Time data and solver parameters

Time step: internally evaluated based on stability criteria

Simulation time: 20 s

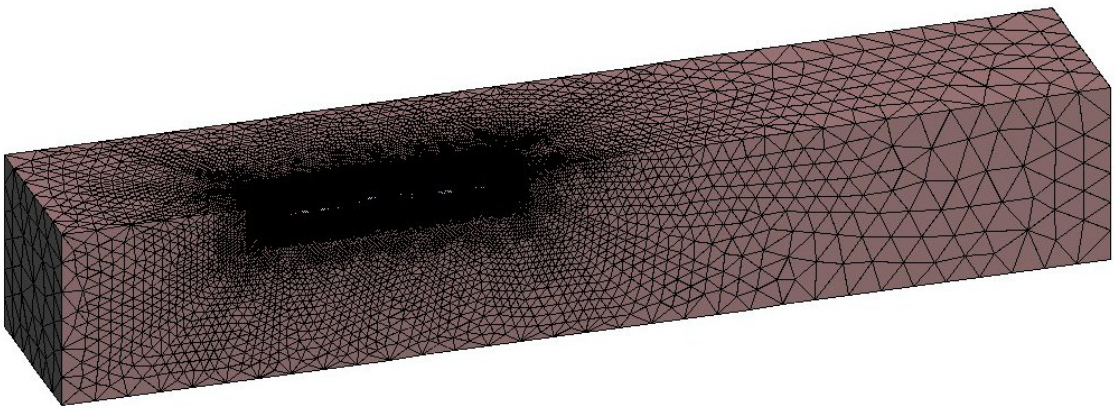
Symmetric solver: Stabilized bi-conjugate gradient (tolerance = 1.0E-7) with and ILU preconditioner

Mesh

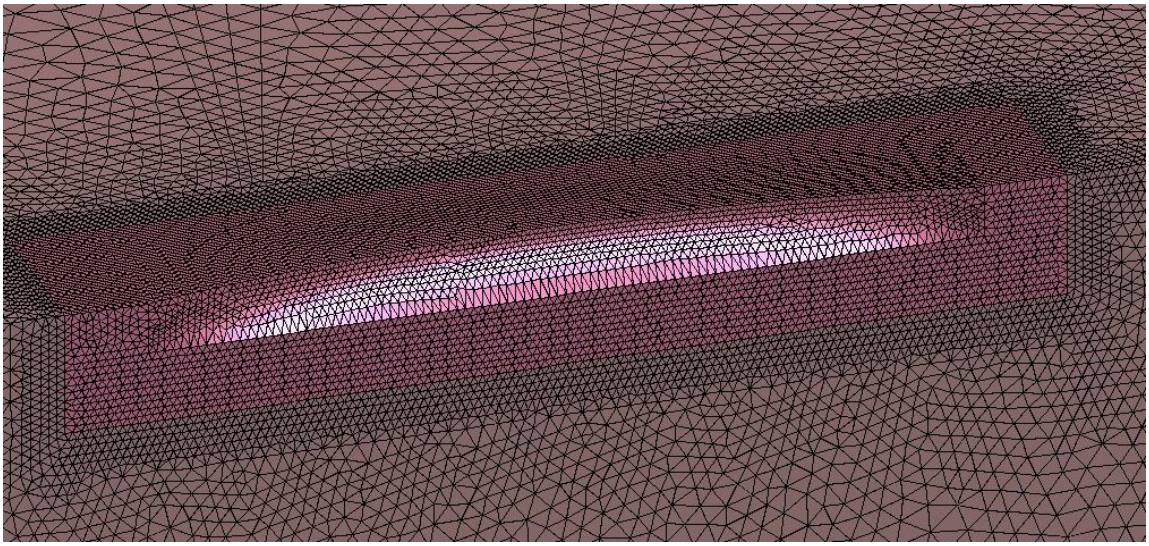
Mesh properties for the present analysis are summarized in the following table:

Mesh properties	
Min. element size	0.01
Max element size	0.15
Mesh size transition	0.1
Number of elements	694,121
Number of nodes	117,044

The following figures show the resulting mesh used for the present analysis. First, an isometric view of the whole domain is presented. Next, a detail of the mesh close to the surface of the Wigley hull is shown where mesh transition can be appreciated.



Mesh of the whole domain



Detail of the mesh close to the surface of the wigley hull

Results

First, the evolution of the dimensionless wave resistance coefficient is presented. The drag coefficient Cw is defined as:

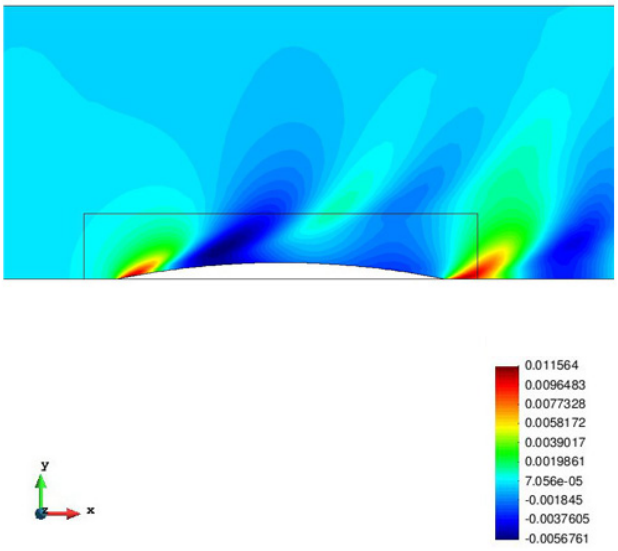
$$C_w = \frac{2F_d}{\rho v^2 A}$$

where

F_d is the drag force, which is by definition the force component in the direction of the flow velocity, ρ is the mass density of the fluid, v is the velocity of the hull relative to the fluid andA is the reference area.

Notice that the simulation converges to a value near 0.00132. Values obtained from towing test, using the ITTC line for stimating the viscous drag, lead to a wave resistance value about 0.0015.

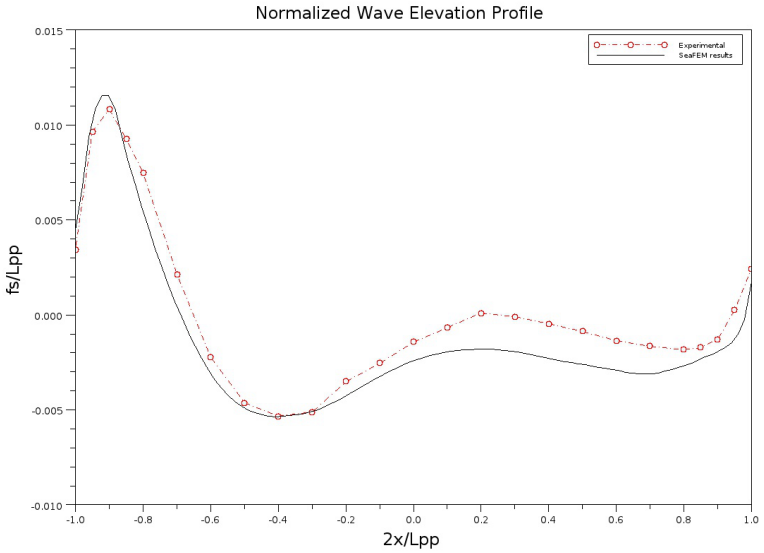
Next, the wave field is analyzed. The following figure shows the total wave elevation around the wigley hull.



It can be noted that the scattered waves dissipate quickly when moving away from the body (see cover image for instance). This is because wave absorption is artificially promoted during the calculation in order to avoid numerical artifacts generated by wave reflection at the edges of the computational domain. The beginning of the absorption area is specified by the user by giving a "beach" distance from a reference point located somewhere on the free surface. In the current analysis, the "beach" distance is one meter and the reference point is located at

the center of the wigley hull. Hence, no artificial dissipation occurs inside of a circular region containing the entire wigley hull.

For a more quantitative analysis, the wave elevation profile obtained by SeaFEM is compared against experiental data as shown in the graph below. In such a graph, wave elevation is nomalized to the length of the wigley hull and plotted against the normalized X-coordinate measured along the advancing direction.



References

[1] E. Oñate, J. García. A Finite Element Method for Fluid-Structure Interaction with Surface Waves Using a Finite Calculus Formulation. Computer Methods in Applied Mechanics and Engineering 191: 635-660 (2001)

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018