

Photogrammetry of Kalhovd dam

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LULEÅ
UNIVERSITY
OF TECHNOLOGY

MCE
Laboratory

Concrete
structures

Bridge
engineering



Composite
&
steel structures

Fire
engineering

Timber structures

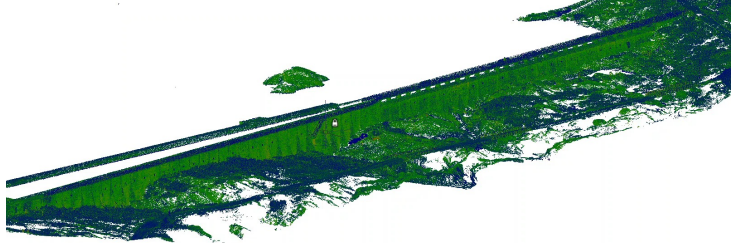
Photogrammetry

What is it?



Kalhovd Dam

Case study of Stable Dams (2015-2019)



386 m long, 10 m high

66 pillars

5 m span



Norway, Telemark

1940 - 1948



Sliding safety

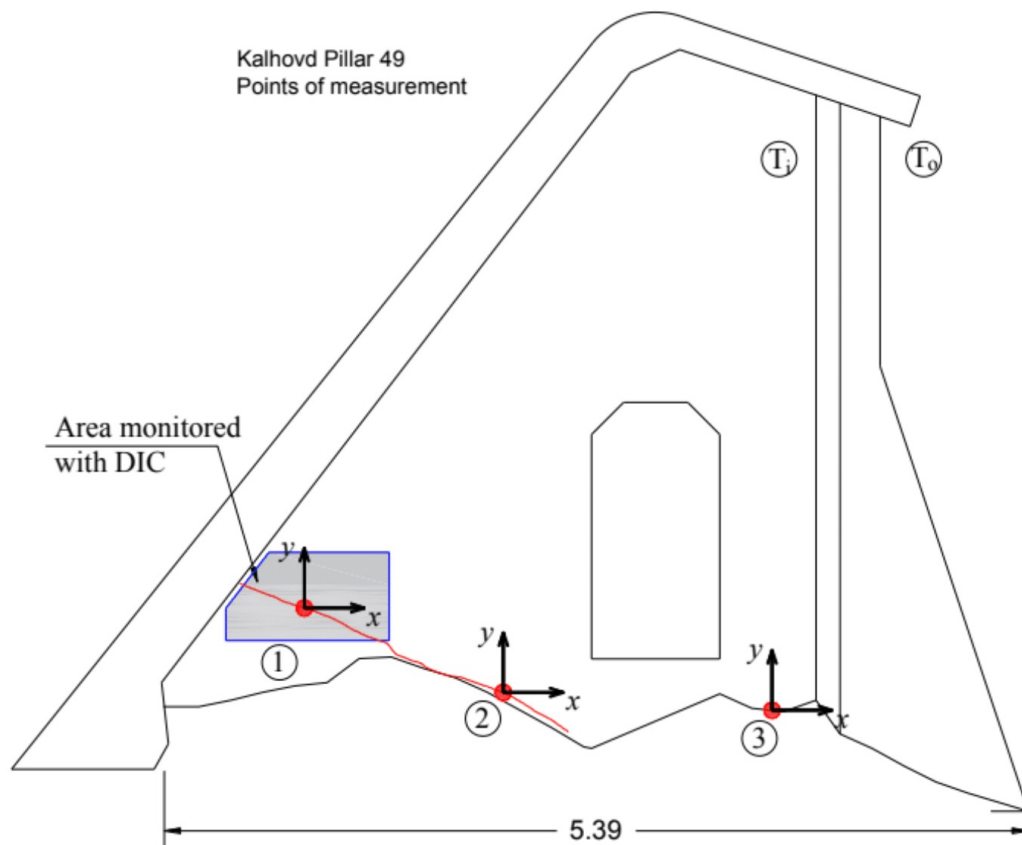
“Good” condition

Pillar 49: condition assessment

1. What caused the crack in concrete and the crack at interface ?
2. Is the process still active?



Pillar 49: Long term - monitoring plan



- Displacements:
3 points along the interface
- Crack evolution:
Photogrammetry -DIC
- Temperature:
inside & outside

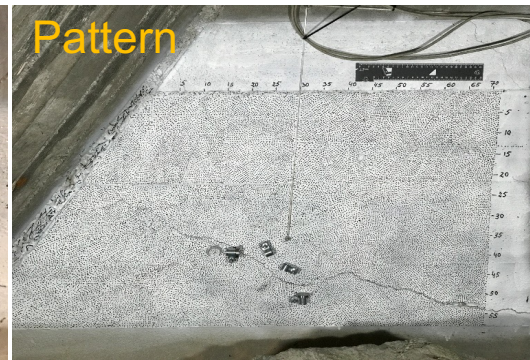
Photogrammetry for crack evolution

Measurement plan

- 2D digital image correlation
- Area monitored (700 × 550 mm)
- Photos every 90 minutes

Equipment

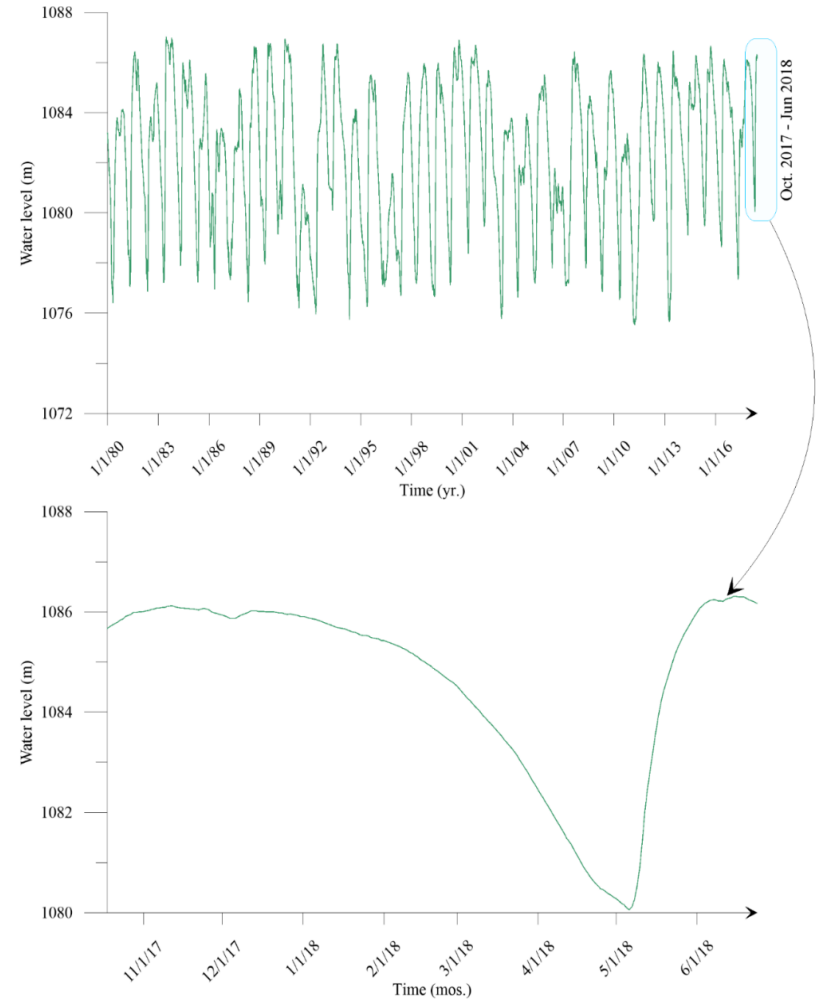
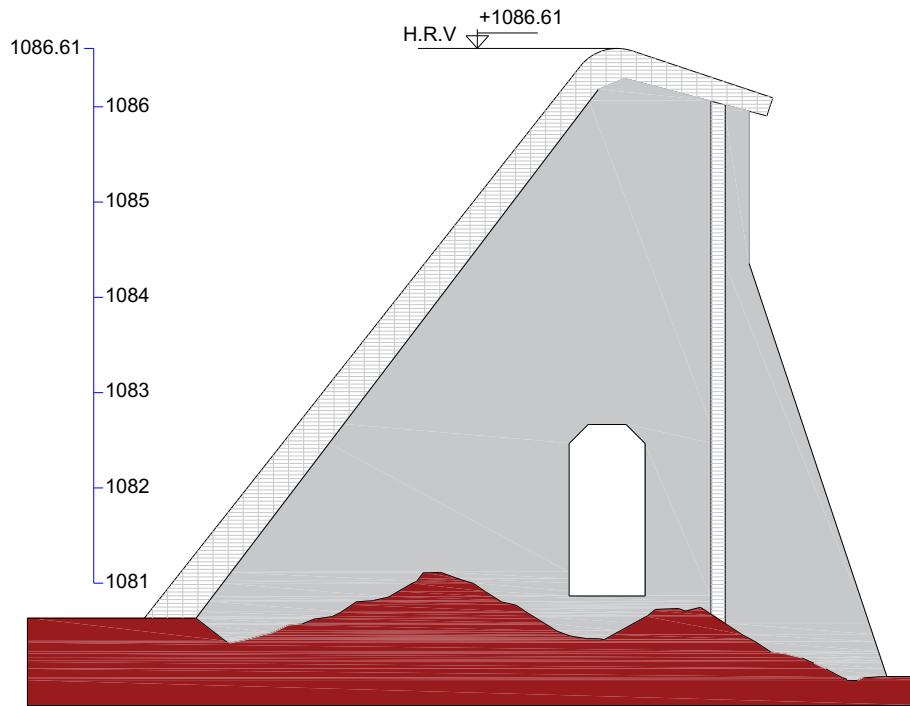
- Canon 80D
- 24 megapixels
- APS-C sensor (i.e. not full frame)
- Canon EF 35mm wide-angle prime lens
- Two led lamps
- Carbon fiber tripod



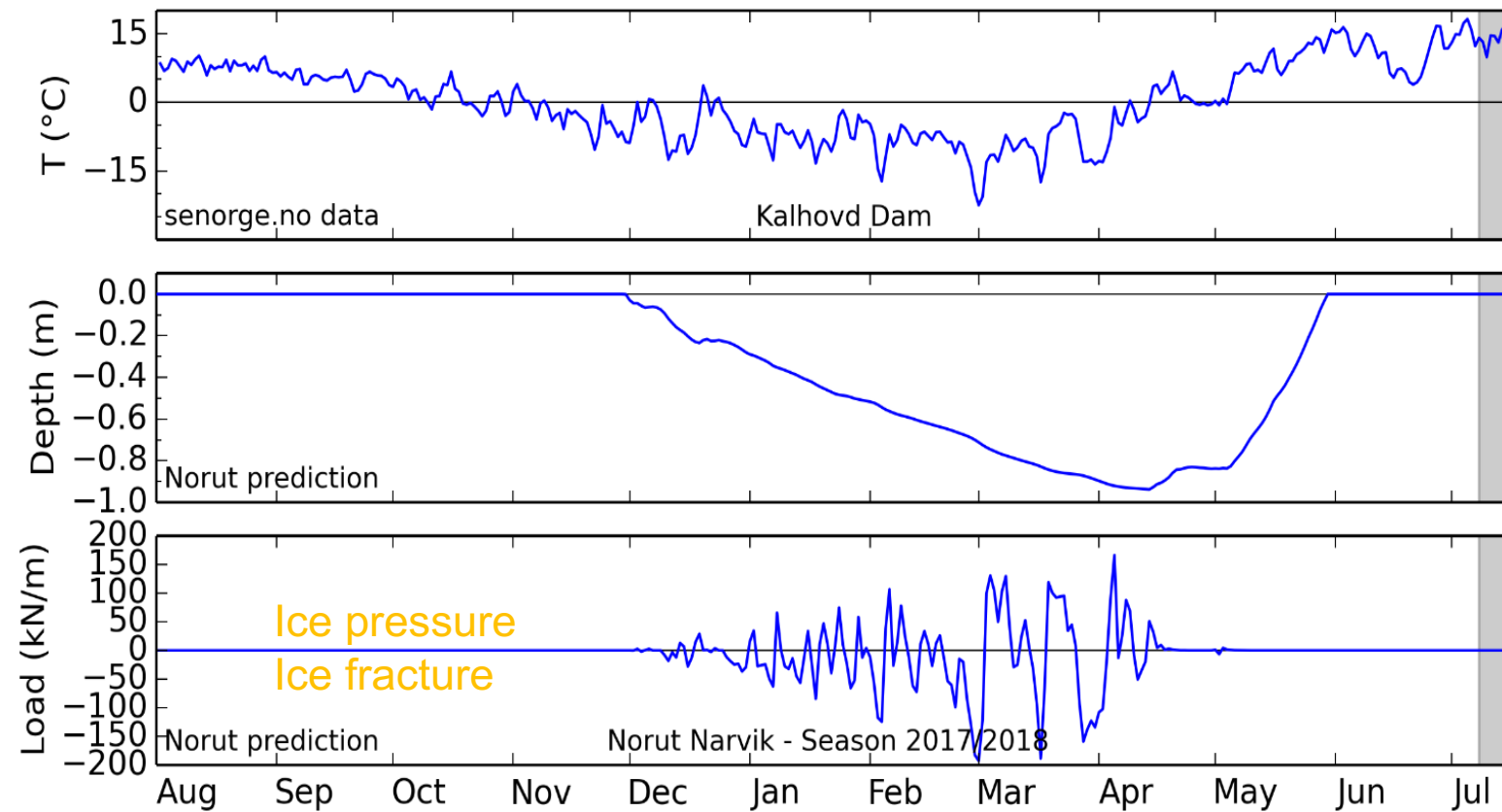
Photogrammetry for crack evolution

The image is a composite of three parts. On the left is a schematic diagram for a Kalho system. It shows a 'GSM Internet WR31' module connected to an 'Ethernet' network. This module is linked to a 'Relay' and a 'Digital IO' block. The 'Relay' is connected to another 'Digital IO' block, which is in turn connected to a 'DAQ HBM' (Data Acquisition Hardware) module. The 'DAQ HBM' is connected to an 'RS232' interface and a 'UPS' (Uninterruptible Power Supply) unit. The 'UPS' is connected to a 'Power network' and provides 'USB UPS Status' feedback to the 'DAQ HBM'. The central photograph shows a tunnel interior with a camera mounted on a tripod, a light source, and a wall-mounted enclosure. The enclosure is a white metal cabinet with a door open, revealing internal components. On the right is a close-up photograph of the wall-mounted enclosure, showing an orange interior panel, a black heat sink, a digital display showing '13.95', and various cables and components.

Results: Water level

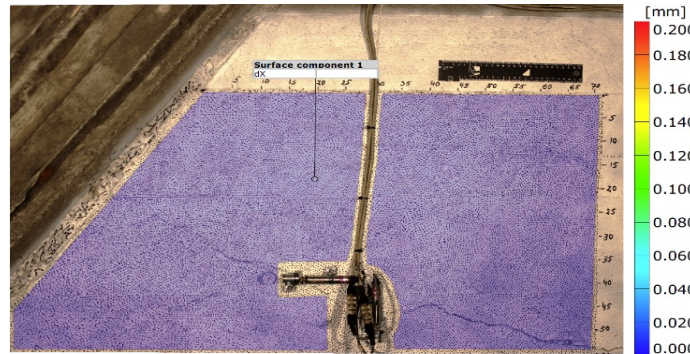
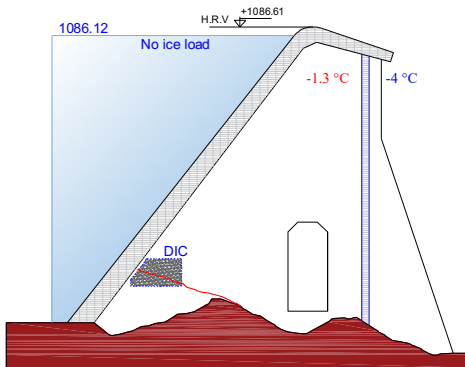
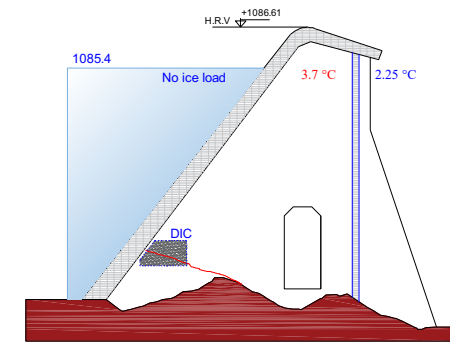


Results: Ice load prediction

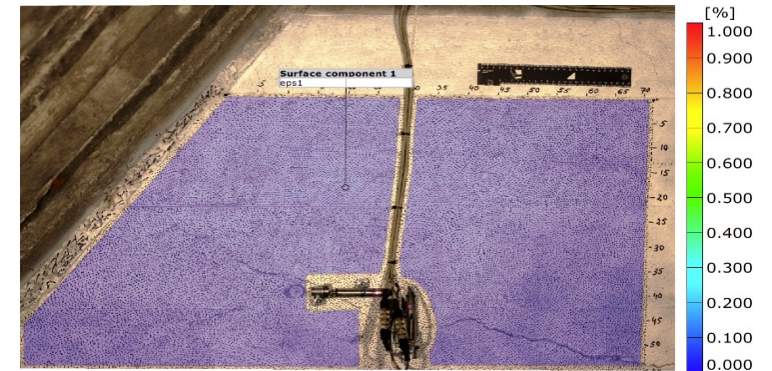


Ice loads predictions based on daily temperature variations (<https://ndat.no/sd/>).
Calculations based on Petrich et al. (2015).

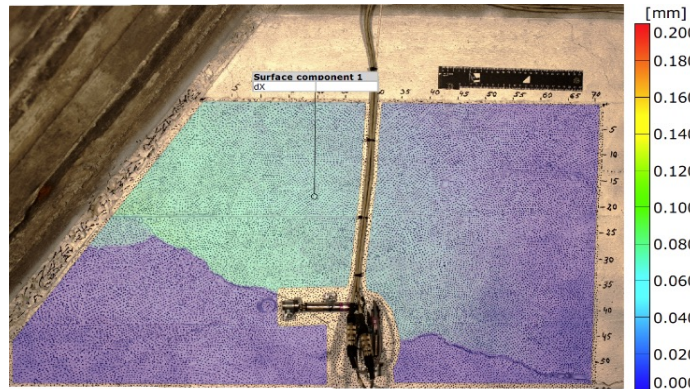
Results: Photogrammetry – DIC – max water level



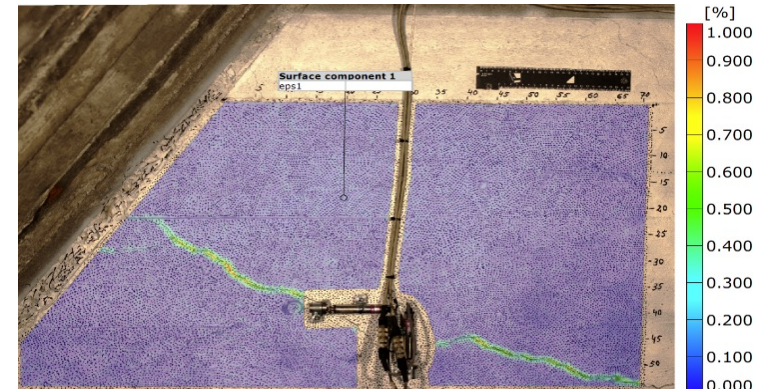
Reference image (2017.10.18) – dx



Reference image (2017.10.18) – eps

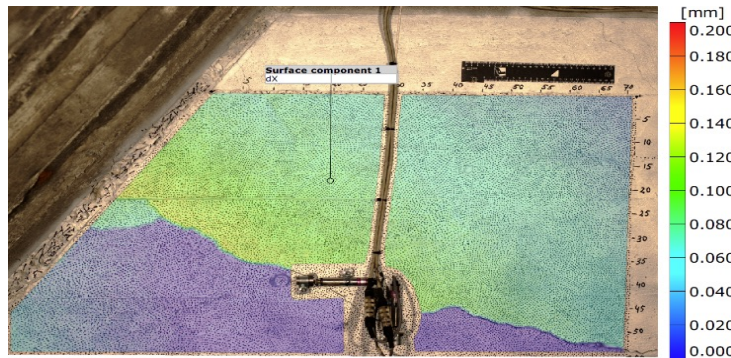
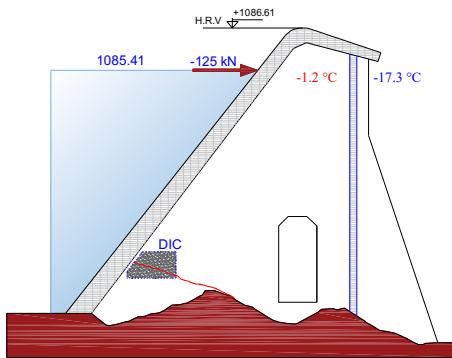


Max water level #1 (2017.11.11) - dx

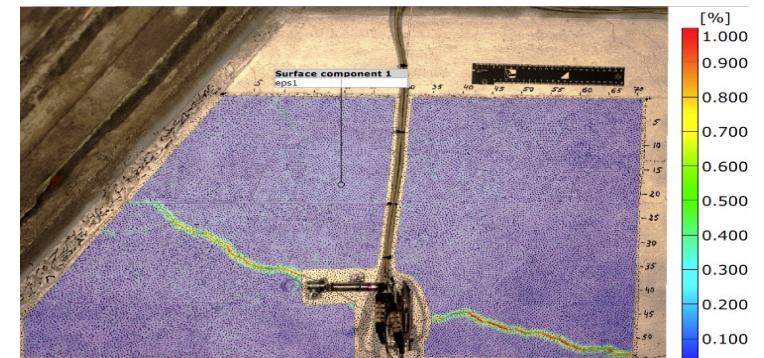


Max water level #1 (2017.11.11) - eps

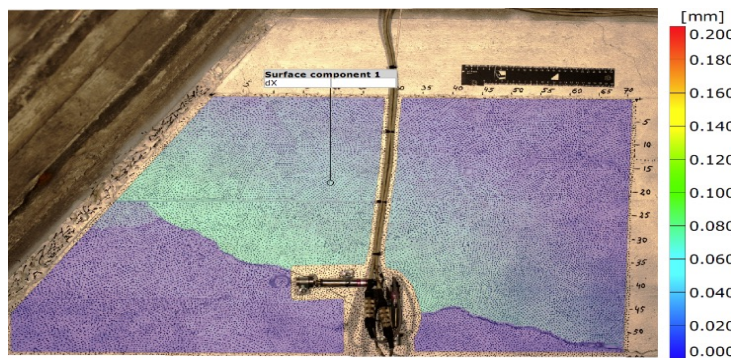
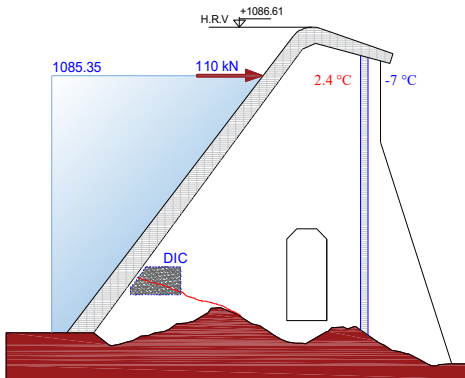
Results: Photogrammetry – DIC – peak ice load



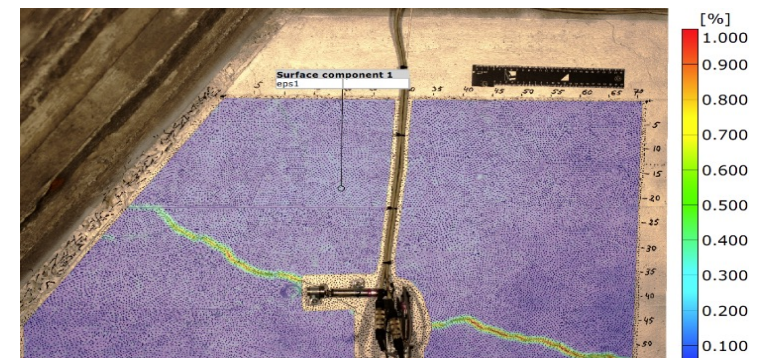
1st "peak" ice fracture (2018.02.02) – dx



1st "peak" ice fracture (2018.02.02) – eps

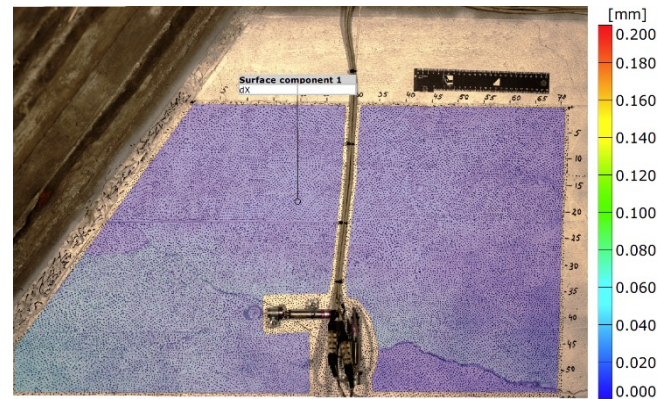
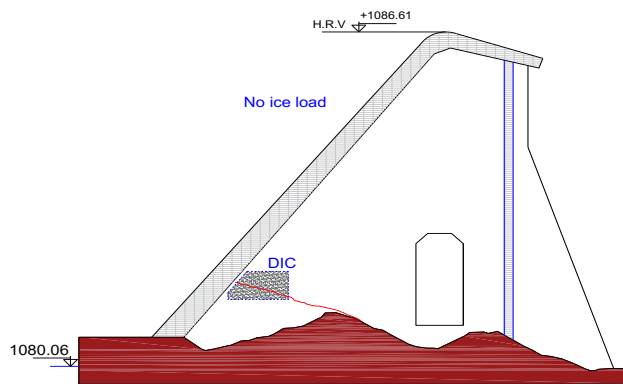


1st "peak" ice load (2018.02.05) – dx

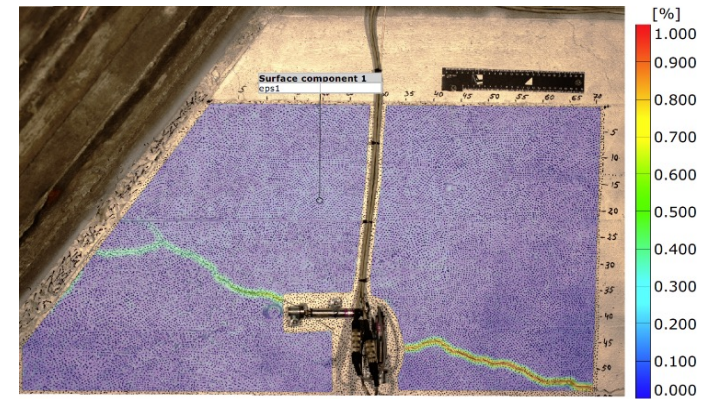


1st "peak" ice load (2018.02.05) – eps

Results: Photogrammetry – DIC – no water



Min water level (2018.05.06) – dx



Min water level (2018.05.06) – eps

Analysis

October to mid - February

Max water level observed

Peak ice loads 100 kN/m

Predominantly sliding movement of the pillar

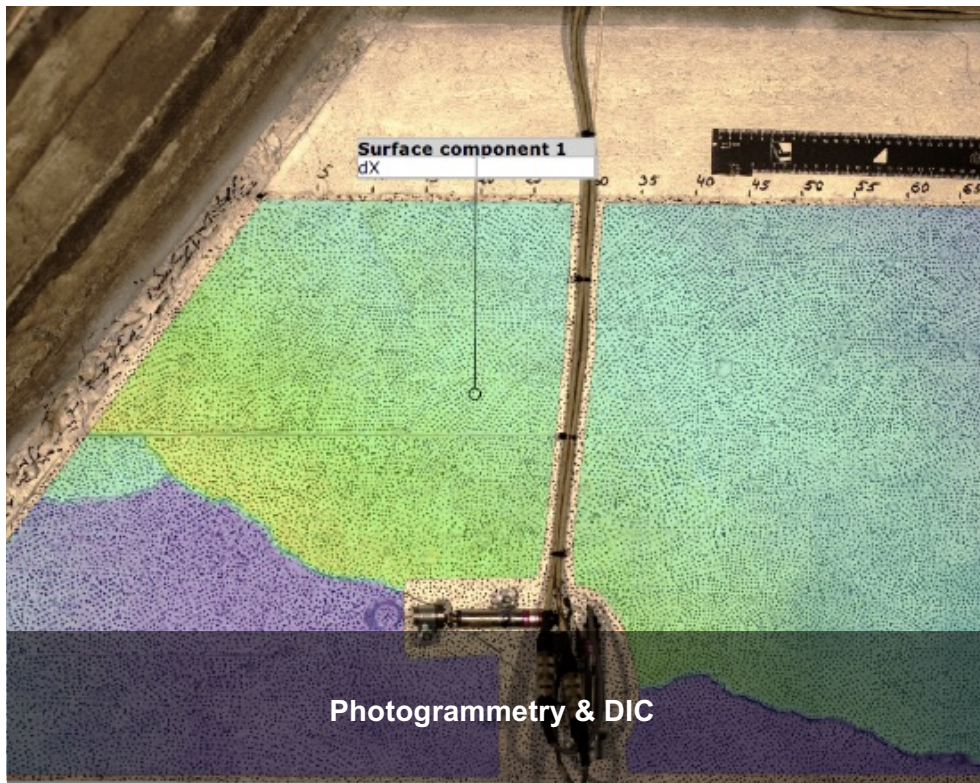
Mid-February – onwards

Water level dropped and increased rapidly

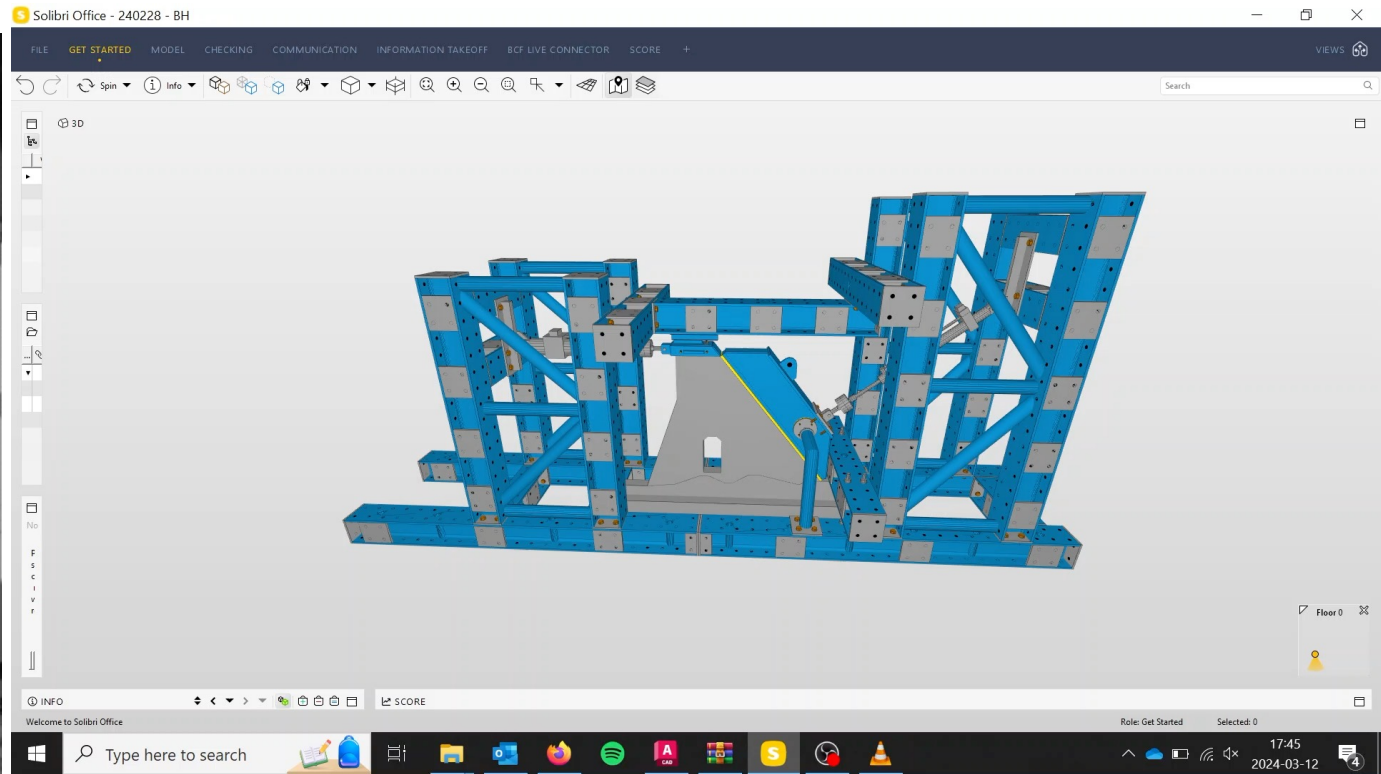
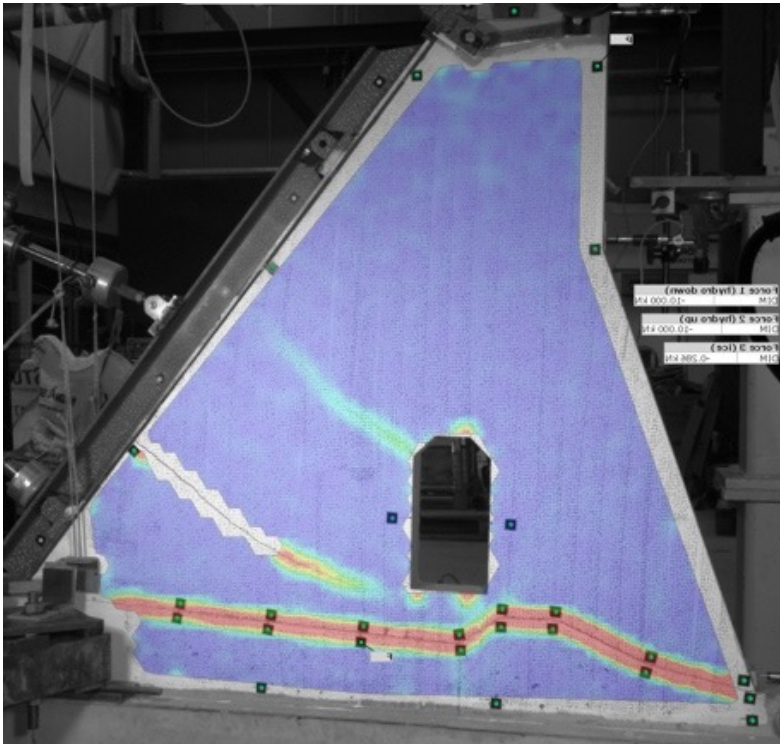
Max ice loads 160 kN/m and drops to zero in April

Trend suggest the the pillar is “silding back” towards its original position

Summary of the pilot study



DIC on model tests in 2018 and new model tests in 2024





Automated damage inspection based on photogrammetry

Acknowledgements

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