The potential of detecting flaws in an experimental dam at Älvkarleby, Sweden, using P-wave traveltime tomography

Silvia Salas-Romero, Christopher Juhlin & Christian Bernstone
Outline

• Background and project goals
• Survey layout: hydrophones and boreholes
• What is P-wave traveltime tomography?
• Synthetic models:
  – Cavity
  – Horizontal permeable layer
• Summary & Outlook
• References
Background

• A large number of earth embankment dams were built in the second half of 20th century in Sweden

• Defects (e.g., seepages and internal erosion) inside the dams can be detected but not located with precision using indirect methods

• Vattenfall initiated a research project for detecting damages in this type of dams, using blind testing through continuous seismic, resistivity, and temperature measurements
Goals of this work

- Test and, if possible, detect built-in flaws of unknown position and size within the core of an experimental dam using synthetic and real P-wave traveltime tomographic data

- Support the interpretation of P-wave reflection seismic data

Experimental dam design

- 20 m long and 4 m high, composed of four parts: A (impermeable core), B (fine filter), C (coarse filter), and D (support filling)

- Seismic data recorded with 5 lines of hydrophones and one 3C-geophone in the deep boreholes, using a P-wave sparker as seismic source in every borehole
Survey layout
P-wave traveltime tomography

1. Shooting seismic source
2. Raypath affected by cavity
3. Picking traveltimes (first arrivals) from shot records
4. Traveltime inversion for P-wave velocities ($V_p$)
Inversion parameters

- Program: PStomo_eq (Tryggvason et al., 2002)
- Cell size (x,y,z): 0.1 x 0.1 x 0.1 m
- Number of iterations: 9

\[ V_p \]

- A: 3000 m/s
- B: 2200 m/s
- C: 1800 m/s
- D: 2000 m/s
- Bedrock: 5000 m/s
- Water: 1500 m/s
- Air: 340 m/s
Synthetic model: cavity

Cavity

Size: 0.4 x 0.4 x 0.4 m

\[ V_p = 1000 \text{ m/s} \]
Synthetic model: horizontal permeable layer

Horizontal permeable layer

Size: 2 x 1 x 0.2 m

$V_p = 1000$ m/s
Summary

• Synthetic modelling results show, in general, that the defect position can be identified by tomography

• Velocity and size of the defects are not well recovered by the method (seismic ray coverage is limited in some areas)

Outlook

• Continue modelling synthetic and real traveltime data

• Reflection seismic surveys every 2 months (the reservoir will be operated at its max. water level for about 18 months)

• Interpretation of reflection seismic data together with P-wave traveltime tomography
References