Exercise 4

Verification of an embankment dam

CIVIL-411

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Introduction

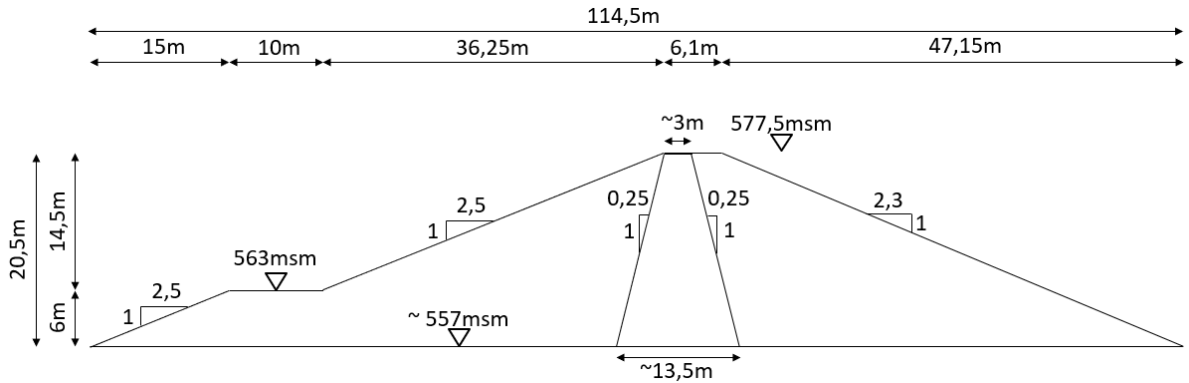
Source: Courtesy of MHYD

Introduction

Source: https://commons.wikimedia.org/wiki/File:17.93804E_5.01000N_Lake_Boali.png?uselang=fr

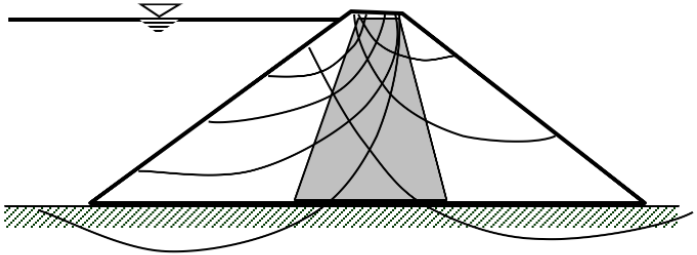
Introduction

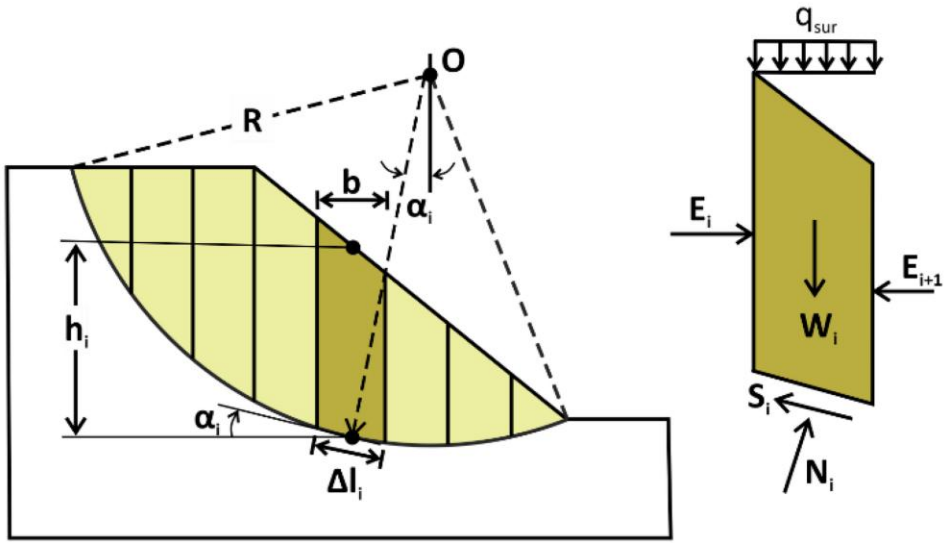
- The dam comprises a concrete and an embankment section. The safety assessment of the concrete structures has already identified a number of shortcomings, so particular attention needs to be paid to the embankment section.
- It is requested that the static and seismic safety of the earth-fill parts of the structure is verified in line with international best practices.



Stability analysis (safety against sliding)

- Principle: Control of sliding stability for various possible slip surfaces
- Analytic methods: The heterogenous mass is instable and cut into vertical slices (slices method)
  - Circular slip surface (Fellinius, 1948, Bishop 1955, …)
  - Various slip surfaces (Janbu 1954, Morgenstern - Price 1956, Krey …)





- Janbu method
  - Circular and non-circular
  - Equilibrium of forces
- Bishop method
  - Circular
  - Equilibrium of moments
- TGC 18

Source: https://www.mdpi.com/water/water-11-02146/article_deploy/html/images/water-11-02146-g006.png

Load cases (according to the C3 Swiss directive)

Individual loads	Load combinations for embankment dams, including abutments and foundations							
	Normal load combinations (Type 1)		Extraordinary load combinations (Type 2)				Extreme load combinations (Type 3)	
							Static	Dynamic
	Empty reservoir (drained embankment)	Full reservoir	Empty reservoir (upon completion of construction)	Design flood	Rapid discharge	Avalanche or mudslide	Flood safety level	Earthquake
Own weight	X	X	X	X	X	X	X	X
Hydrostatic pressure at normal operating level[i]		X				(X)		X
Pore water pressure at normal operating level[i]		X			X [iv]	(X)		X [iii]
Hydrostatic pressure corresponding to flood level				X			X	
Pore water pressure corresponding to flood level [ii]				X [ii]			X [ii]	
Pore water pressures before consolidation		(X)	X					
Earthquake								X
Pressure due to avalanche or mudslide						X		

Hypotheses

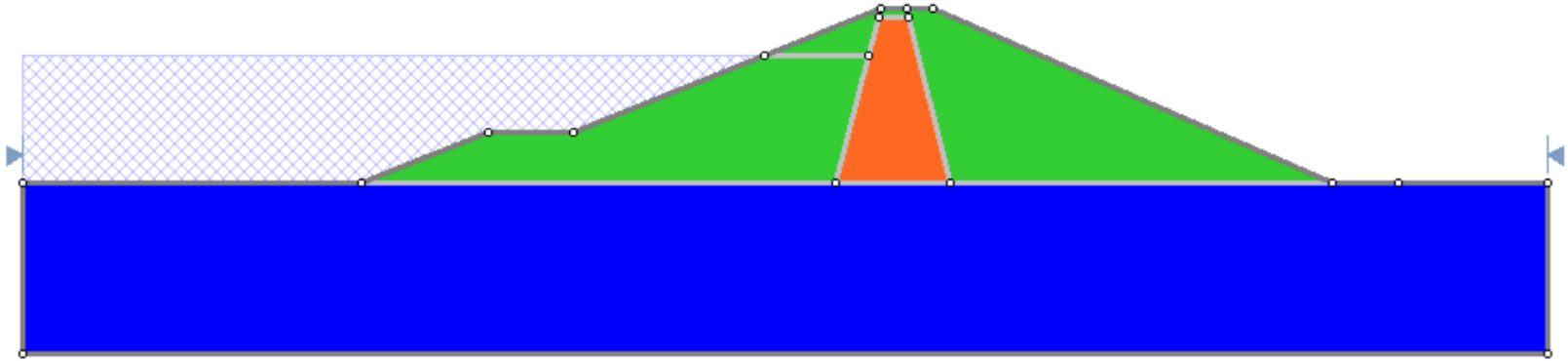
- It is assumed that the clay core and the drainage system are functioning. Pore pressures downstream of the core must therefore be zero at the base of the dam.
- Type 1 (normal) load cases must comply with a safety factor of 1.5.
- Type 2 (extraordinary) load cases must comply with a safety factor of 1.2
- Type 3 (extreme) load cases must comply with a safety factor of 1.0 for static cases, or have a freeboard of at least 1 m after settlements for dynamic cases.

Questions

- Verification of static safety
  - Reservoir at Full Supply Level (FSL)
  - Rapid drawdown
    - *Make the conservative assumption that the water has not had time to escape from the dam body. The water line will follow the geometry of the dam on the upstream section.*
- Study the impact of permeability by implementing the first load case with a fully permeable earth fill. **Comment on previous results and use the worst-case permeability for seismic calculations.**
- Verification of seismic safety
  - According to the C3 directive
  - Makdisi & Seed method
  - Critical earthquake

Practical information: Slide2

- Access to the virtual machine «enac-sgc»
- Tutorial on https://www.rocscience.com/help/slide2/tutorials/tutorials-overview/quick-start-tutorial
- Additional information relevant for exercise on Moodle «Help for Slide 2»



Practical information: Moodle

- Assignment
- Presentation
- Help for Slide2
- Help for Makdisi & Seed
- Calculation sheet for Makdisi & Seed
- Accelerogram for the method according to the C3 directive
- C1 directive (French)
- C3 directive (French)

Practical information: Hand-in

- Hand-in as calculation note
  - Report in pdf
  - Approximately 10 pages + annexes
  - As required in engineering offices from a legal liability point of view
  - Includes:
    - Title page
    - Brief introduction to the problem
    - **Basic data and hypotheses**
    - Questions and solutions
    - Conclusions and references
- Please also include your working files (Slide2 and Excel) for partial credit

- Questions during dedicated class hours or email:
  - stefanie.tietz@mhyd.group

Hand-in date: 23.12.2025 23h59