34th PIANC WORLD CONGRESS
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CANAL DE PANAMÁ

LEVELLING THE NEW SEA LOCKS IN THE NETHERLANDS; INCLUDING THE DENSITY DIFFERENCE

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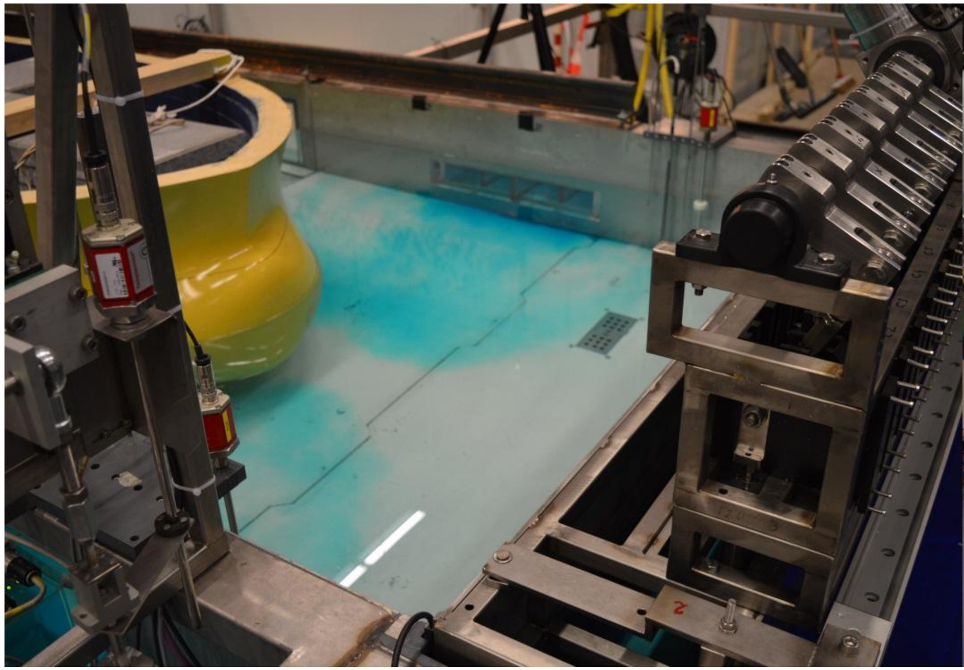
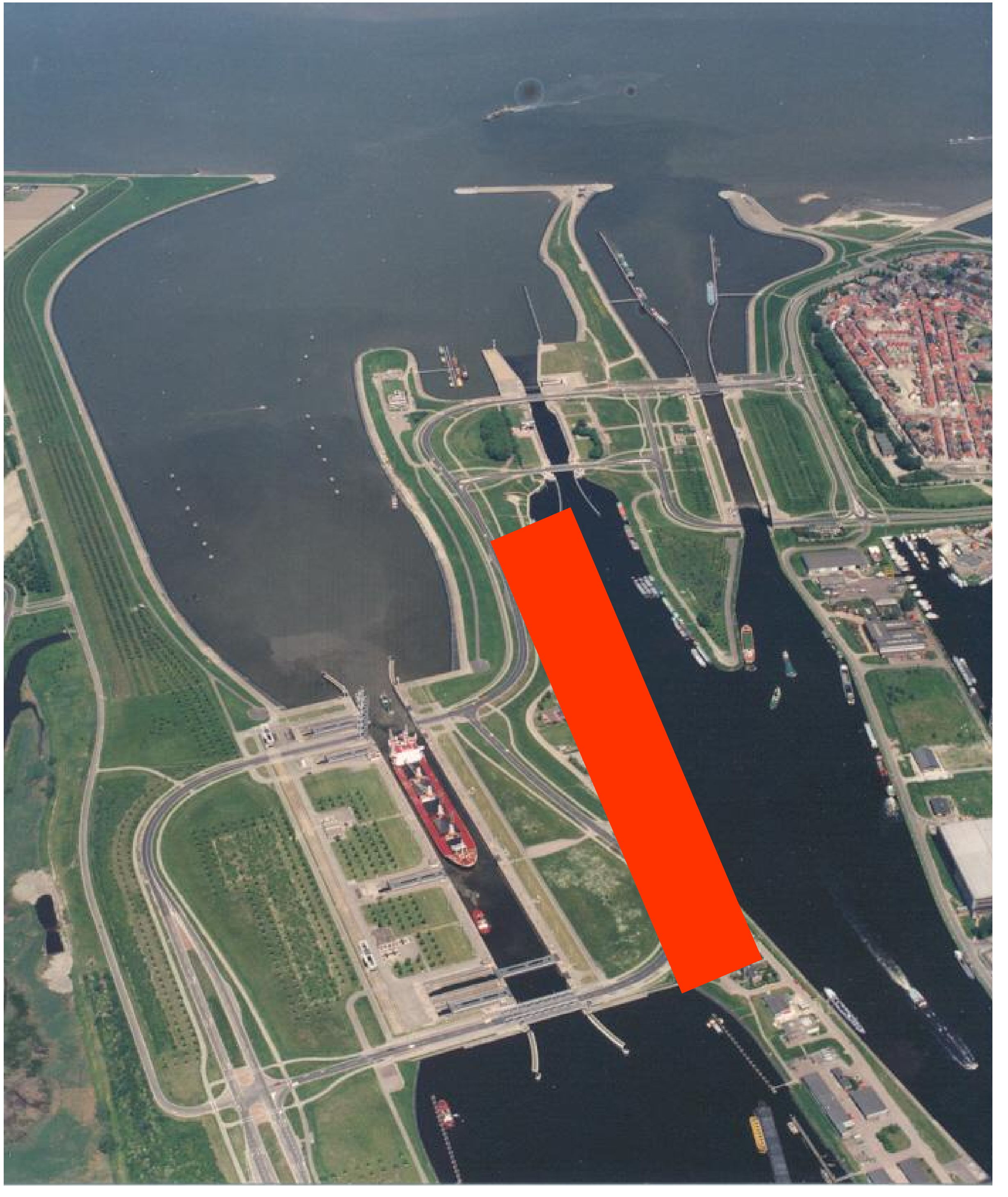


North Sea - IJmuiden Locks – Canal

North Sea
Western Scheldt Estuary

Terneuzen Locks

Ghent-Terneuzen Canal

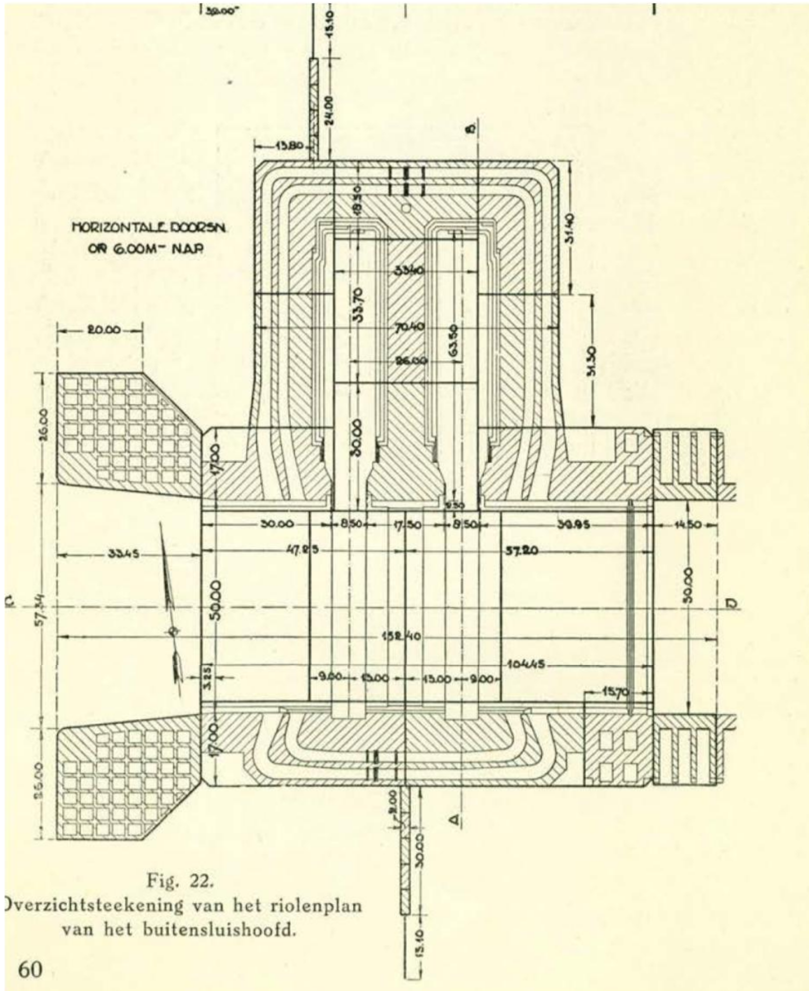


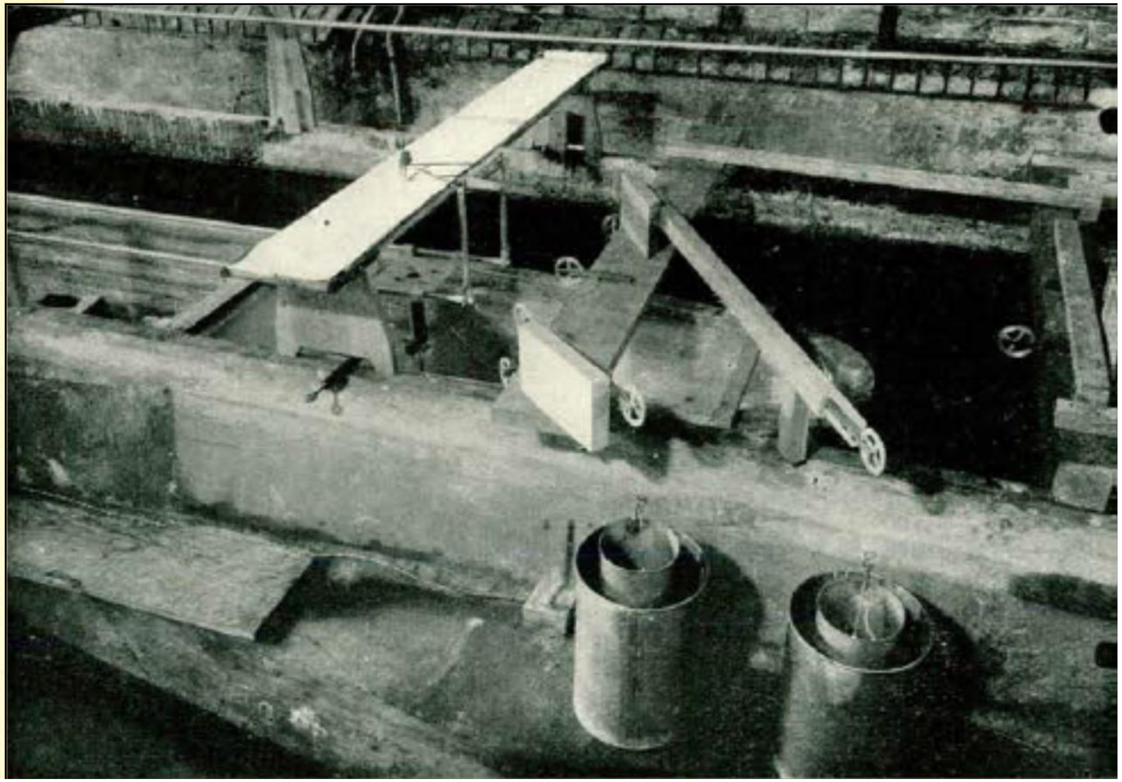
IJmuiden North Lock (1929), 400x50x15m^3

Mean spring tide Δh = - 0.3 m ⇔ 1.6 m

Short culverts in lock heads

~~gate openings~~

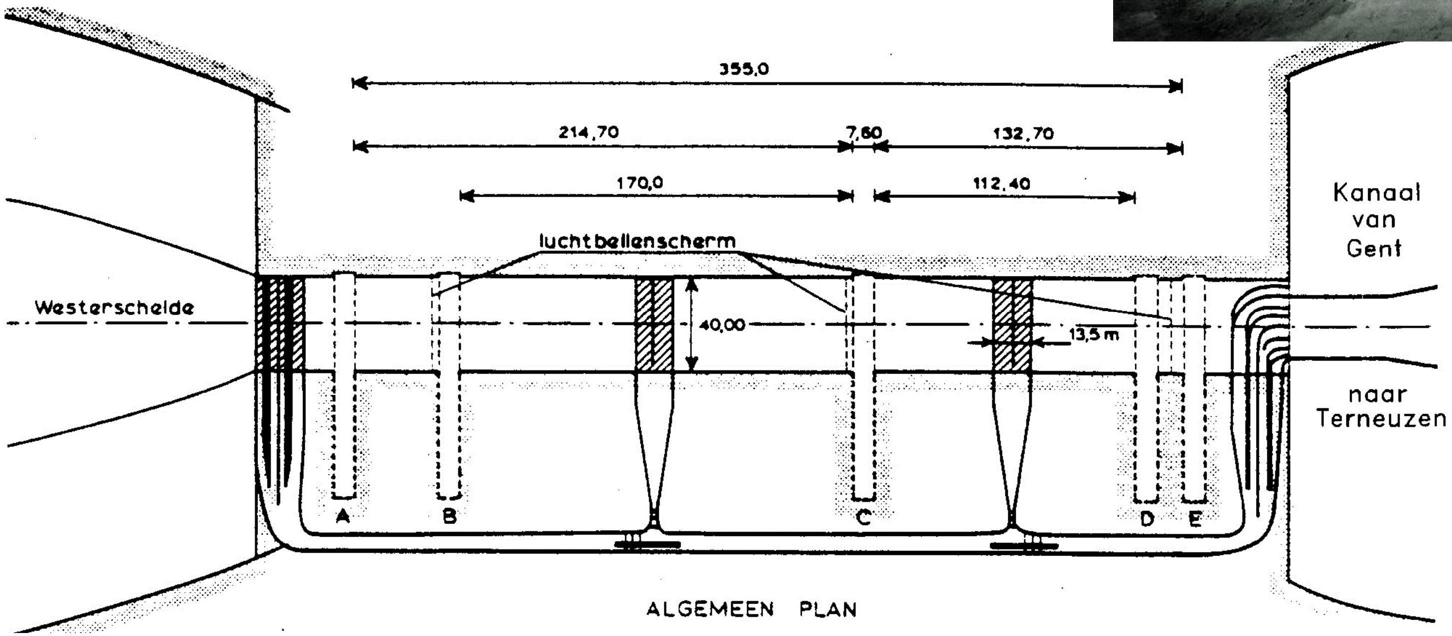




Terneuzen West Lock (1965), $355x40x13m^3$

Canal = mean sea level + 2.1 m
Mean spring tide Δh = - 4.3 m ⇔ 0.6 m

Longitudinal filling system to reduce translatory waves and density currents



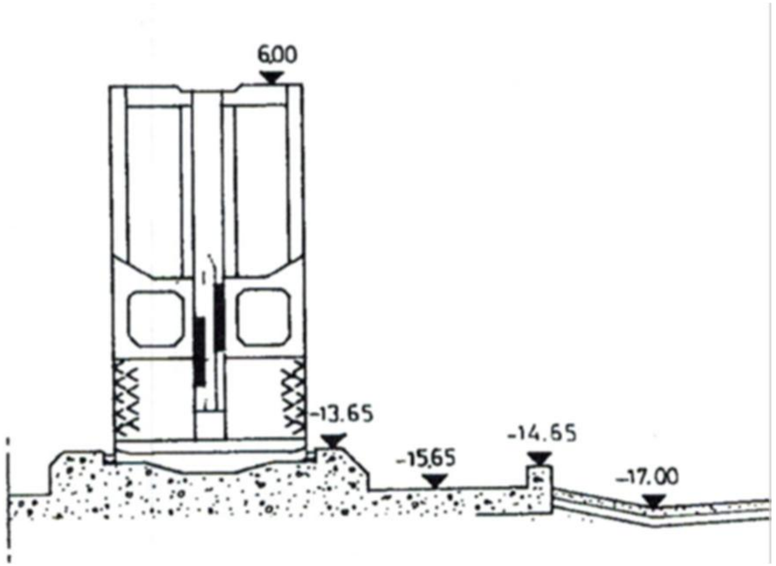
Design Approach

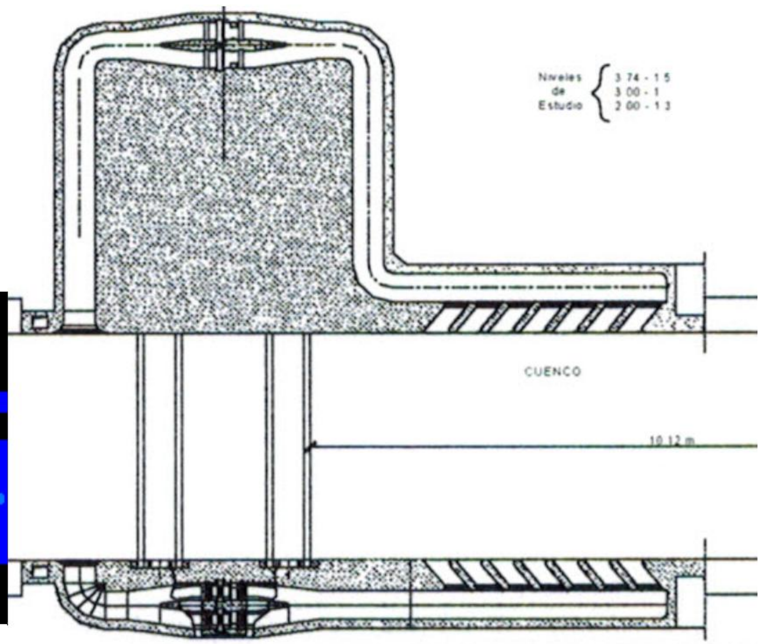
Type of levelling system

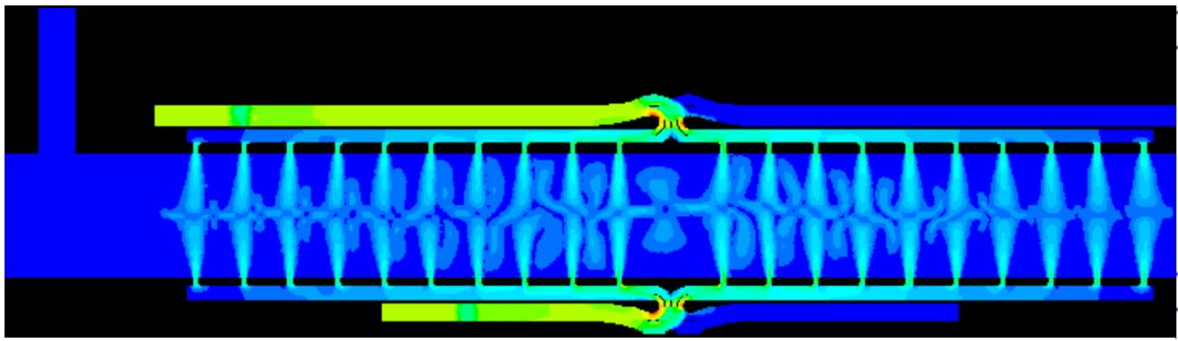
- Through-the-gate or short culverts
- Longitudinal system

IJmuiden   daily Δh = 1.4 m
Terneuzen daily Δh = 4 m

through-the-gate/short culverts







Design Approach

Dimensions

- Through-the-head

  LOCKFILL: 1-D flow-force model incl. translatory waves, jets, density currents

- Longitudinal system

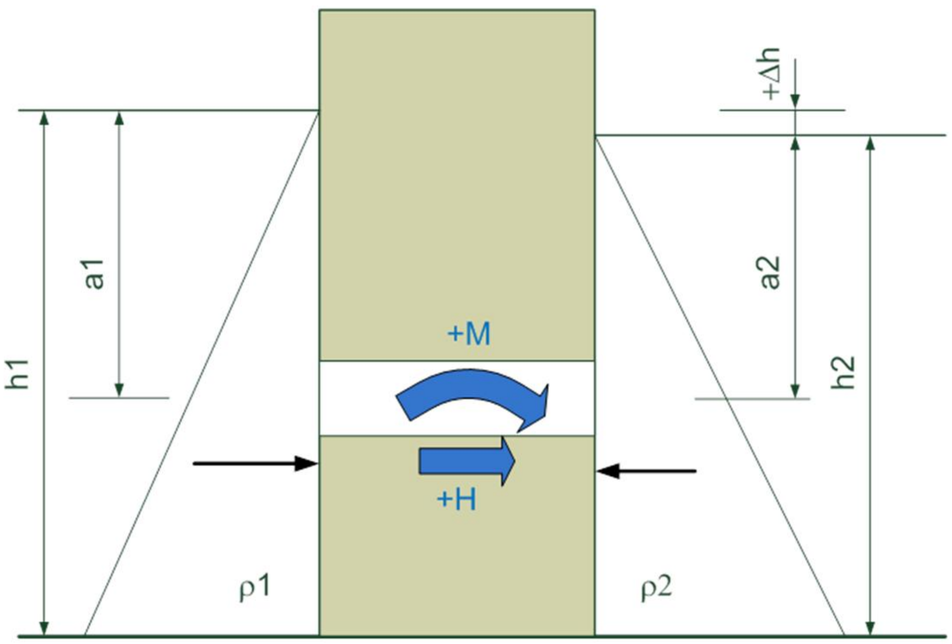
  WANDA: 1-D model for nonstationary flow and pressures in closed conduits (without $\Delta\rho$)

Vertical position

Δh at start of opening gate

Inlets/outlets at half the water depth

Reduction of residual moment, horizontal force on gate, incoming translatory wave



Design Approach

Hydraulic design

Streamlining, shaping using 2-D/3-D CFD incl. turbulence   Stationary flow

- Flow conditions
- Detachment points
- Flow distribution
- Loss coefficients

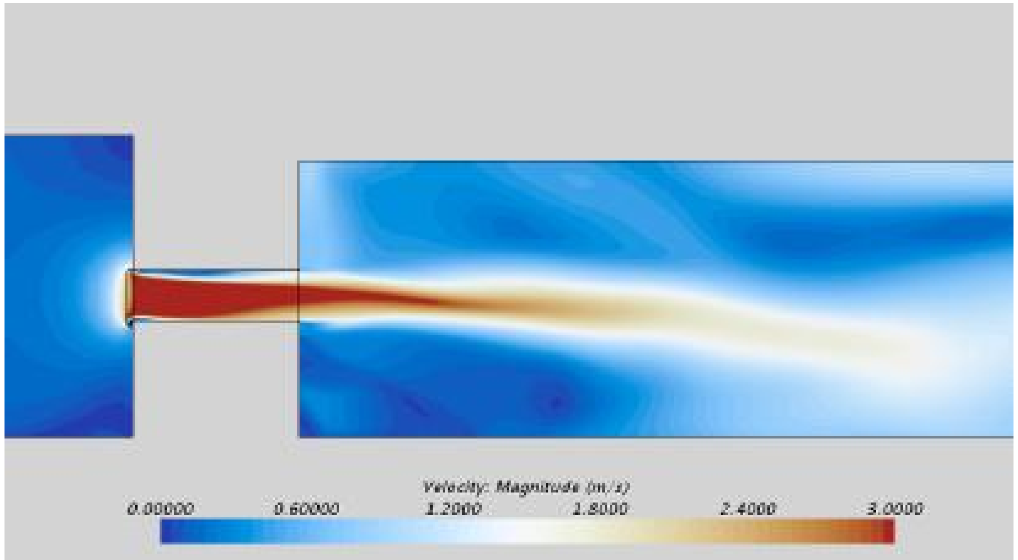
Repeat 1-D LOCKFILL/WANDA using loss coefficients from CFD   Nonstationary

Density currents

Different flow pattern during levelling

Additional longitudinal/transverse forces on vessel

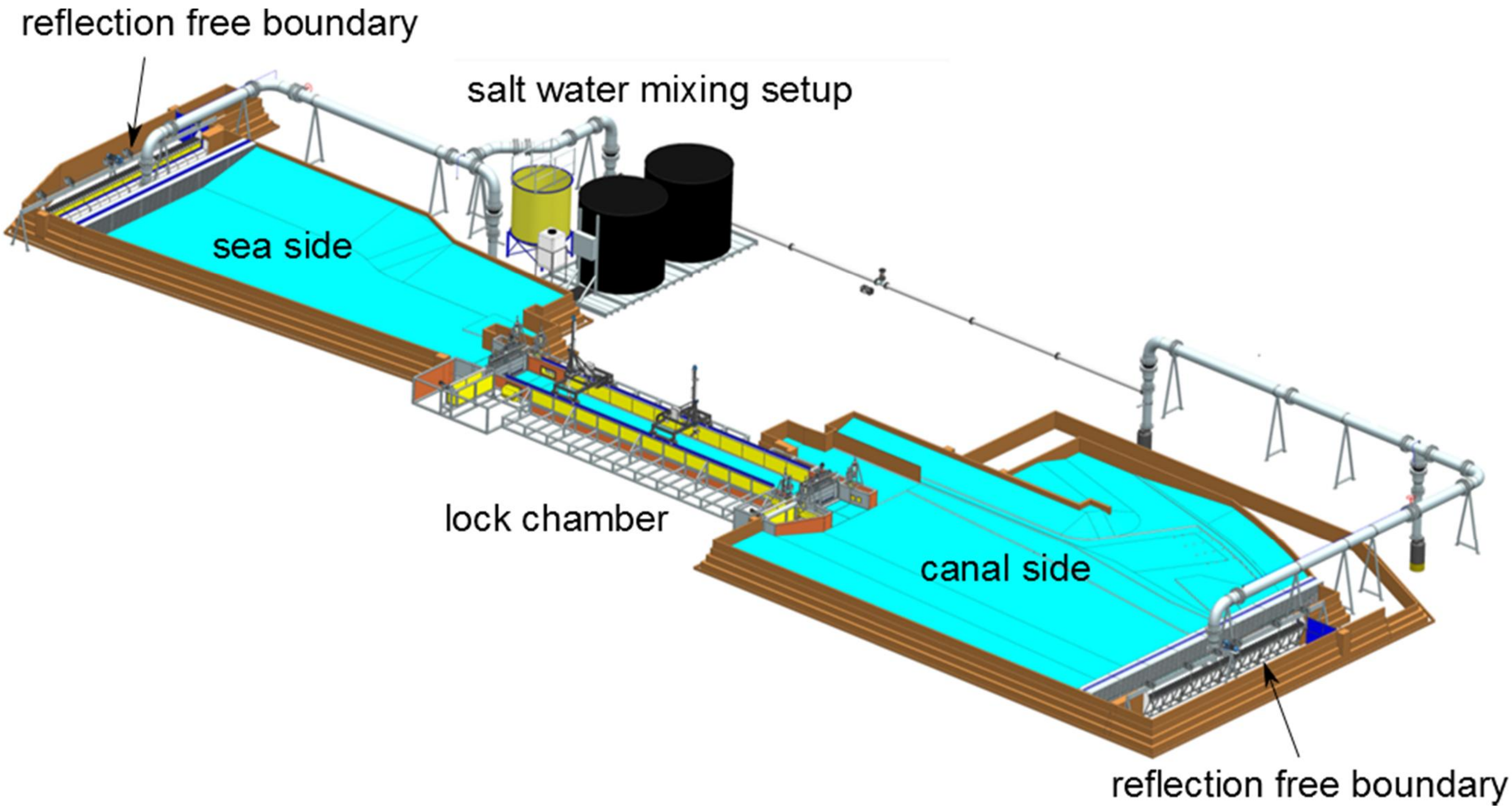
Indicative CFD simulation with density currents



Lock exchange at North Lock

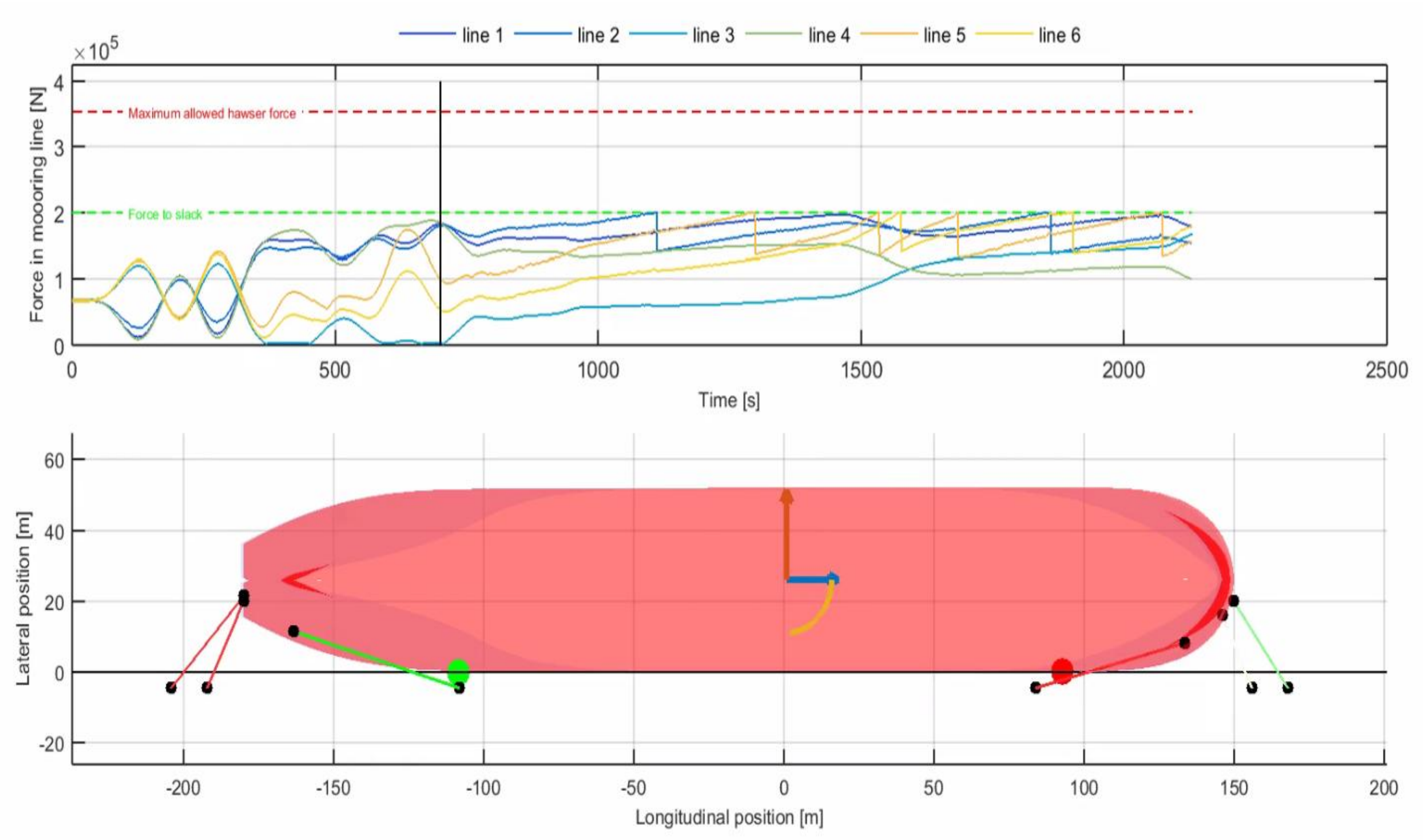
Design Approach

Scale model 40 to 1 / 30 to 1



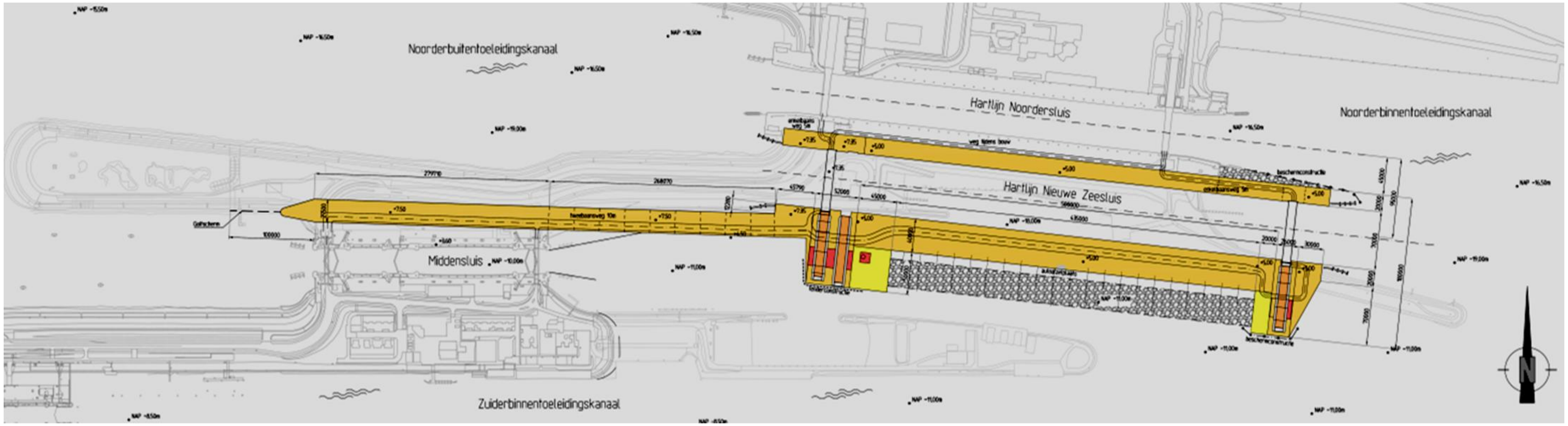
Design Approach

Hydrodynamic force criterion



Reference Design New IJmuiden Lock

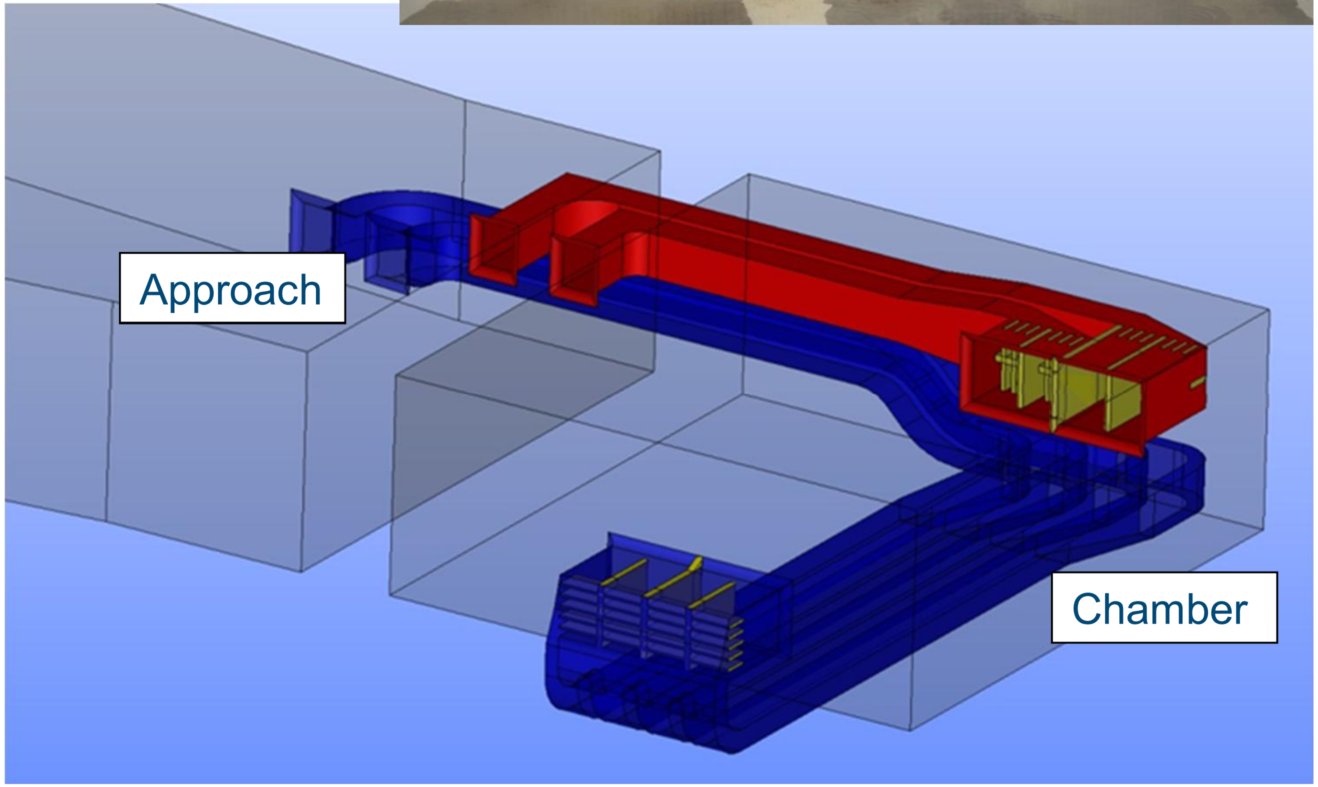
Lock chamber: 545 m x 70 m x 17.25 m



Reference IJmuiden

Ducts in gates or short culverts

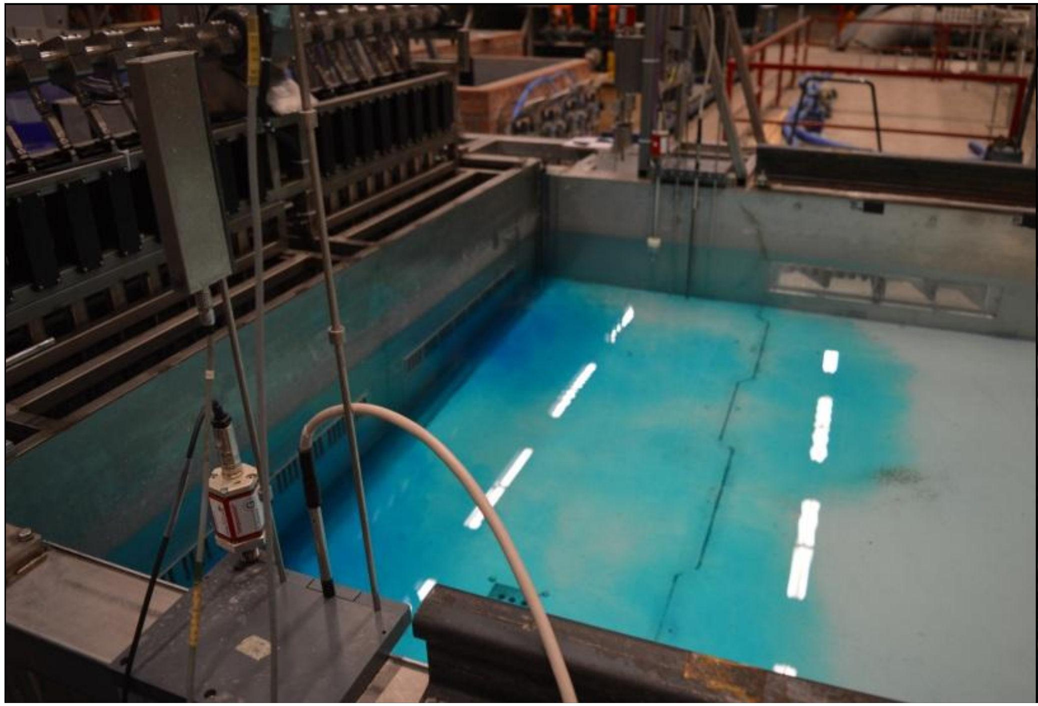
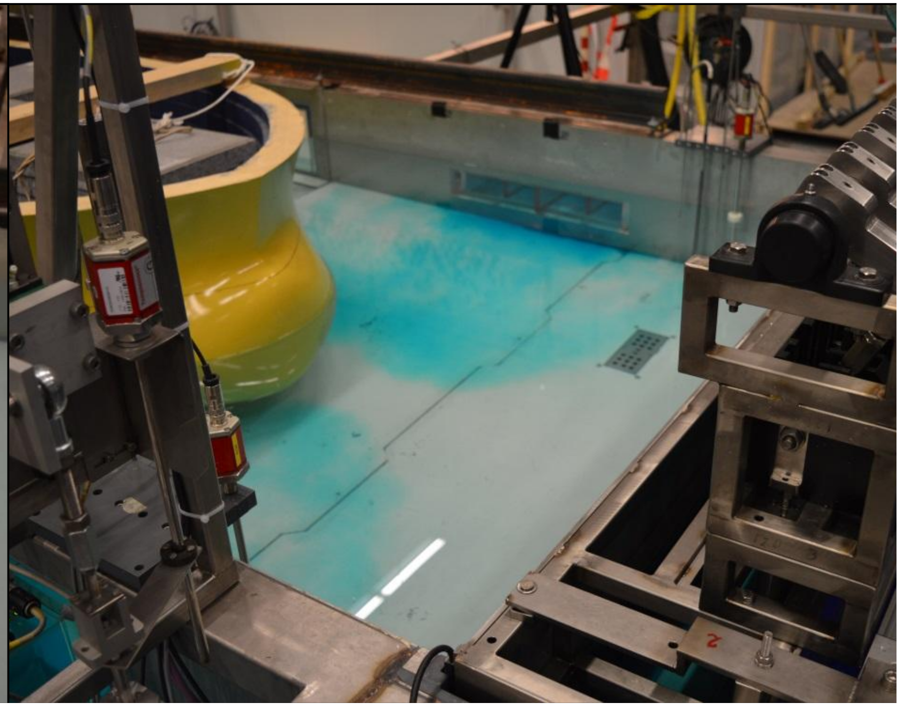
14 ducts ($14x2.2x3m^2$) or
4 culverts ($4x4x5m^2$)
at half the water depth



Reference Design IJmuiden

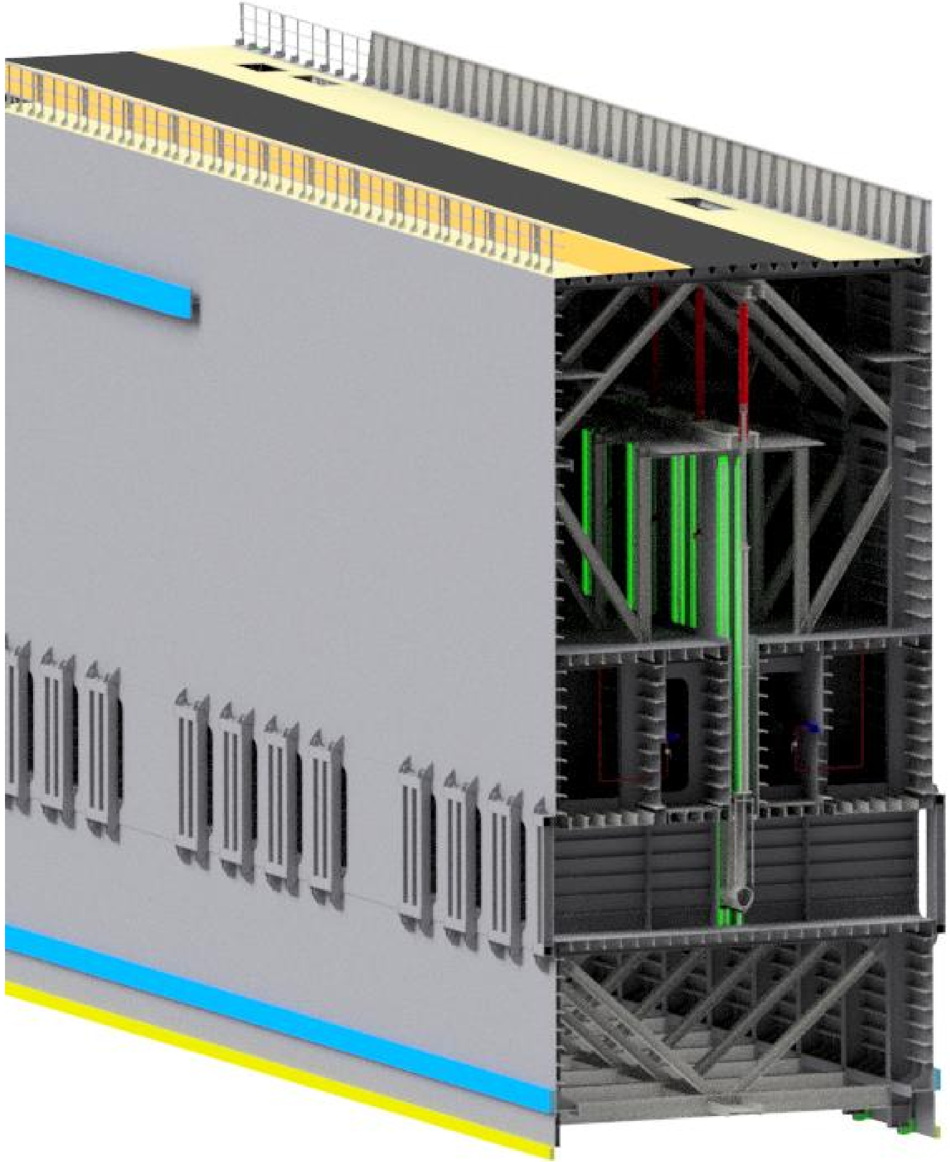
Scale model

- Longitudinal and transverse forces exceed criterion due to density component
- Valve speeds had to be reduced
- Longer levelling times with gate ducts than with short culverts

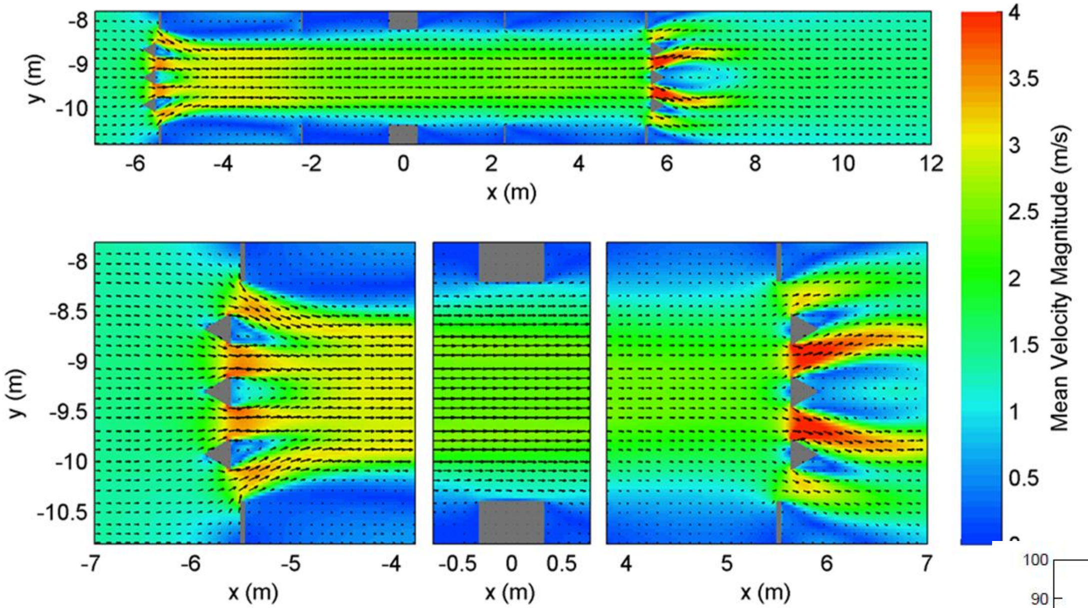



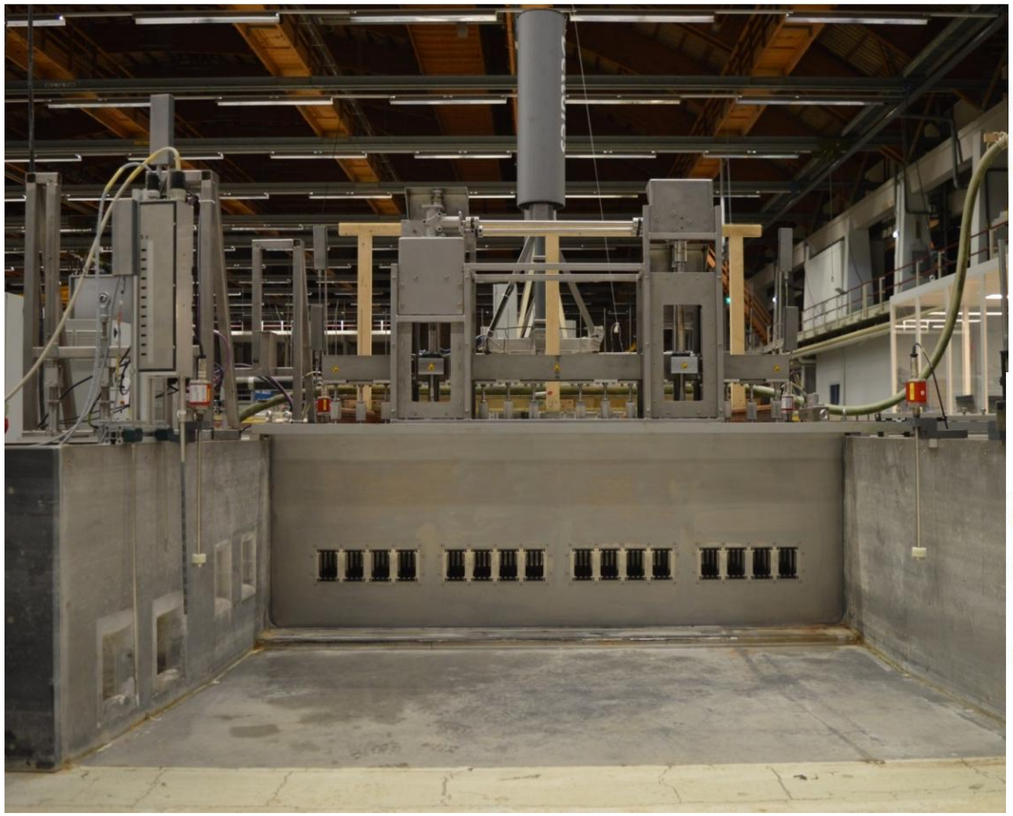
New IJmuiden Lock

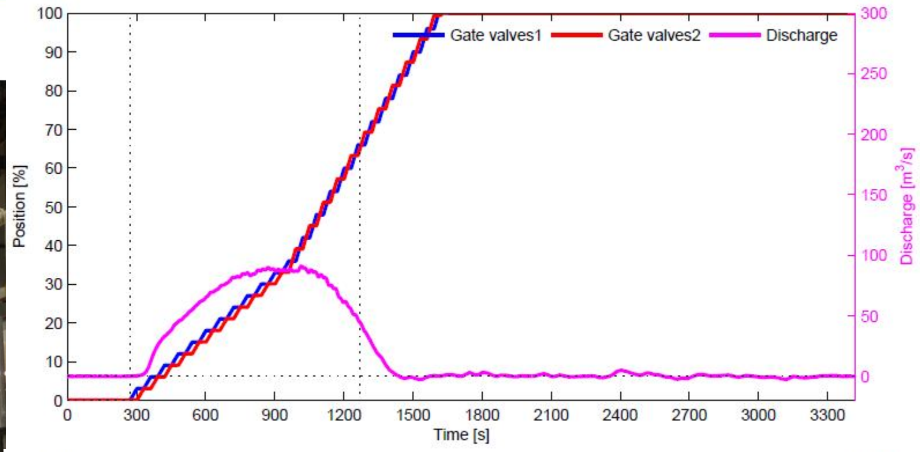
Final Design

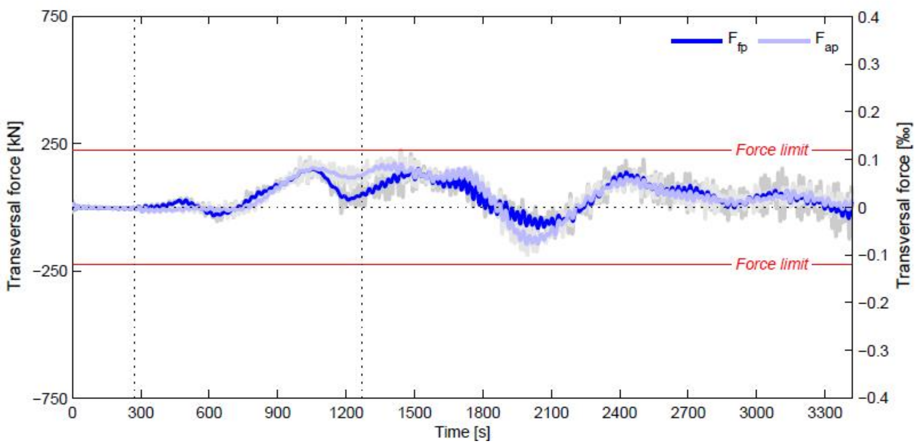


Final Design IJmuiden



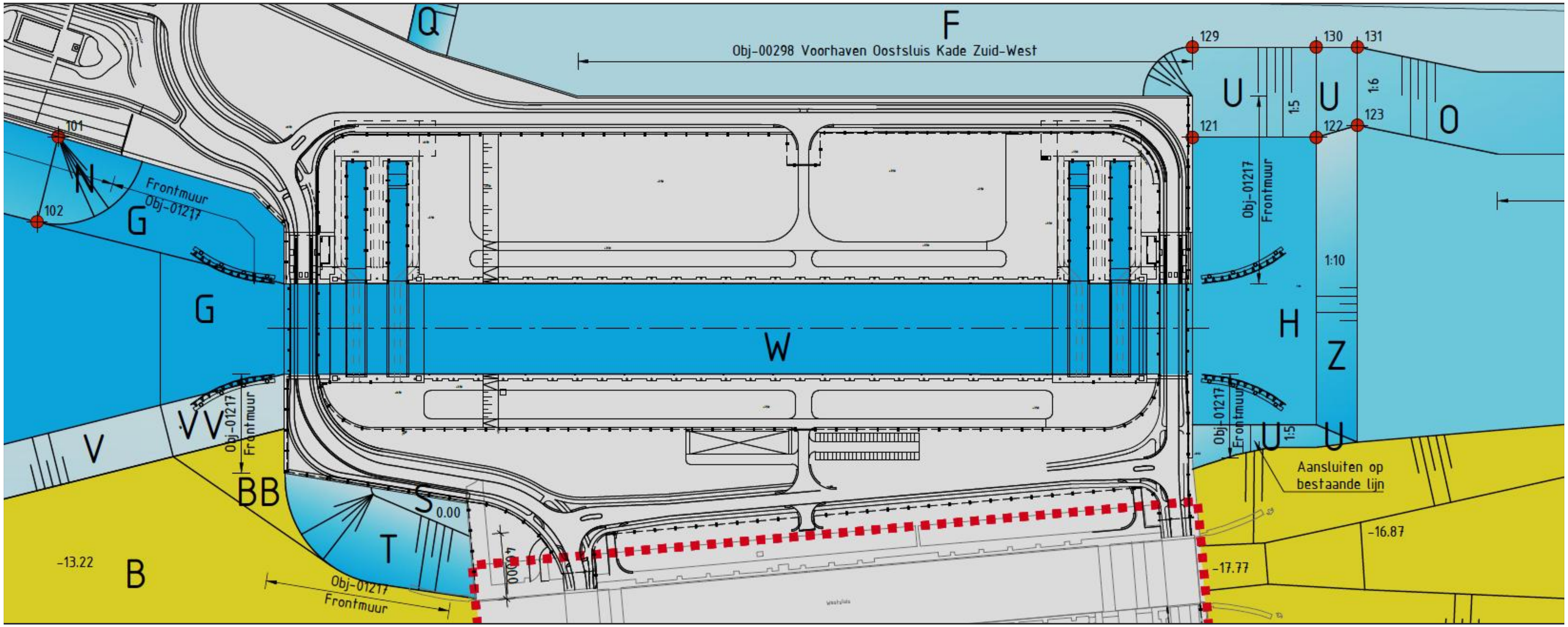




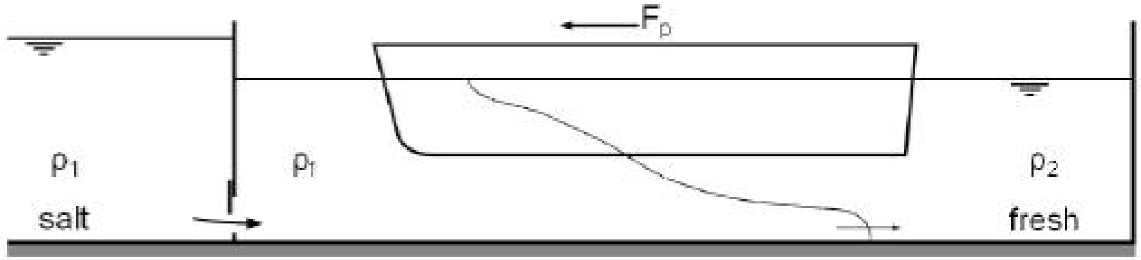


Reference Design New Terneuzen Lock

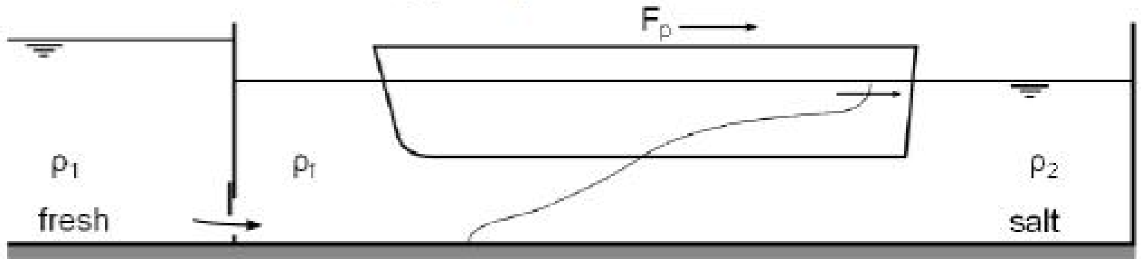
Lock chamber: 452 m x 55 m x 16.44m



Reference Design Terneuzen



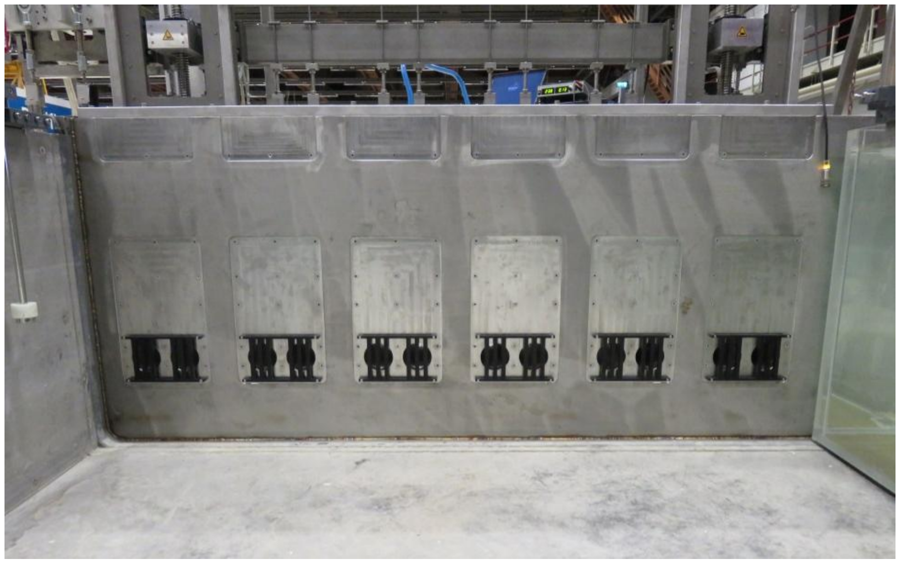
(a) Filling with salt water

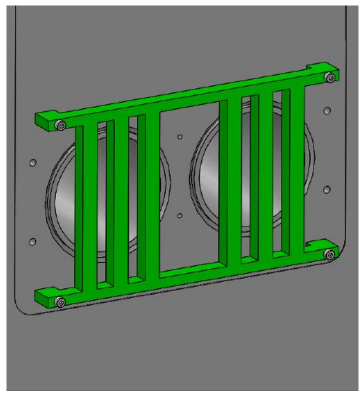


(b) Filling with fresh water

~~Ducts in gate~~

~~Short culverts~~

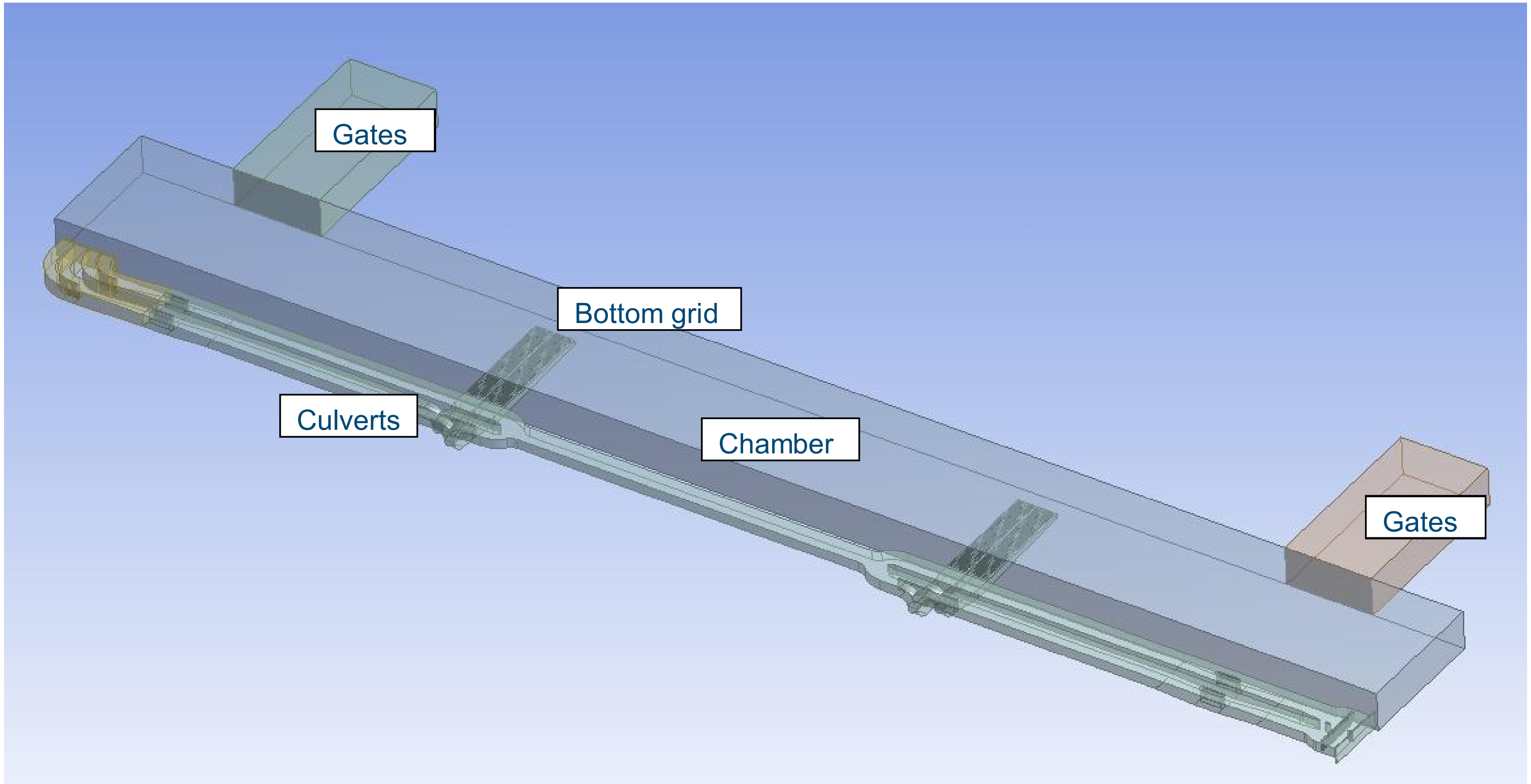




Reference Design Terneuzen

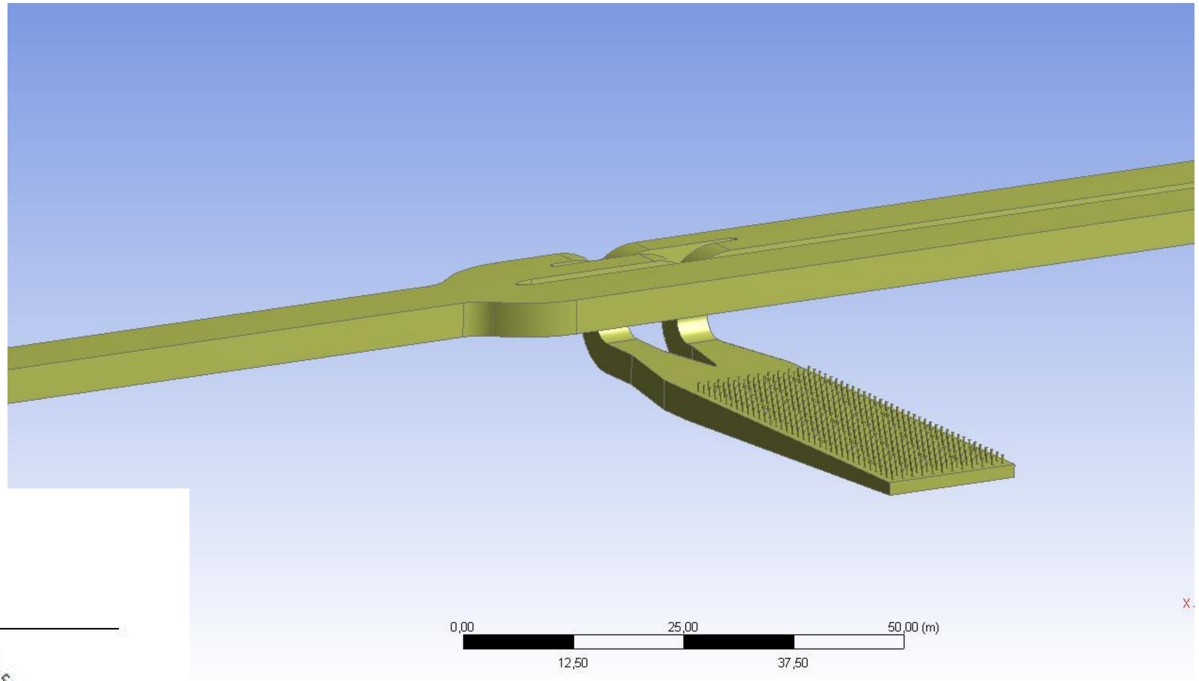
Longitudinal system with bottom grids
Culverts 8 m x 4 m, total area at valves 60 m^2

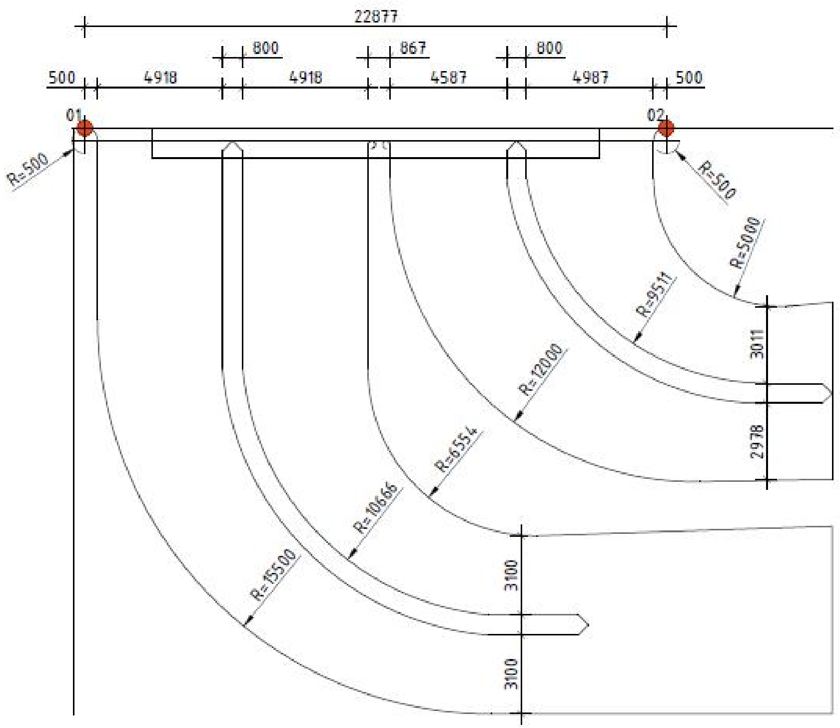
Account for residual Δh, residual forces on the gate



Reference Design Terneuzen

Hydraulic design





Final Design Terneuzen

Requirements

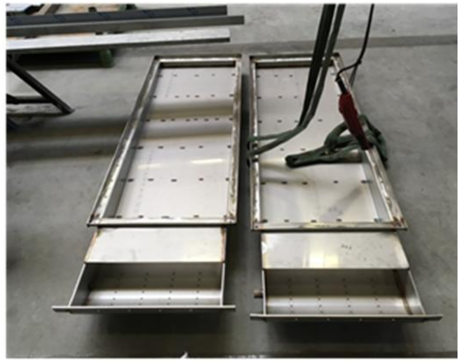
Discharge capacity: $\mu A = 34.5\ m^2$

Distribution between grids: 45%/55%

Overtravel: 0.25 m

Aiming at levelling time 15 min

at Δh = 4 m



Contractor: ‘balancing the flow by bottom grids’

Conclusions

- Include the **density effect**

- **New IJmuiden Lock**
  Δh = 1.4 m, T = 15-20 min, filling with salt water: ducts in gate

- **New Terneuzen Lock**
  Δh = 4 m, T = 15-20 min, filling with fresh water: longitudinal system

- **Residual head**: link between levelling system design and gate design

  Terneuzen gates: extend initial phase, moving at creep speed

Thank you!