

# Dynamic load and response interaction for hydropower civil structures

**Erik Nordström (Adj.Prof.)**

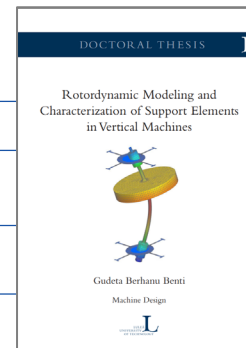
*Department of Concrete structures*

KTH

**Gudeta Benti (Post-doc)**

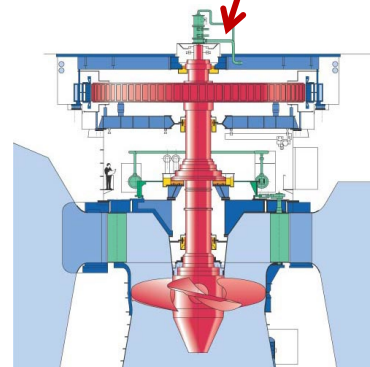
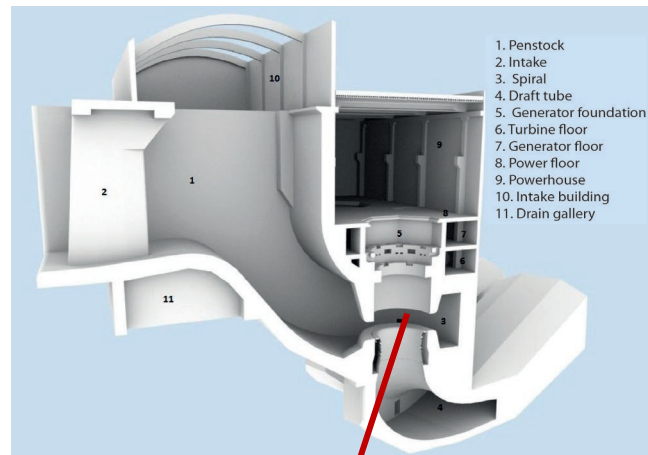
*Department of Concrete structures*

KTH



# Background

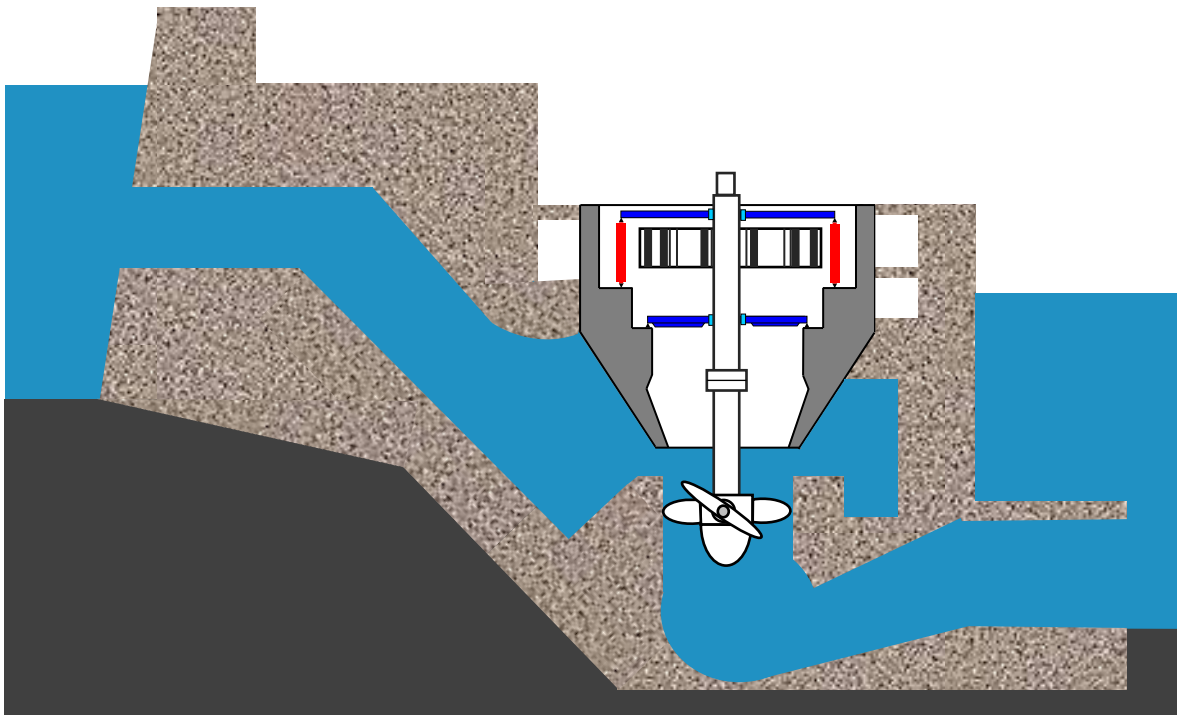
- Concrete structures in HPP exposed to **several unit renewals**
- Questions regarding **influence from cracks** (short/long-term)
- Operational patterns** different than during design



Lack of real data  
on structural  
behaviour !

# Background

## Hydropower system

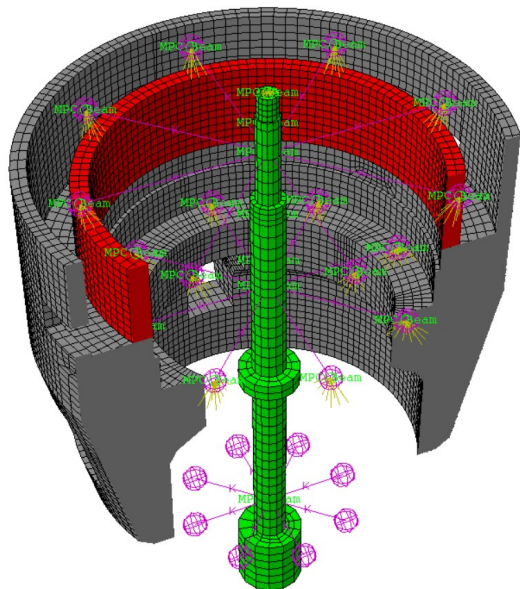


## Objectives

1. **Understand bidirectional interaction** between the hydropower unit and surrounding concrete supports
2. **Investigate the potential impact** from today's operational patterns on the concrete structure
  - a. **Mechanical factors:** (Unbalance load, axial load, misalignment, contacts, ...)
  - b. **Electrical factors:** (UMP, Tangential forces, short circuits ...)
  - c. **Hydraulic factors:** (Hydraulic load, water hammer, Cavitation ...)
3. **Assess risk of fatigue** in concrete or reinforcement
4. **Field measurement**
  - a. Analyse data from Vattenfall
  - b. Validate numerical models

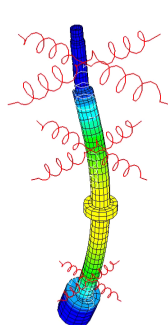
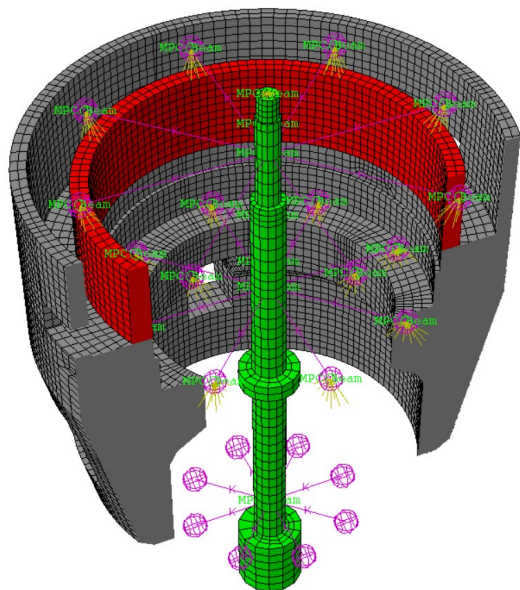
# Simulation

## Individual vs coupled system



# Simulation

## Individual vs coupled system

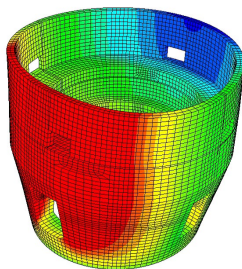
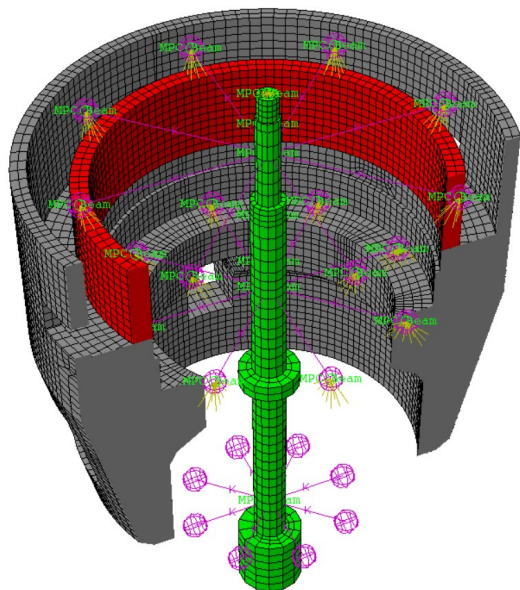


Angle: -180

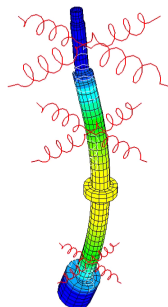
42.6 rad/s

# Simulation

## Individual vs coupled system



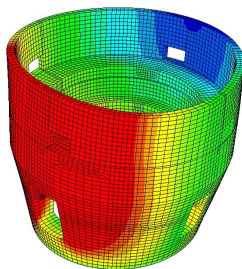
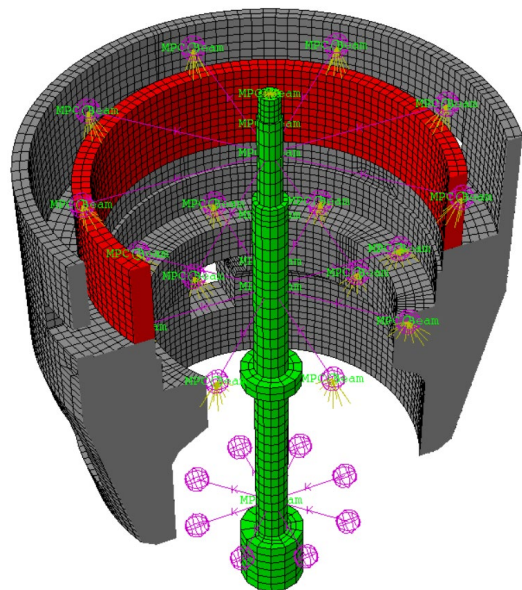
192.9 rad/s



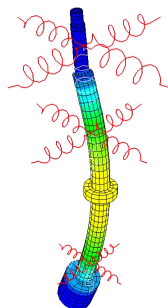
42.6 rad/s

# Simulation

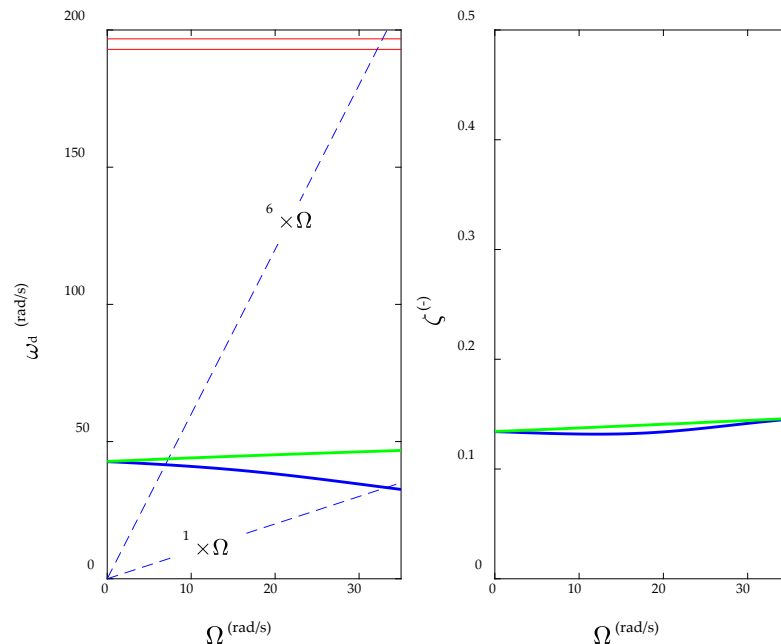
## Individual vs coupled system



192.9 rad/s



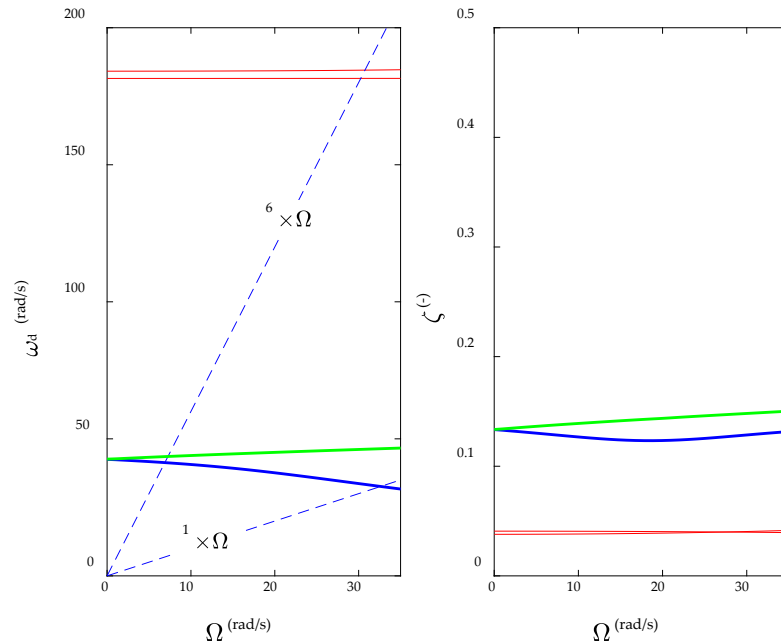
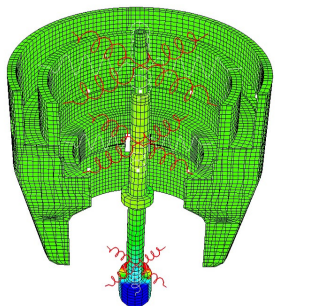
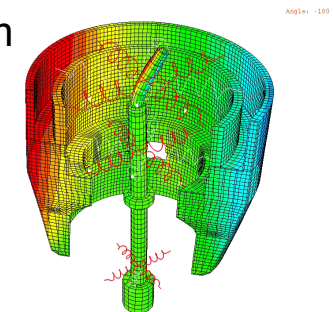
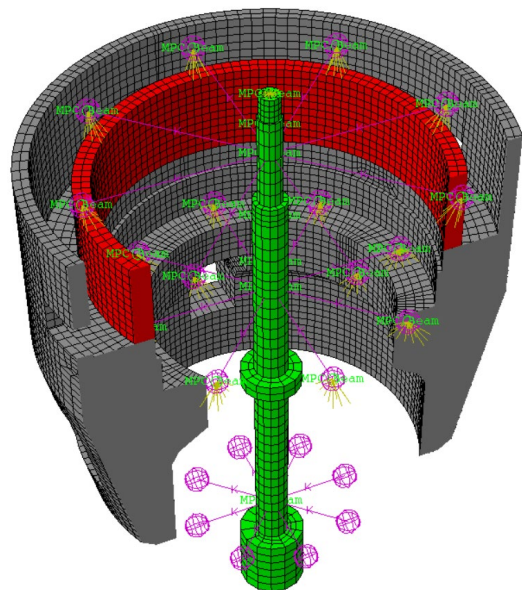
42.6 rad/s



Individual system

# Simulation

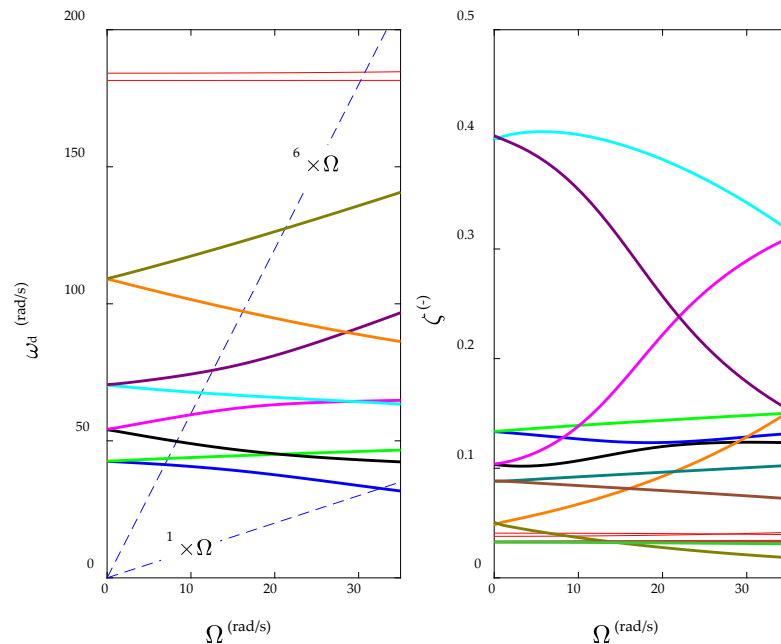
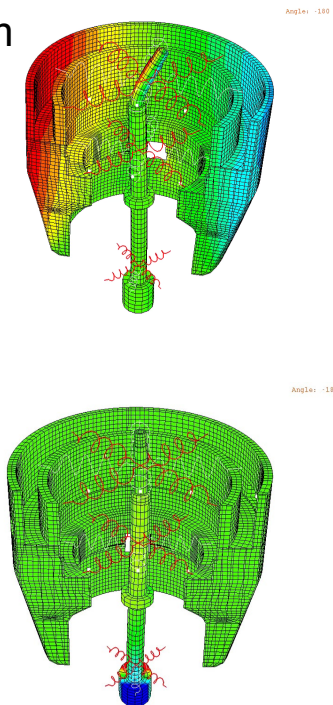
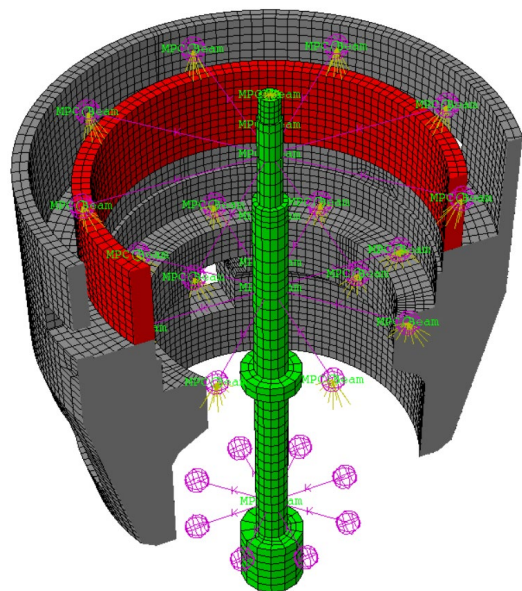
## Individual vs coupled system



## Coupled system

# Simulation

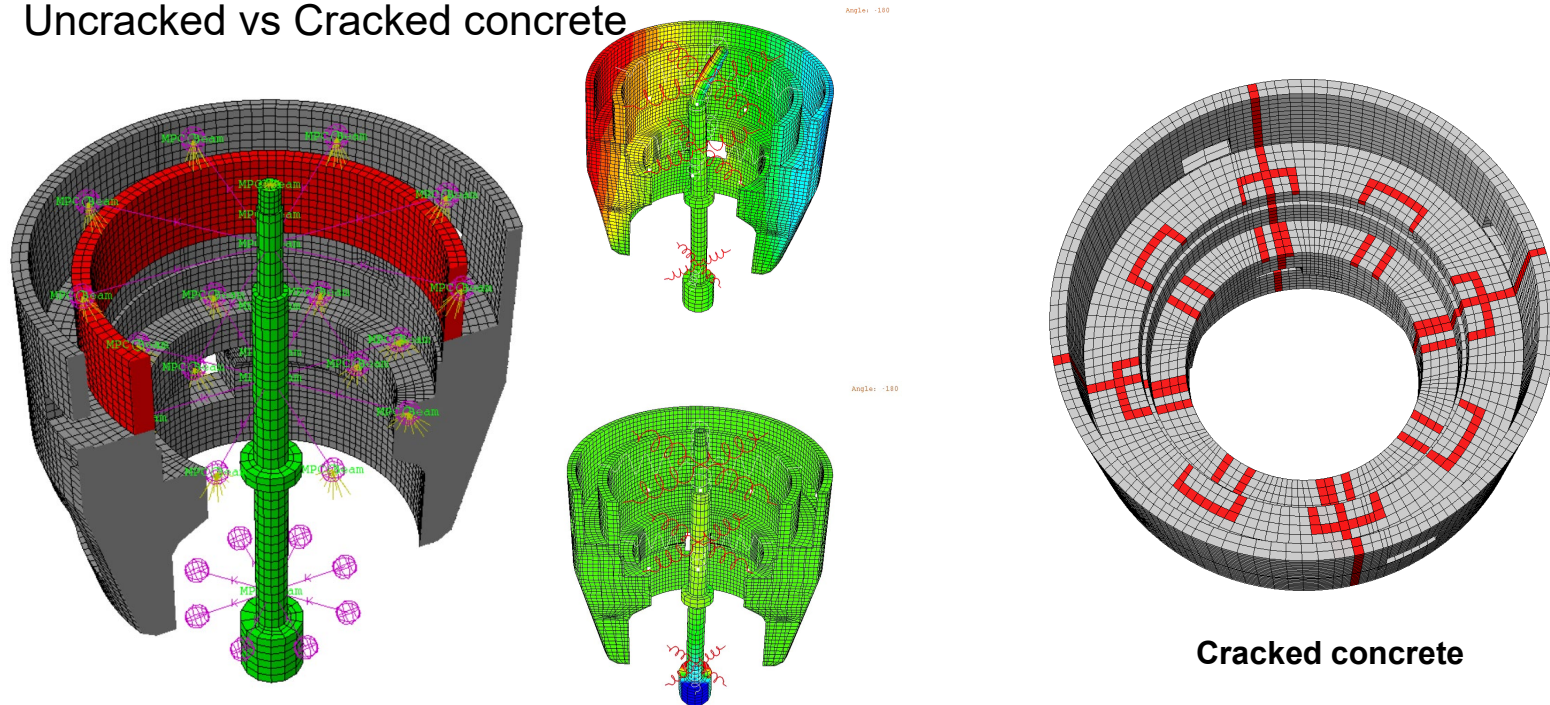
## Individual vs coupled system



## Coupled system

# Simulation

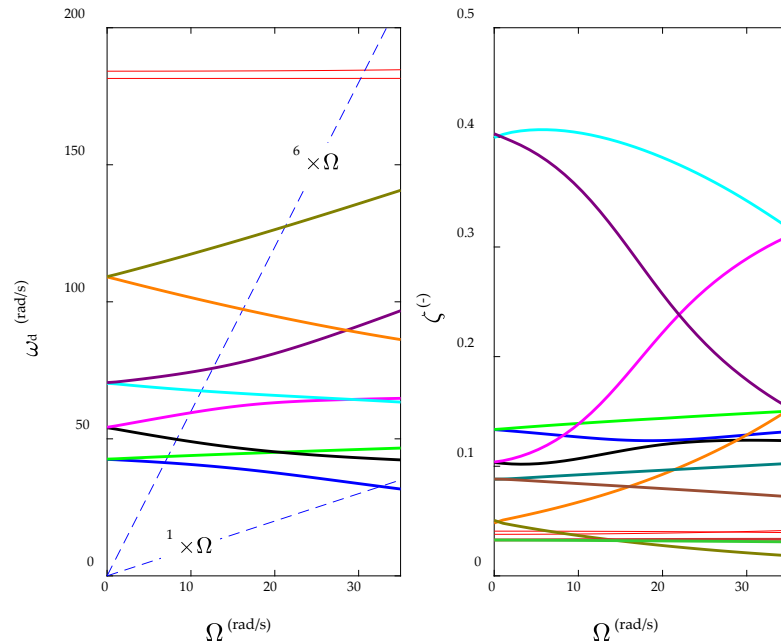
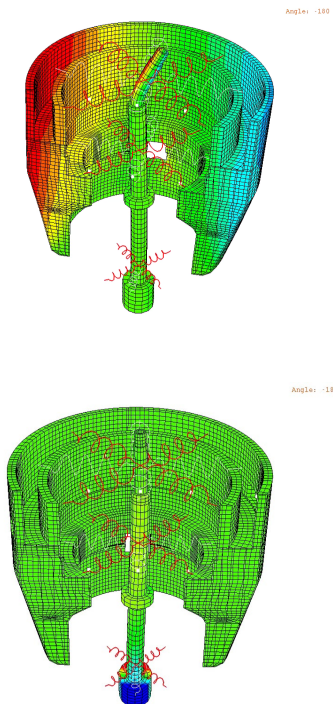
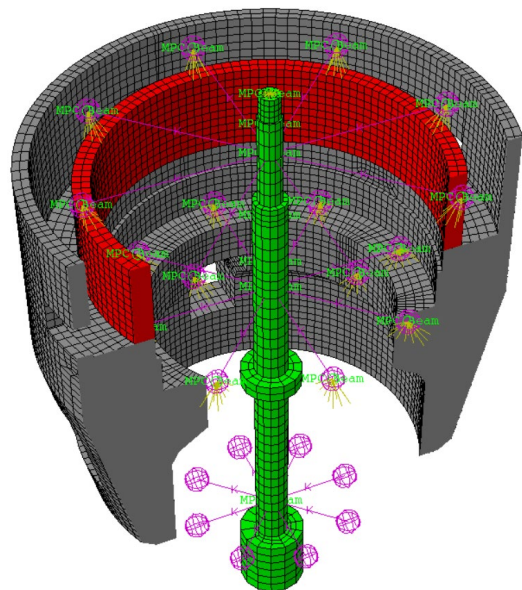
Uncracked vs Cracked concrete



**Cracked concrete**

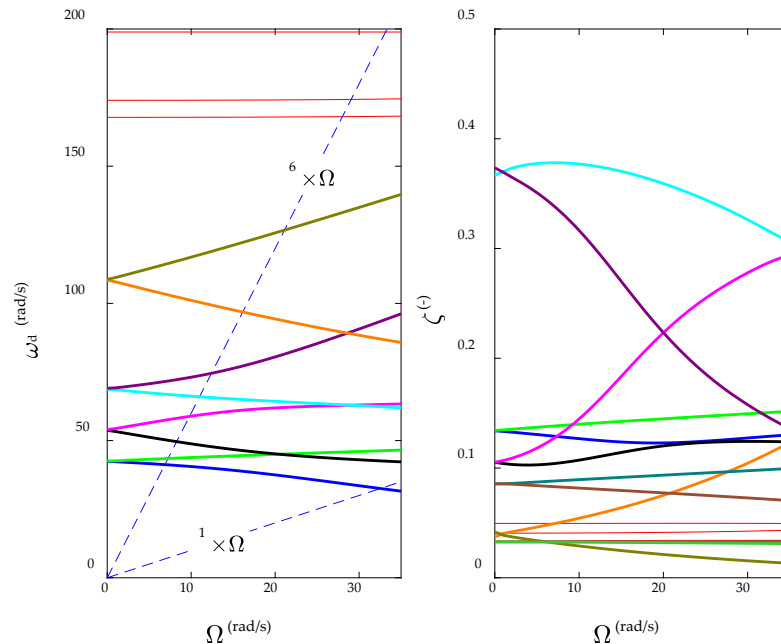
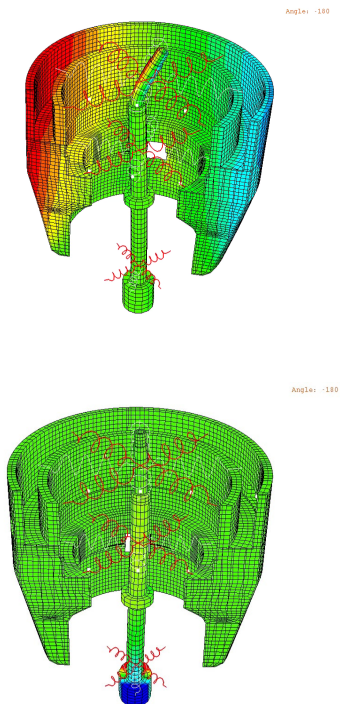
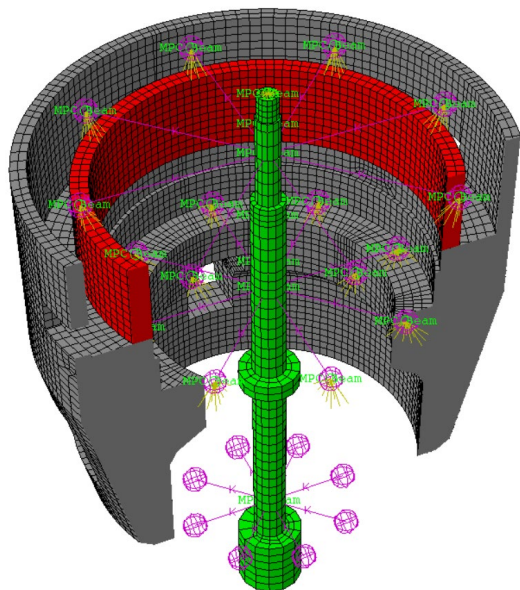
# Simulation

## Uncracked vs Cracked concrete



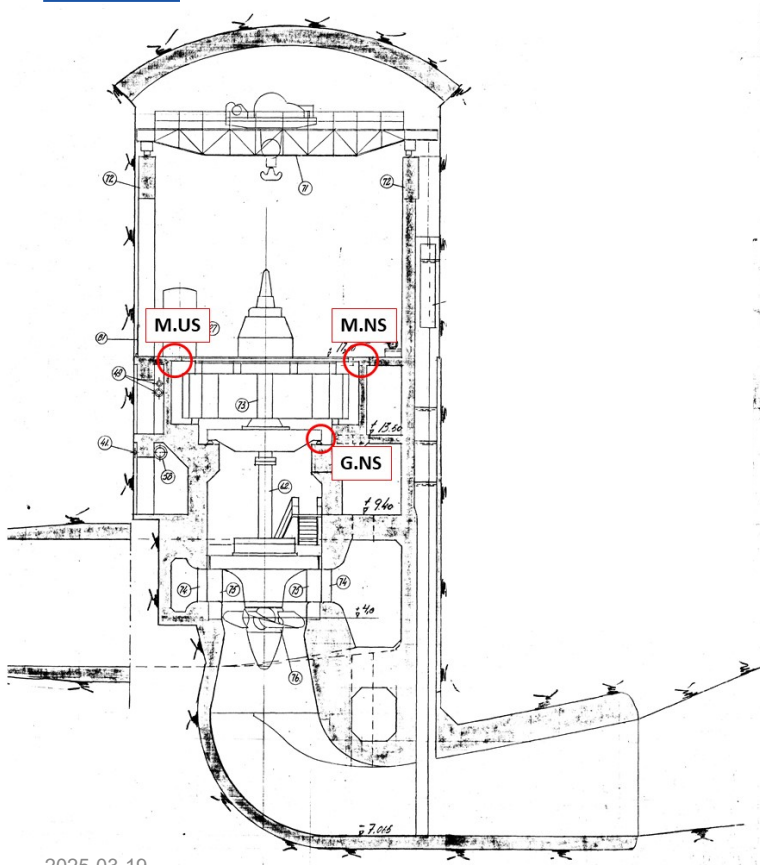
Model with uncracked concrete

## Uncracked vs Cracked concrete



Model with cracked concrete

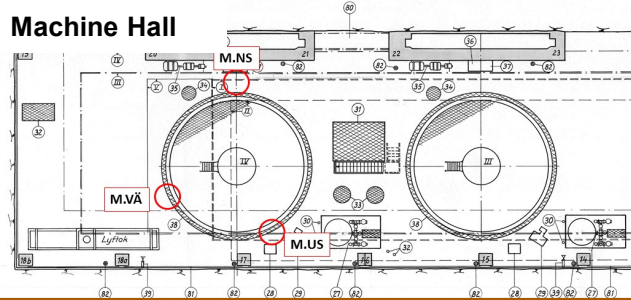
# Field Measurement



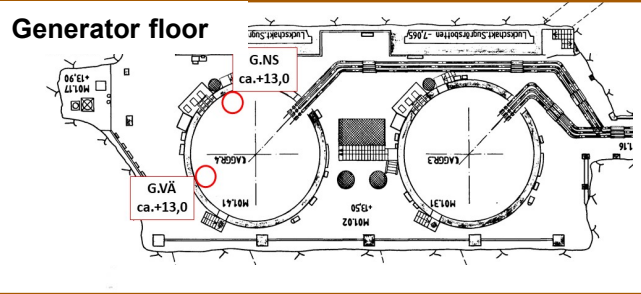
- Long-term measurement: 2019 - ongoing
- Measurement condition
  - I. Static Loading: ( $F_s = 5$  Hz)
  - II. Dynamic Loading: ( $F_s = 600$  Hz)
- Different sequences
  - continuous operation
  - start/stop
  - summer/winter

| Cases                                | 2019-06-18 | 2019-10-10 | 2019-12-05 | 2020-02-25 | 2020-05-15 | 2020-09-02 | 2020-09-04 | 2020-09-29 | 2020-09-30 | 2020-10-21 | 2020-10-27 | 2021-06-15 | 2021-06-23 | 2021-11-19 | 2022-02-21 | 2022-05-17 | 2022-11-03 |
|--------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Static loading<br>( $F_s = 5$ Hz)    |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |
| Dynamic loading<br>( $F_s = 600$ Hz) |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |            |

## Machine Hall

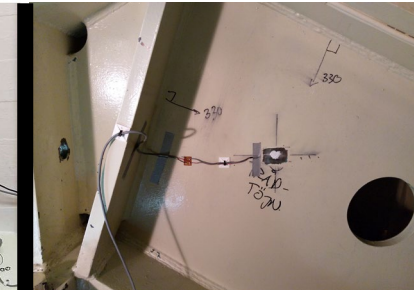
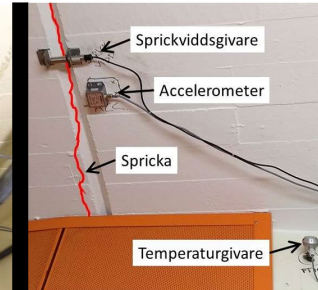
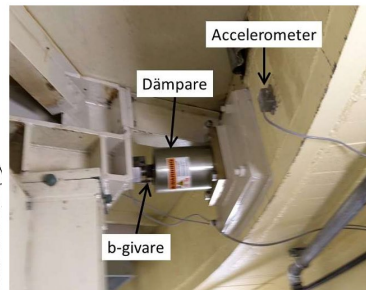


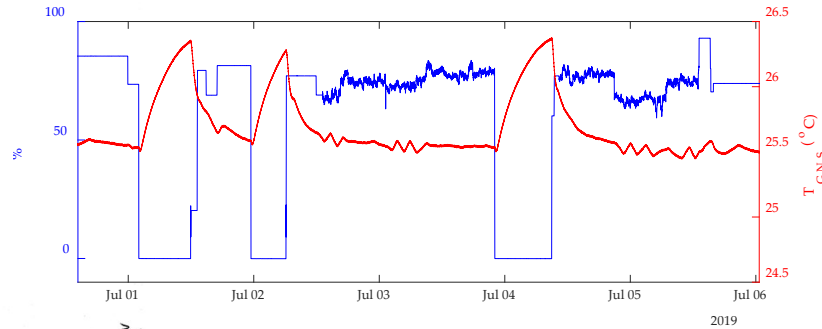
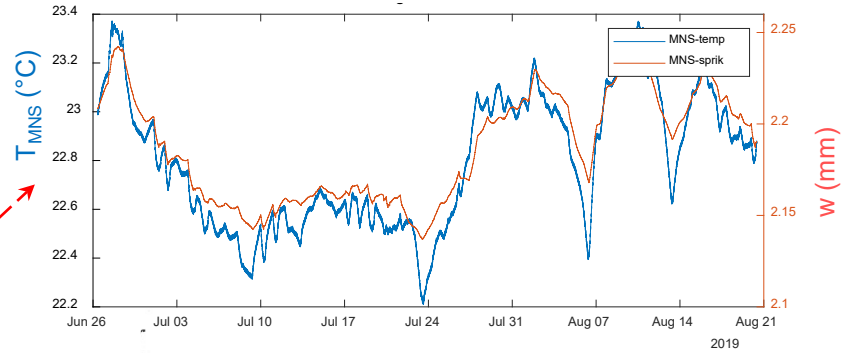
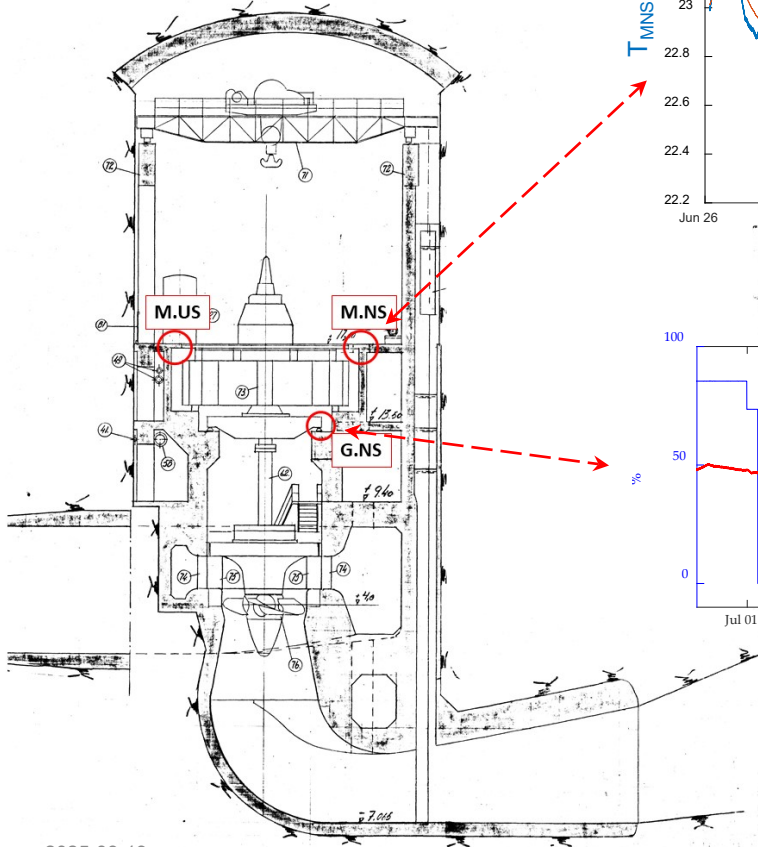
## Generator floor



## Sensors

- **Temperature sensors**  
(mounted on concrete)
- **Inductive sensors**  
for crack width monitoring
- **Accelerometers**  
for vibration measurements
- **Inductive sensors**  
for damper displacement
- **Strain gauges**  
to measure bracket strain







# Summary

- Post-doc (Gudeta Benti) recruited from WP3 – Rotor dynamic knowledge
- Initial FE-modelling of a coupled system (continuation of Tobias Gasch PhD-work)
- Analysis of field monitoring data from Vattenfall unit
- Additional field measurements of vertical loads planned together with WP3
- Numerical model of Vattenfall unit and validation with monitoring data

Close co-operation between research groups (WP2-WP3) at KTH and LTU !

Thanks you for your attention!