

# New fish cage designs

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# New fish cage designs

- Motivation and requirements for new fish cage design
- Method for finite element analysis of net cages
- Results from analysis of traditional net cage
- New net cage design
- Comparison and conclusions
- Further work

# Motivation for new design

- Reduce the probability of escape of cultured fish
  - Tearing of the netting during operation (main focus)
  - Damage of the net cage due to abrasion from adjacent components as cage collar and weights
  - Tearing of the netting due to conflicts with boats
- Simplified production
- Increased effective volume in current
- Easy operation
  - Intuitive to handle in the optimal manner

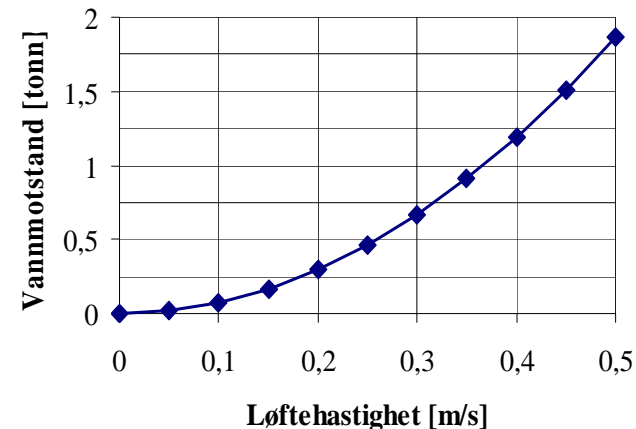
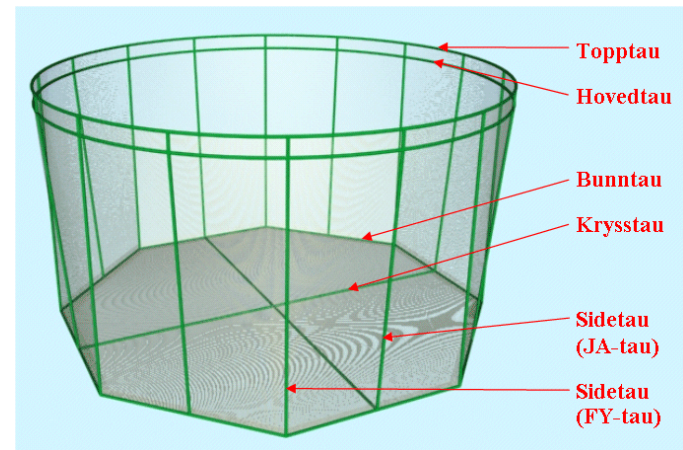


# Requirements for new design

- The designs should be possible to implement in a short period of time
- The traditional equipment (cage collar, mooring...) and operation methods should be applied for the new designs
- The same materials and production methods as traditional net cages
- The properties of the new design should be equal or better than the properties of the traditional net cages
  - Weight
  - Shape

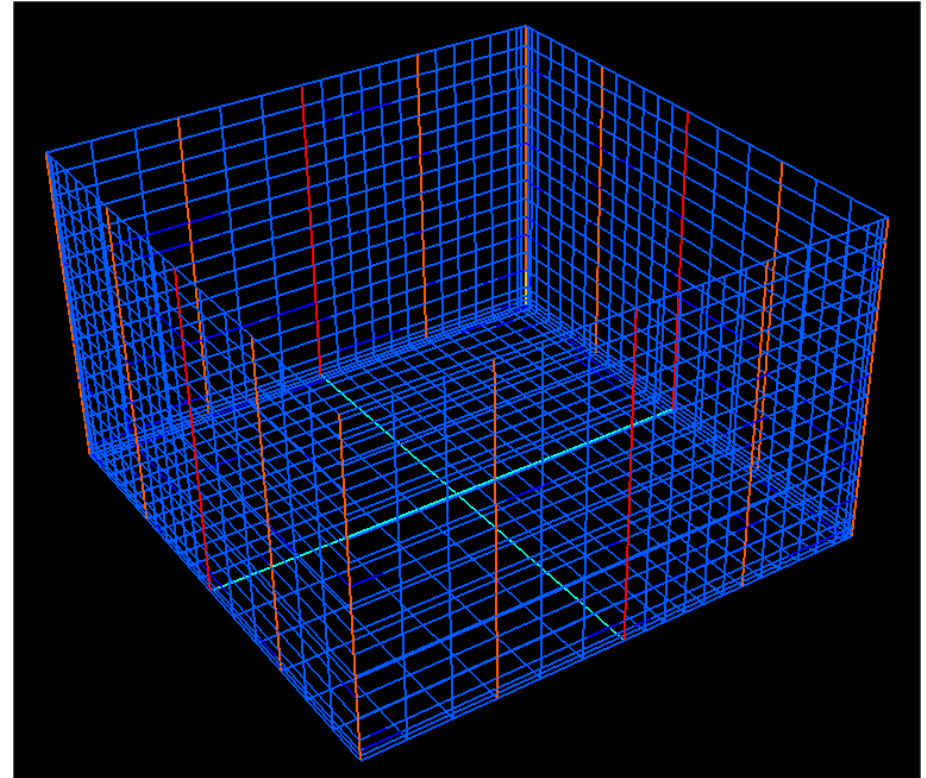
# Tearing of the netting during operation

- Lifting of the net cage through ropes with no connection to cross rope(s)
  - Loads are transferred to the netting (should be avoided)
- Loading of the netting may get critical due to
  - Lifting equipment that are too powerful compared to the strength of the cage construction
  - High lifting velocity and accelerations
  - Bio-fouling (increase in drag coefficient)
  - Worn net cage, weak spots or local stress concentration (from production)
  - Little focus on routines for operation and insufficient training of the workers



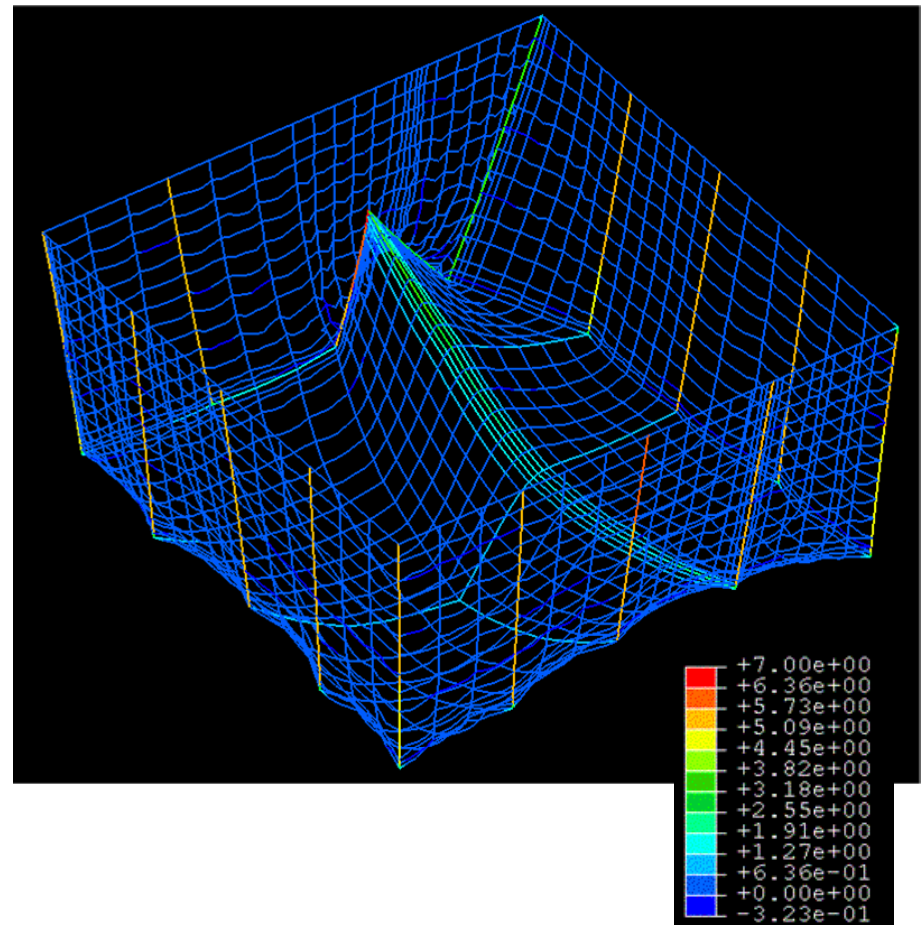
# FEA -Finite Element Analysis

- Explicit analysis
  - ABAQUS Explicit
  - To numerically handle slack in the netting
- The complete net cage is modelled
- The netting is modelled in various detail in order to achieve an acceptable duration of the analysis
- Lifting operations and current are simulated in order to assess the loading of the netting and the deformation of the net cage

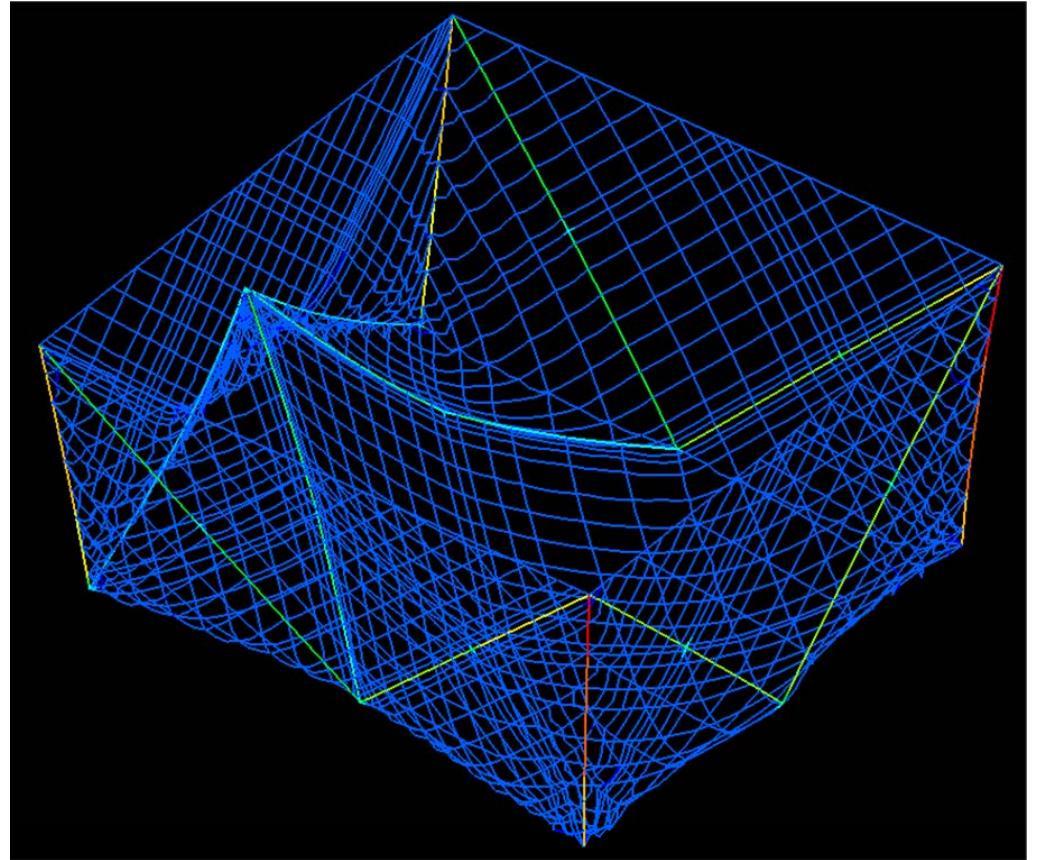
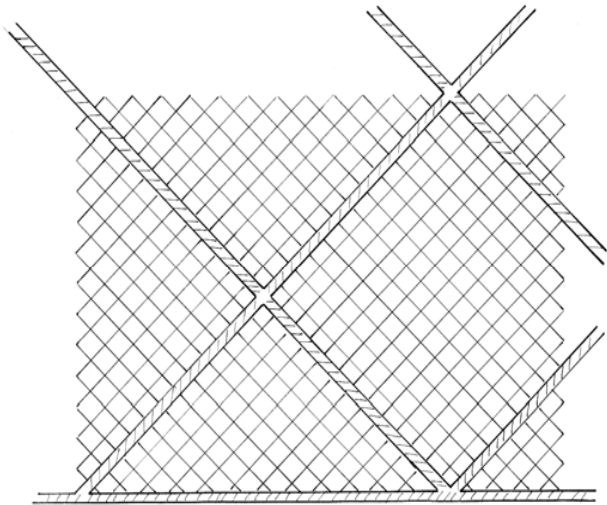
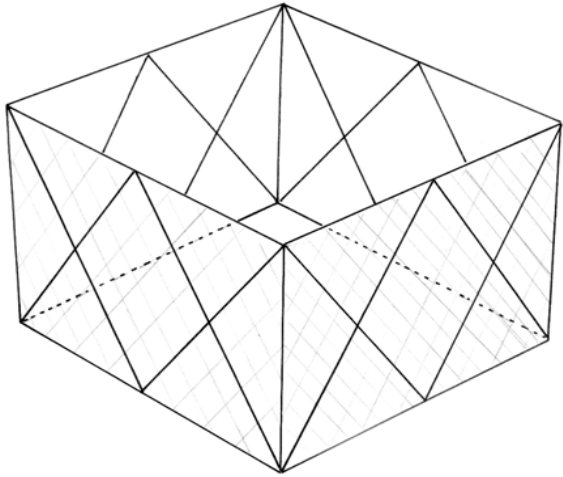


# Unfavourable lifting of traditional cage

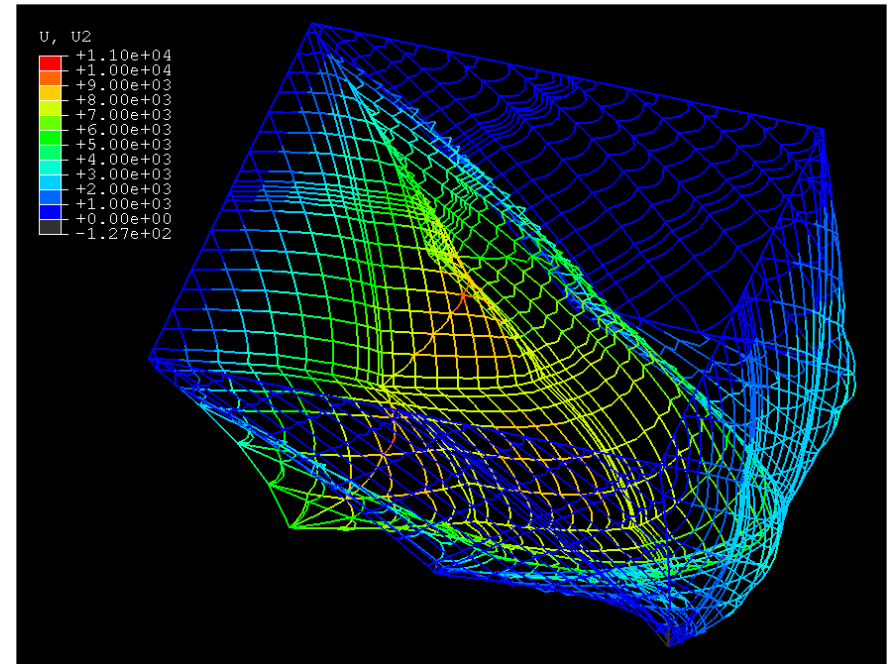
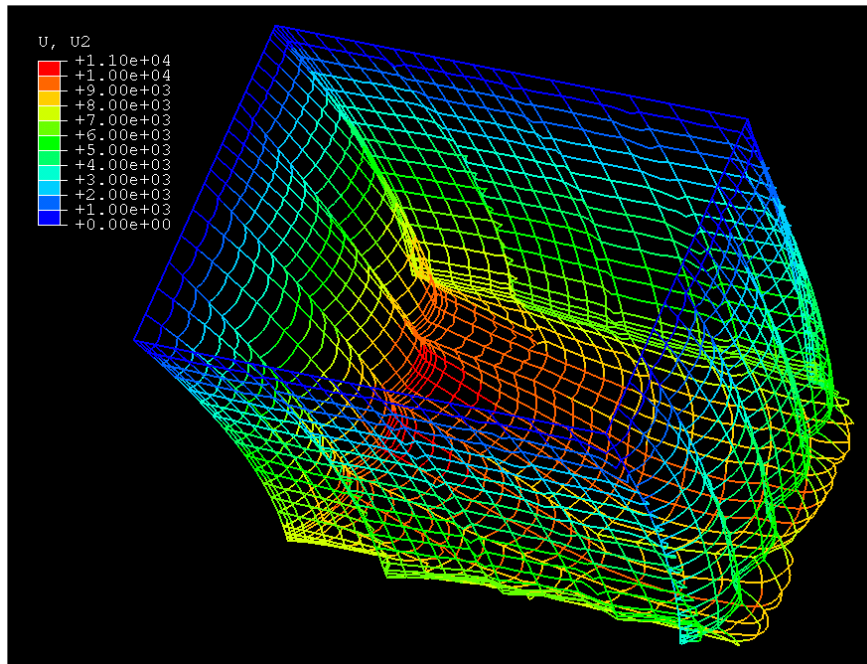
- Pulling weight ropes not connected to cross ropes in the bottom
- This can damage the net cage and in worst case lead to tearing of the netting and escape of fish
- Large drag- and mass loads
  - Fast lifting of a net cage with heavy fouling and weights
  - Large acceleration (jerk at start of lifting operation)



# New net cage design

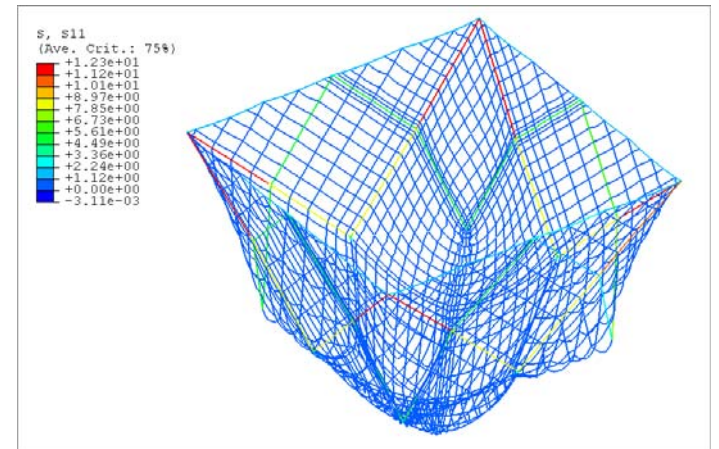
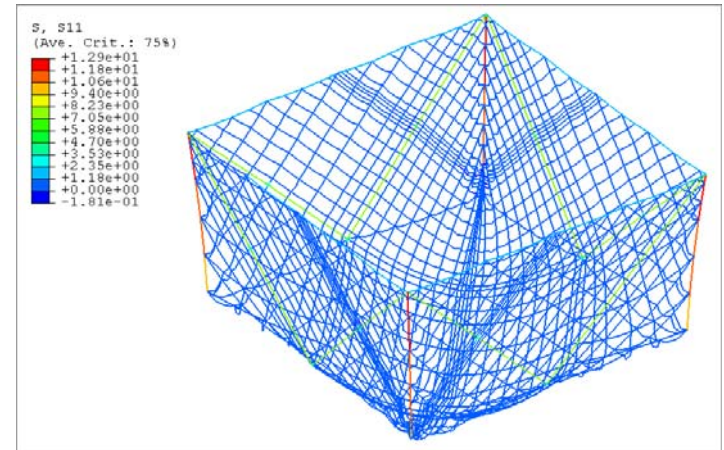


# Net cage volume in current



# Conclusions of new design

- The probability of tearing the netting during operations is reduced
- Abrasion from cage collar and weights should be reduced
- Conflicts with boats is less likely
- Lower current induced stress in the netting
- BUT: The net cage will have a more baggy shape, increasing the risk of dead fish being collected at the sides of the net cage. And less volume in current.



# Further work

- Establish plastic material models for Raschel knitted netting (both new and used netting), based on tensile testing. Include damage effects and time dependent behaviour.
- Establish suitable material and load factors for strength analysis of net cages.
- Analyses of more load cases (e.g. combined current and lifting), including dynamic loads (e.g. from waves).
- Dynamic analysis where drag loads are calculated directly from the velocity at each node.
- Investigate the risk of fatigue and establish method for fatigue calculations (e.g. SN-curves).