Department of Naval Architecture and Ocean Engineering

SIMULATIONS OF WAVE LOADING ON STATIC STRUCTURES USING OpenFOAM

Inno Gatin

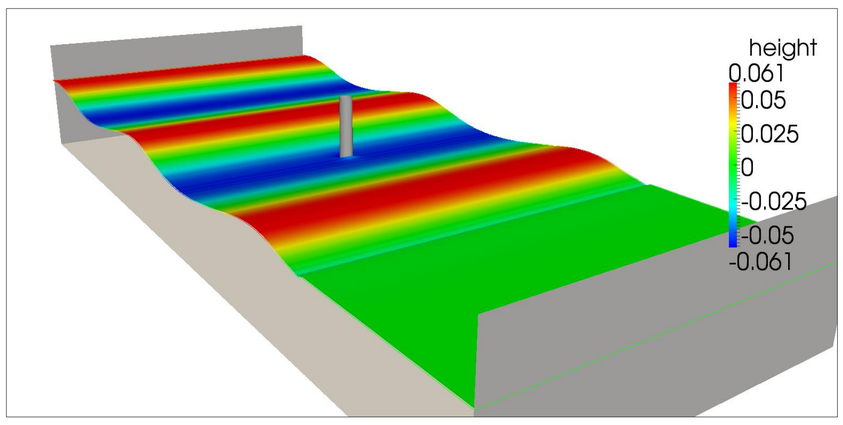
SIMULATIONS OF TWO PHASE FLOWS IN OpenFOAM

Three different simulations involving free surface problems are carried out using the `Naval Hydro` Pack. In the first simulation a vertical truncated cylinder is immersed in water and exposed to incoming regular waves. Waves are initialized using the inlet relaxation zone, while the outlet relaxation zone is used for wave damping and to prevent reflection. The second simulation is an example of violent free surface effect, where a dam break on a vertical square column is shown. Results for above mentioned simulations are compared with experimental results. In the third simulation freak wave is initialized using the Pierson-Moskowitz sea energy spectrum. Phase shifts of individual components are aligned to give a positive superposition at a desired location and time. Realistic free surface profiles are obtained.

HARMONIC WAVE LOADS ON VERTICAL CYLINDER

Simulations are based on the experiment where forces on immersed cylinder in harmonic wave train are measured. Wave parameters used for simulations are shown below. Simulation domain with initialized wave field is shown in figure below.

Index N	Frequency f, Hz	Wave slope $k*\eta_a$, rad	Wave number k, rad/m	Wave height h, m	Wave length λ, m	Period T, s
1	0.70	0.06	1.97	0.060	3.19	1.43
2	0.70	0.12	1.97	0.120	3.19	1.43
3	0.90	0.20	3.26	0.123	1.93	1.11
4	1.10	0.12	4.87	0.050	1.30	0.90
5	1.43	0.20	8.83	0.049	0.76	0.70

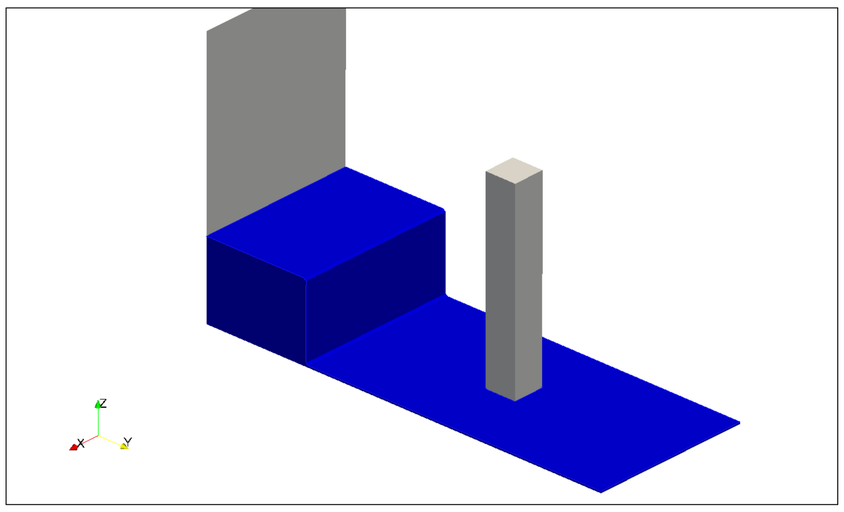


The comparison with experimental resutls is given in table below. Results for the first three waves show excellent agreement with experimental data. For waves 4 and 5 results show larger errors. This is due to higher frequency of those waves; thus better results could be expected by further mesh refinement.

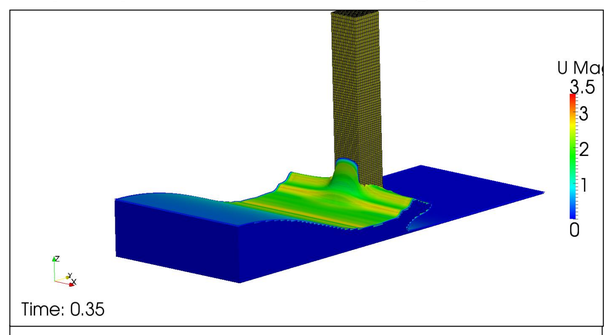
Wave index N	CFD results F_x, N	Experimental results F_x, N	Relative error Err, %	Number of cells	Courant number Co	α Courant number αCo
1	1.778	1.80	1.22	1 728 490	6.0	3.0
2	4.790	5.00	4.20	1 728 490	6.0	3.0
3	5.573	5.70	2.23	1 728 490	2.0	1.5
4	2.390	2.80	14.64	1 728 490	1.5	0.75
4	2.361	2.80	15.68	2 805 810	1.5	0.75
5	2.650	3.08	13.96	1 728 490	2.0	1.5
5	2.854	3.08	7.34	2 629 410	2.0	1.5

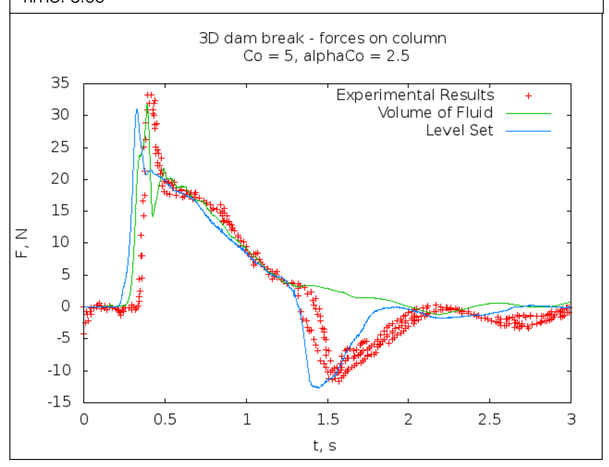
3D DAM BREAK ON A SQUARE COLUMN

The setup of this simulation is shown in figure below; it corresponds exactly with experimental data. Gates used to release the water in the experiment are not simulated. Two methods for interface capturing are used; Volume of Fluid and Level Set. Mesh consists of one million cells.



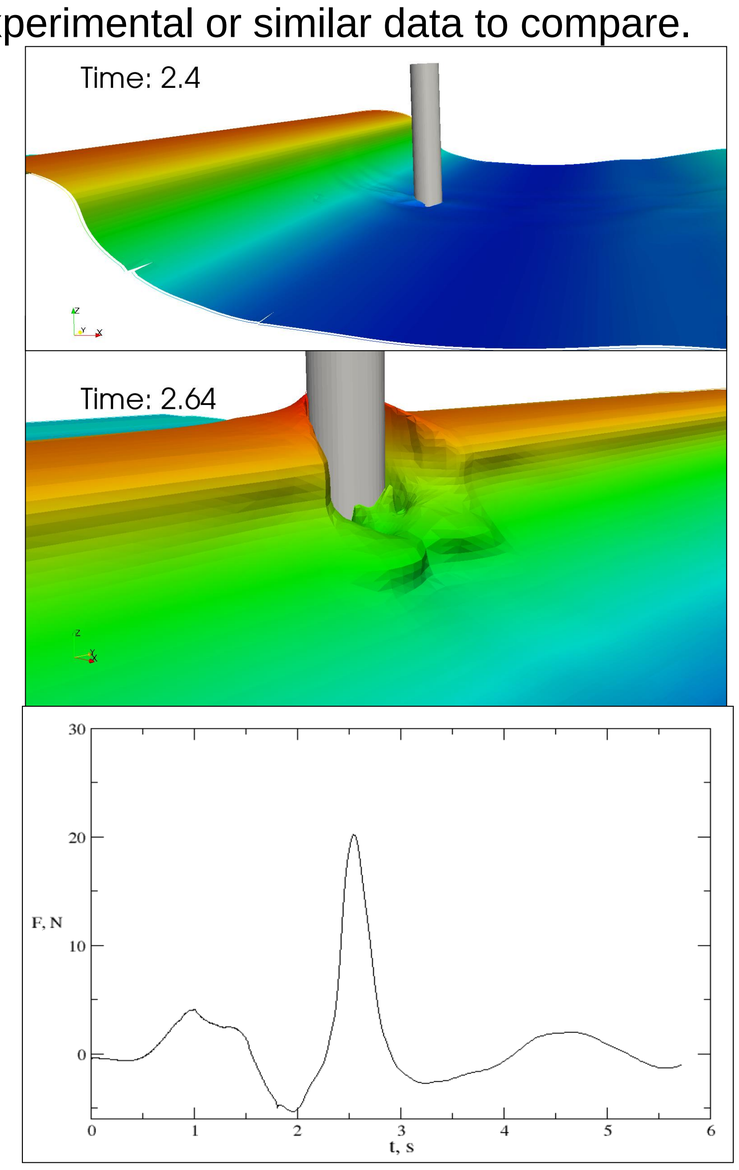
The snapshot in the moment of water impact is shown in figure below. Forces exerted on the column are calculated and compared to experimental results.The comparison is shown in graph below. Both simulations offer excellent agrement in the first force peak, while second negative peak is not well presented by the Volume of Fluid simulation. This is caused by numerical diffusion of volume fraction field after violent effects near the sharp square column edges.





FREAK WAVE SIMULATION

Freak wave is initialized using wave focusing. Figures below show the freak wave in the moment of focusing and in the moment of impact, respectively. Force signal exerted on the cylinder is also shown. There is no experimental or similar data to compare.



Bachelor's thesis
2014.

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