ADVANCED SOLUTIONS FOR ASSESSMENT OF EXISITING CONCRETE DAMS

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NORWEGIAN HYDROPOWER CENTRE

Dipen Bista

NTNU

About the project

- Project: Stable Dams
- Project Owner: NORUT Northern Research Institute
- Project Partners

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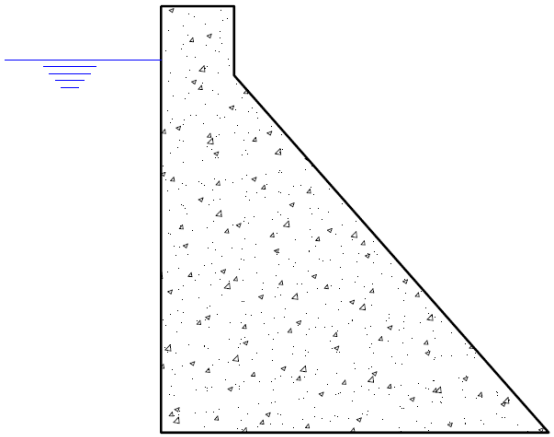
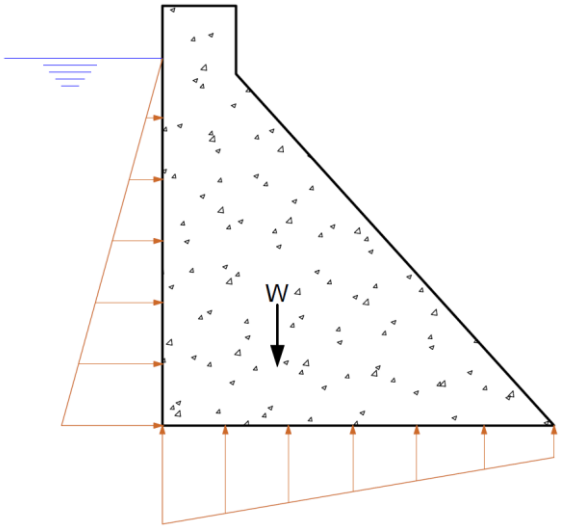
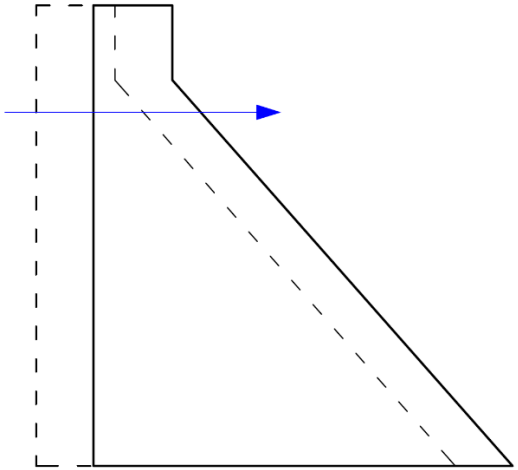
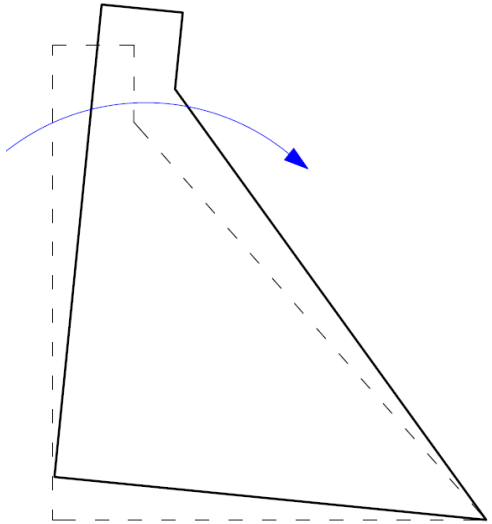
Concrete gravity dams



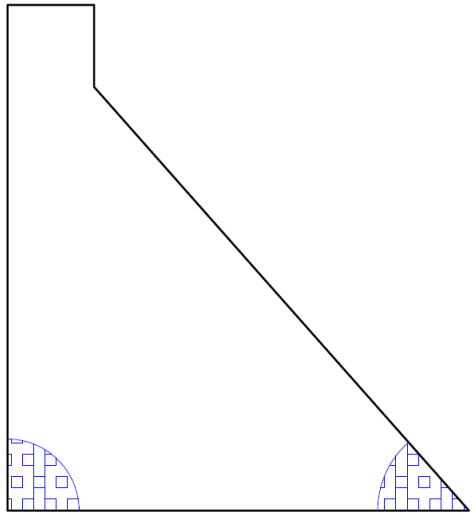




Sliding Failure



Overturning Failure



Overstressing

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Background

- Most of the small concrete dams (<15m) in Norway were built between 1950-1970
- Safety factor requirement has been revised (for eg. 1-1.5 for sliding stability in design load)
  - Dams are theoretically unsafe
- Safety calculation is based on simple calculation models

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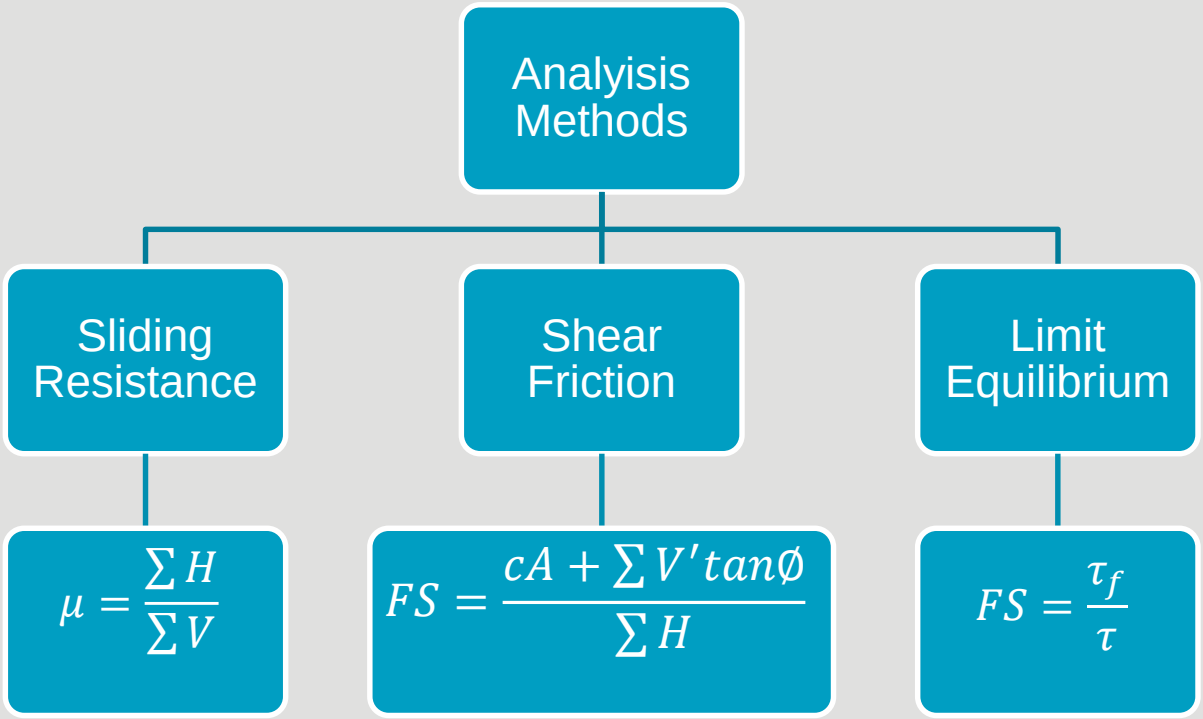
Background



- Different ways of defining factor of safety
- Results in different factor of safety
- Have different acceptance criteria
- Shear Friction method is used in Norway
- Shear strength commonly described by Mohr-Columb criteria

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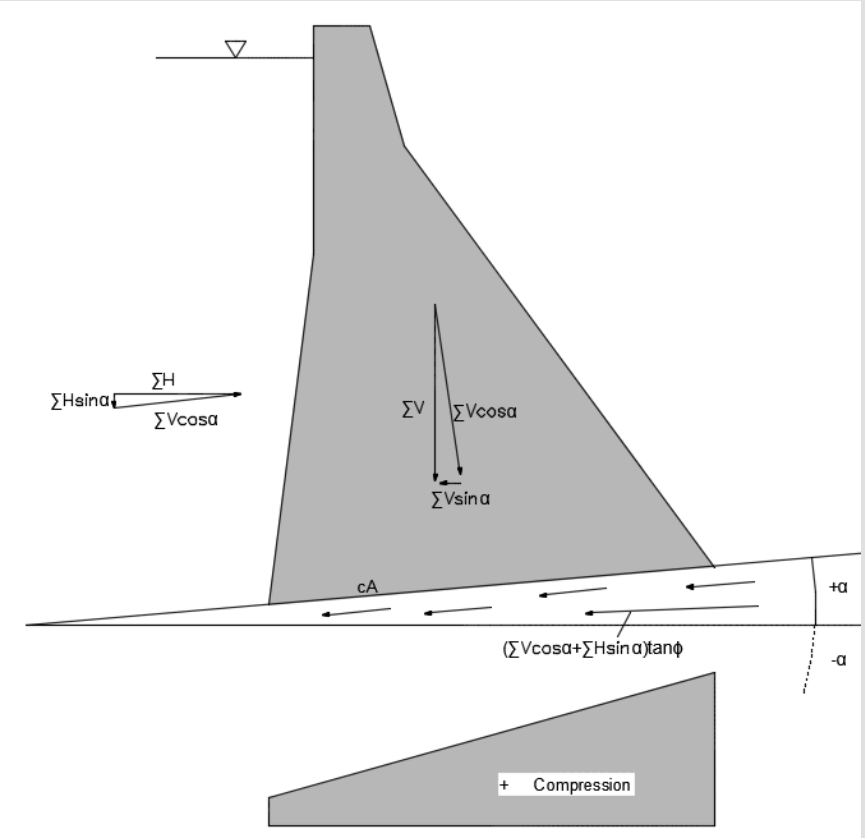
Current analysis method



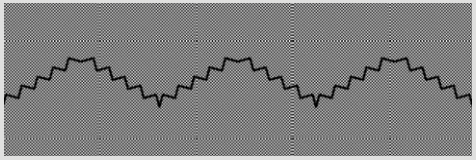
Uncertainities in

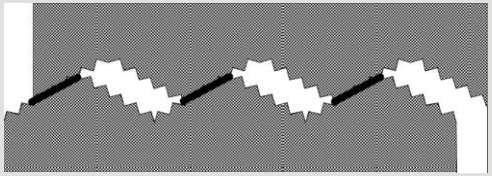
- The shape of potential failure plane
- Contribution for cohesion

The current method donot incorporate

- Contribution from rock bolts
- Distribution of shear and normal stress

$$FS = \frac{\frac{cA}{cos\alpha(1 - tan\alpha.tan\emptyset)} + \sum V' \tan(\alpha + \emptyset)}{\sum H}$$





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Research Questions

- How can cohesion at a potential failure plane be reliably estimated, rock bolts detected and their condition evaluated?
- How do discontinuities in a potential failure plane's profile affect a dam's stability?
- How does the elastic deformation of the materials affect stability?
- How are forces redistributed along a dam, and how can their effects be accounted for when calculating its stability?

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Ipto Dam test

- Built in 1972
- Rock bolts and inner reinforcements contribute to stability (designed as cantilever)
- **Not safe according to current NVE guidelines**
- But shows no signs of overloading
- Aim of the test
  - *Existence of rock bolt*
  - *The contact surface (friction plan) between the dam and the bed rock*
  - *The bedrock integrity close to the dam*

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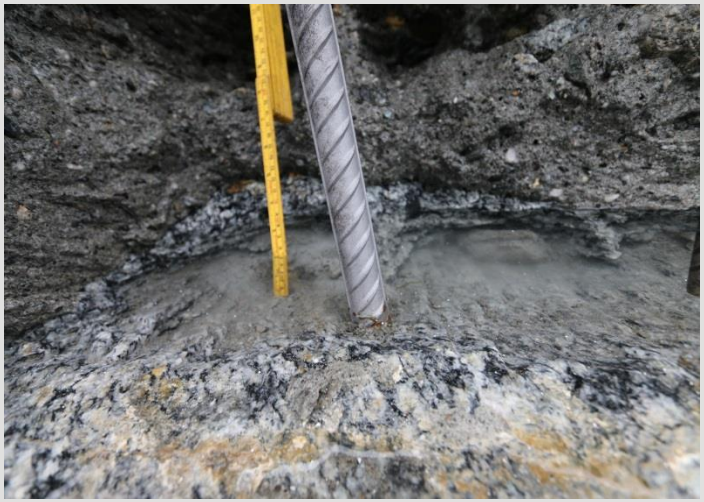
Ipto Dam test



<u>NDT tools used</u>

- MIRA ultrasound 3D tomographer
- GPR system
- Reinforcement cover meters

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Ipto Dam test

- Rock bolts were detected every 800 mm, No damage due to corrosion was observed (by NDT and drilling)
- No substantial discontinuity or air interface found between dam and bedrock
  - Friction and Matedness
- Bedrock was found intact upto 2 m depth

First step in preventing prevent unnecessary physical strengthening of dams

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The Way Foreward

- Investigate failure history
- Methods to characterize material properties
- Methods of design and assessment
- NDT tools
- Statistical Methods

- Select and callibrate NDT tools
- Devise inspection method

- Develop guidelines for resistance assessment
- Test feasibility of new methods and tools

- Full scale test
- Revise methods developed

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THANK YOU

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