Vortex Induced Vibrations in Fish Farm Structural Elements

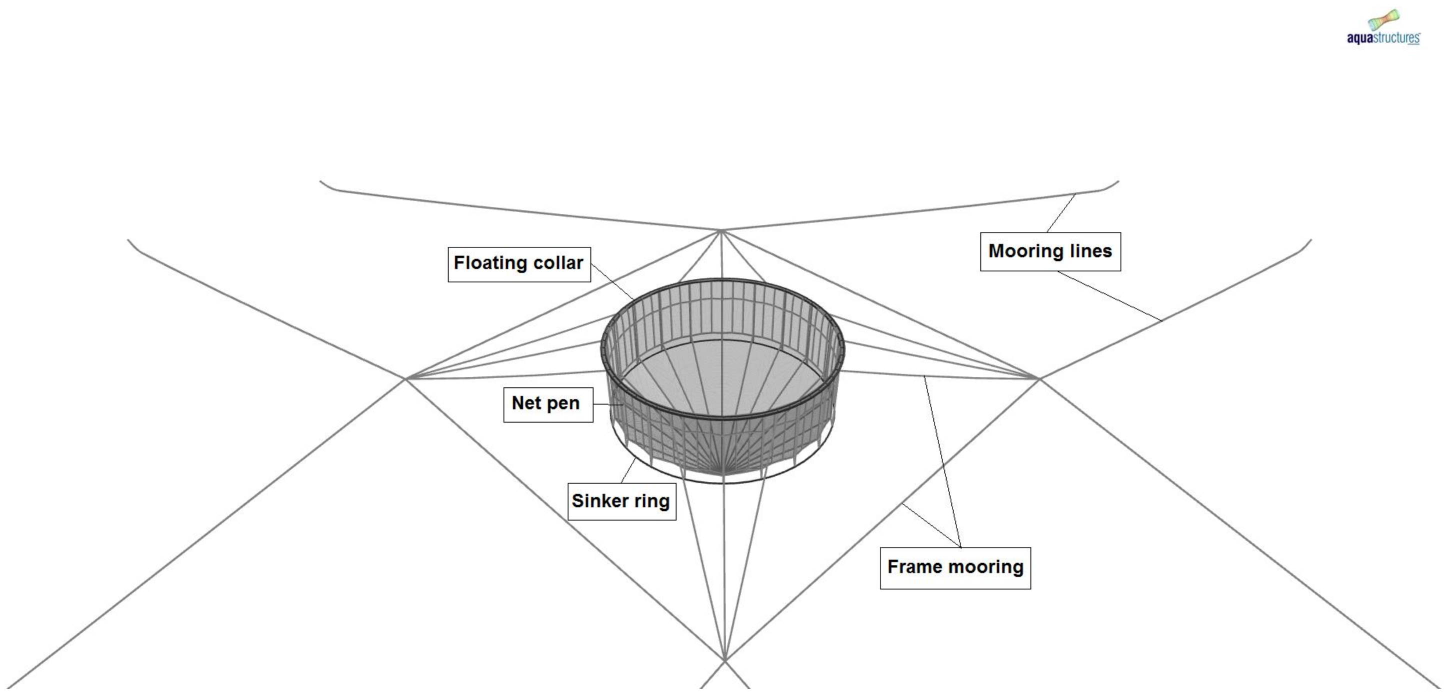
Therese Wergeland
Supervisor: Professor Carl M. Larsen

Norwegian University of Science and Technology (NTNU), Department of Marine Technology

Introduction

Norway produces over 14 million meals of salmon every day. This corresponds to an annual value of close to 40 billion NOK. The world's continuous population increase will require a substantial increase in food production. The aquaculture industry in Norway has a great potential for growth. But first, several challenges related to sustainability need to be solved. One of them is to prevent escapes from cages.

Fish cages are exposed to waves and currents, and all components should be designed to survive expected load conditions. A typical fish farm structure has a sinker ring hanging beneath the net to keep it stretched and distended when exposed to environmental loads. Due to currents, vibrations due to vortex shedding on the ring can occur.



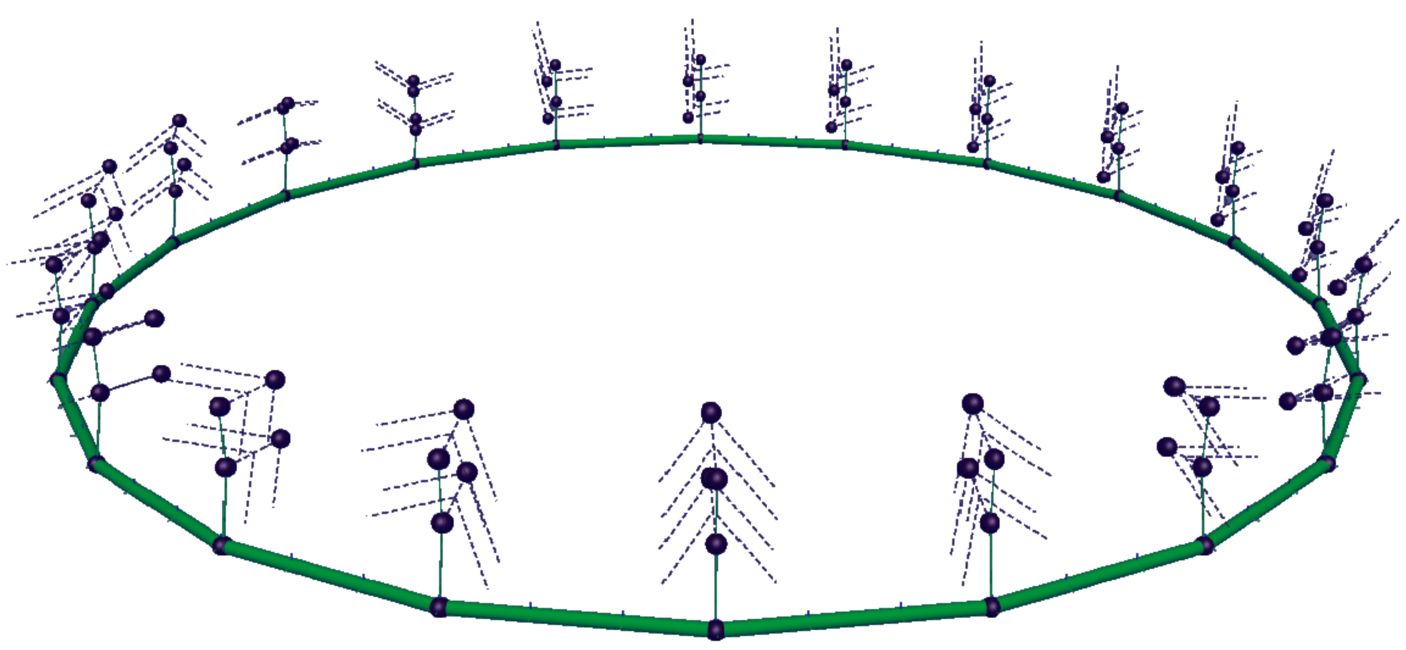
In this thesis, a local model of the sinker ring in a fish cage was established in RIFLEX and the effect of vortex induced vibrations (VIV) on the sinker ring was investigated using VIVANA.

Modeling

The sinker ring has a circumference of 160m, and the cross-sectional diameter is 400mm. 20 ropes connects the sinker ring with the net pen. In RIFLEX, the sinker ring with connection ropes has been modeled as seen in the figure below. 20 "springs" on top of the connection ropes has been modeled to obtain the correct stiffness from the net pen. The connection points were also given prescribed displacements describing the deformed shape of the ring after current forces was applied. This was done to obtain correct axial forces in the ring. The stiffness of the springs and the displacement pattern were found analyzing a complete model in AquaSim. AquaSim is a simulation tool for fish farms based on finite element analysis (FEA).

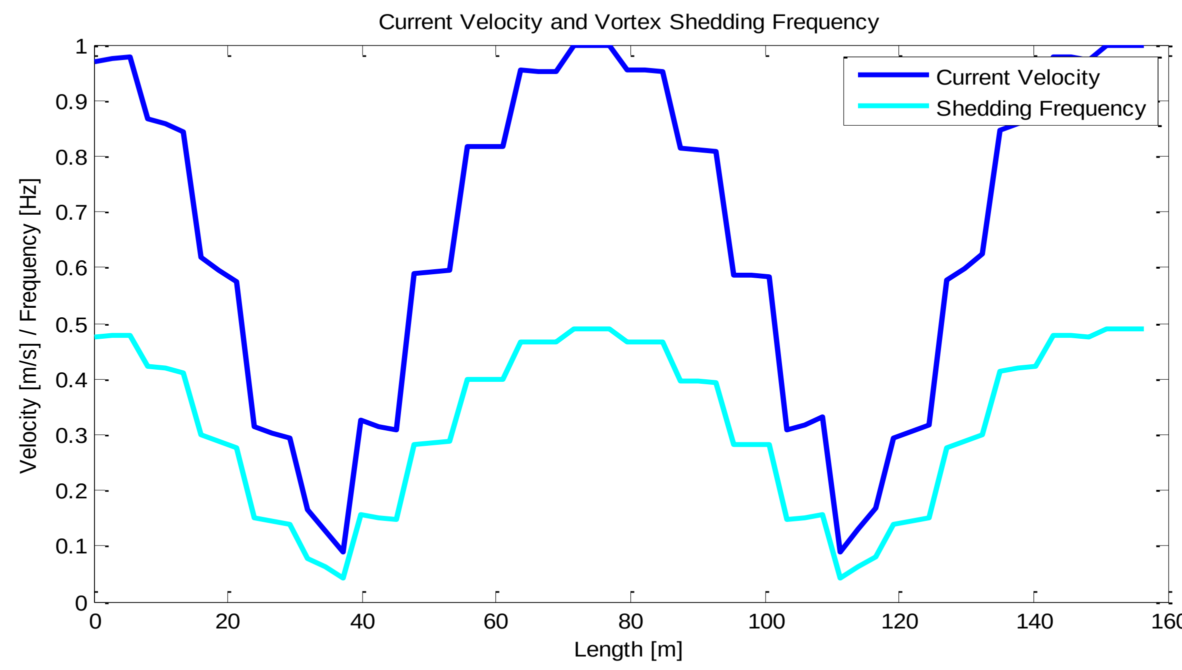
VIVANA was used for eigenfrequency and VIV analysis. VIVANA is a semi-empirical analysis program for prediction of VIV for slender marine structures. VIVANA is based on FEA, and is a module in the MARINTEK software SIMA.

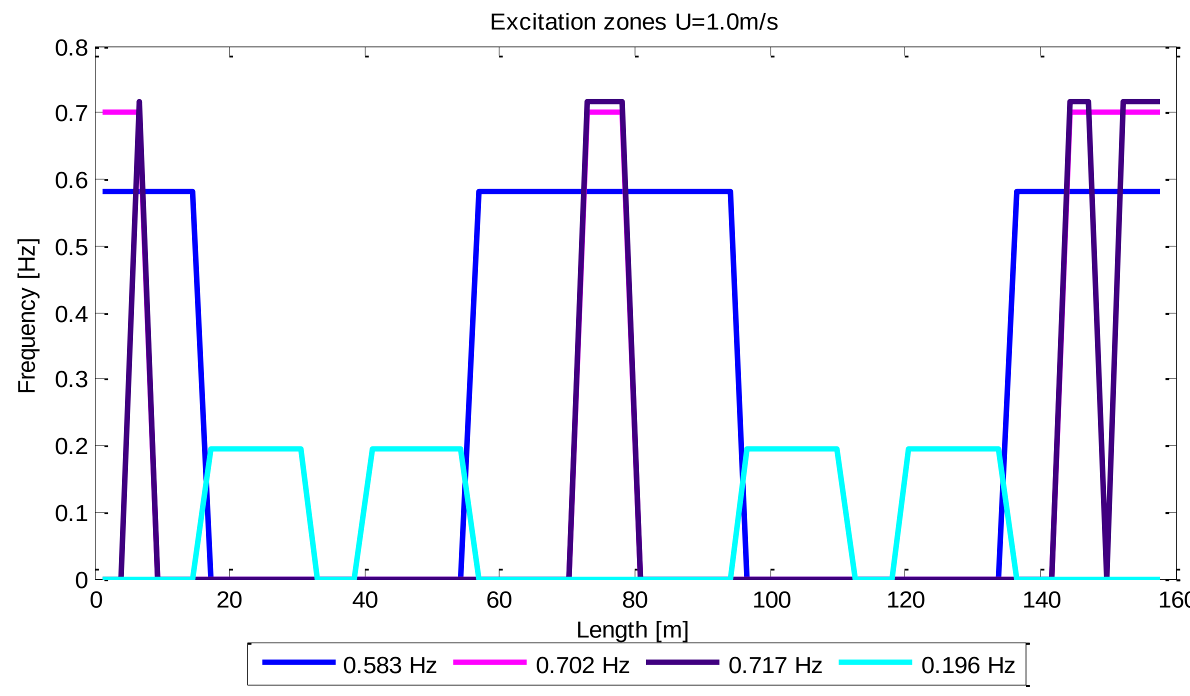
A range of current velocities from 0.1-1.4 m/s was investigated.

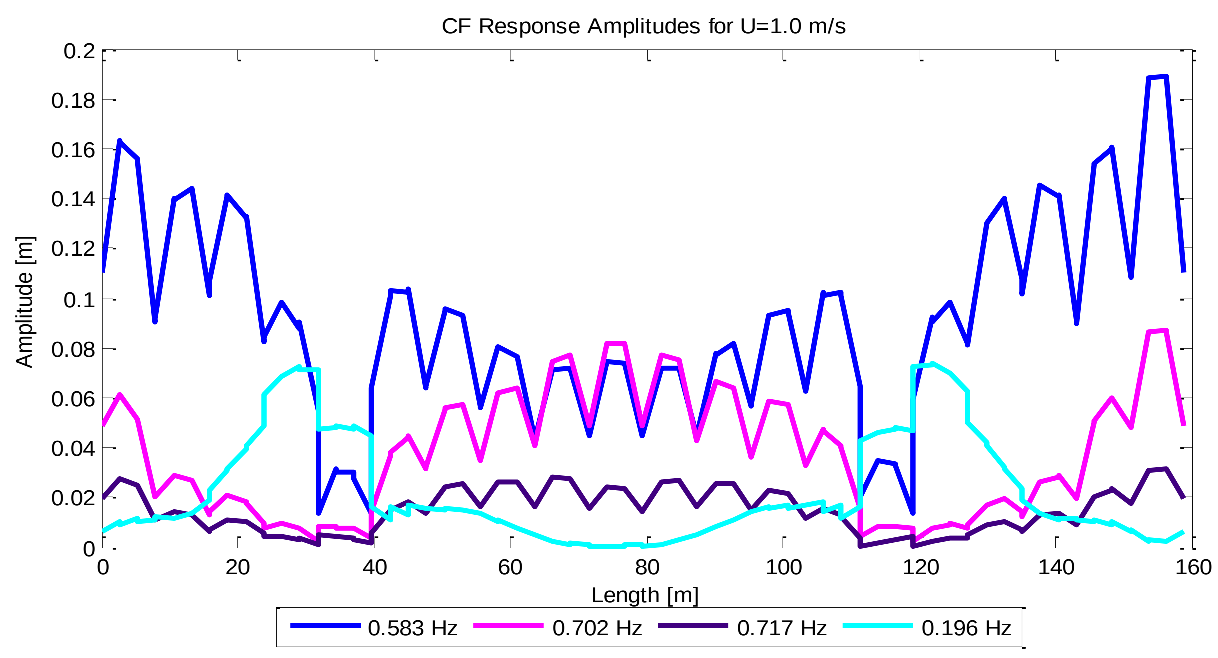


Results

VIV were not observed for current velocities less than 0.7 m/s. The figures below show results for the velocity distribution and vortex shedding frequency over the length of the ring, the excitation zones and the cross flow response at current velocity U=1.0 m/s.







Four frequencies will be excited. Only one frequency will be active at a time. f=0.58 is the dominating frequency and gives a response amplitude of almost 0.5D.

Conclusions and Recommendations

VIV will occur at current velocities larger than 0.7 m/s. The largest cross flow amplitude (0.26m) was observed at U=1.3 m/s at f=0.702 Hz. The trend is that the maximum response amplitude occurs in the upstream part of the ring. This is where the maximum velocity acts.

From a simple prediction of VIV made prior to the analyses, one should expect VIV to also occur at lower velocities. Further investigation of the problem should be performed before making final conclusions regarding the survivability of the sinker ring. A statistical analysis of the current conditions at a typical location to calculate the fatigue damage and the fatigue life of the sinker ring is also recommended.

Contact Information

Email: theresev@stud.ntnu.no