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Laboratory of
Applied
Mathematics and
Mechanics

LES simulation of flow around dam gate section

JASS 2009

March 30 – April 7

St. Petersburg, Russia

Contents

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- 2D case
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  - Results
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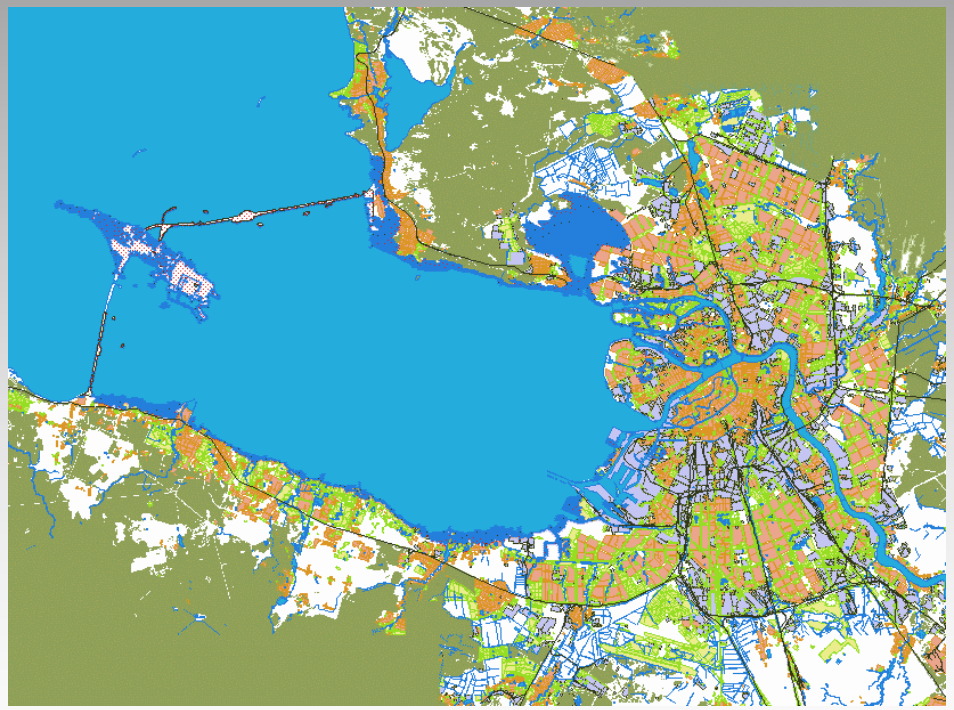
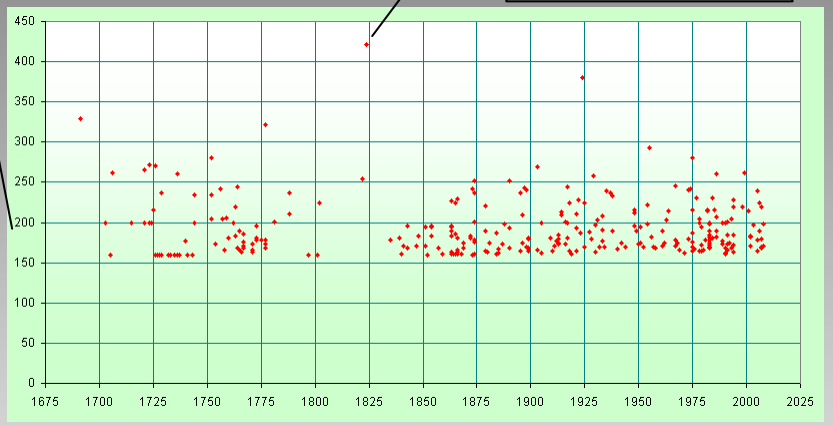
Flood menace for St.Petersburg

Max 4.2 m

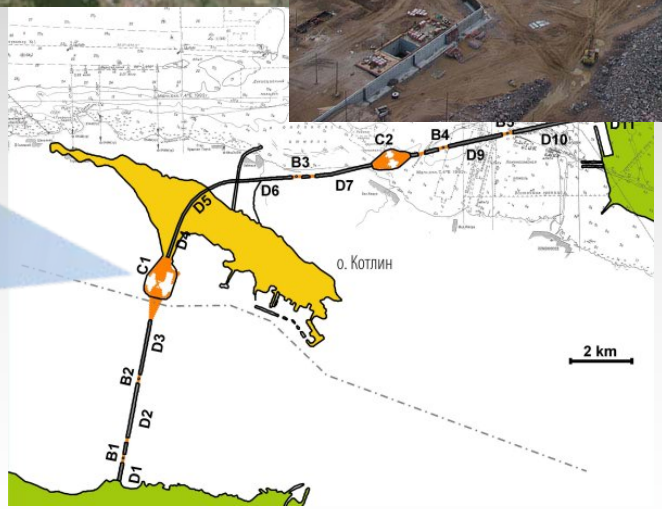
Mean 1.8 m





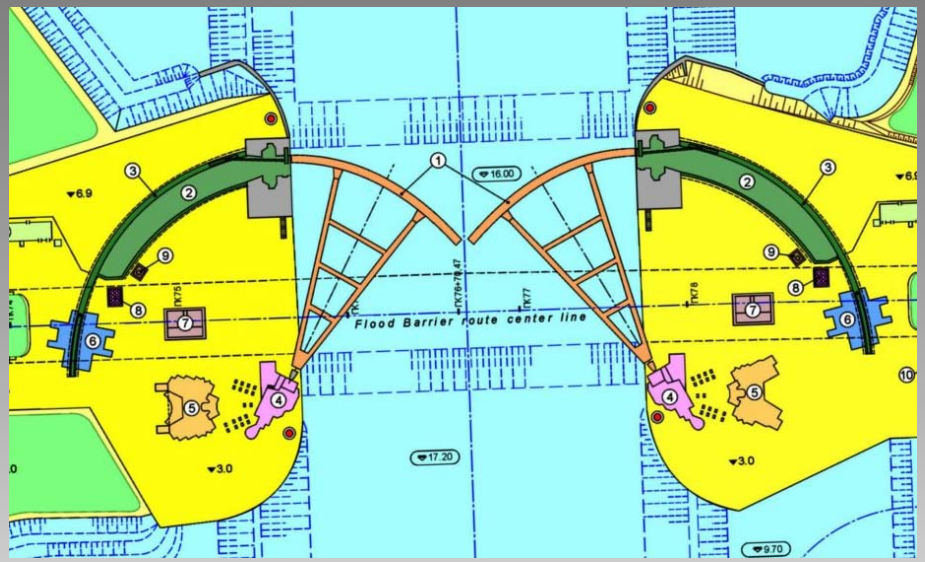
The flood in Saint Petersburg, February 3, 2008

St. Petersburg flood defense system



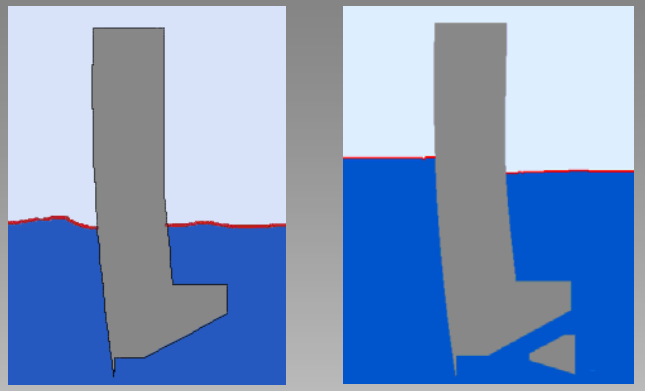
Ship-passing channel C1

Ship passing channel

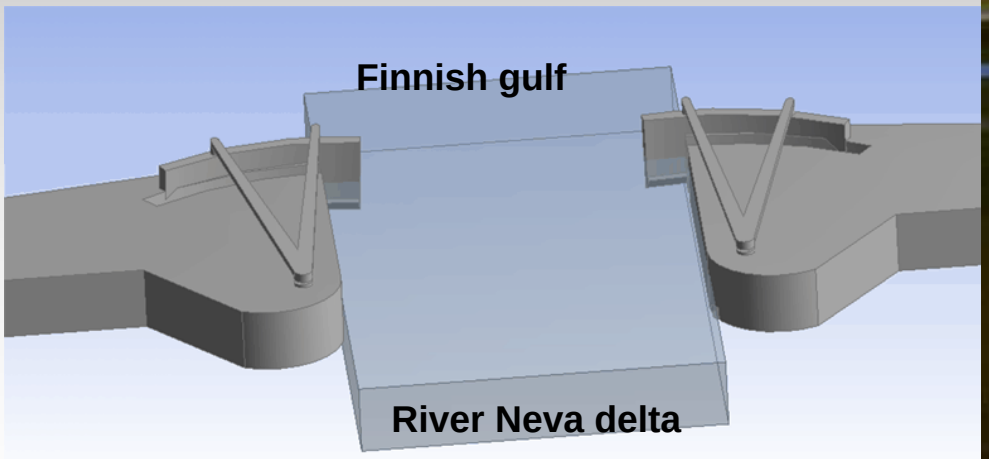


Ship-passing channel scheme

Gate cross section



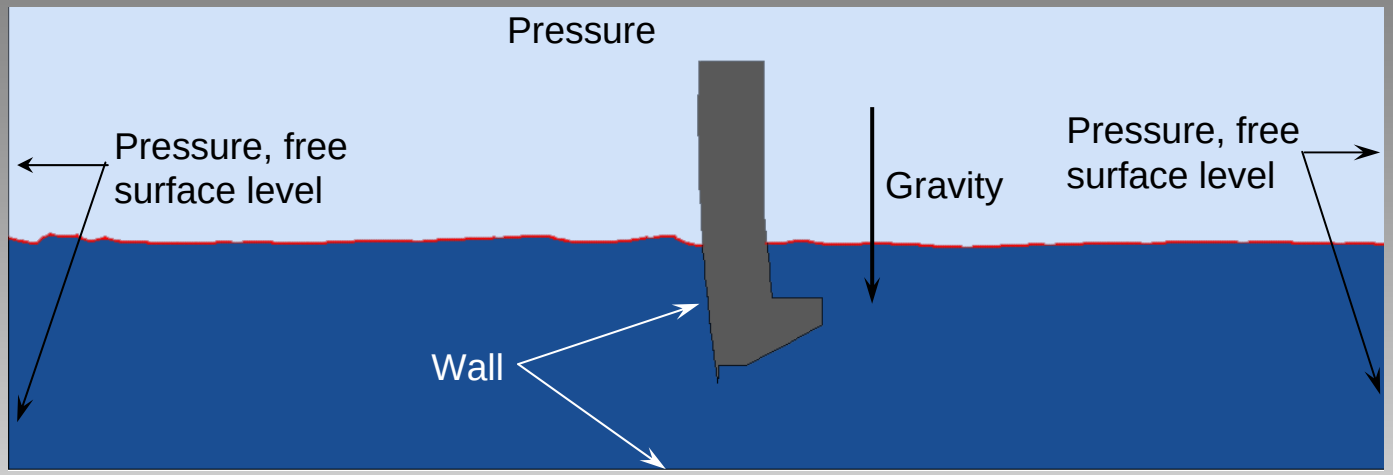
Initial Current

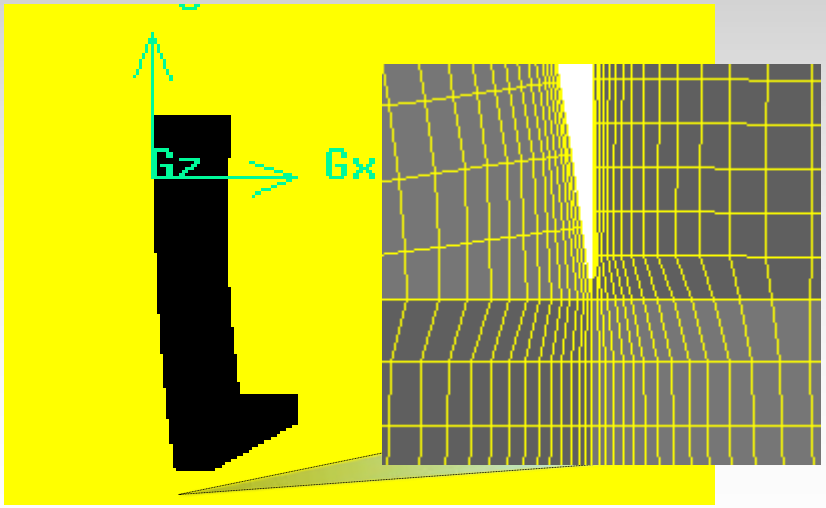


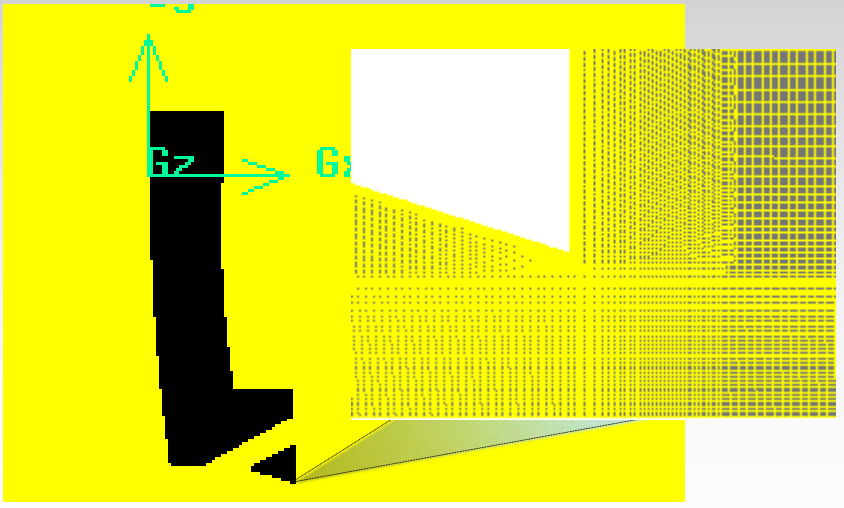
Gate operation

Physical tests with scaled model

Problem statement, 2D case



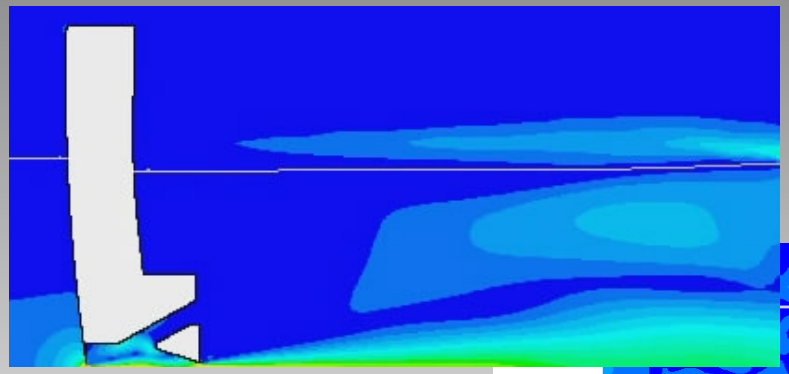




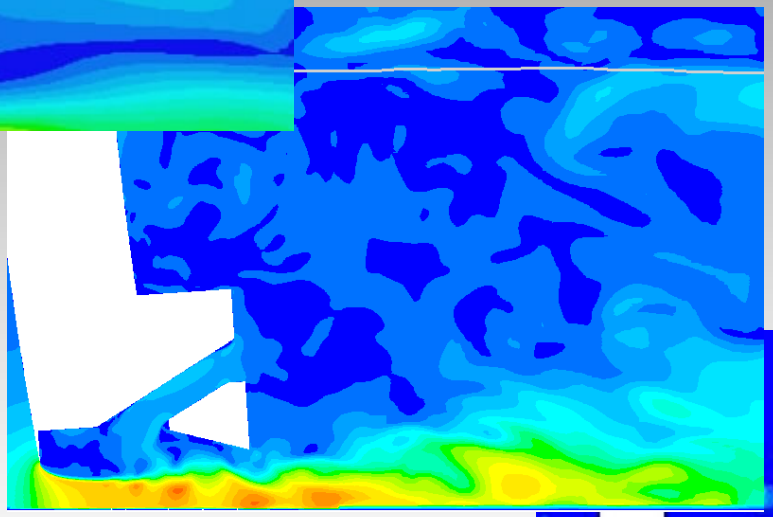
Mesh size: typical – 200-250k cells, up to 800-900k cells

Turbulence model options

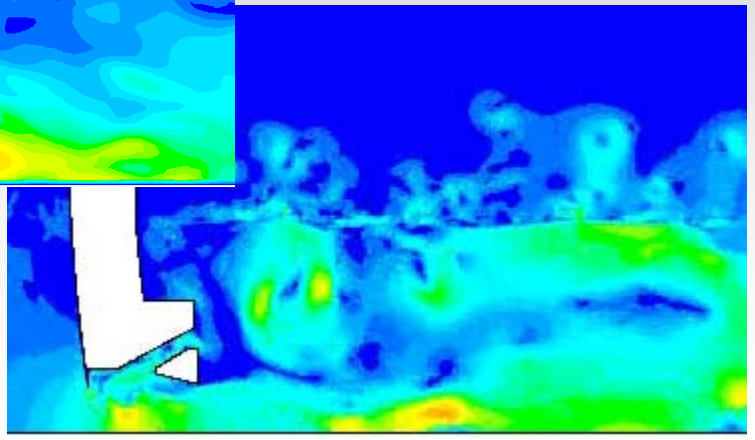
RANS models (standard k-e)



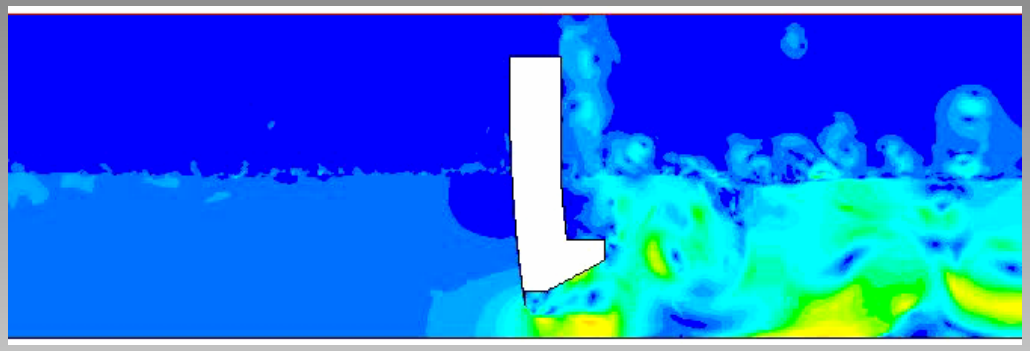
LES (Dynamic SGS)



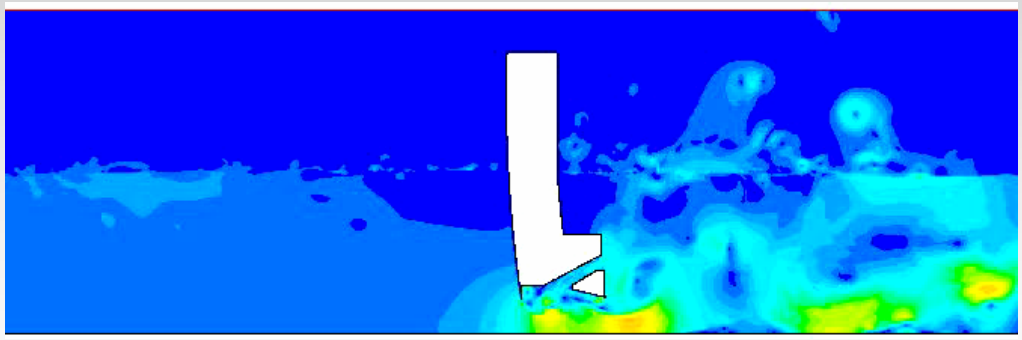
No-model approach



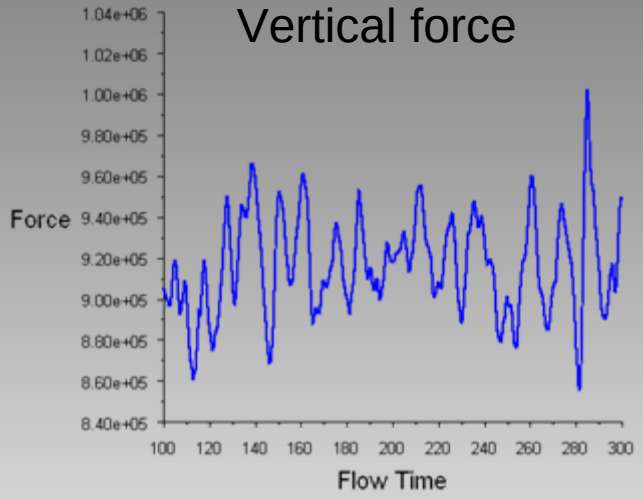
No-model approach

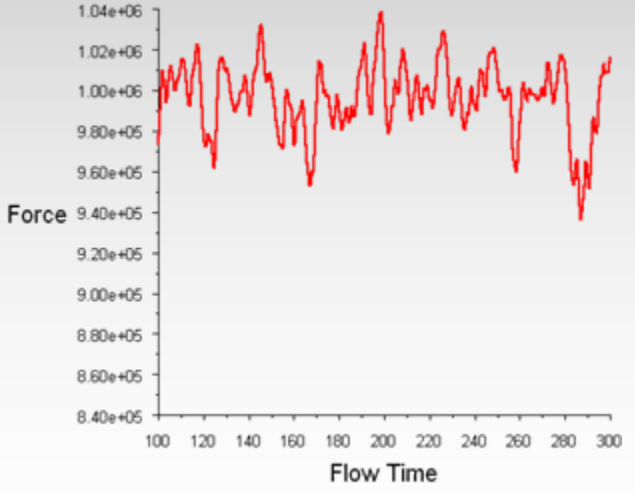


Flow pattern for initial construction

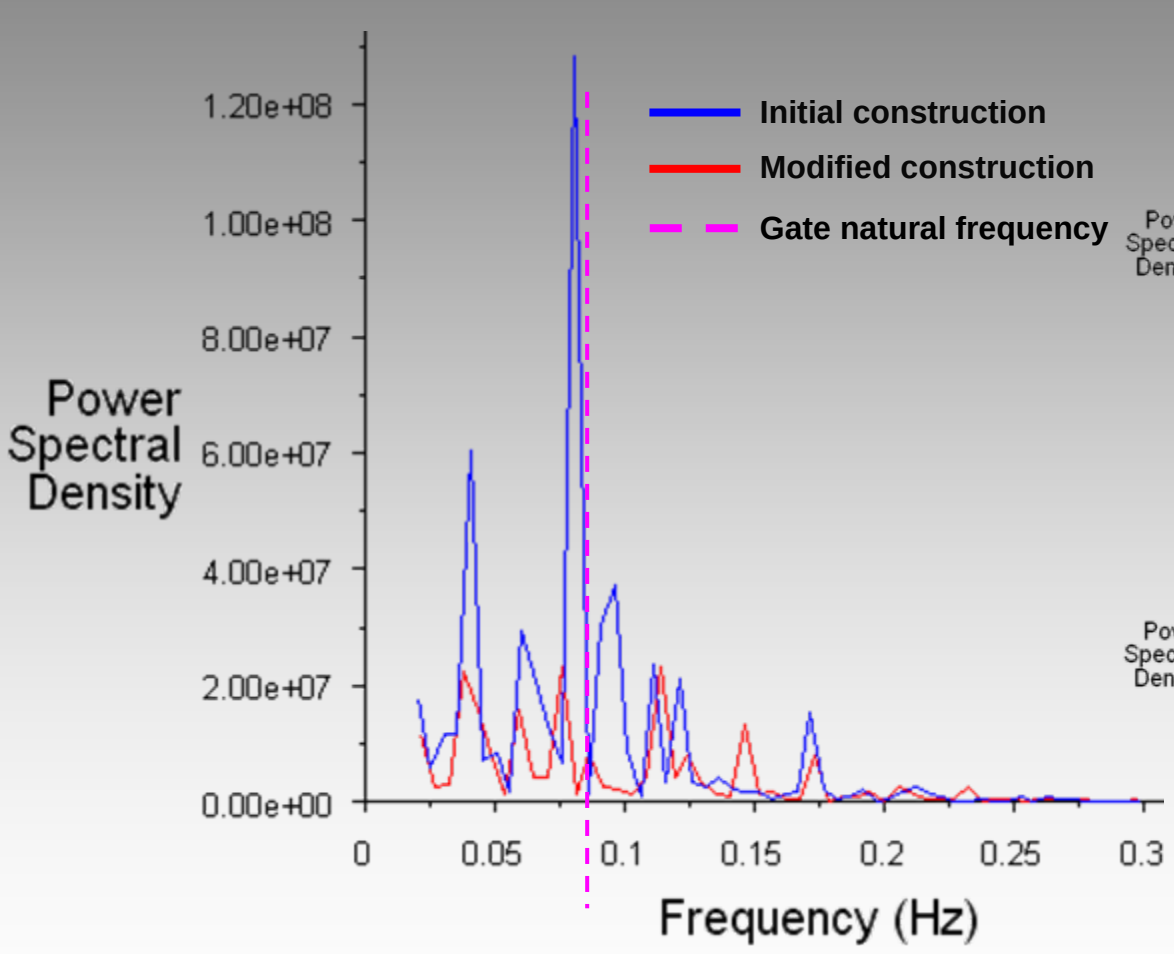


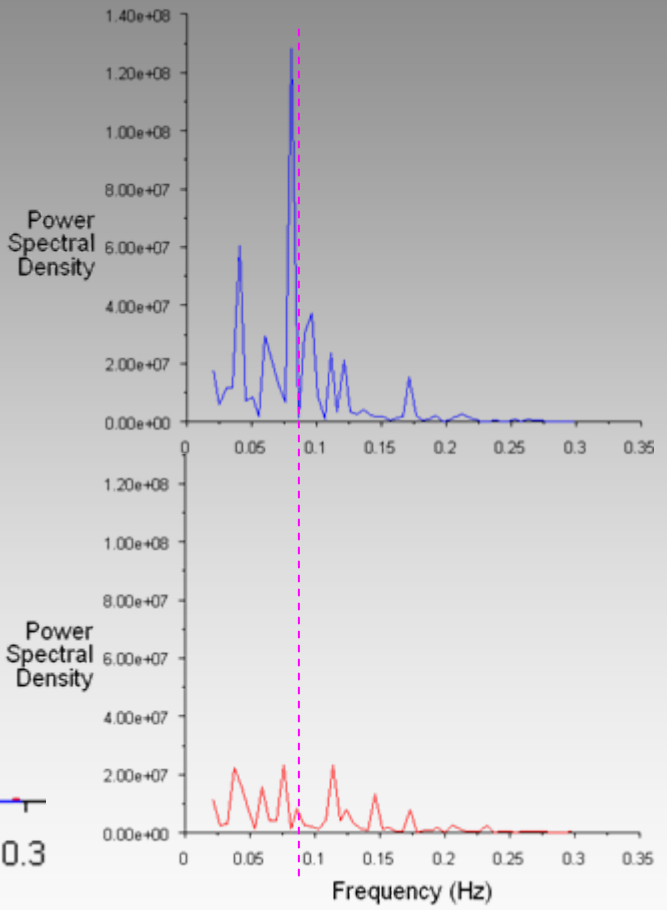
Flow pattern for modified construction





Vertical force FFT





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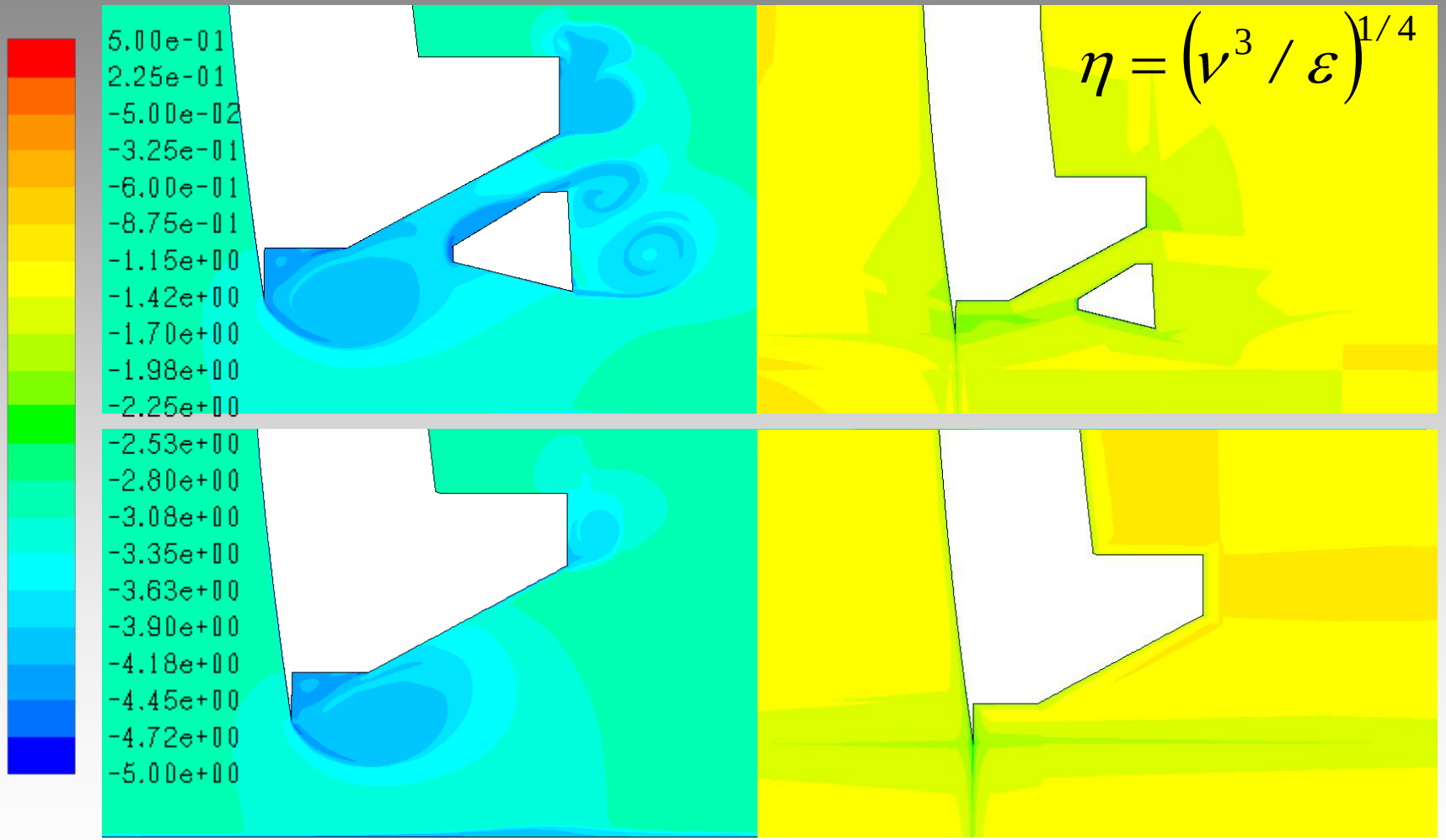
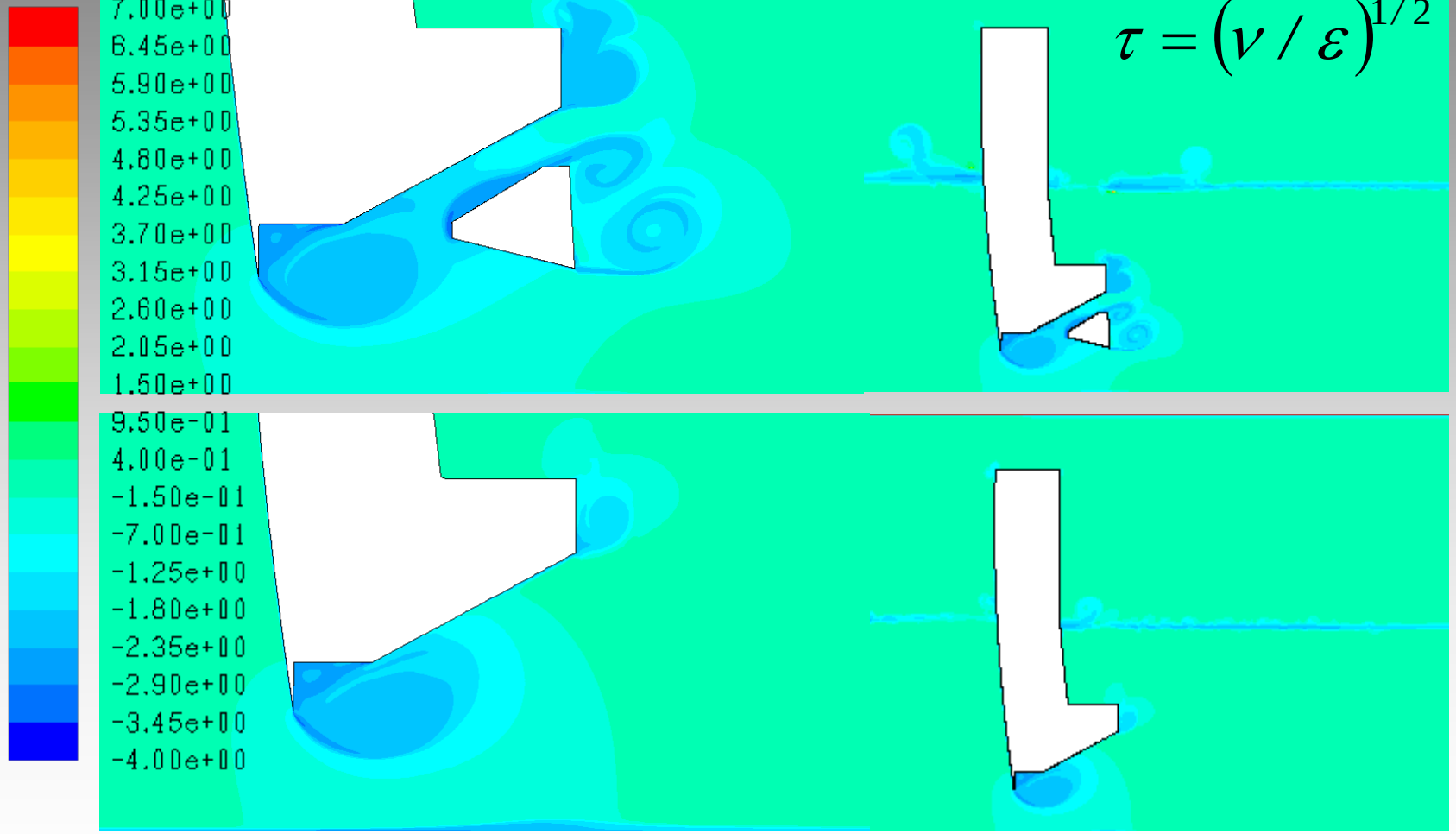
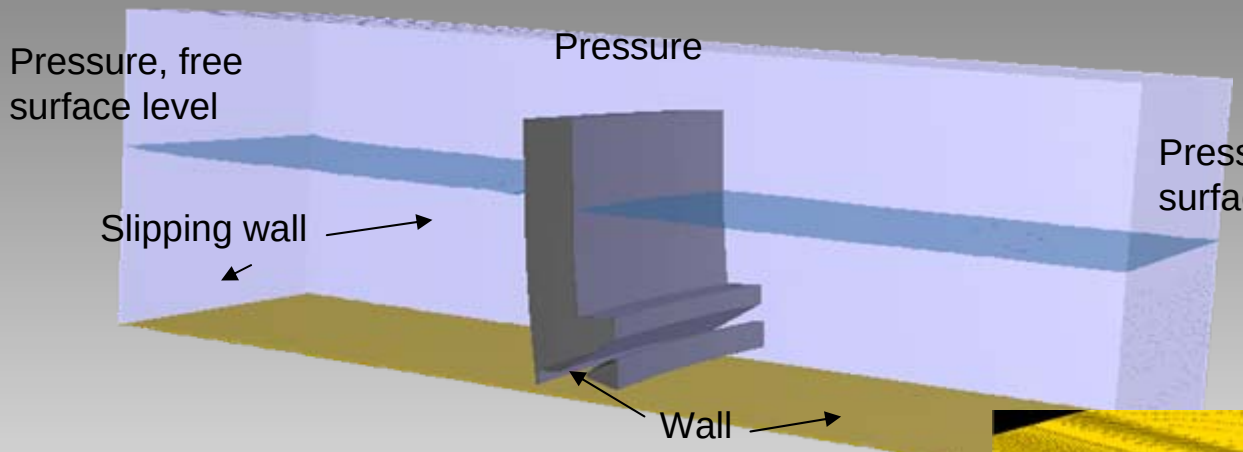
Kolmogorov microscales (length)



Kolmogorov microscales (time)



Problem statement, 3D case

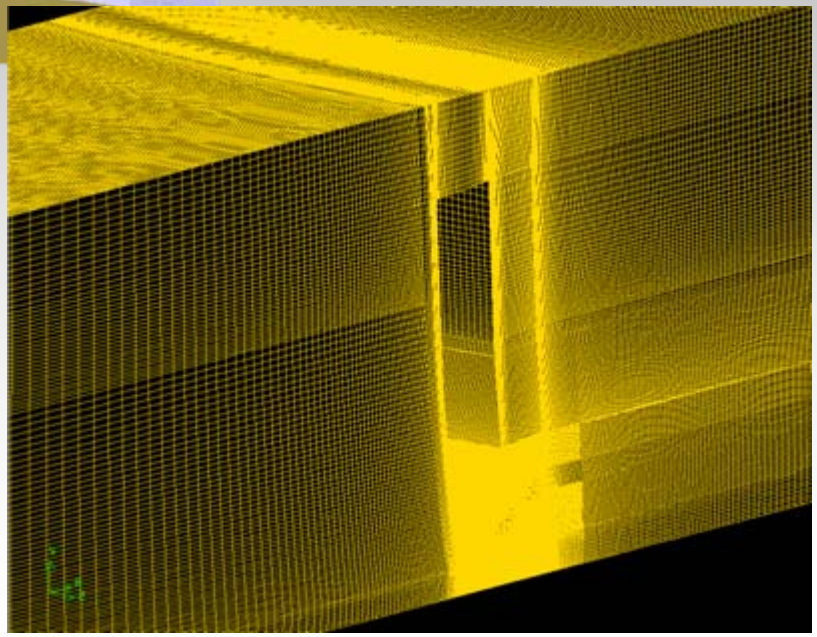


Mesh sizes:

- 8.2-8.5M cells
- 15.2M cells
- 16M cells

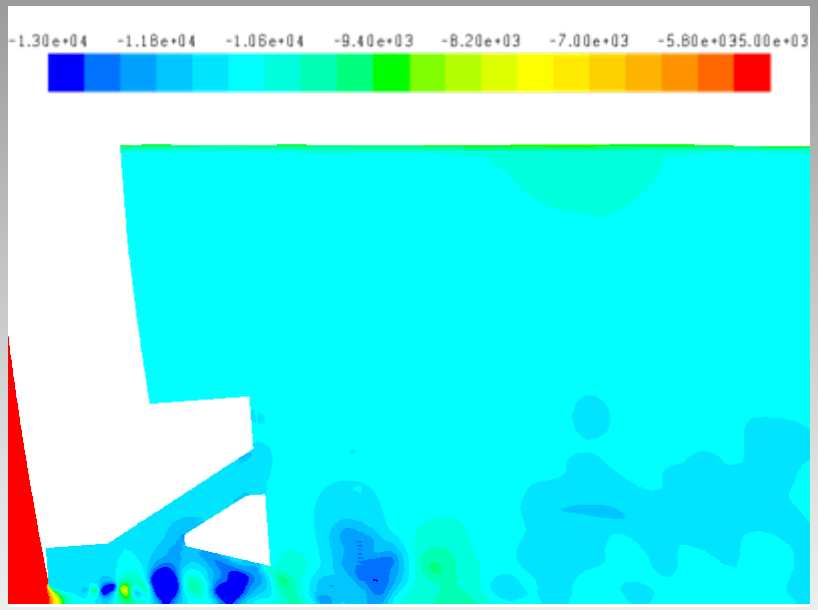
Studied cases:

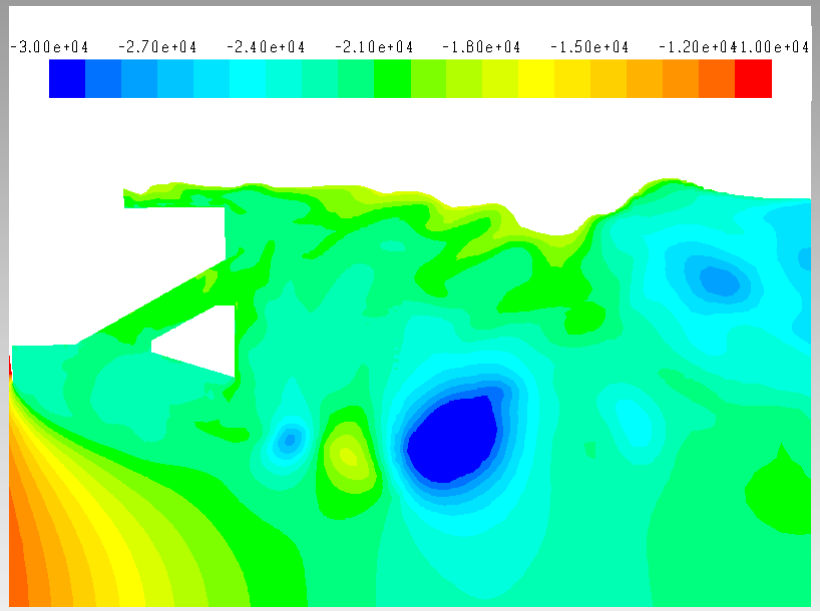
- Distance from gate to bottom:
  - 2, 3, 10 m
- Water level difference:
  - 1, 1.7 m



Flow pattern, pressure

Contours of [static pressure – hydrostatic pressure] on domain middle section





Distance to bottom: 2 m

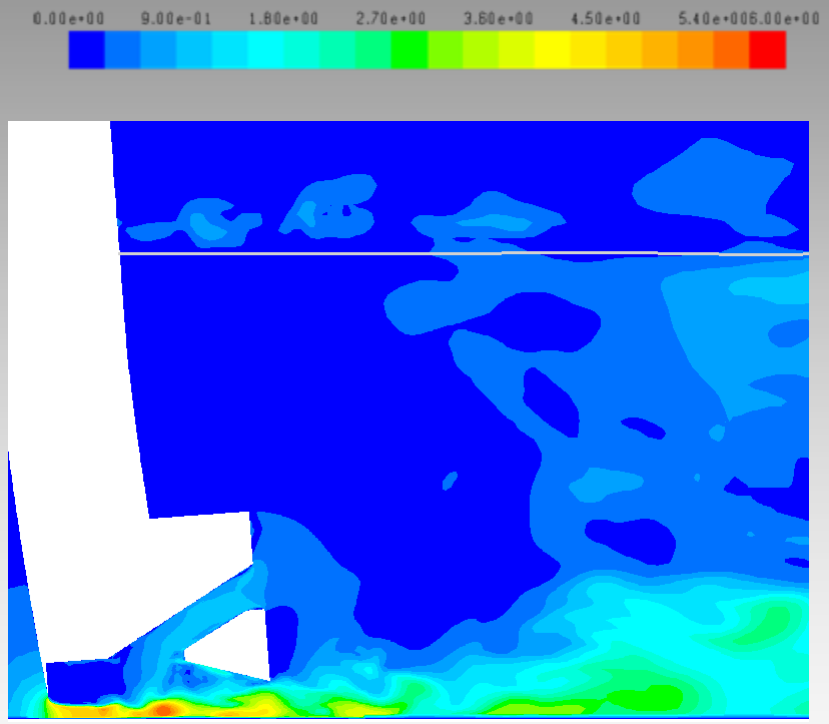
Level difference: 1 m

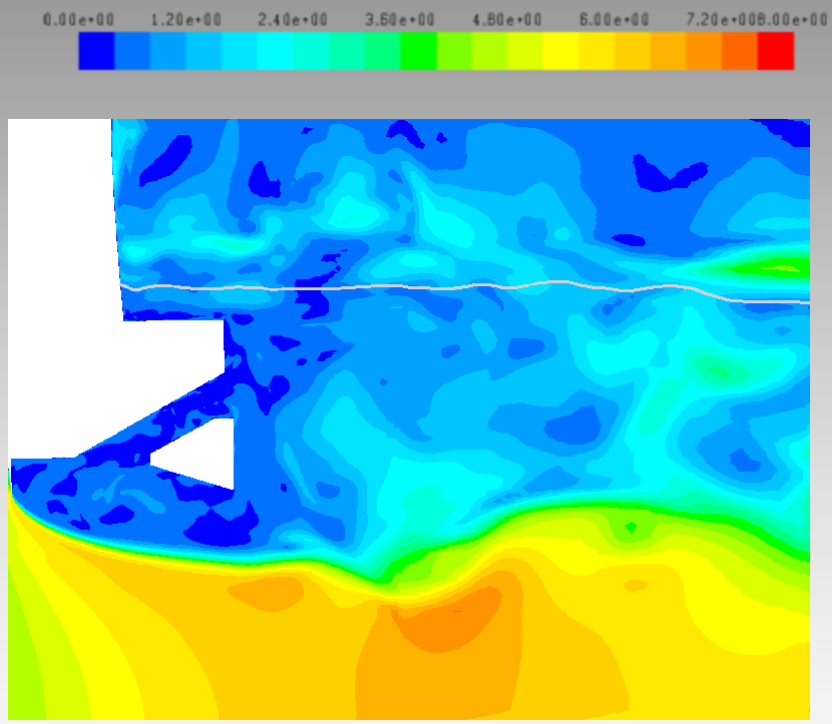
Distance to bottom: 10 m

Level difference: 1.7 m

Flow pattern, velocity

Contours of velocity magnitude on domain middle section





Distance to bottom: 2 m

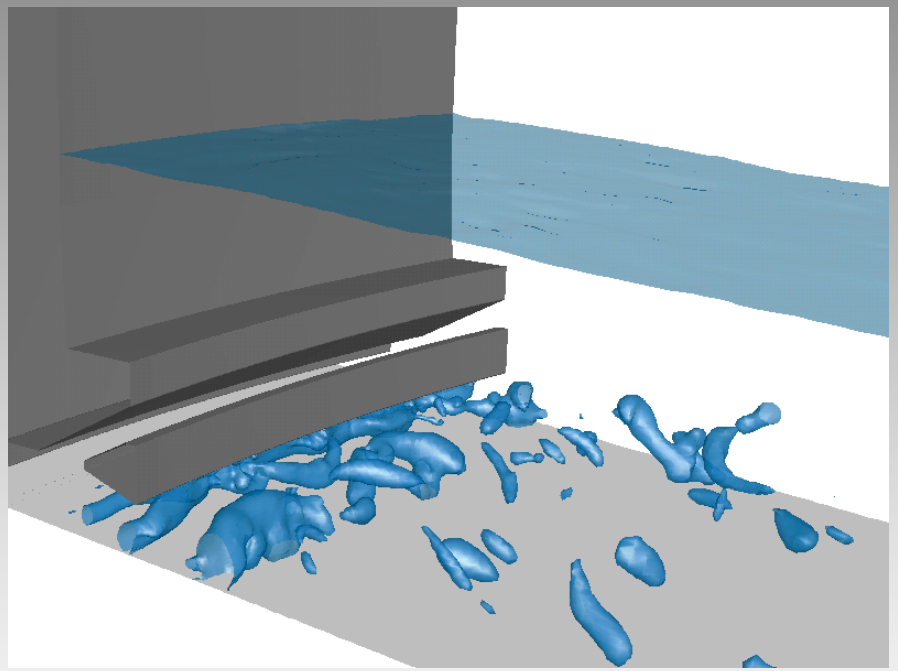
Level difference: 1 m

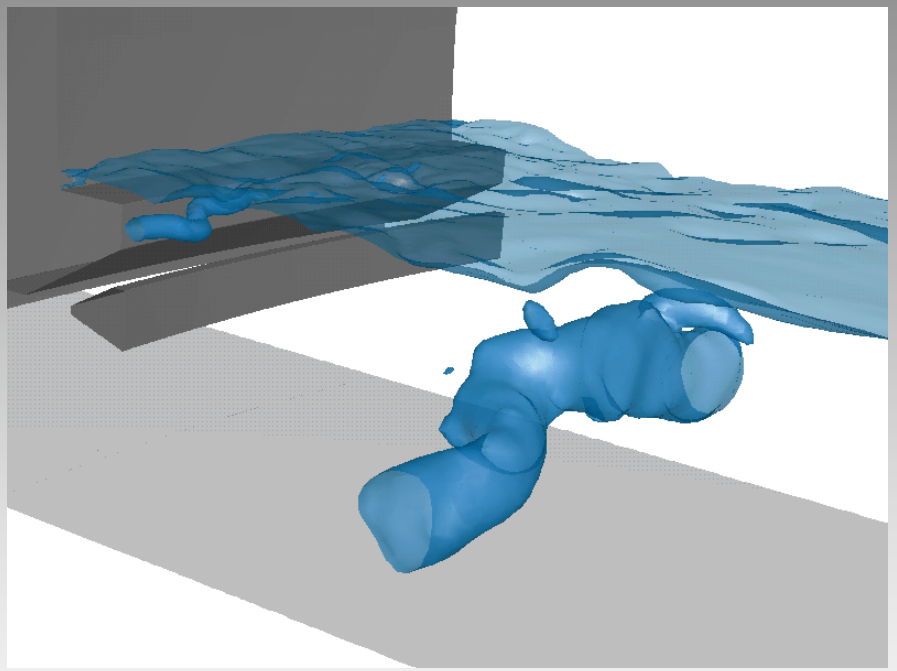
Distance to bottom: 10 m

Level difference: 1.7 m

Pressure isosurfaces

Isosurfaces of [static pressure – hydrostatic pressure]





Distance to bottom: 3 m

Level difference: 1 m

Distance to bottom: 10 m

Level difference: 1 m

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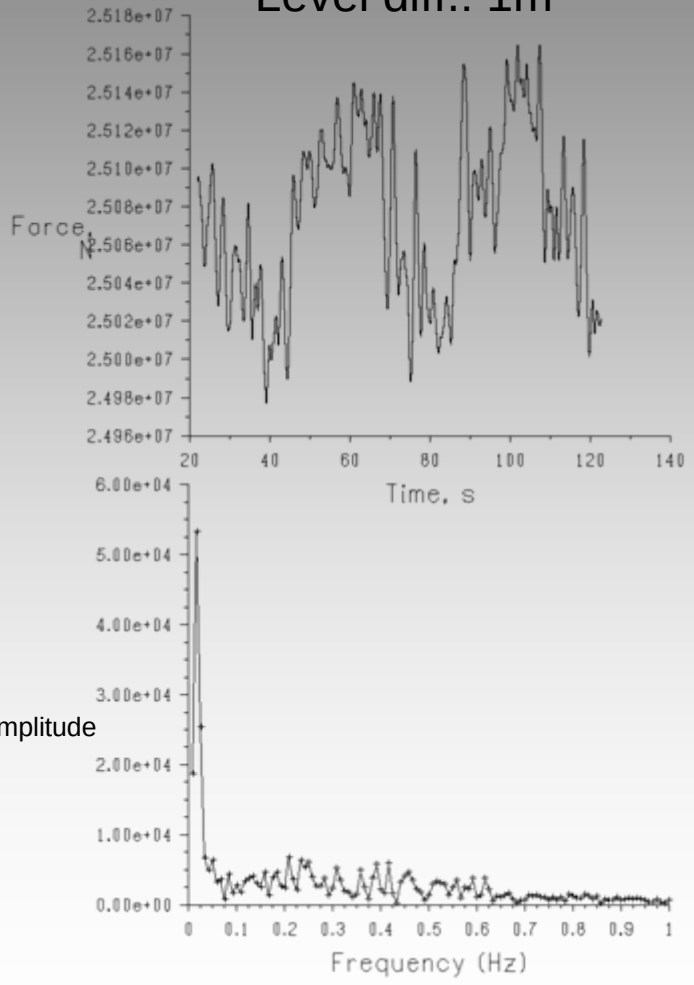
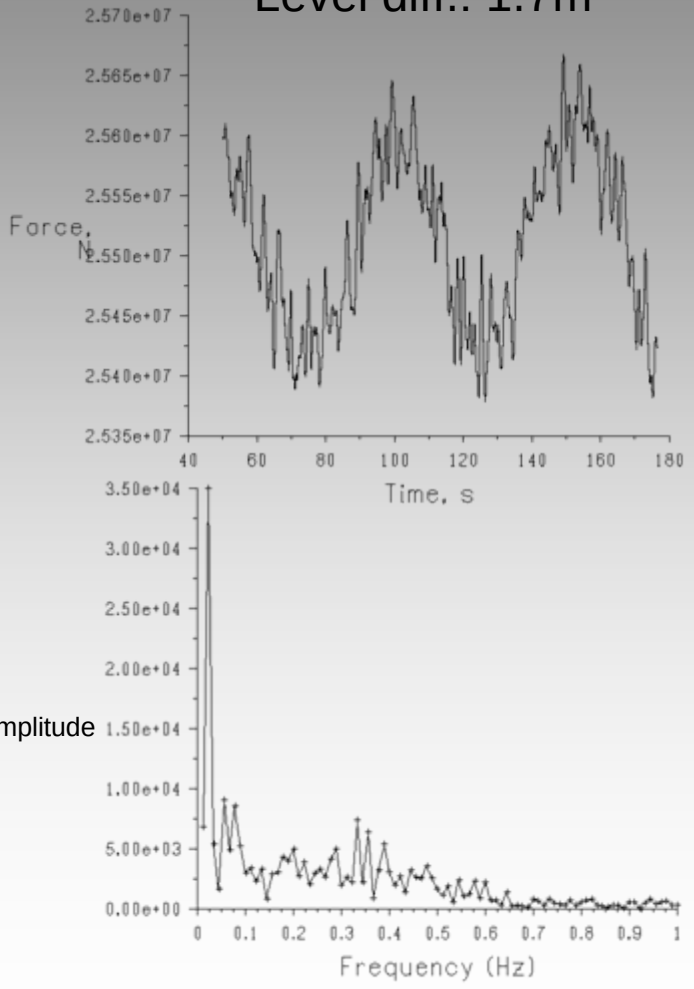
Vertical force, FFT

Distance to bottom: 2 m

Level diff.: 1m



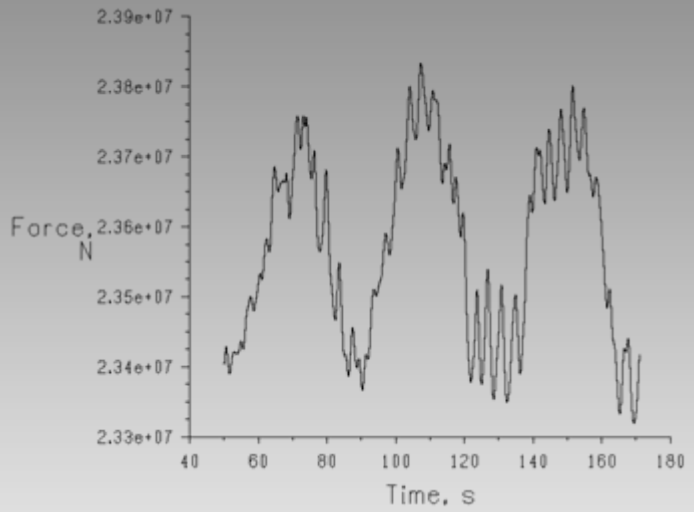
Level diff.: 1.7m

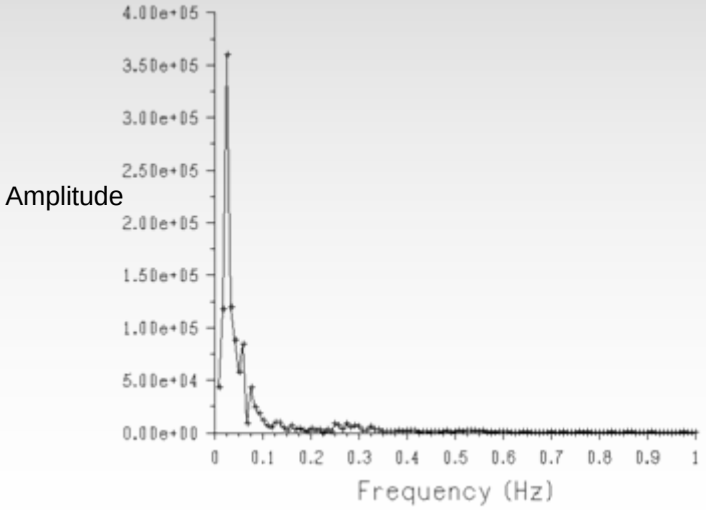


Vertical force, FFT

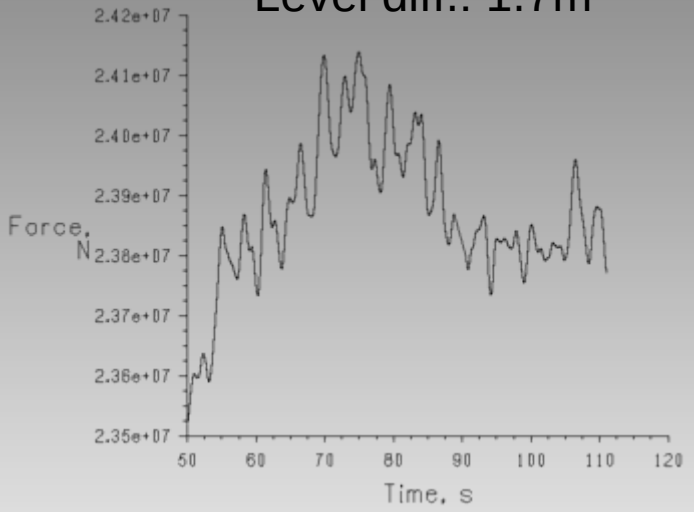
Distance to bottom: 3 m

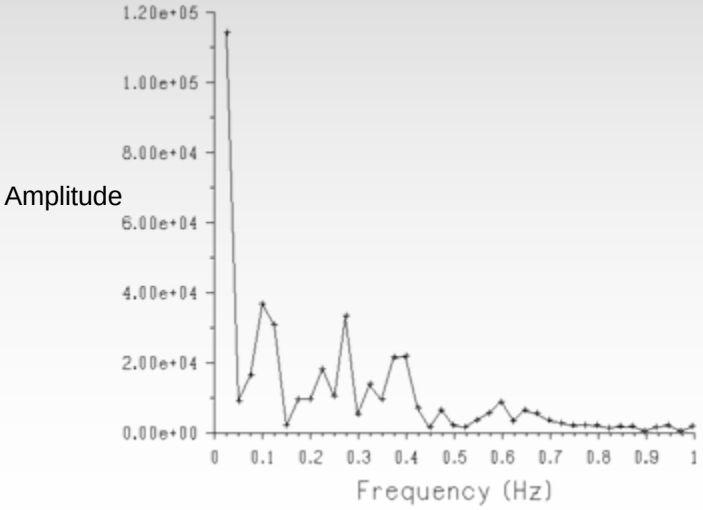
Level diff.: 1m





Level diff.: 1.7m

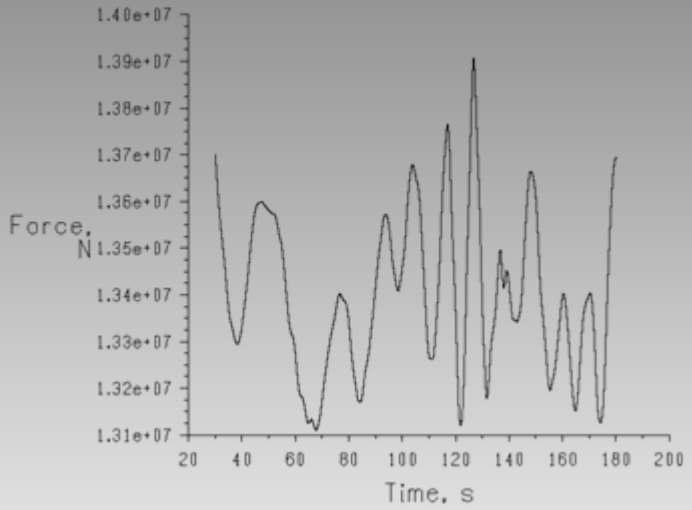


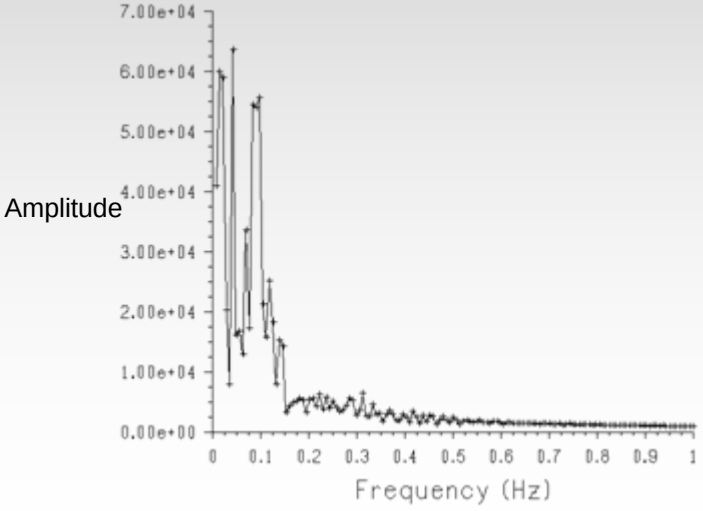


Vertical force, FFT

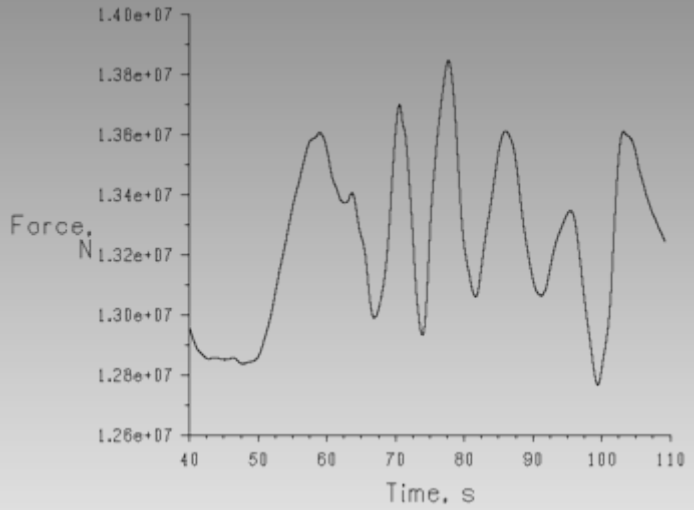
Distance to bottom: 10 m

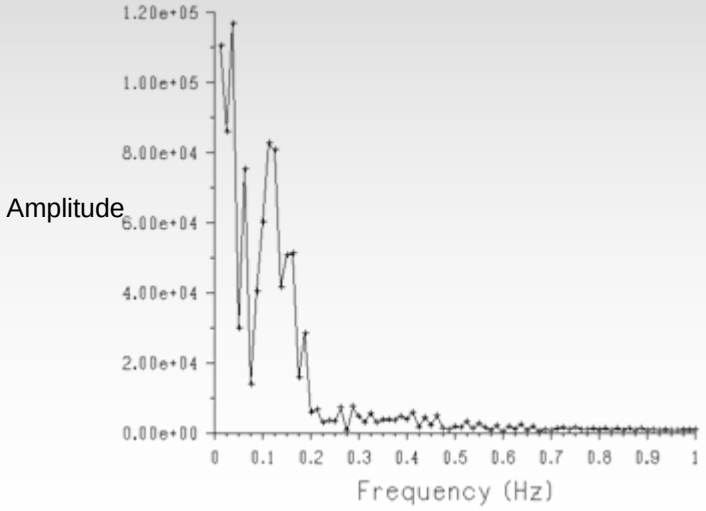
Level diff.: 1m





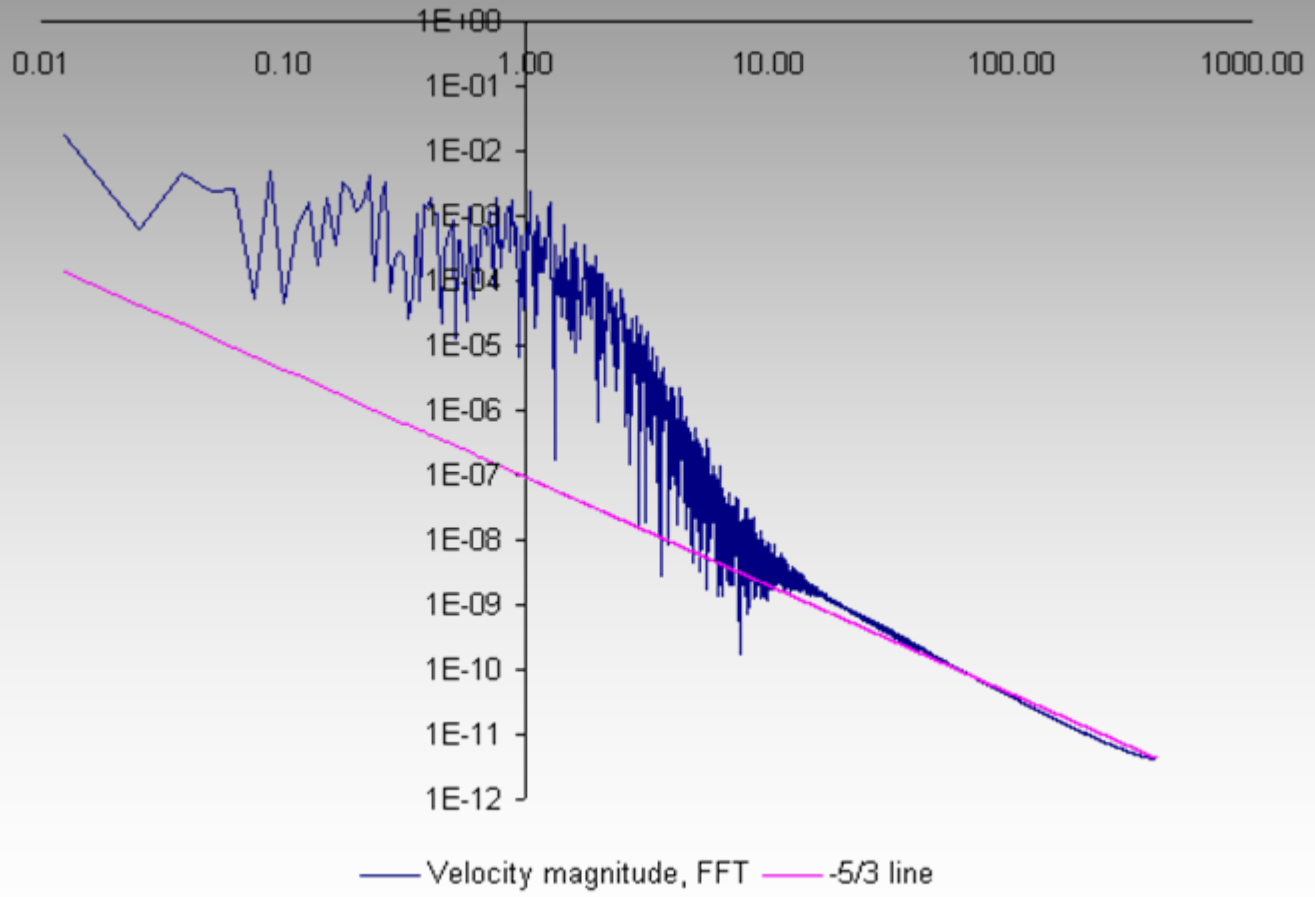
Level diff.: 1.7m



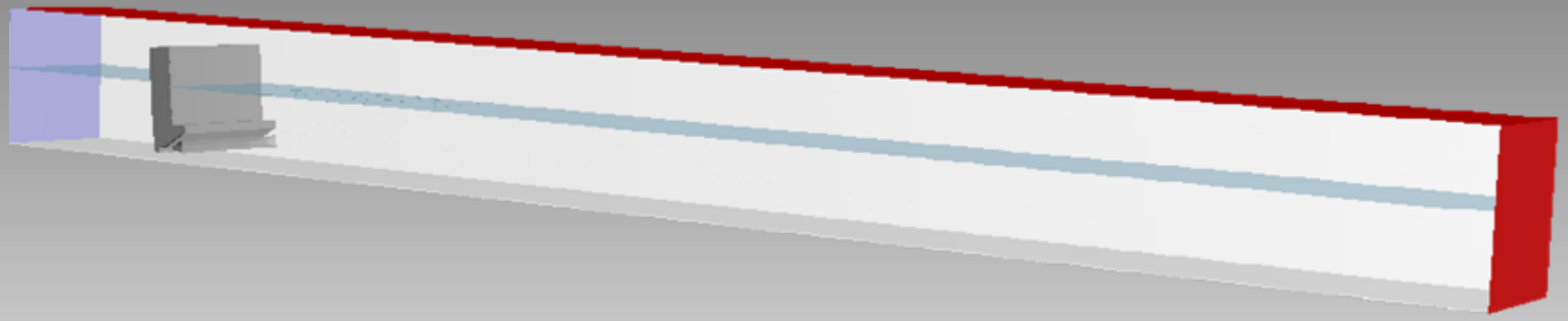


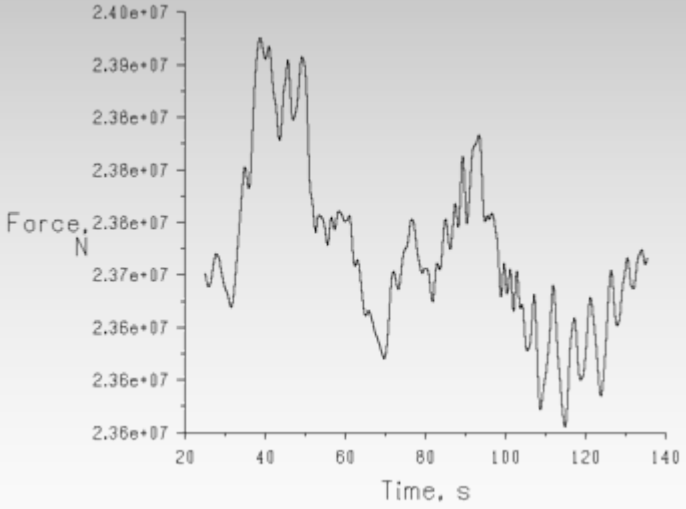
LES simulation correctness

Fast Fourier transform of velocity magnitude at monitor point in log-log scale

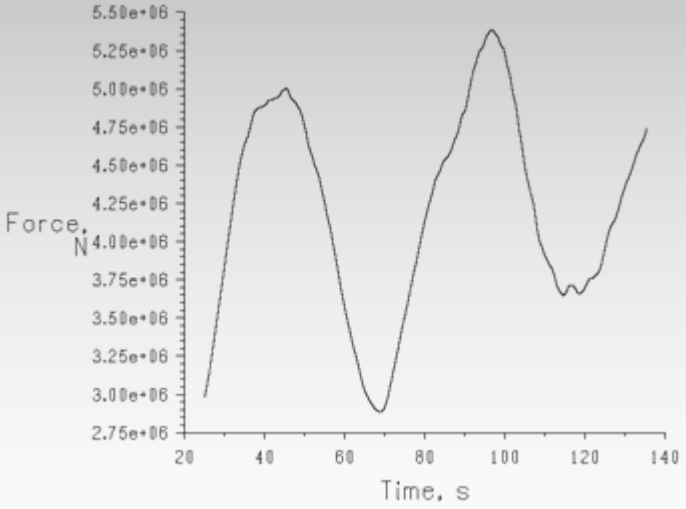


Test case with extended domain





Vertical force component



Horizontal force component

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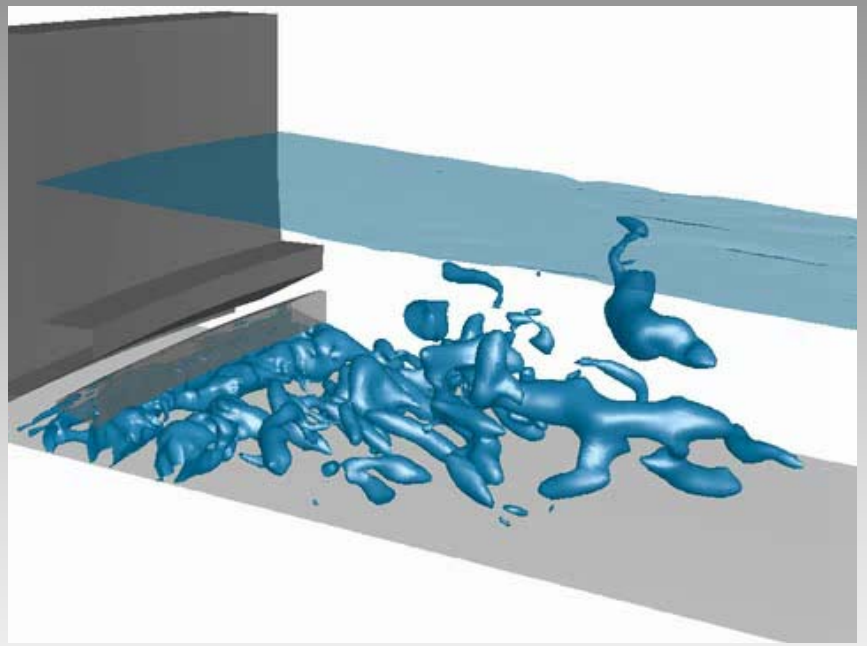
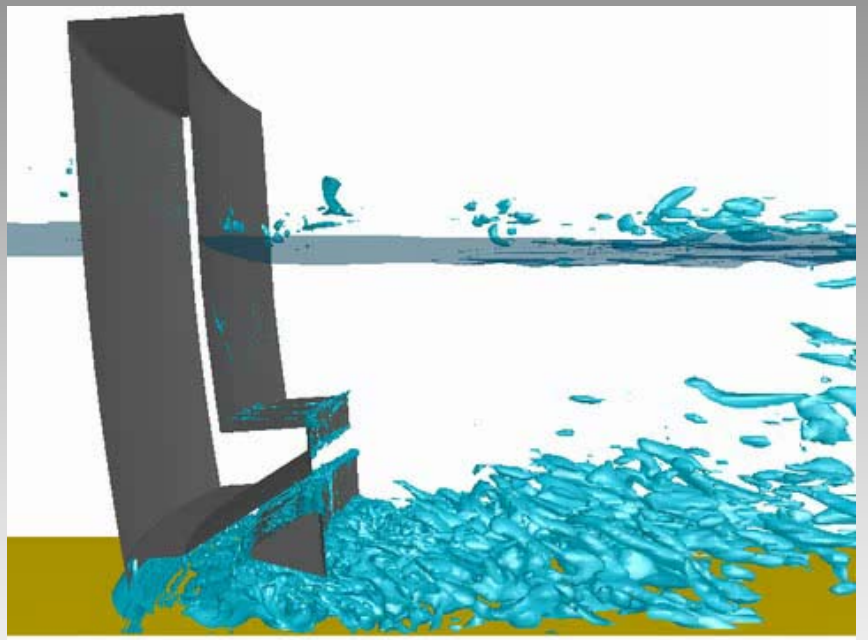
Flow structure



Pressure isosurfaces



S^2-W^2 invariant isosurfaces

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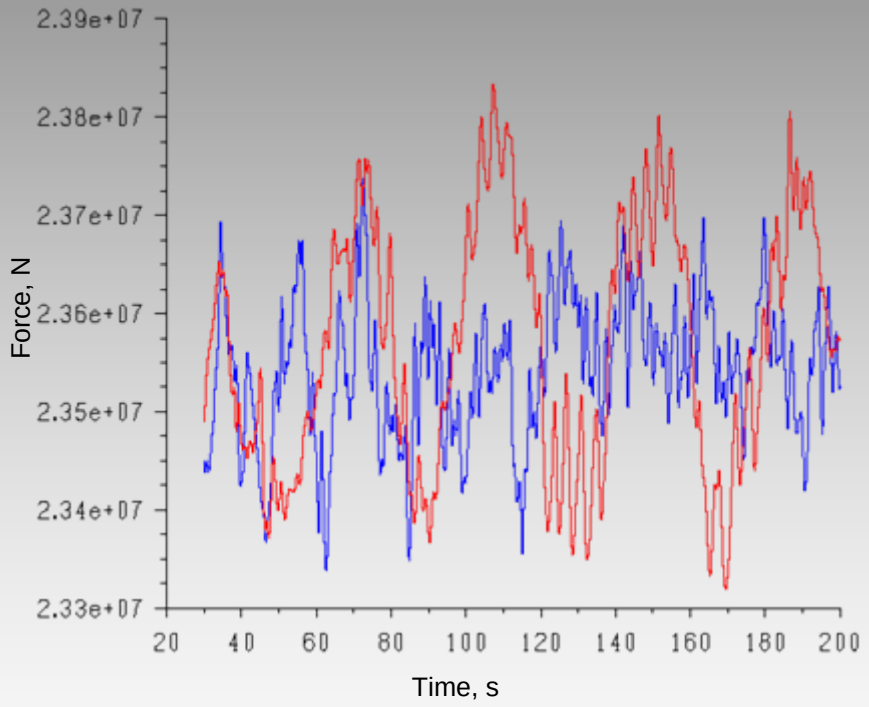
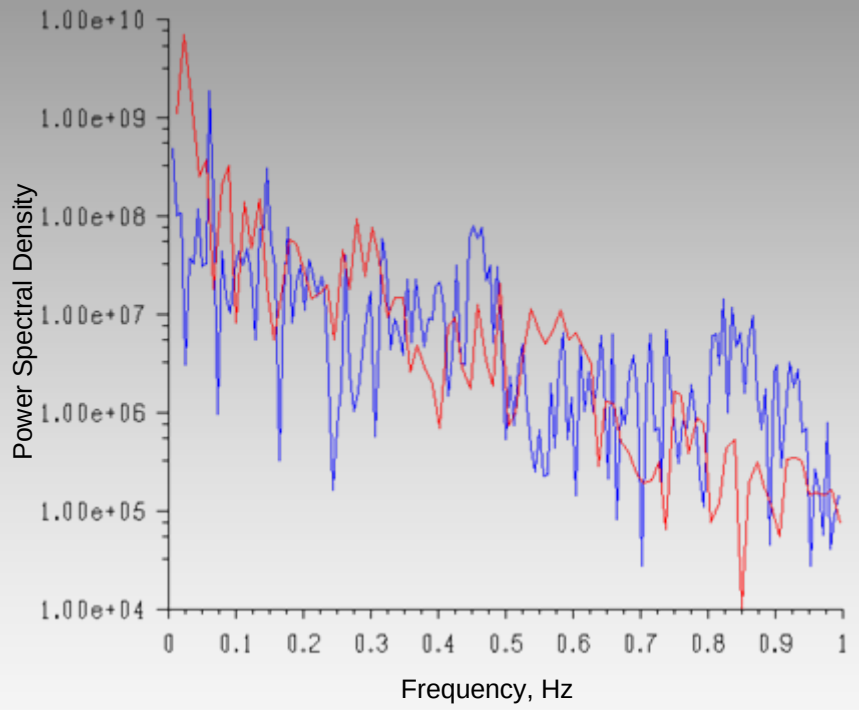
Comparison with scale model

Vertical force (F_y) component



FFT of F_y



Scale (1:30) model **Complete model**

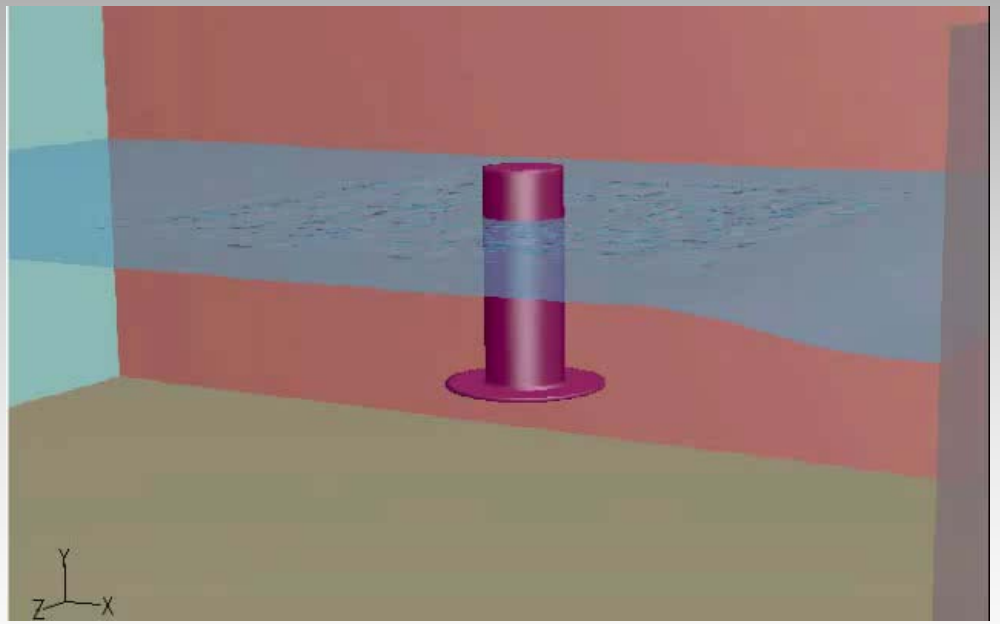
Physical experiment

Scale (1:30) model of gate section

Scale (1:60) model of gate and ship passing channel

Future activity

- Simulation of free motion of gate
- Study of wave load influence



Simplified model of oil platform under wave load

Collaboration with Microsoft

Work supported by Microsoft Research program.

Thank you!