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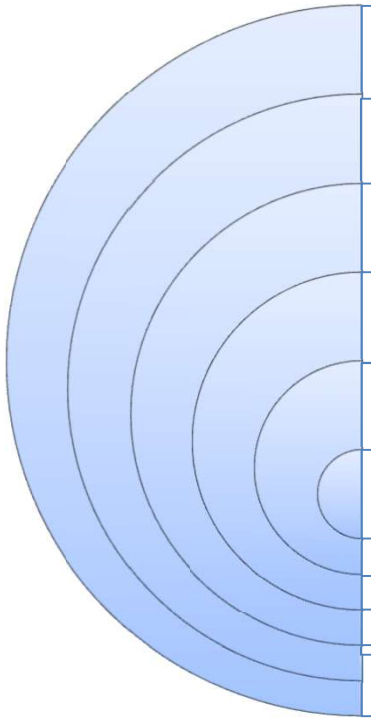
MARINE RÅDGIVNINGSTJENESTER AS



A supplier of documentation to product development

- Structural capacity of constructions

- Wave induced motions and fluid flow

- Marine operations (mooring, towing, lifting…)

According to rules and guidelines

Marine structures – **Marine operations** - Marine products

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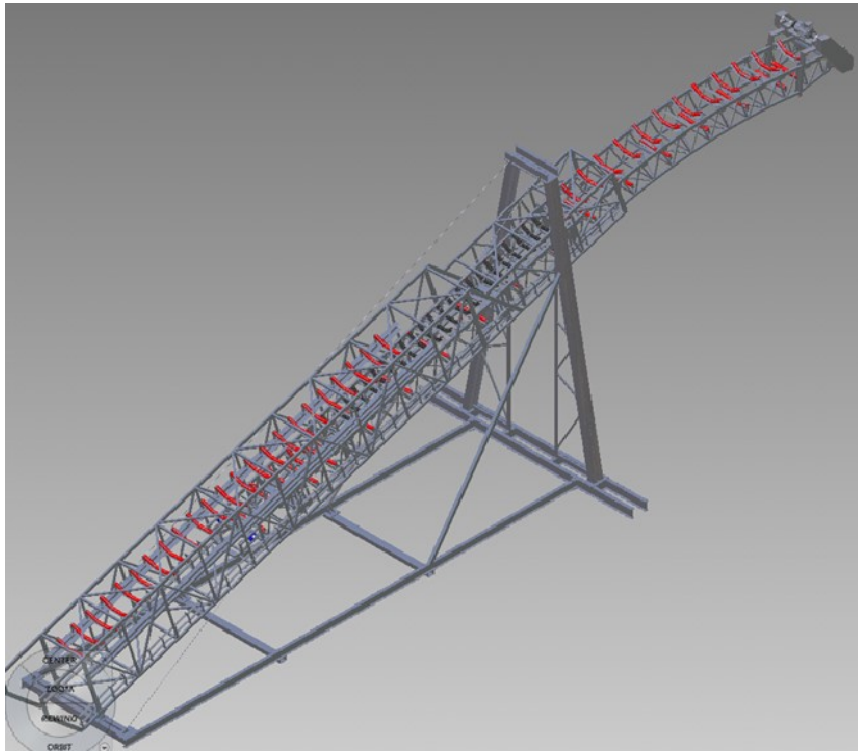
Structures on the quay (Eurocode)



- Ship loader no.1

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Structures on the quay (Eurocode)

- Ship loader no.2

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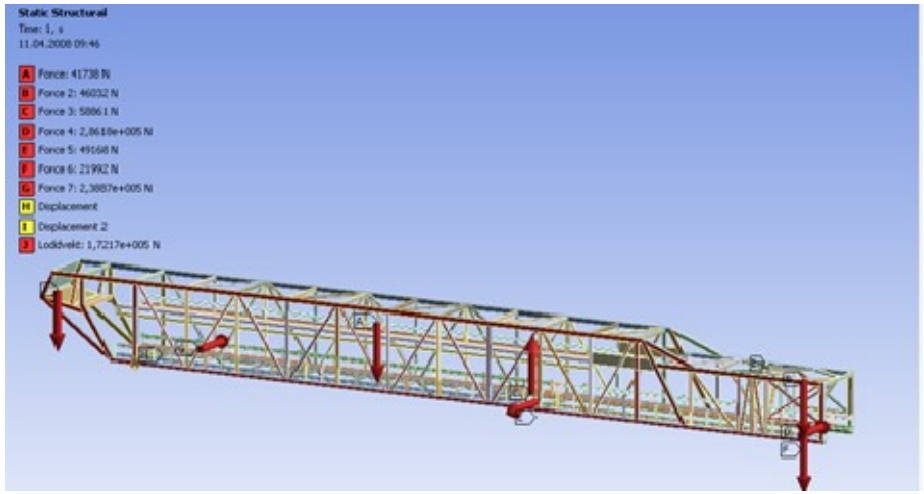
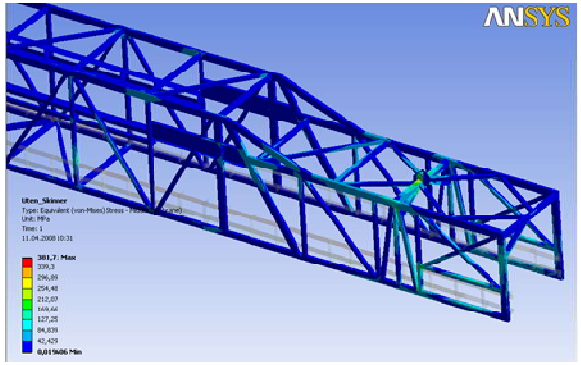
Structures on the quay (Eurocode)





Compute loads &

- static capacity (ULS)
- static capacity (SLS)

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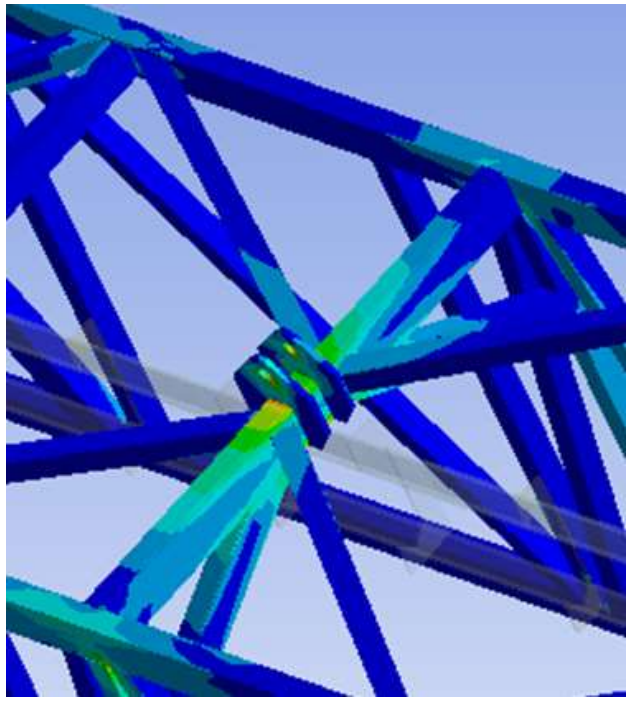
Structures on the quay (Eurocode)



- dynamic capacity (FLS)

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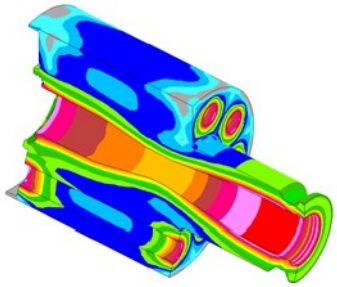
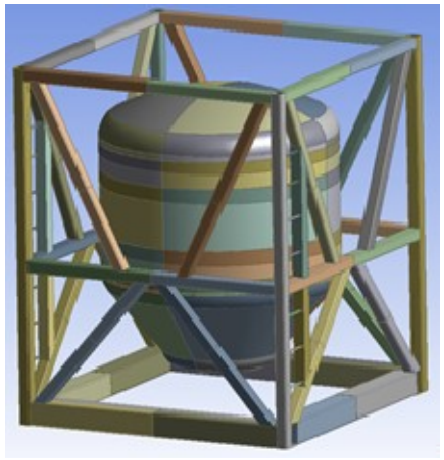
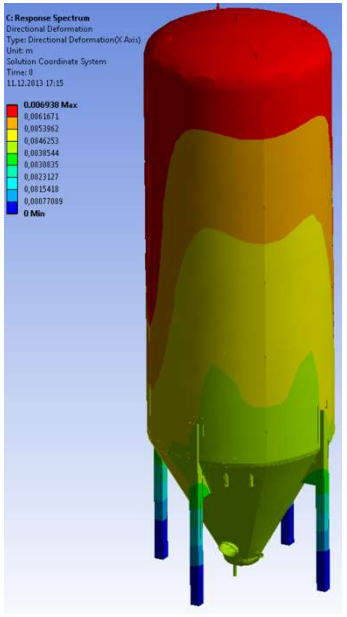
Structures on the quay (PED)







Pressure vessels:

- Document static structural capacity (ULS)
- Document dynamic structural capacity (FLS)
- Document accidental load capacity (ALS)
  - Eq & blast

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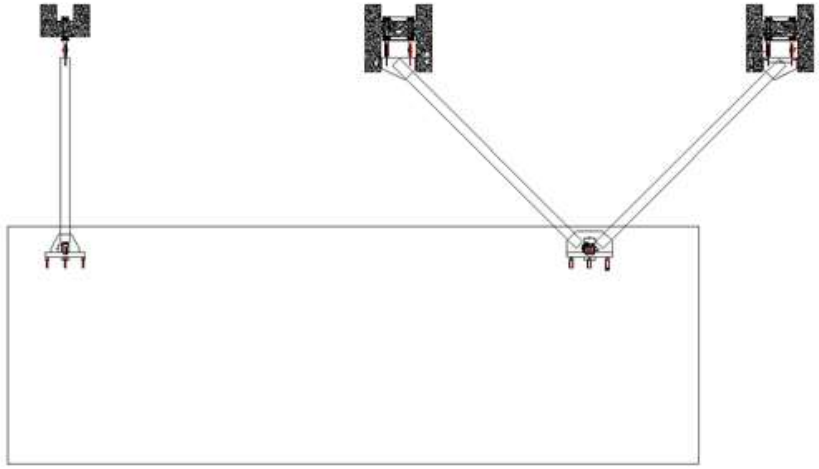
Structures at the quay (Which rules?)



- A permanently moored barge, or a floating quay
- A quay for loading of rock dumpers

Requirements to a permanent mooring:

- Allow tidal movement
- Allow wave induced motions (heave, roll and pitch)
- Withstand loads from vessels moored at the quay

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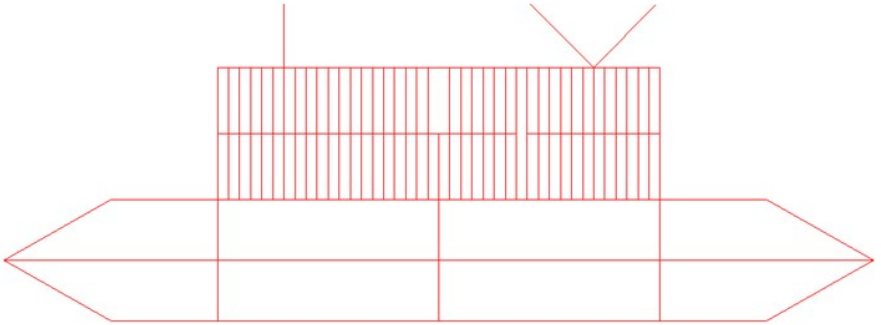
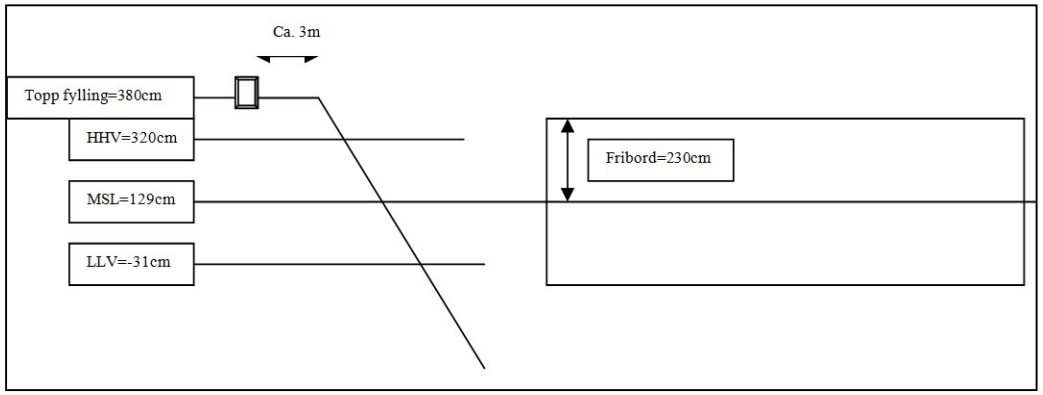
Structures at the quay ()





- A rock-dumper moored at the floating quay

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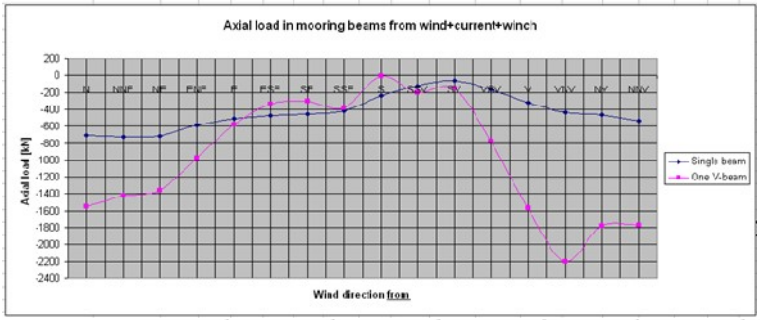
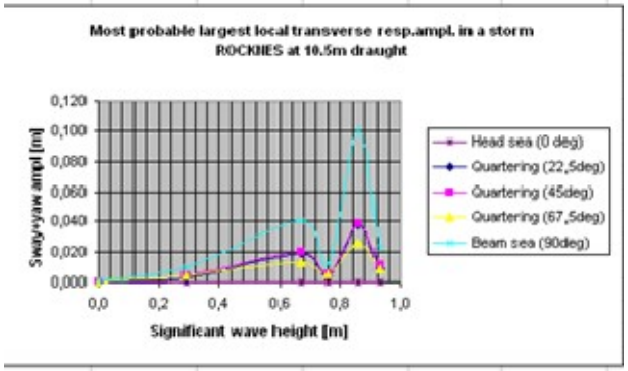
Structures at the quay ()





Find:

- Wind, current & winch forces
- Wave induced motions

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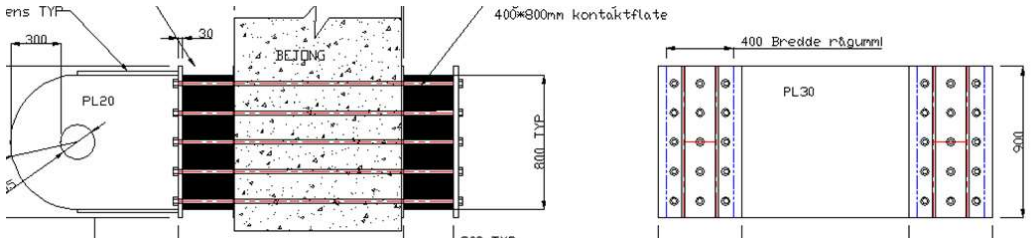
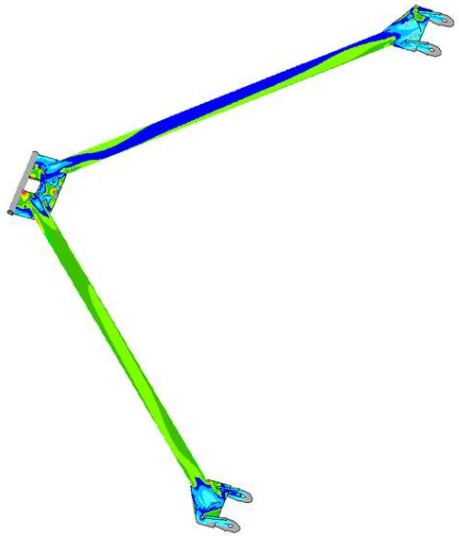
Structures at the quay (NORSOK/DNVGL)



Find:

- Impact loads on supports
- Static structural capacity
- Buckling capacity
- Dynamic structural capacity
- Barge local strength



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At-shore structures

- Development of guidelines for NCA

[NCA=Norwegian Coastal Admin.]

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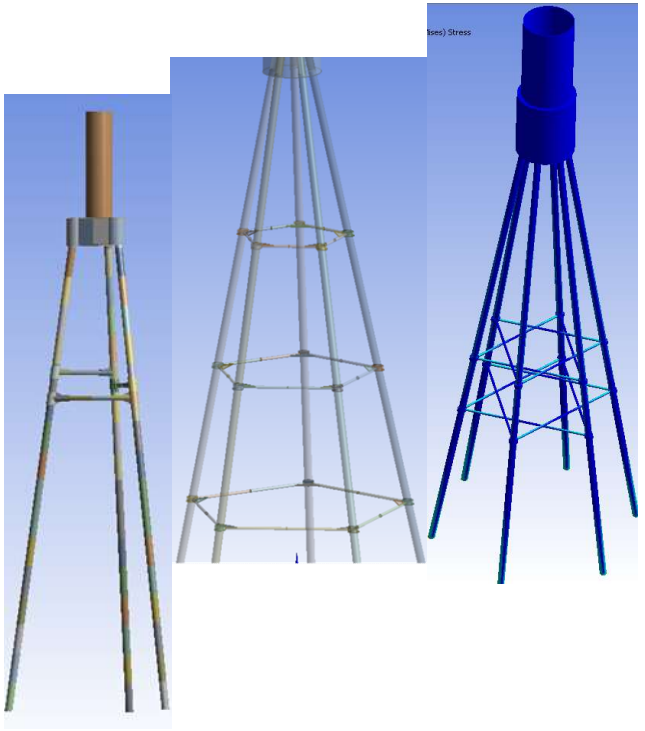
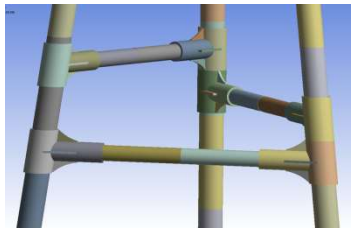
NCA at-shore structures



With 1,3,4,5 or 6 legs

- Holes drilled in the rocky bottom
- Installed piece by piece
- Requires a small crane
- Welding/casting on the site
- “On-site fabrication”



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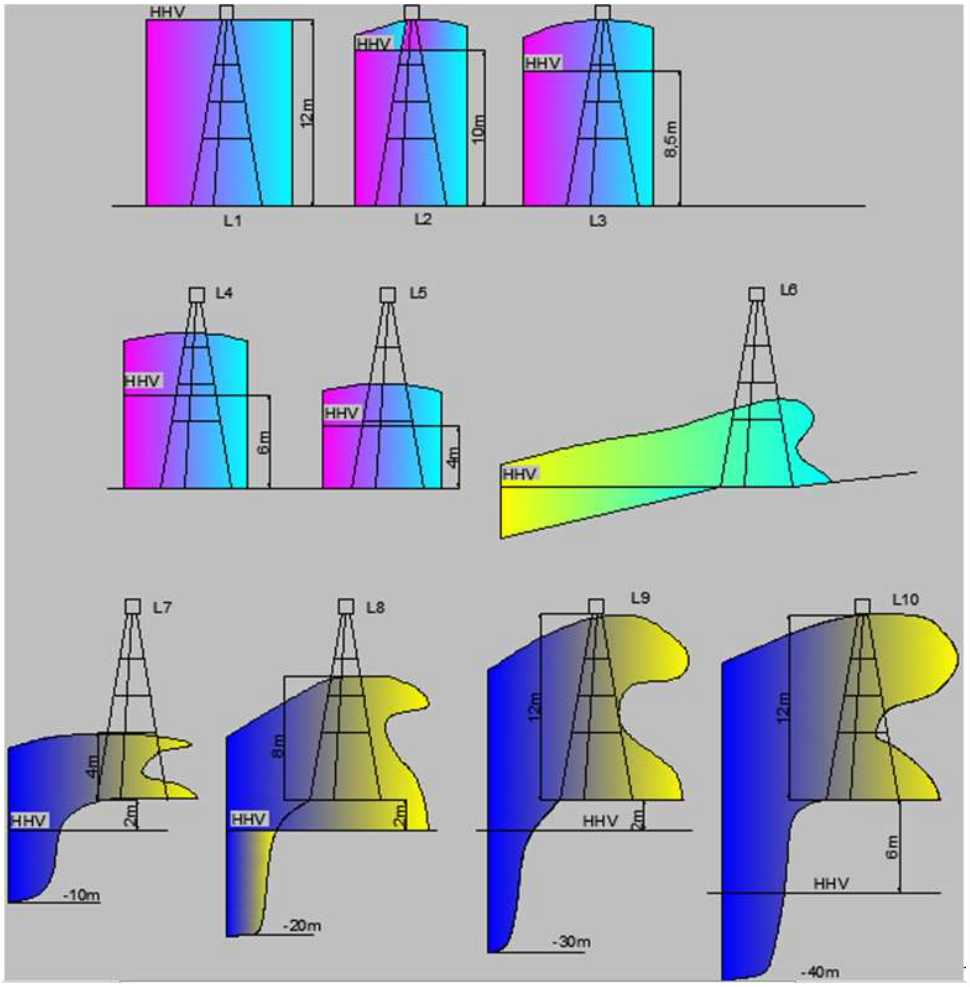
Which type of NCA at-shore location?

-Deepwater

-Shallow water

-Beach

-Onshore



NCA limit:

-The water surface shall not touch the node

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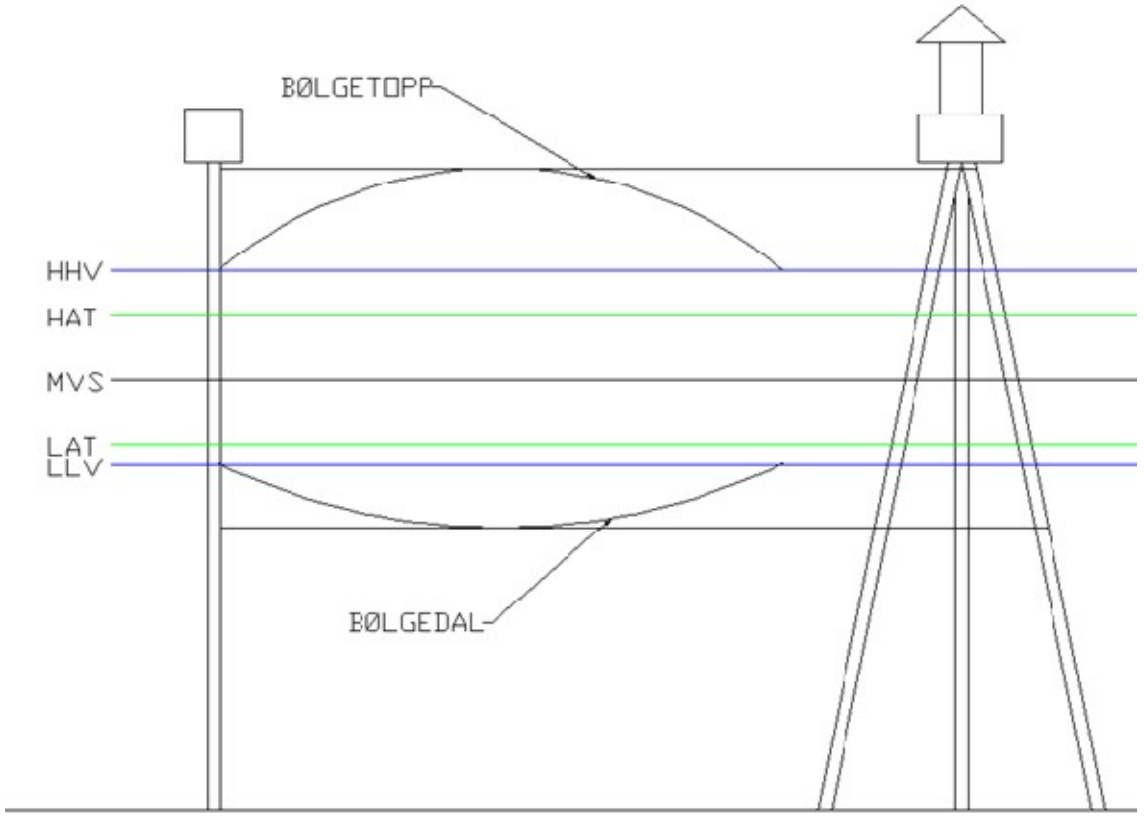
NCA at-shore structures



- Design wave, for deep/finite water conditions

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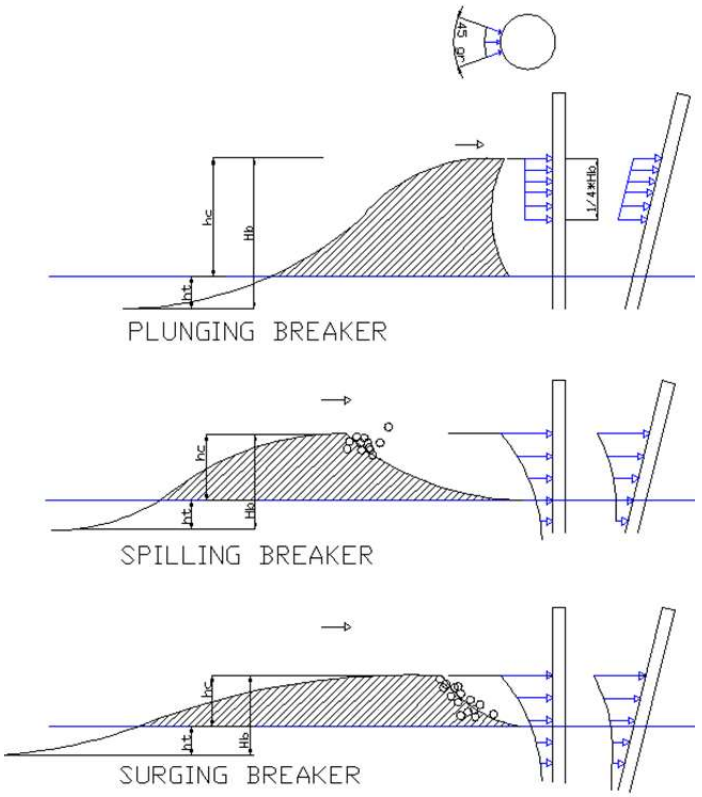
NCA at-shore structures



- Loads from breaking waves
- Slamming loads (wave impact loads)

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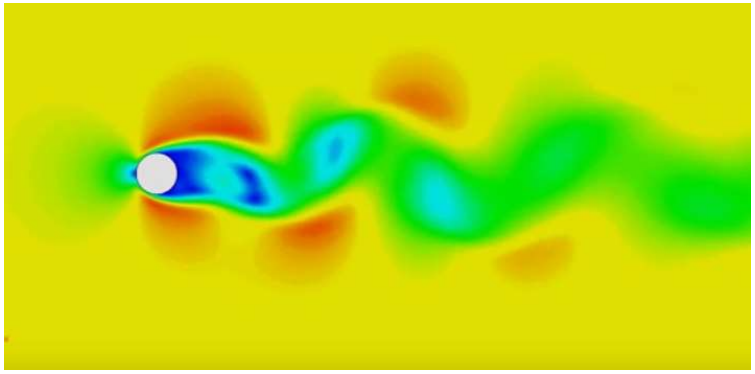
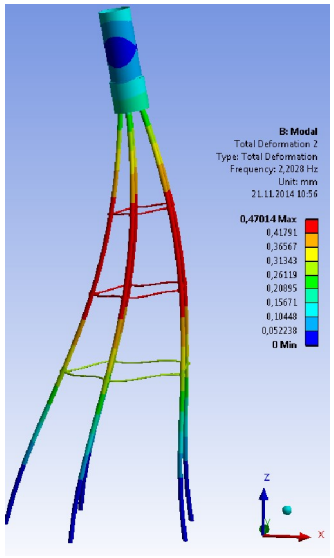
NCA at-shore structures





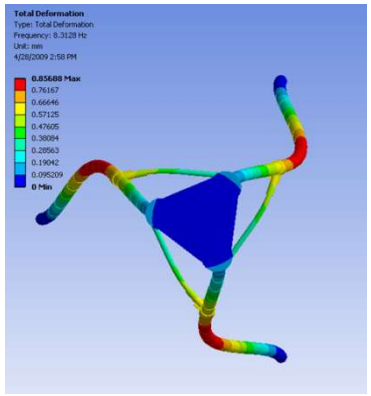
Vibrations?

- Assess eigenmodes for the structure
- Find frequency of dynamic loads, initiated by

→Vortex shedding from wind

→Vortex shedding from current

→Vortex shedding from waves



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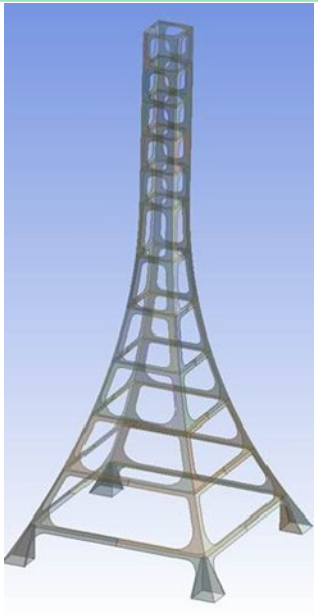
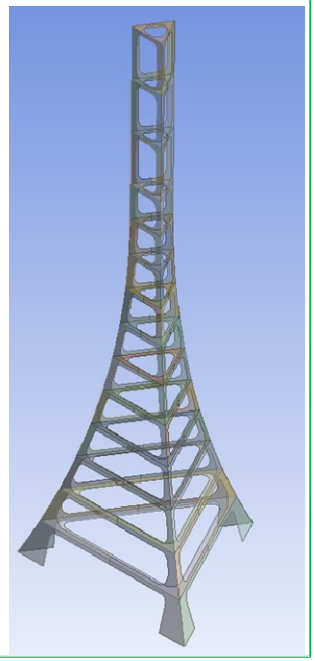
At-shore structures





The “MAR Plate Jacket” ©

- Can’t be built on the location
- Must be pre-fabricated
- Can carry moderate loads, on the shore or in a fjord
- It can be built of steel plates
- It can be built of FRP plates
- It can have dynamic capacity over and above a tubular jacket

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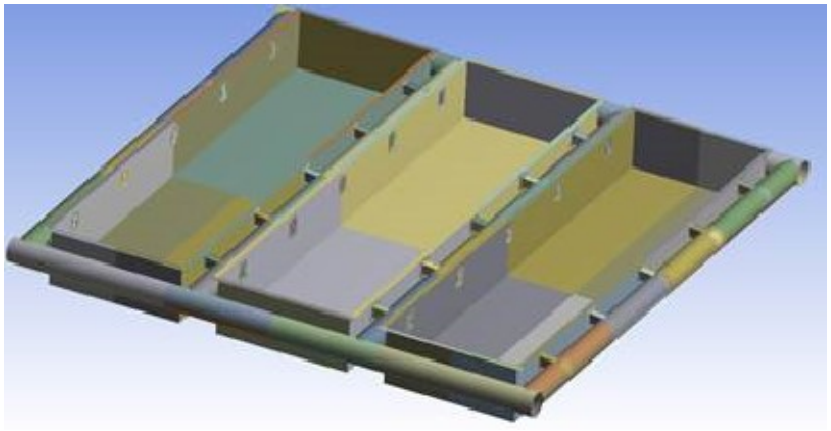
Inshore structures (NS9415)



- Closed fish farm, rigid steel structure, steel or FRP cages
- Halibut fish farm, by Tubilah AS, 2014-2016
- MAR supplied the hydrodynamic analyses and documented the structural capacity.
- Could not use conventional ship design methods, direct strength analyses was used

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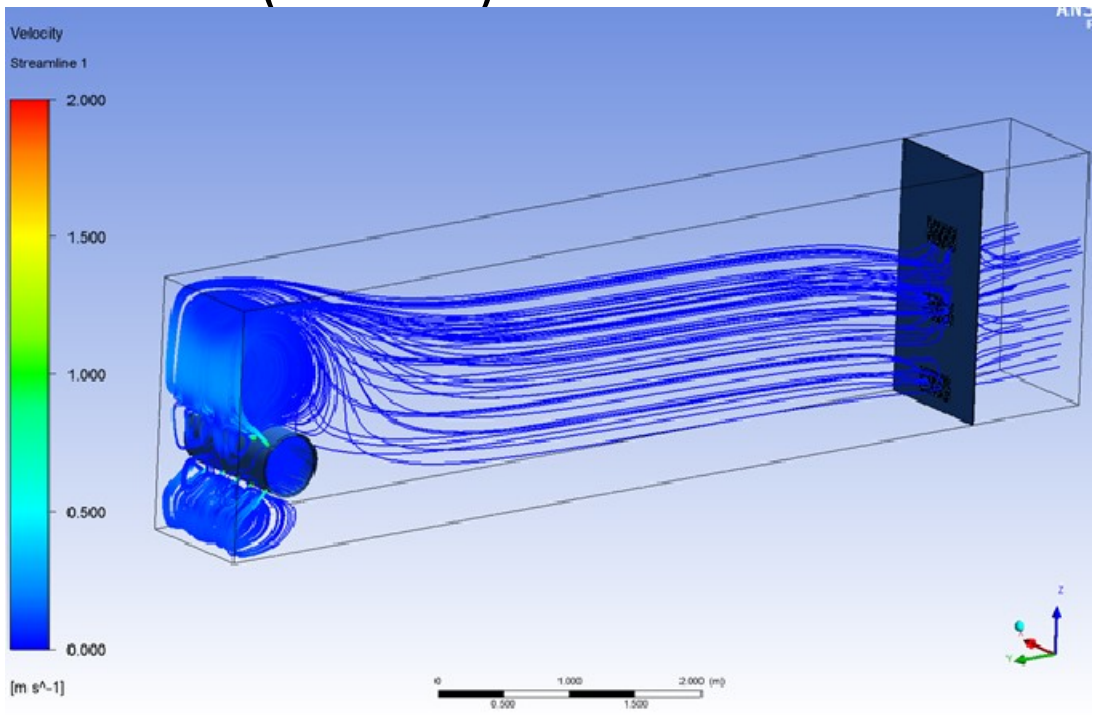
Inshore structures (NS9415)



- The fish in the cages need continuous supply of CO_2,
- Fresh seawater supplied through a perforated pipe (to each cage)
- Water particle streamlines computed by CFD, provided by MAR
- Transverse flow from feed pipe to perforated outlet in the side

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Inshore structures (NS9415)

- The closed fish farm NEPTUN1, by Aquafarm Equipment AS
- Diameter 40m, 19m deep, built in FRP, 2013-2016
- Fresh seawater from deep below pumped into the cage by 4 pumps
- Water outlet through hatches
- MAR documented the structural strength of NEPTUN1 and NEPTUN3. Model tests by Sintef.

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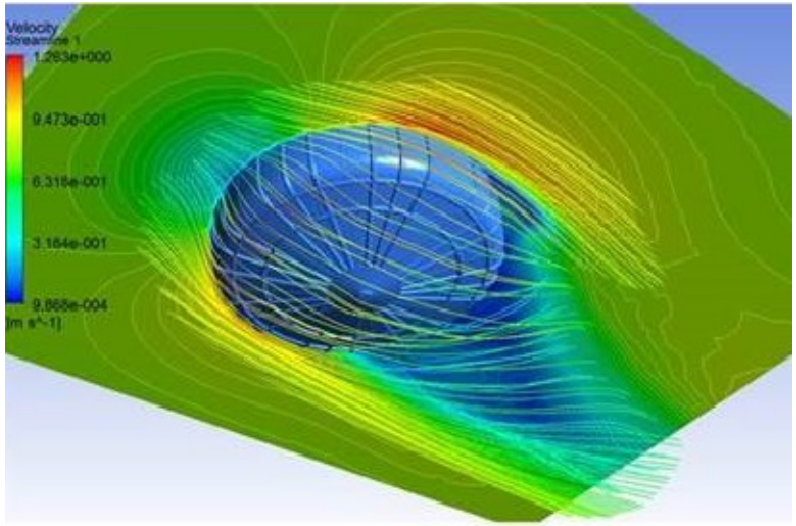
Inshore structures (NS9415)



- In order to design the moorings, the current load must be found
- CFD current load calculations provided by MAR
- Plot above: Transient analysis of external flow on NEPTUN1

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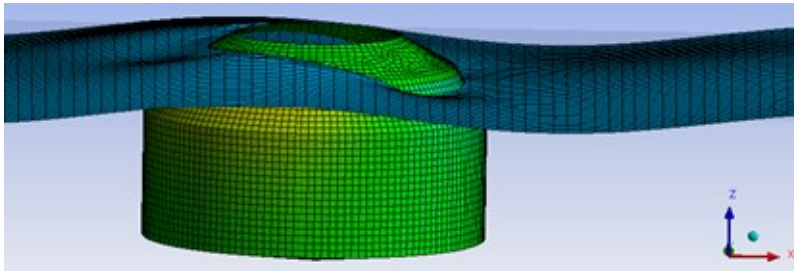
Inshore structures (NS9415)



- FishGlobe V5, a closed fish cage. To be used for fish farming and/or freshwater treatment (lice)
- Contains 4000m^3 of water. Diameter 21m.
- To be manufactured in PE. Therefore, a semi-flexible cage.
- MAR carried out hydrodynamic analyses and documented the structural capacity of the closed cage

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Inshore structures, exposed location (NS9415)

- The rigid & open steel fish farm “ArcticFarm”, built in 1989 by Midsund Bruk AS.
- The salmon was kept in 5 open nets (18*18m), 1 deck
- Operated until ≈2012 on an exposed location, Hs≈3m
- MAR provided hydrodynamic/structural analyses

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Inshore structures, exposed location (NS9415)

- STORM1, a rigid steel fish farm. Installed 2001, in Boknafjorden.
- Two large cages (45*45m), 120T feed storage, ballasting system
- Installed on an exposed location, Hs≈4m. Environmental assessment was not required for fish farms in 2001.
- MAR provided the hydrodynamic analyses and structural strength documentation.

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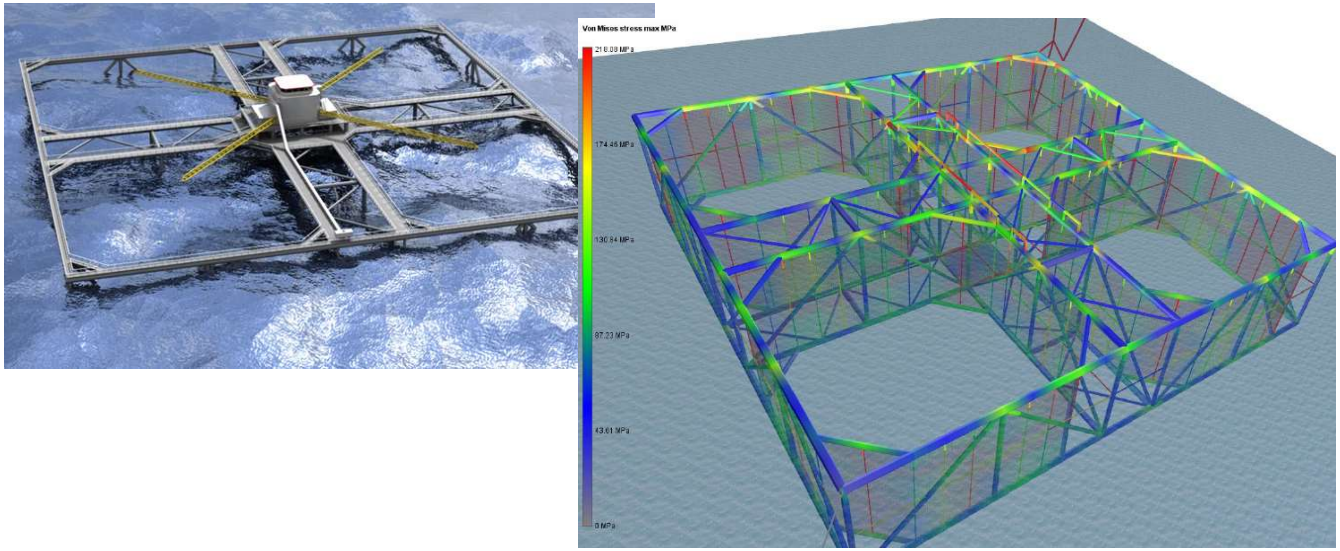
In-shore structures, exposed location (NS9415)



SALMAR's 1.prototype open rigid fish farm for exposed location

- The fish farm size was 160*160m, built of steel tubulars
- Location: Wave Hs=4,5m Current Vc=1,5m/s Wind Vw=30m/s
- Fish nets made of a new type of material

MAR supplied hydrodynamic & structural documentation, feasibility study

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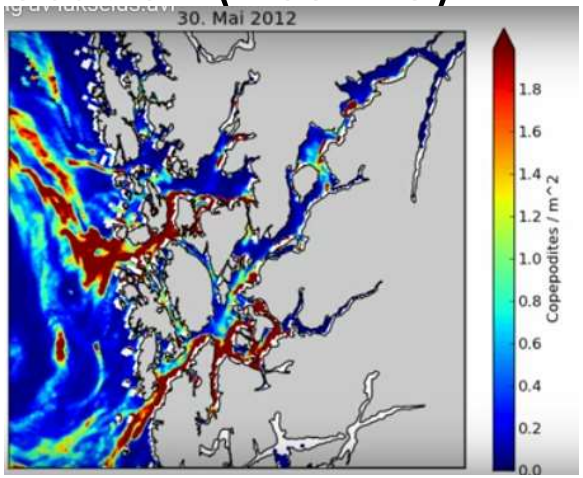
Inshore structures, exposed location (NS9415)



Fish farms on exposed locations:

- There is plenty of lice ➔ (Havf.Inst.)
- Boarding may be difficult
- Cleaning of nets may be more demanding than inshore
- Filling up silo's with fish feed 365 d.pr.y may be a challenge
- Handling of fish to/from the nets also
- The motions/biological conditions for the fish are unproven
- And so on..