ARCH DAM GEOMETRY GENERATOR & DAM APPLICATION

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International Center for Numerical Methods in Engineering (CIMNE)

Overview

DAM GEOMETRY

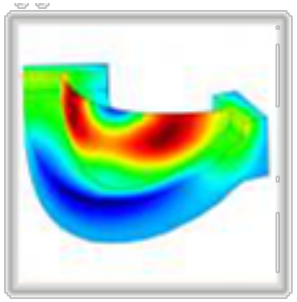
DaGGer

Dam
Geometric
Generator

GiD

NUMERICAL SIMULATION

Dam Application



KRATOS
MULTI-PHYSICS

GiD

CIMNE

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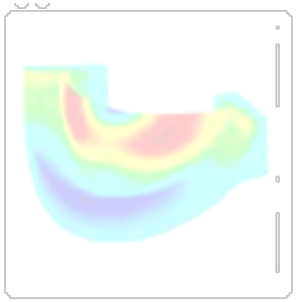


KRATOS MULTI-PHYSICS

GiD

What is a dam?

It is a **wall to hold back water** forming a **reservoir**

Almendra dam, Spain

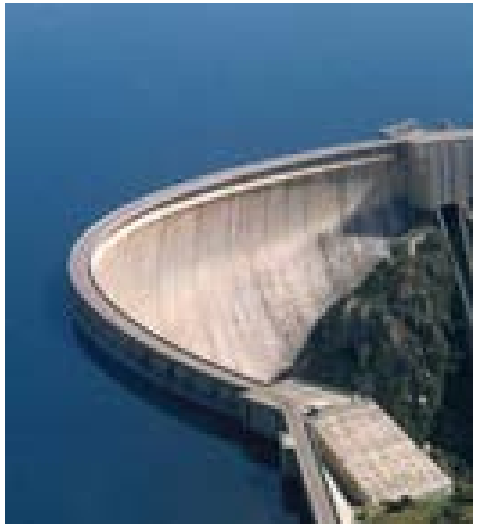
What is an arch dam?

It is a **concrete** dam with **curved shape**

Straight dam

Itoiz dam, Spain

Arch dam

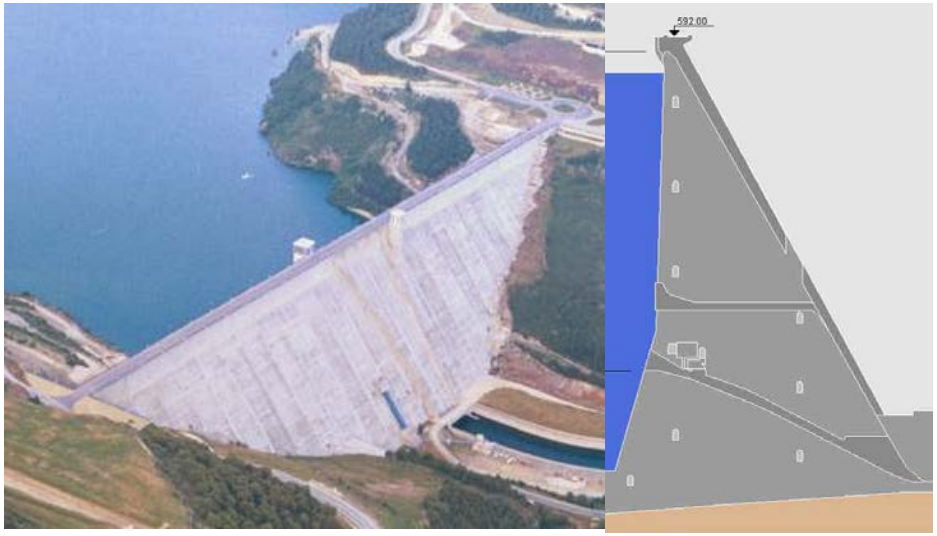


Almendra dam, Spain

What is an arch dam?

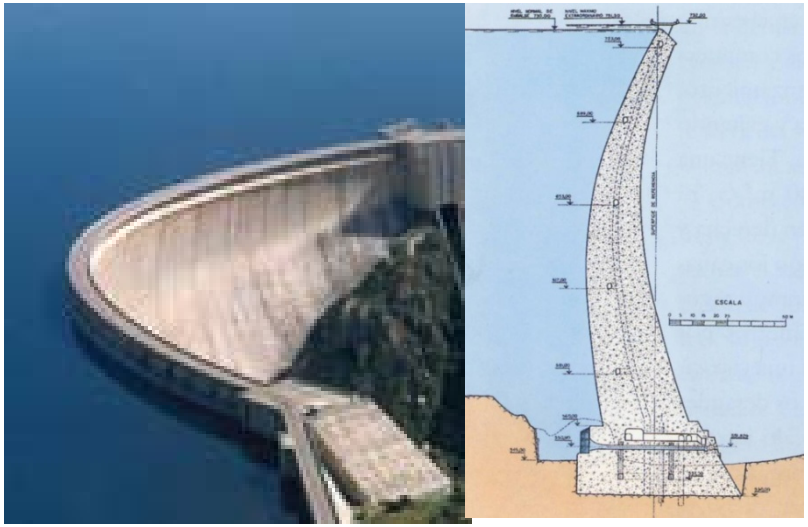
It is a **concrete** dam with **curved shape** that allows defining **thinner sections** than straight dams and **saves concrete**

Straight dam



Itoiz dam, Spain

Arch dam



Almendra dam, Spain

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Straight dam

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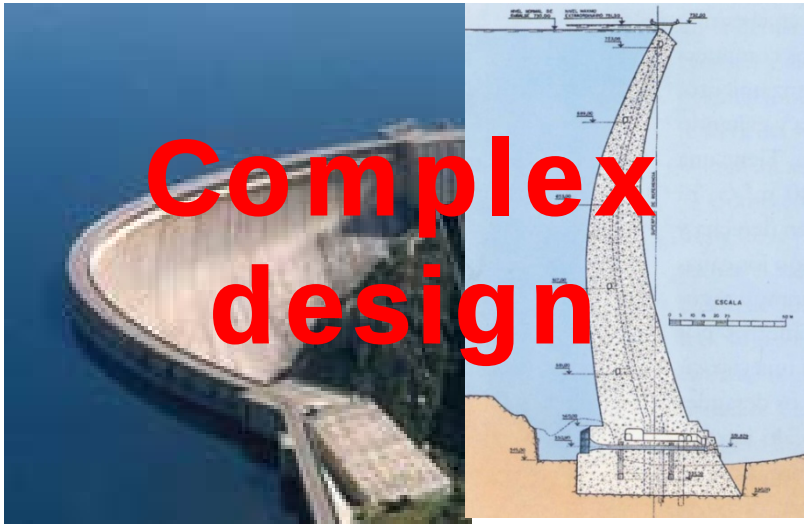
Arch dam



Almendra dam, Spain

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Why are arch dams complex?

- The **dam shape** that minimizes concrete stress **depends on** the **geology of the foundation** and the **valley shape.**
- Each dam has **its own design**

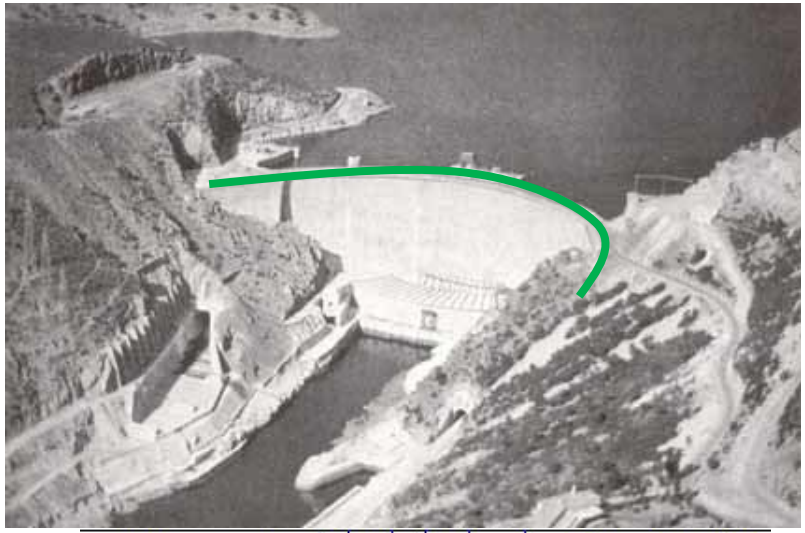
El atazar dam, Spain

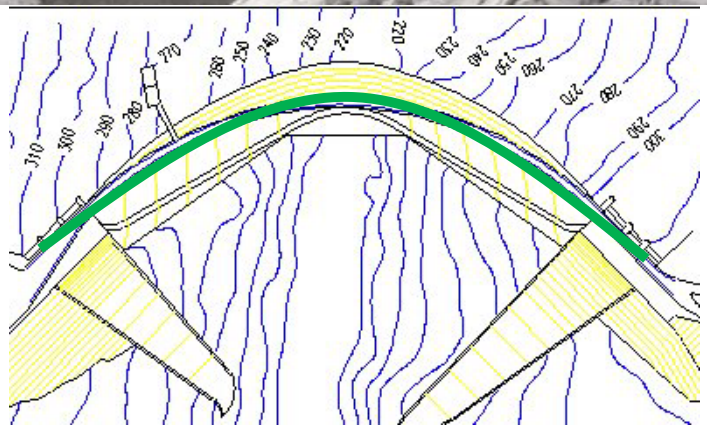
Gordon dam, New Zeland

Why are arch dams complex?

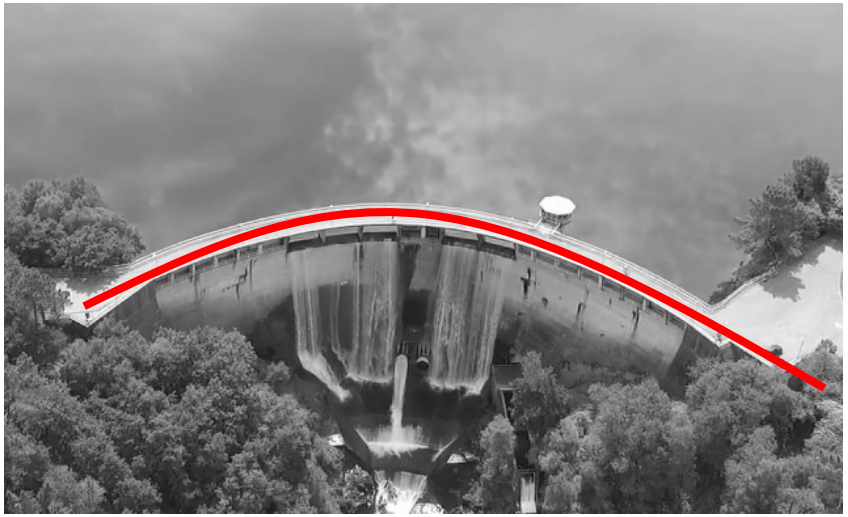
- Each dam has **its own curvature**

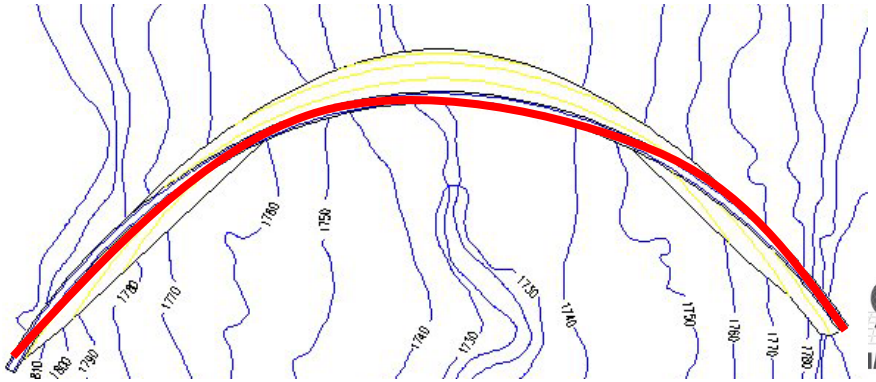
Belesar dam, Spain





Eirás dam, Spain

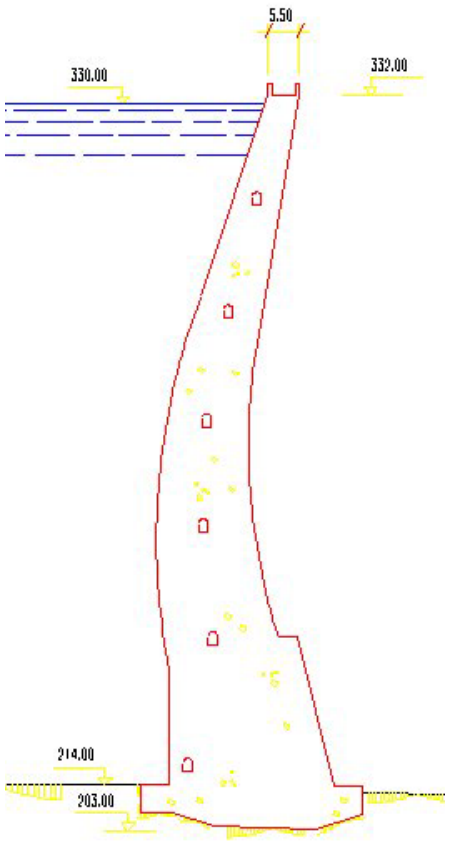




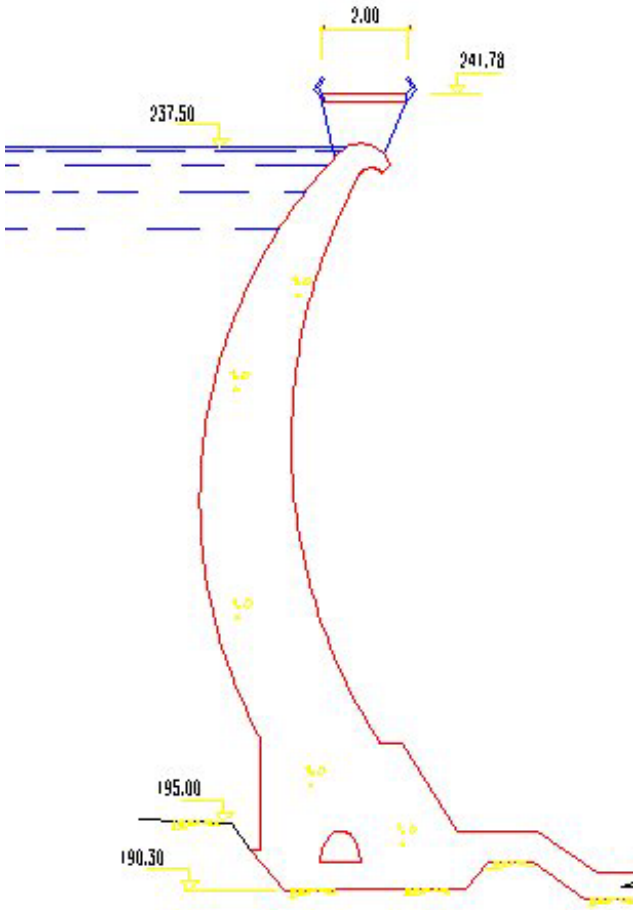
Why are arch dams complex?

- Each dam has **its own cross section**

Belesar dam, Spain

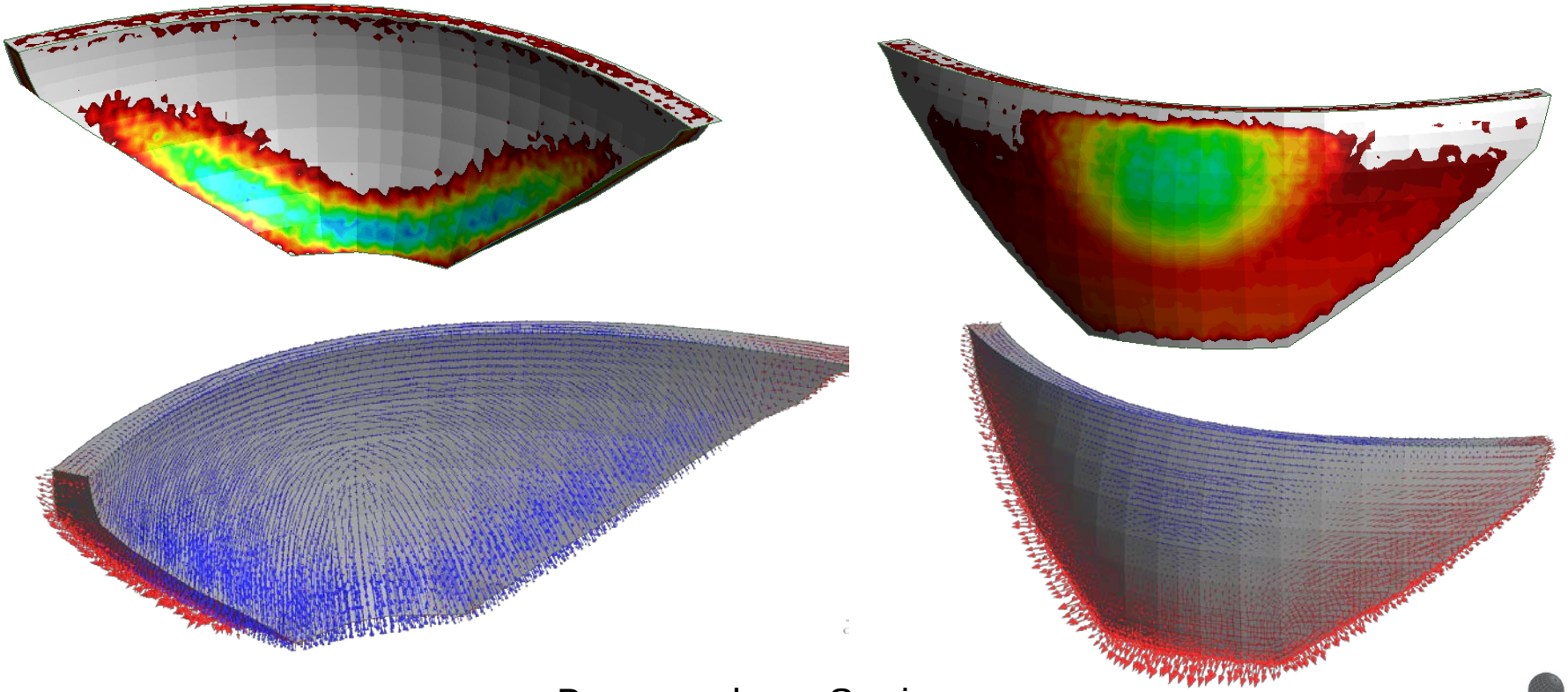


Eirás dam, Spain



Why are arch dams complex?

- Each dam needs **specific numerical simulations** to **ensure a proper behavior**.



Baserca dam, Spain

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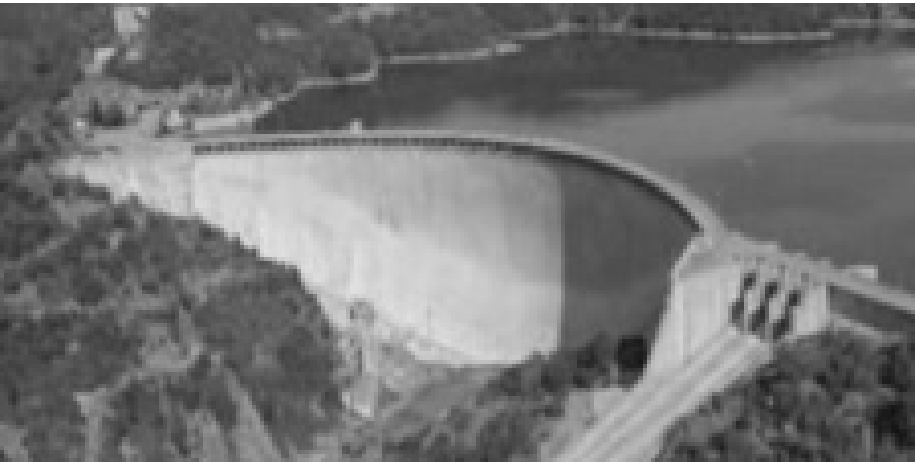
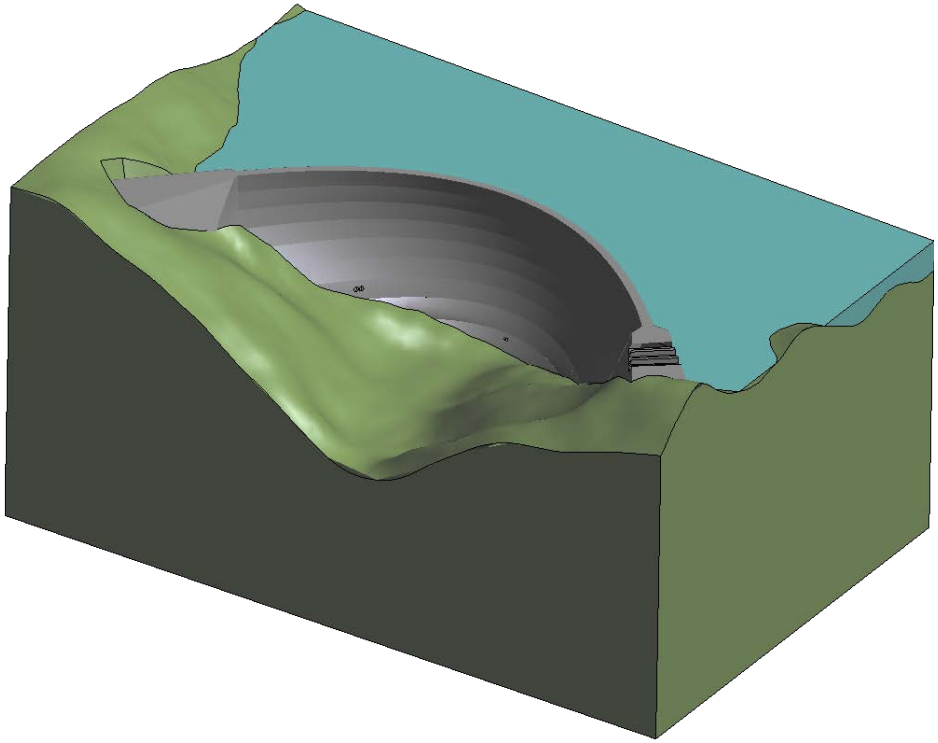
Why are arch dams complex?

- The definition of a **3D model** is a **hard issue**





La Baells dam, Spain

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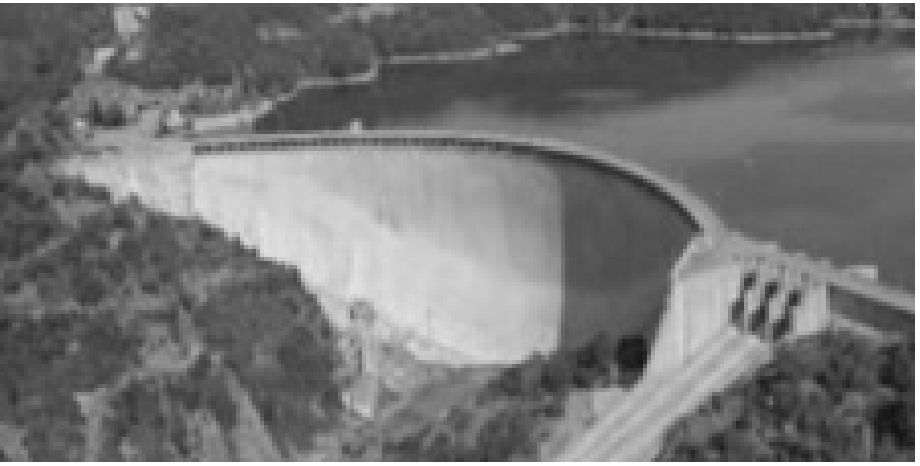
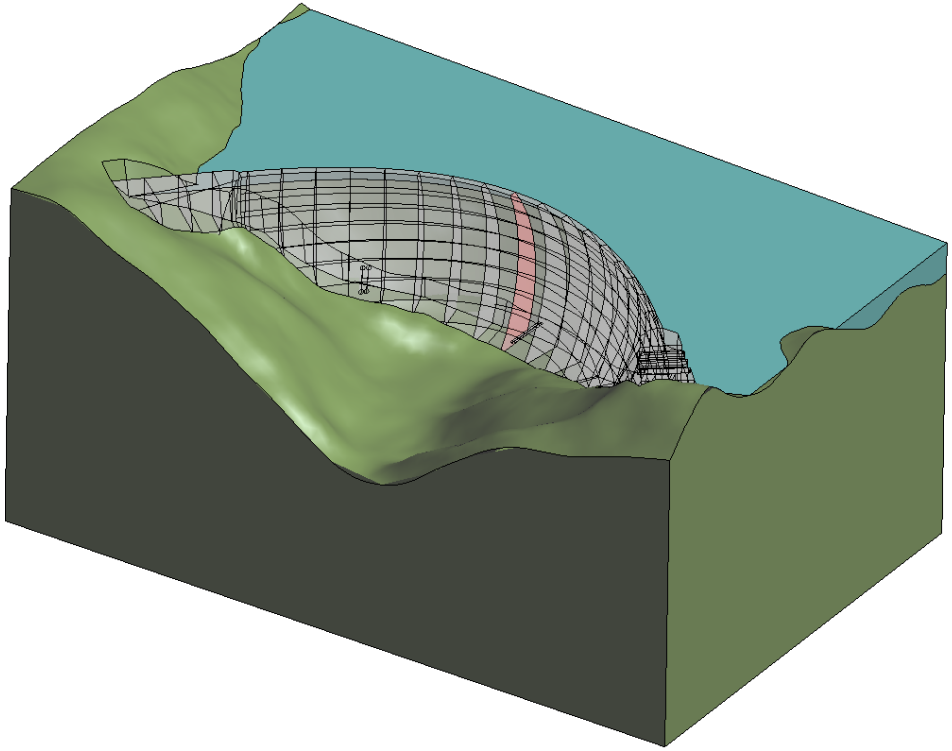


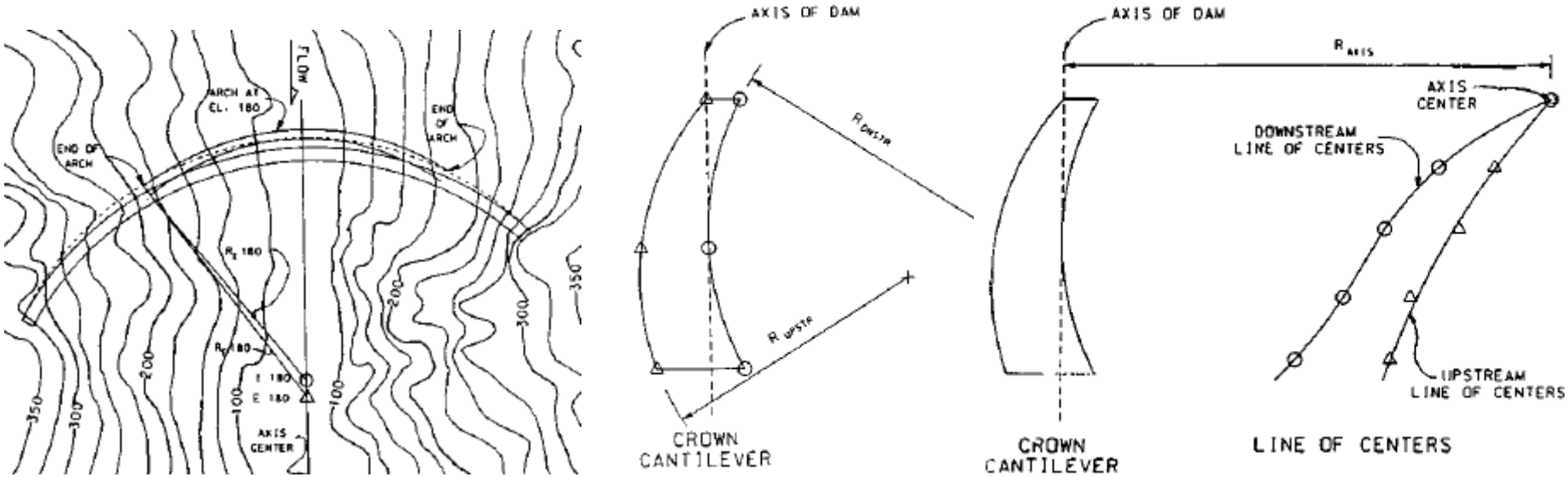


La Baells dam, Spain

How can we design arch dams?

- **USBR** method (1977)

Curvature and **cross sections** are defined by circular arch in a **manual trial-error process** to obtain the final design

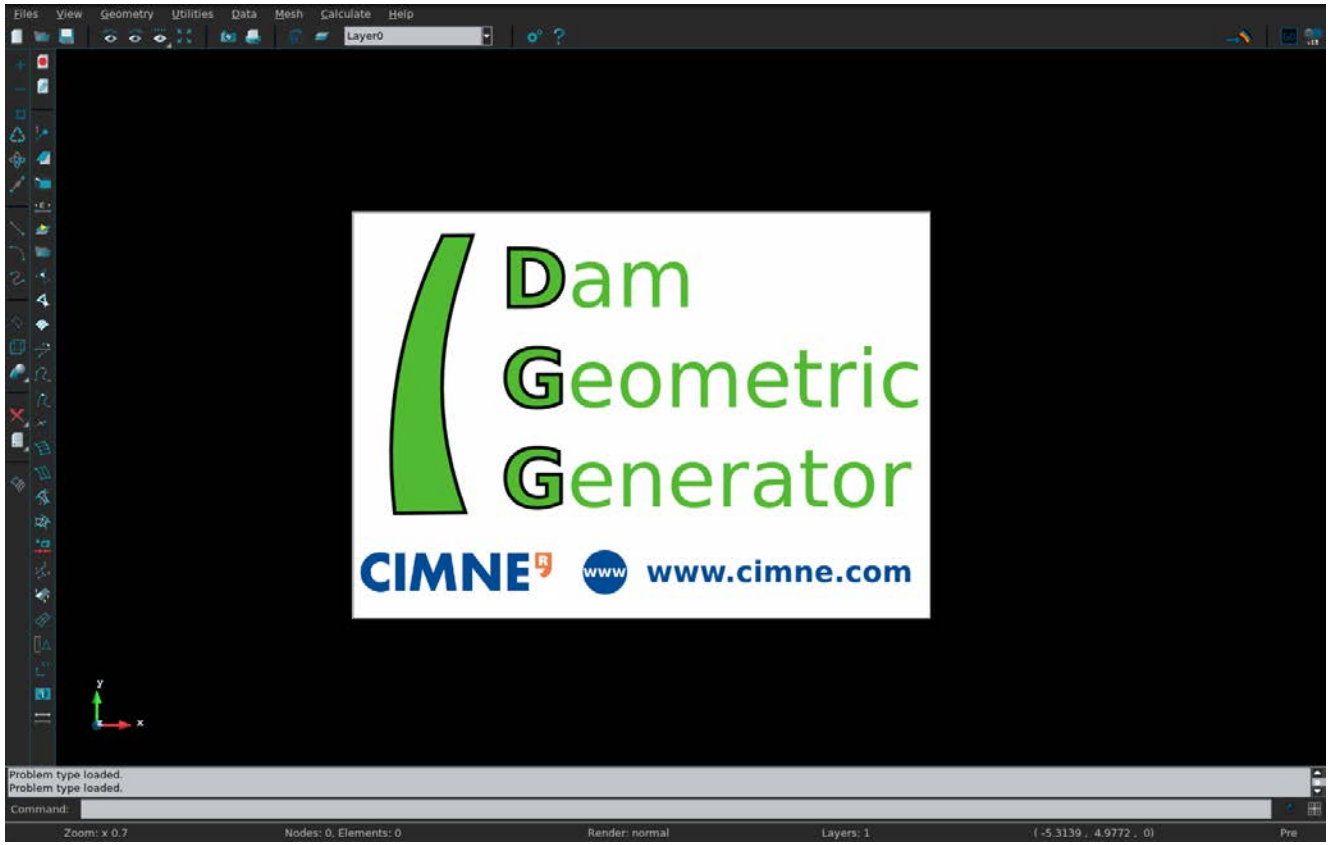


$$v = 0.000002H^2L_2\frac{(H + 0.8L_2)}{L_1 - L_2} + 0.0004HL_1[H + L_1]$$

How can we design arch dams?

➢ DaGGer (Dam Geometric GenERator)

Interactive tool based on GiD for **automatic designing** of arch dams, and **definition of 3D models in a few steps.**



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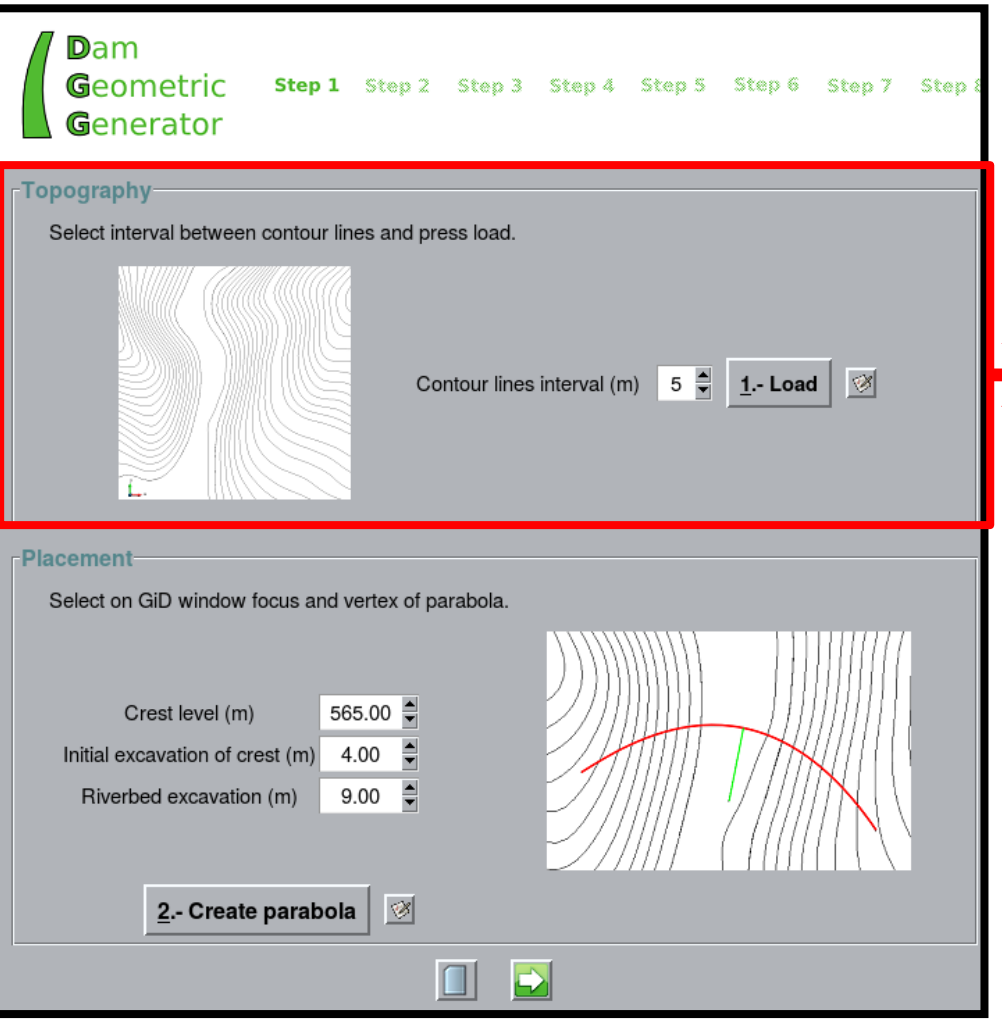
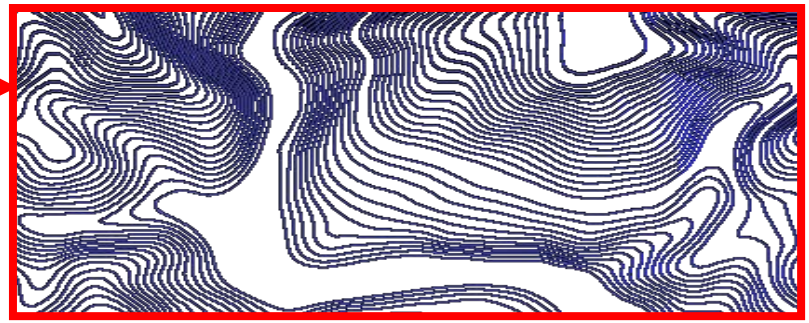
How can we design arch dams?

- **DaGGer (Dam Geometric GenERator)**



- **Step 1A**

Creation of topography
from a DTM list of points



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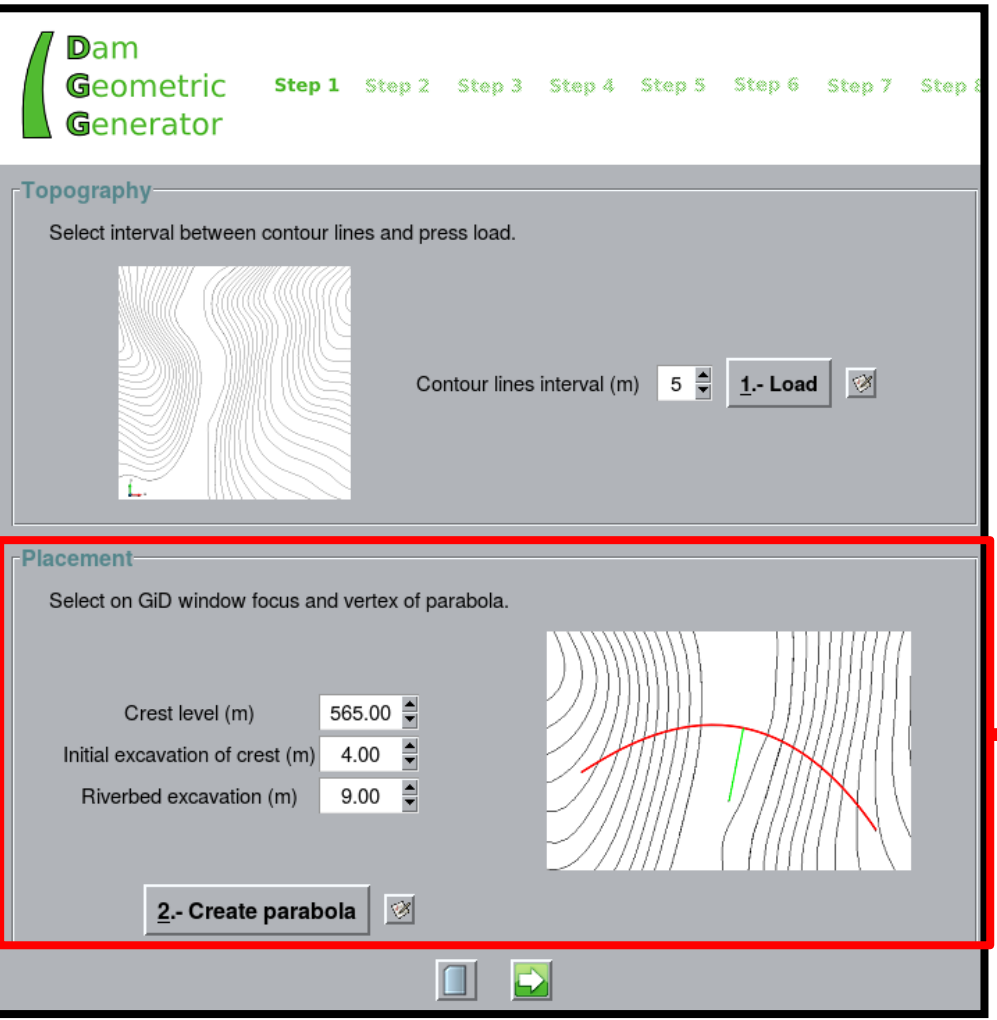
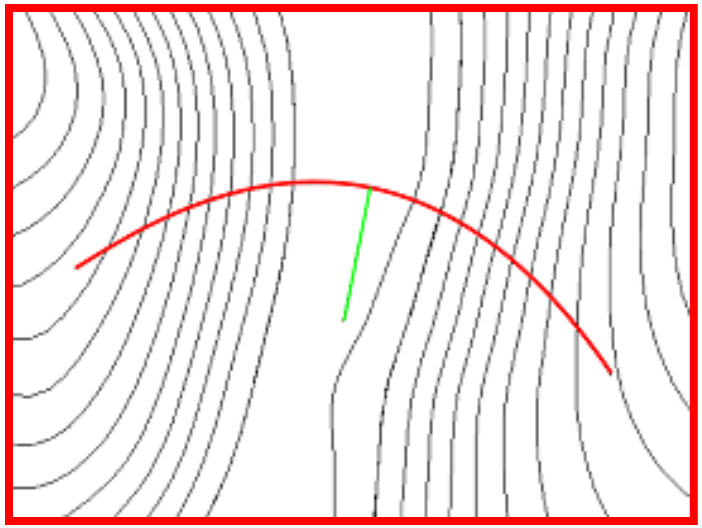


➢ Step 1B

Selection of **placement and curvature** of dam, based on **parabolic or elliptic** shapes



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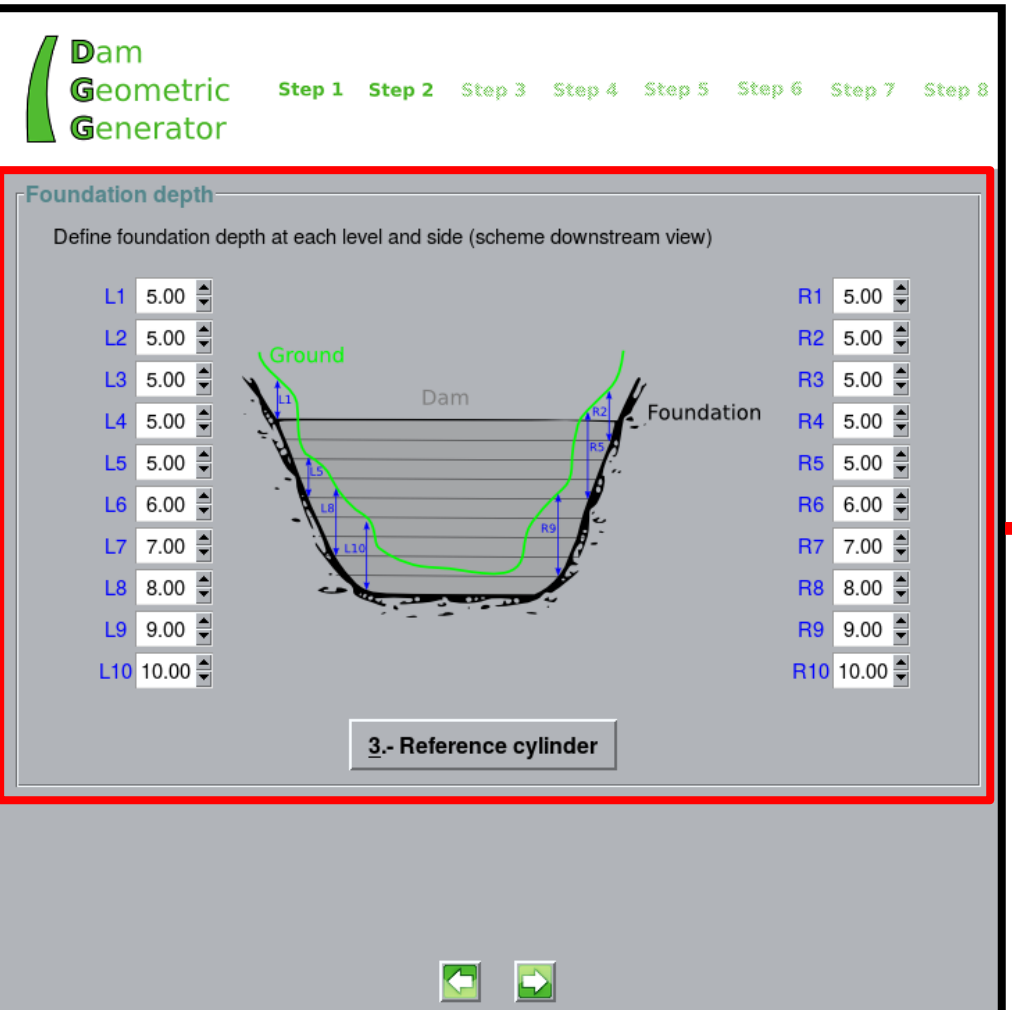
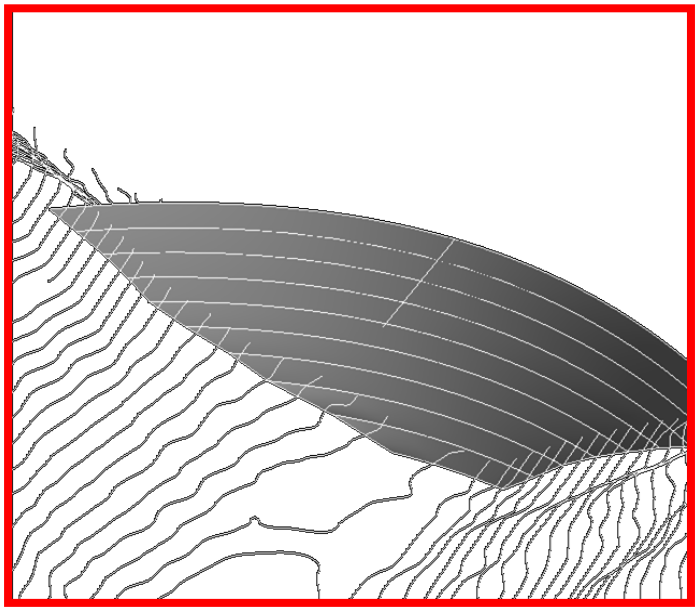


- **Step 2**

Definition of **excavation depth**



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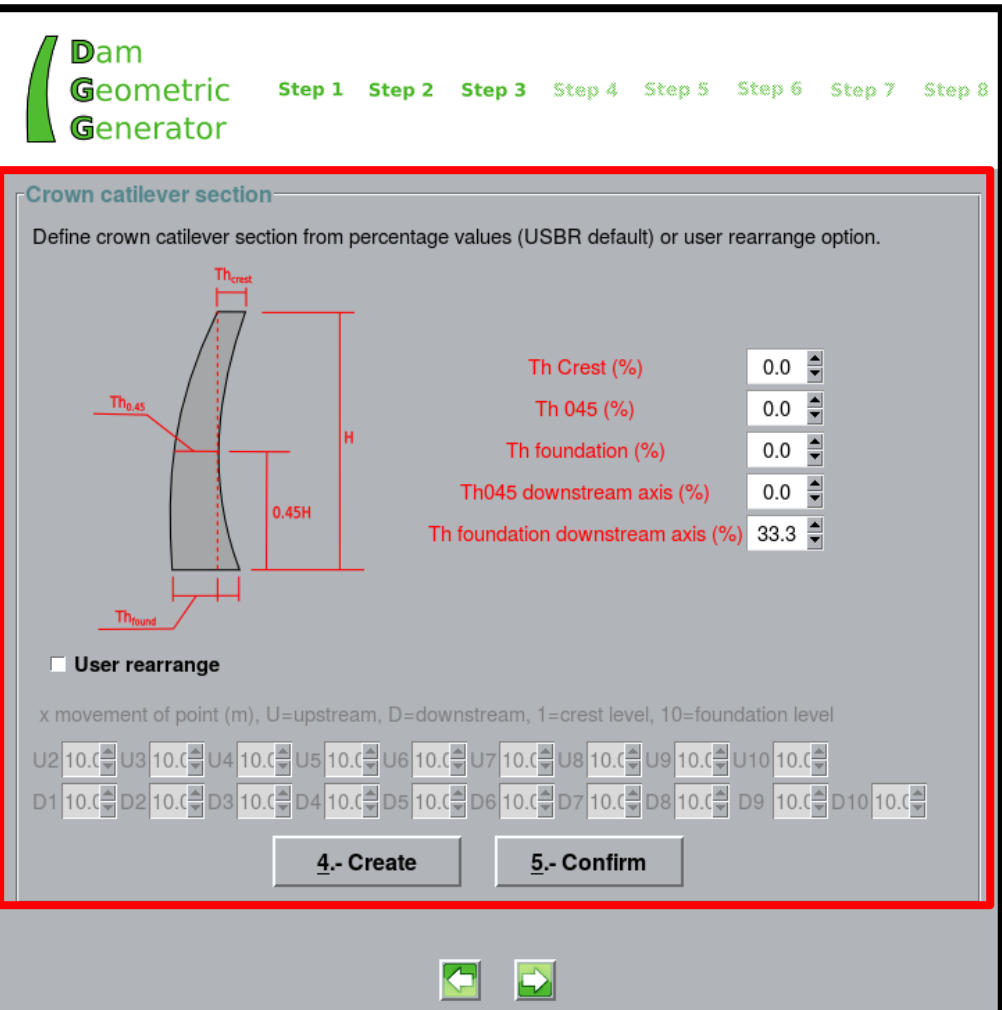
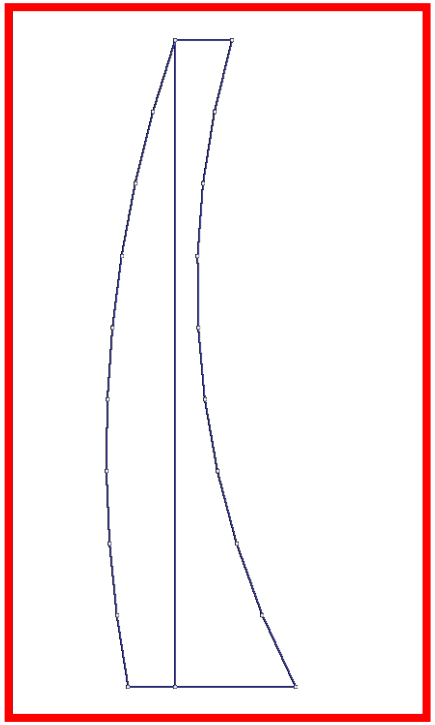


- **Step 3**

Definition of **cross section shape**



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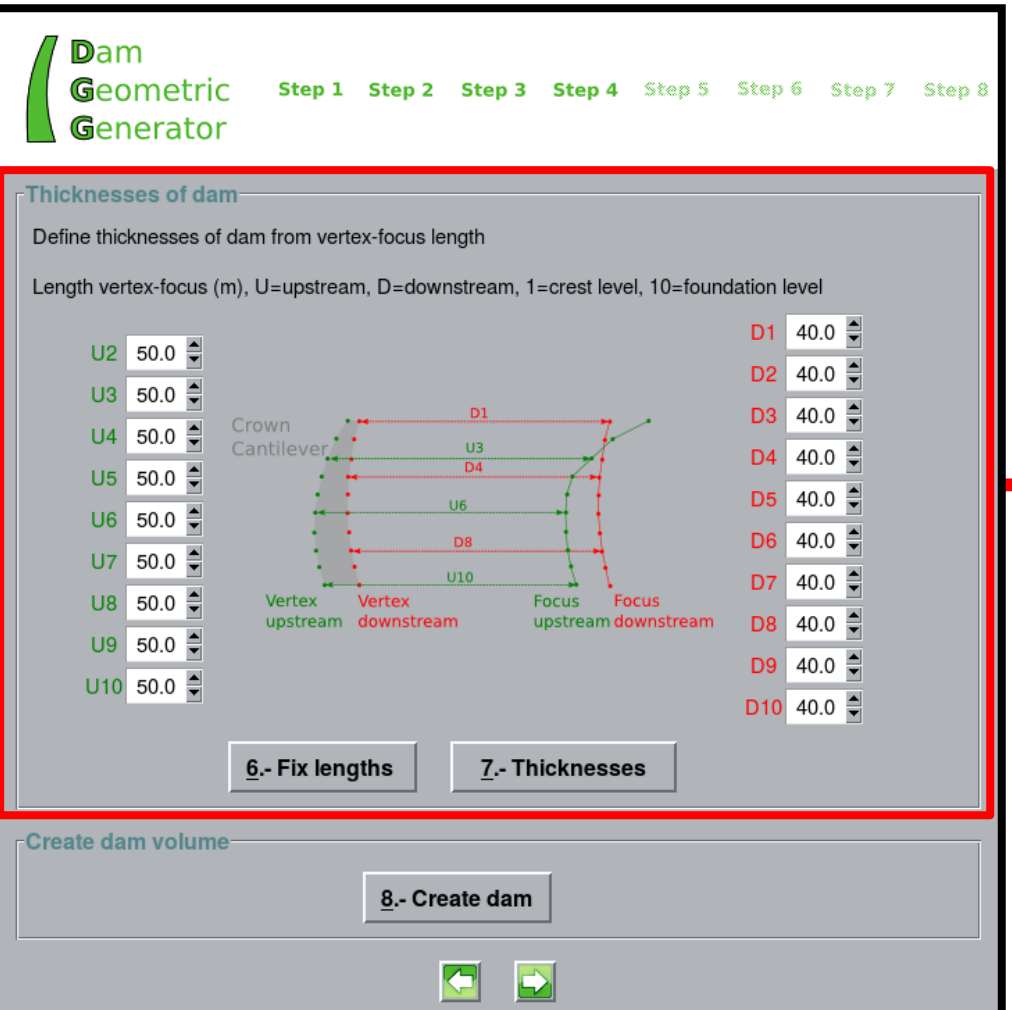
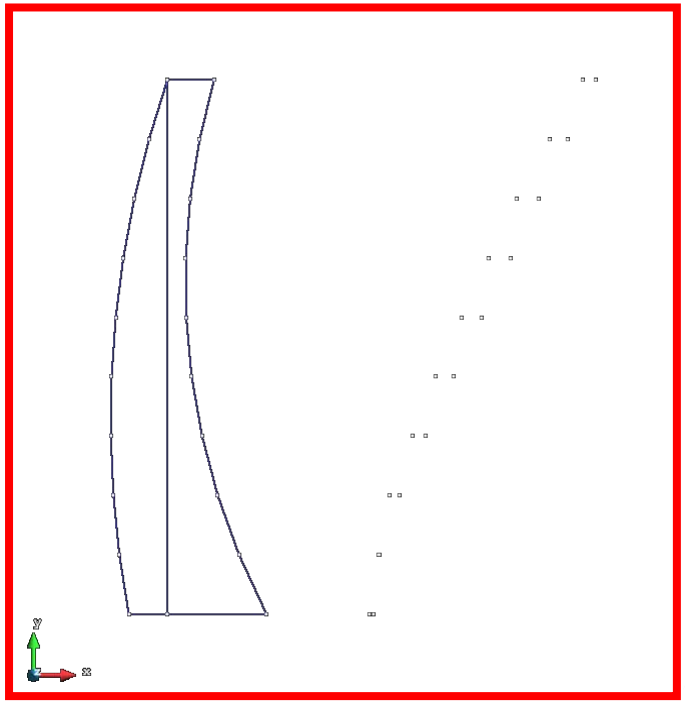


- **Step 4A**

Definition of **curvature laws for intrados and extrados**



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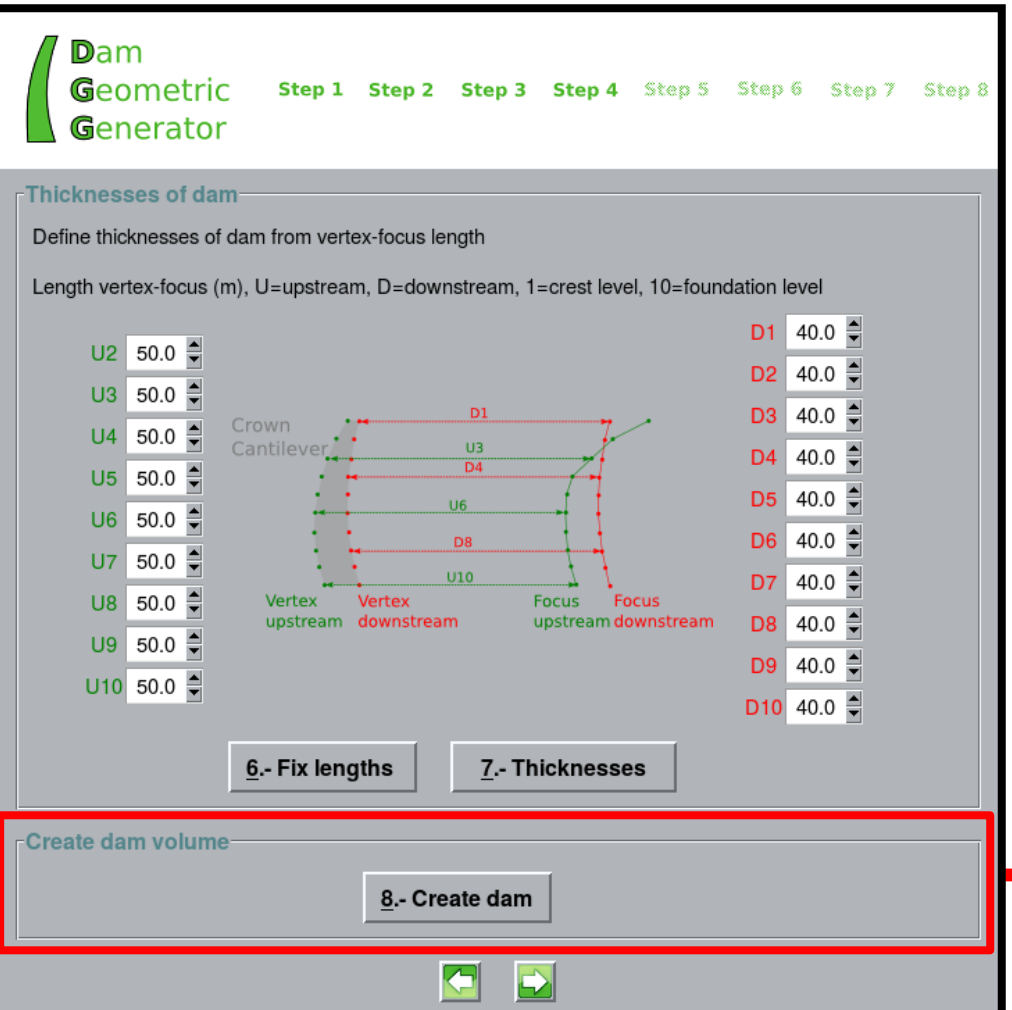
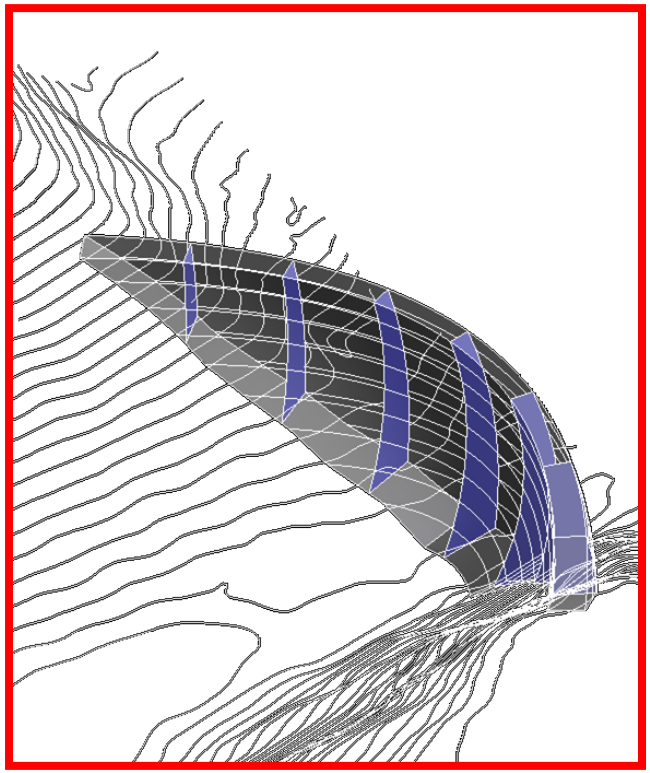


- **Step 4B**

Creation of **dam volume**



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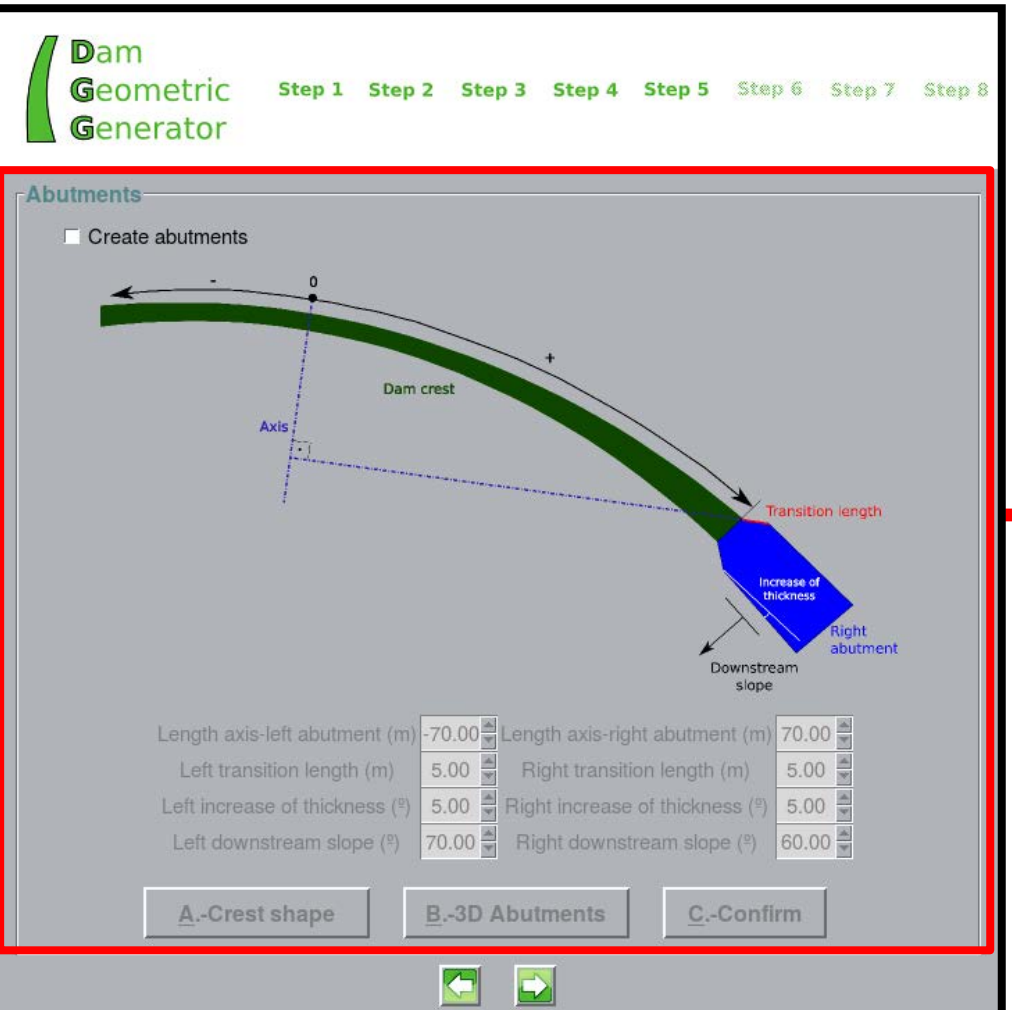
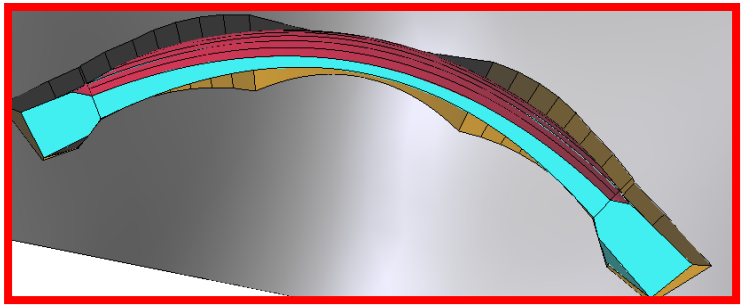


- **Step 5 (Optional)**

Creation of **abutments**



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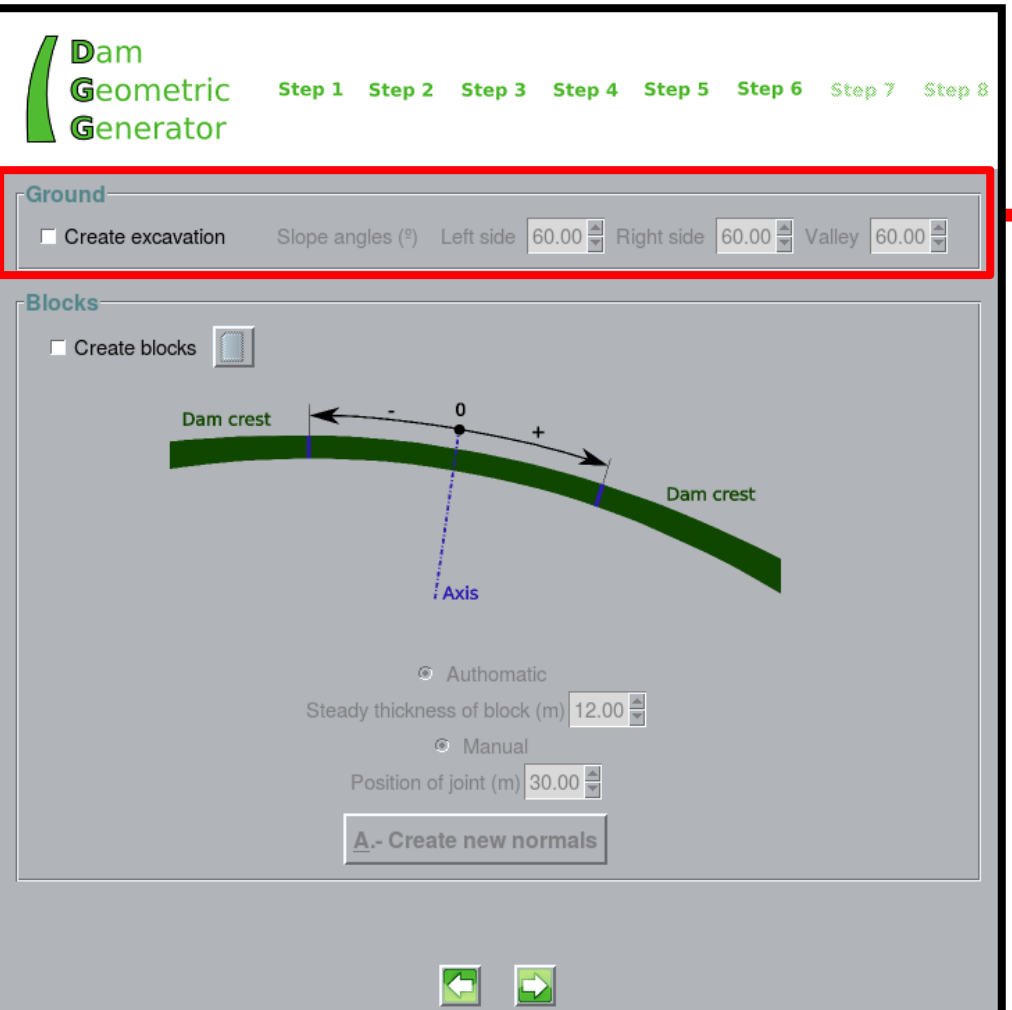
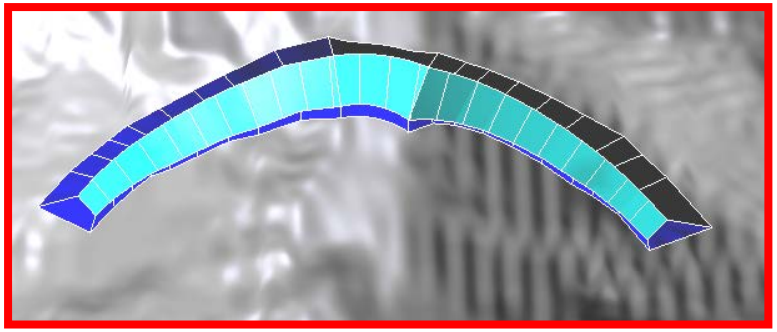


- **Step 6A (Optional)**

Creation of **excavation**



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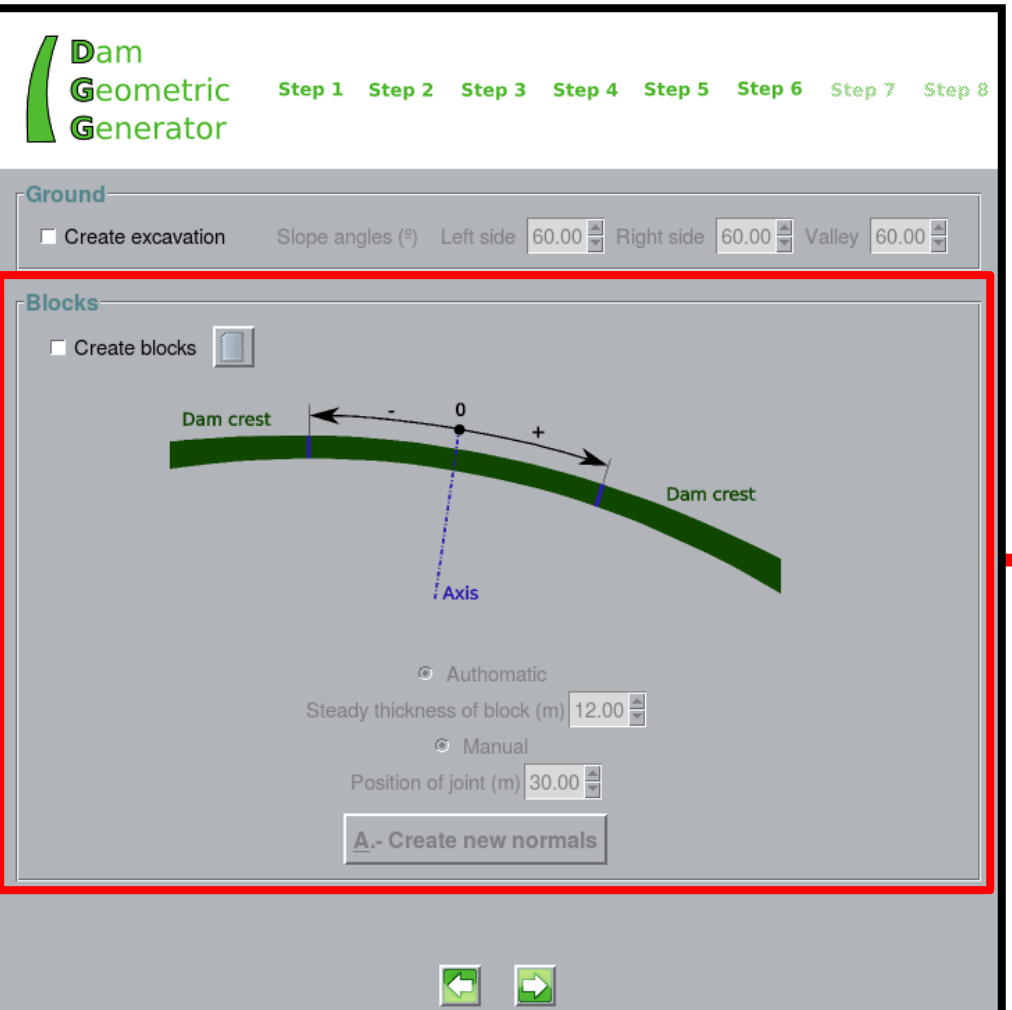
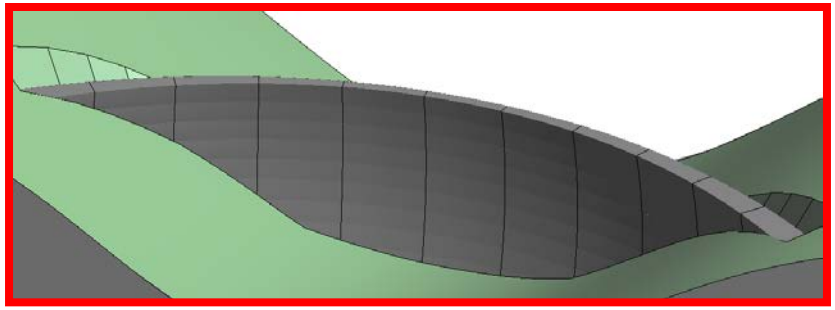


- **Step 6B (optional)**

Creation of construction **blocks**



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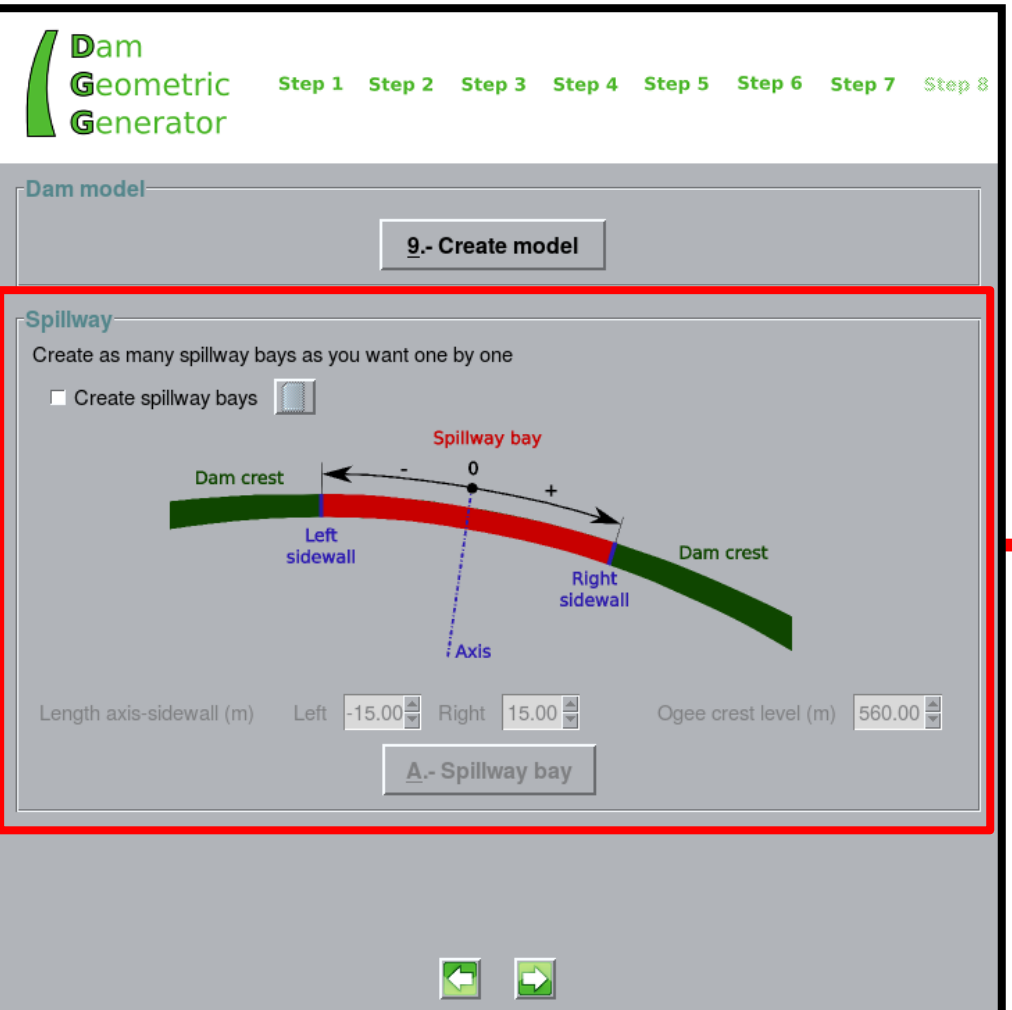
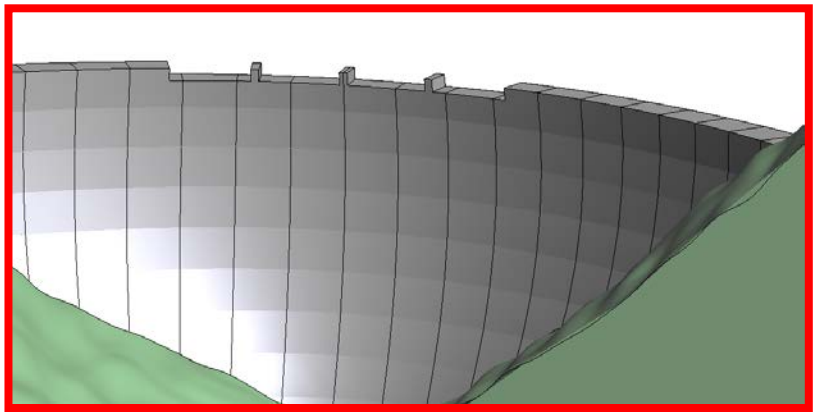


- **Step 7 (optional)**

Creation of **spillway**



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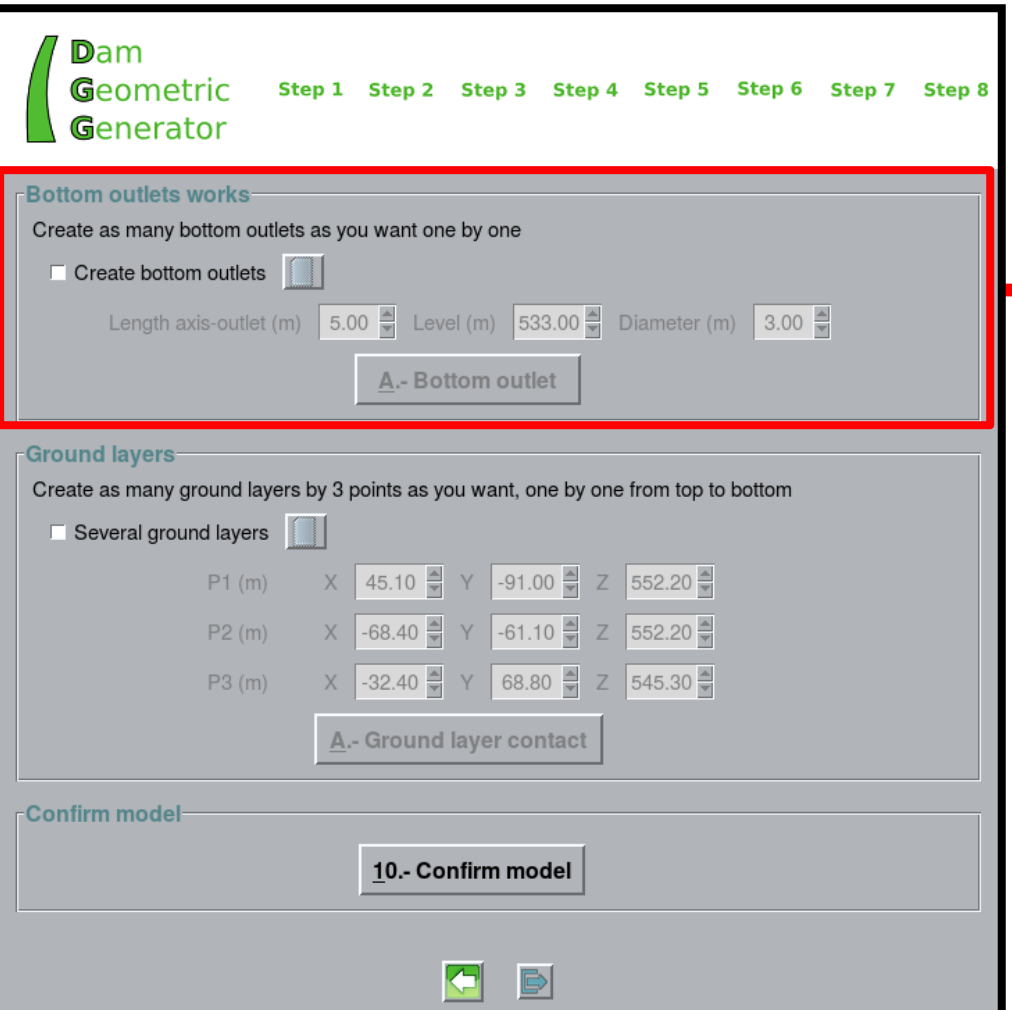
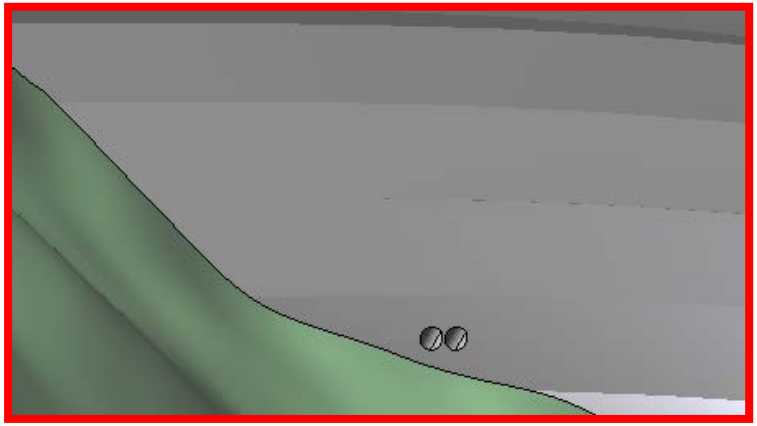


- **Step 8A (optional)**

Creation of **bottom outlets**



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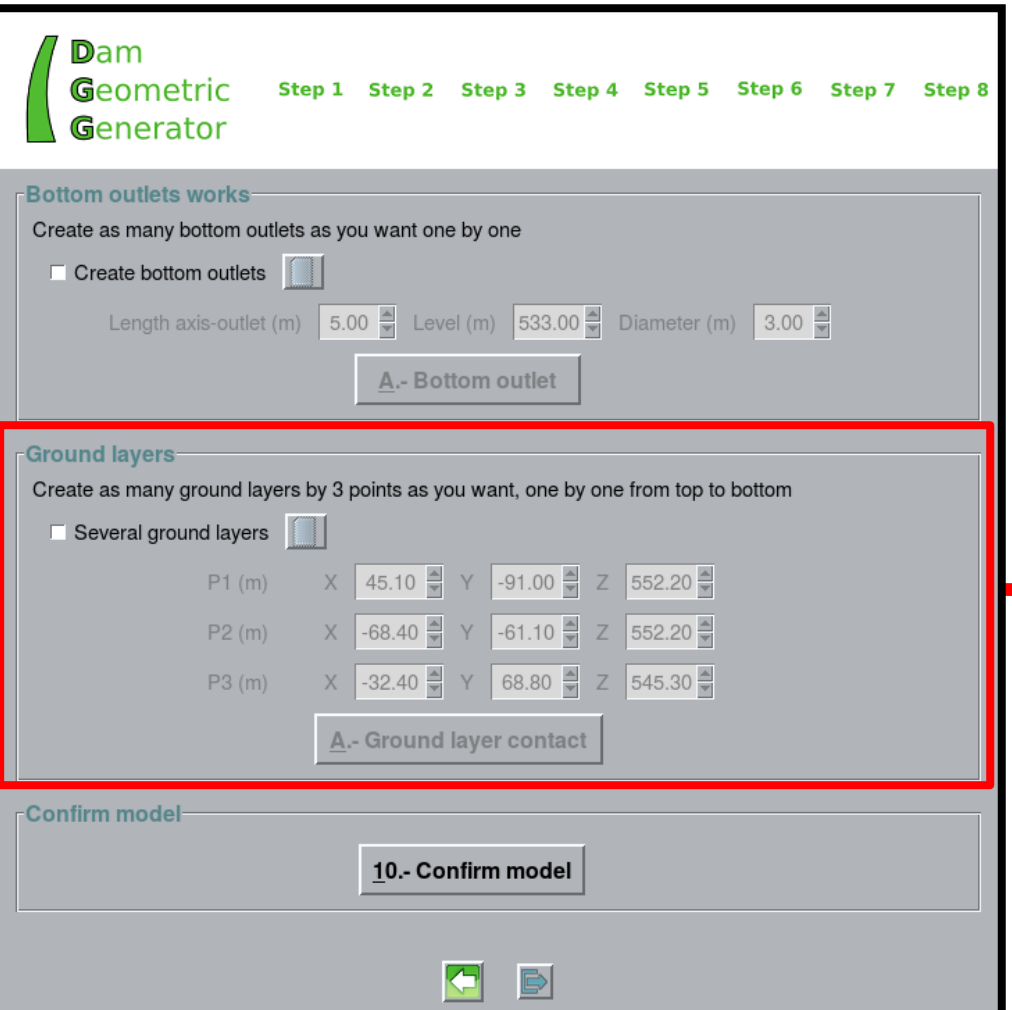
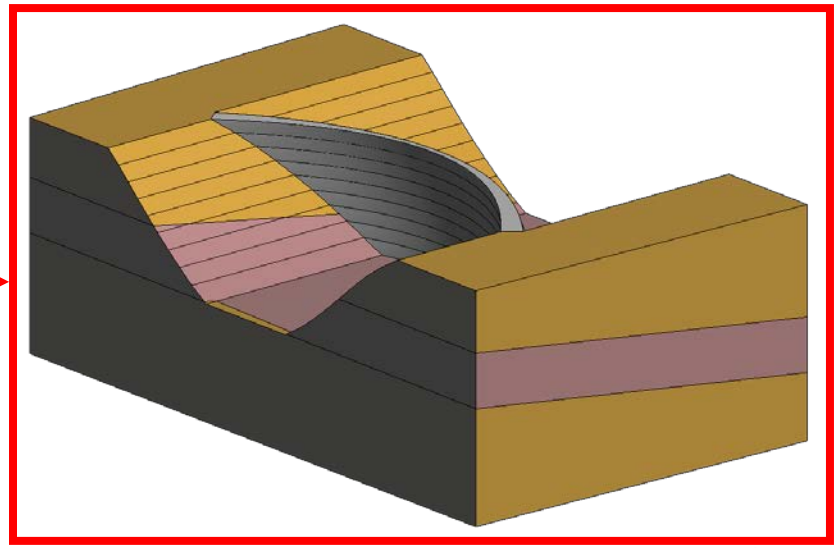


- **Step 8B (optional)**

Creation of **ground layers**



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How can we design arch dams?

- **DaGGer (Dam Geometric GenERator)**

What are the advantages of DaGGer?

Dam Geometric GenERator allows obtaining:

- **Complete definition of the dam in a few minutes**, even considering elements such as **outlets, abutments, spillways, excavation shape and ground layers.**

- **Volume of dam** body and **excavation** in an automatic way. That is imperative to obtain the **optimum solution**, regarding to **minimize** concrete and excavation **volumes** among several solutions **during preliminary studies.**

- **Geometry to export** to other environments **to carry out structural numerical simulations.**

Overview

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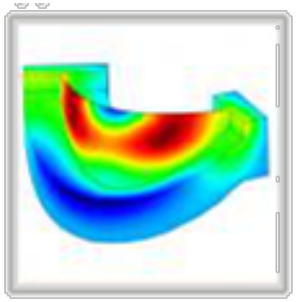
NUMERICAL SIMULATION

Dam Application



KRATOS MULTI-PHYSICS

GiD

What is the Dam Application?

- **Numerical modeling tool to analyze Dams**

GiD

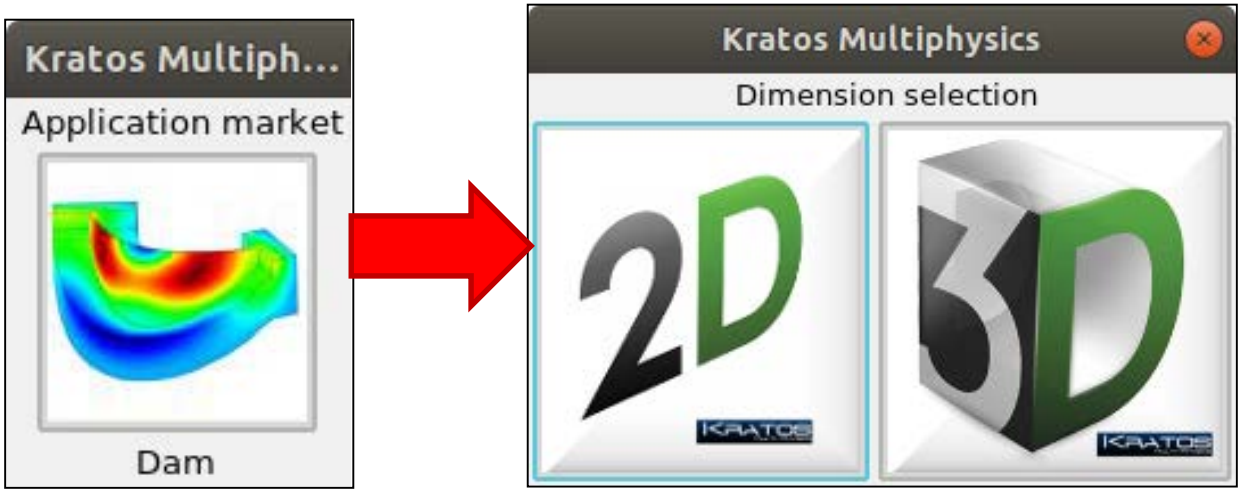
Preprocess

Calculation

Postprocess

KRATOS MULTI-PHYSICS

- Solid Mechanics
- Convection Difussion
- Poro Mechanics



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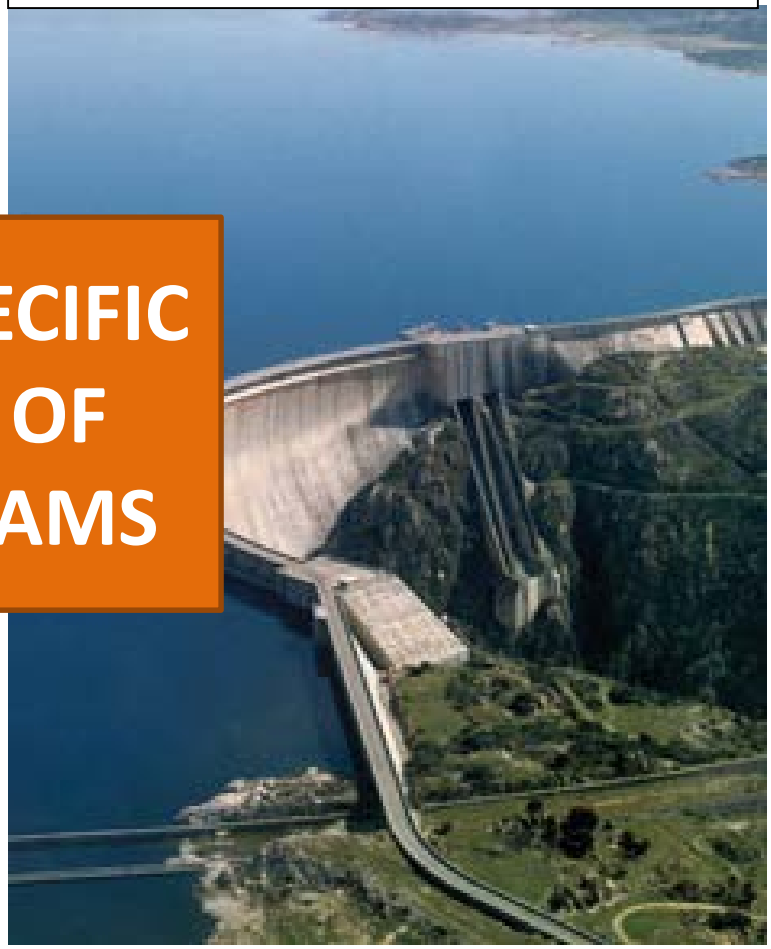
Why Dam Application?

CONSTRUCTION

Zillergründl dam, Austria

OPERATION



Almendra dam, Spain

SIMULATE SPECIFIC PROCESSES OF CONCRETE DAMS

Operation phase

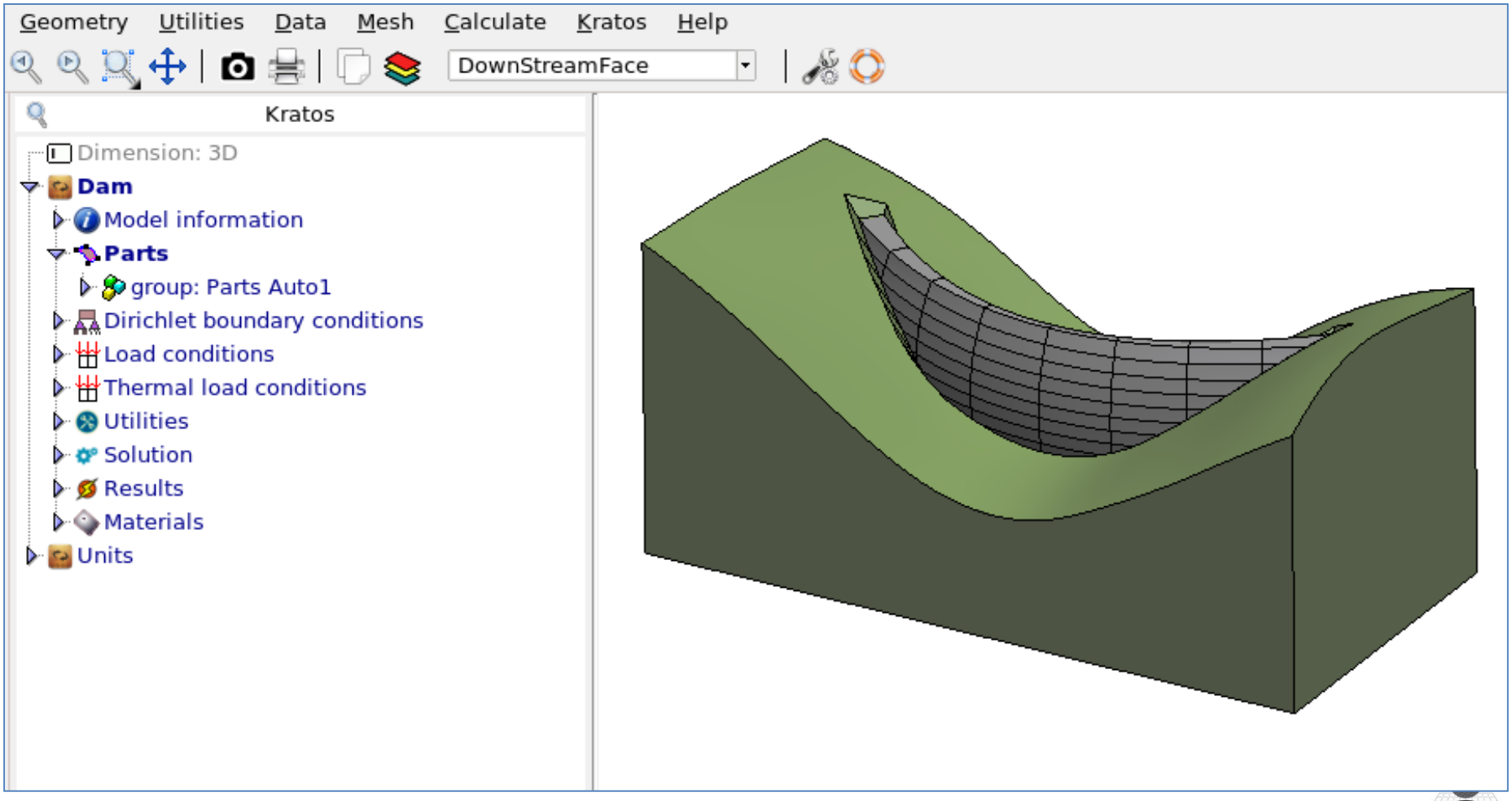
Challenges found to simulate this phase

Processes and utilities

- Transient analysis (tables)
- Time scale: seconds to weeks; different steps for calculation & writing results
- Mechanical loads: self-weight, hydrostatic pressure
- Thermal actions: dam-air exchange (fixed temp. or flux) and water temperature

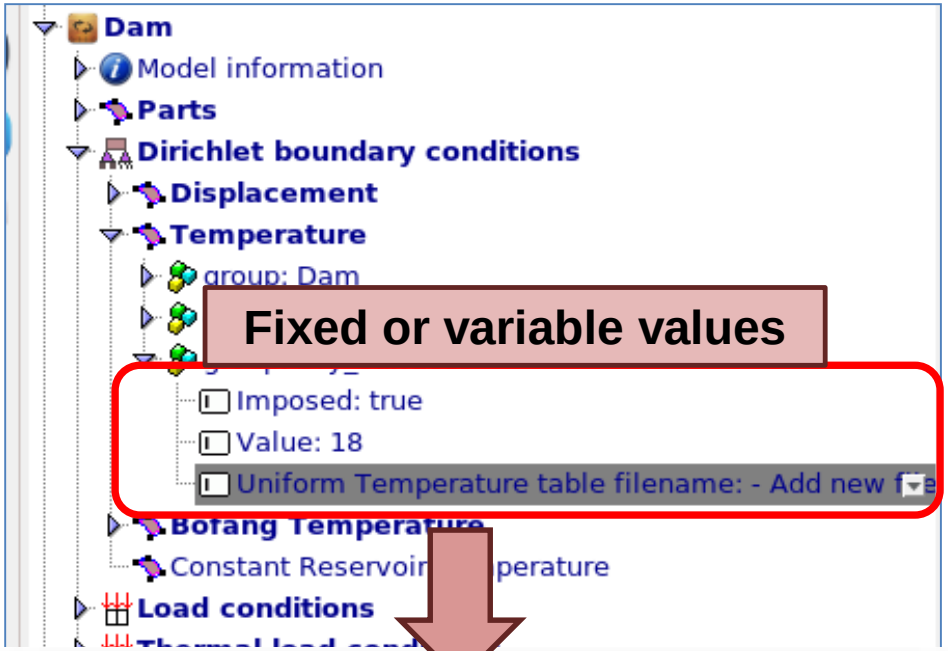
Almendra dam, Spain

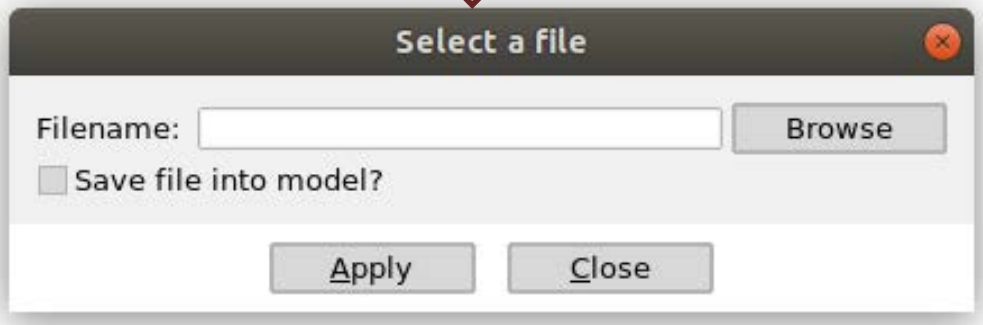
Operation phase



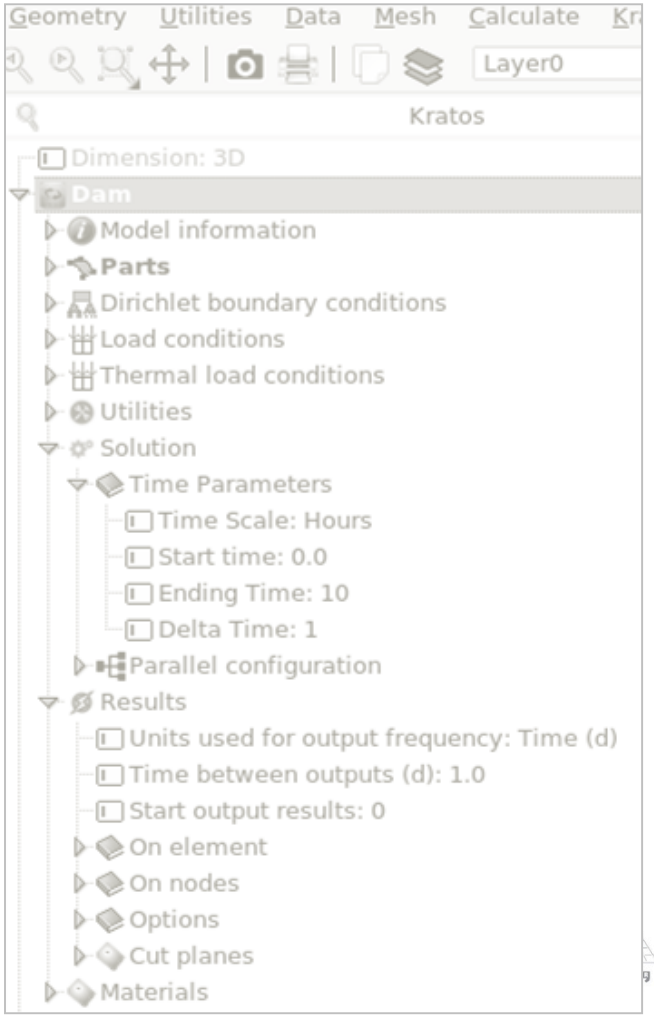
Operation phase

Transient analysis (tables)



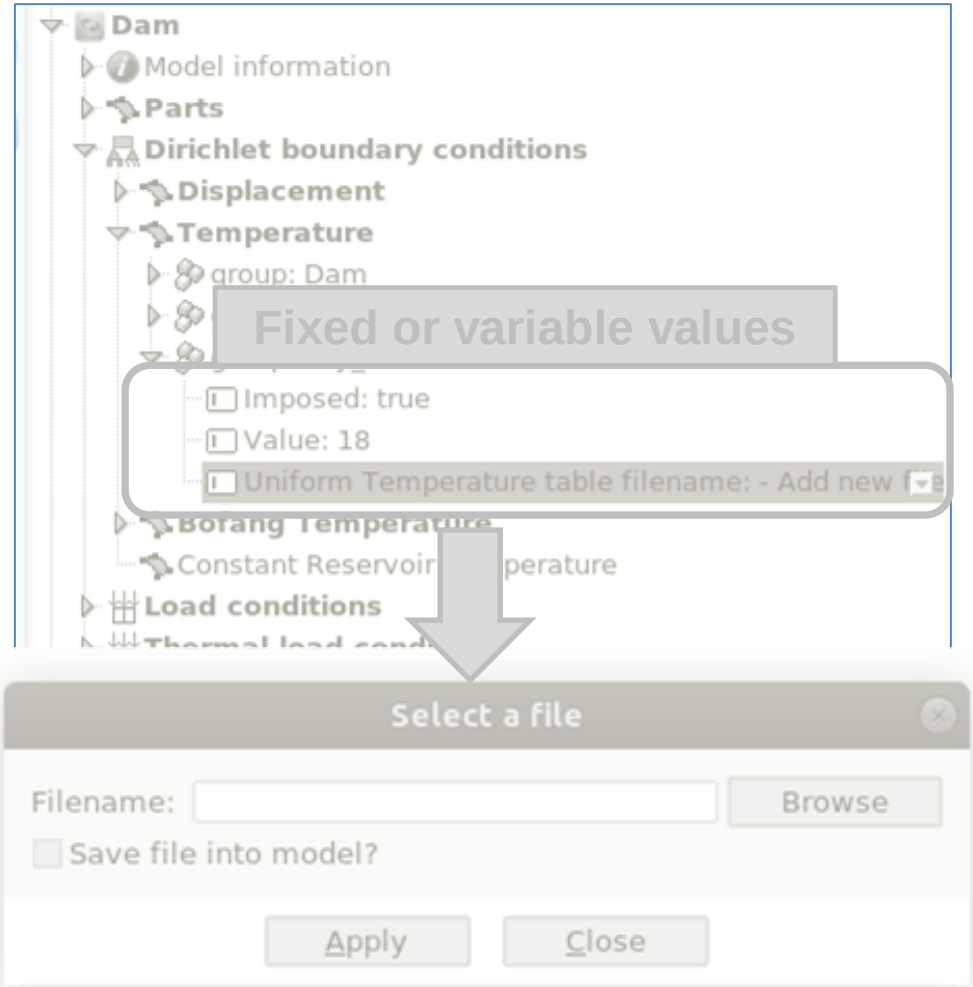


Time scale

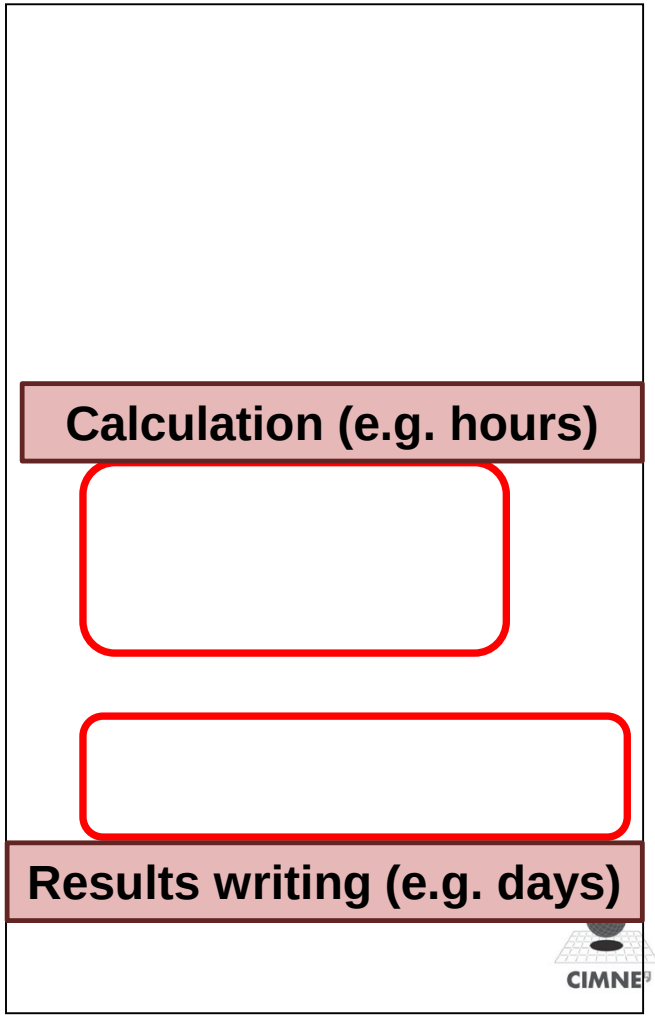


Operation phase

Transient analysis (tables)



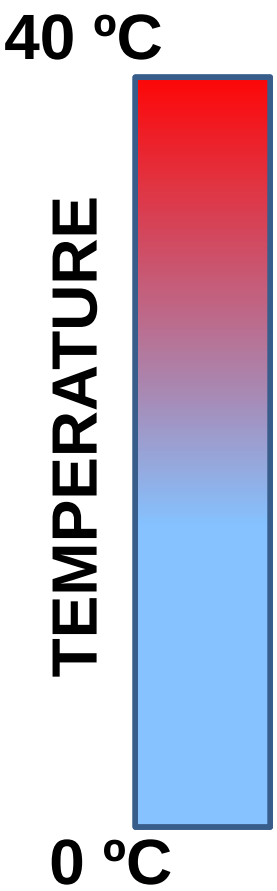
Time scale

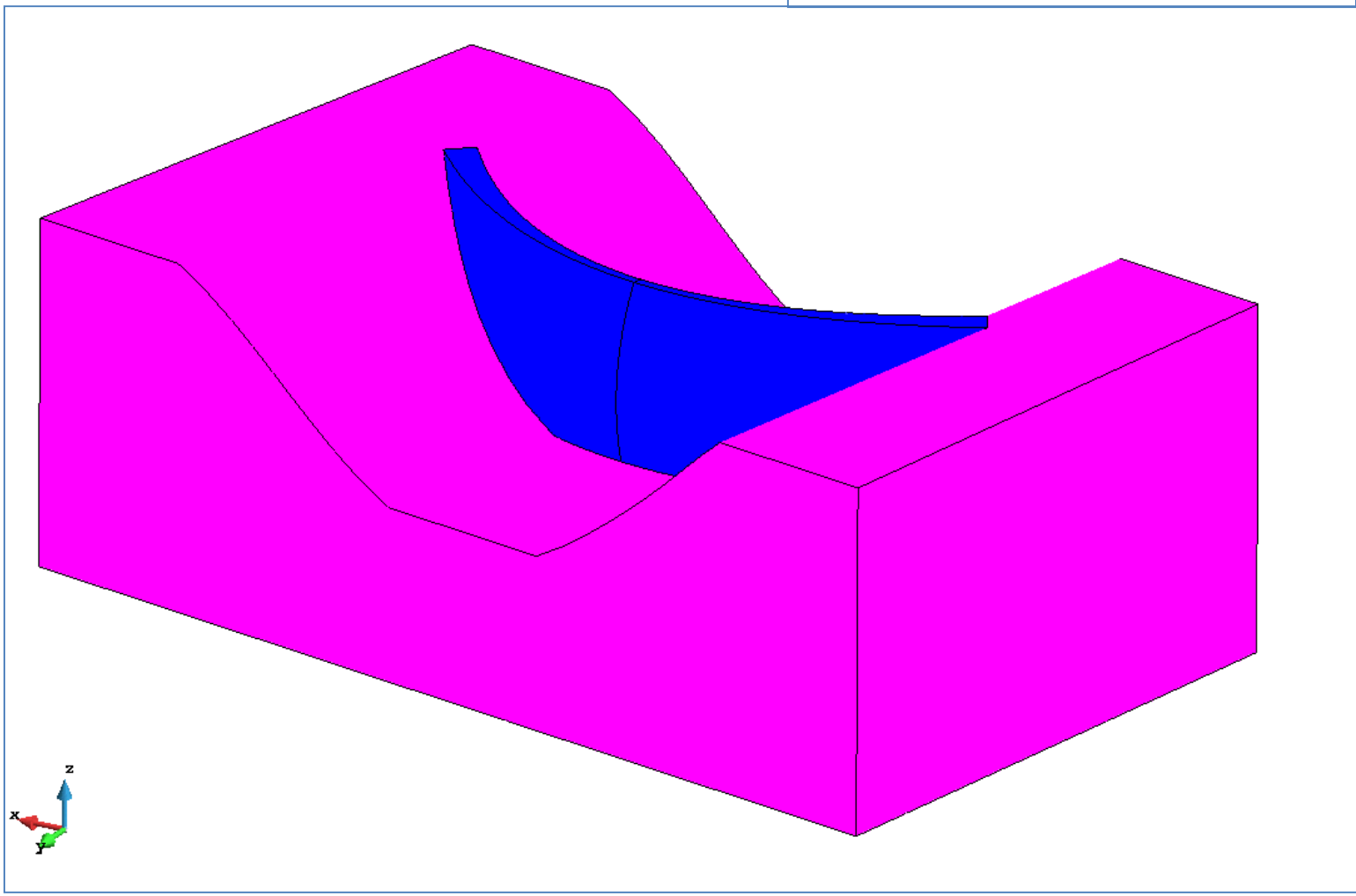


Operation phase

Thermal change: transient analysis

DISPLACEMENT



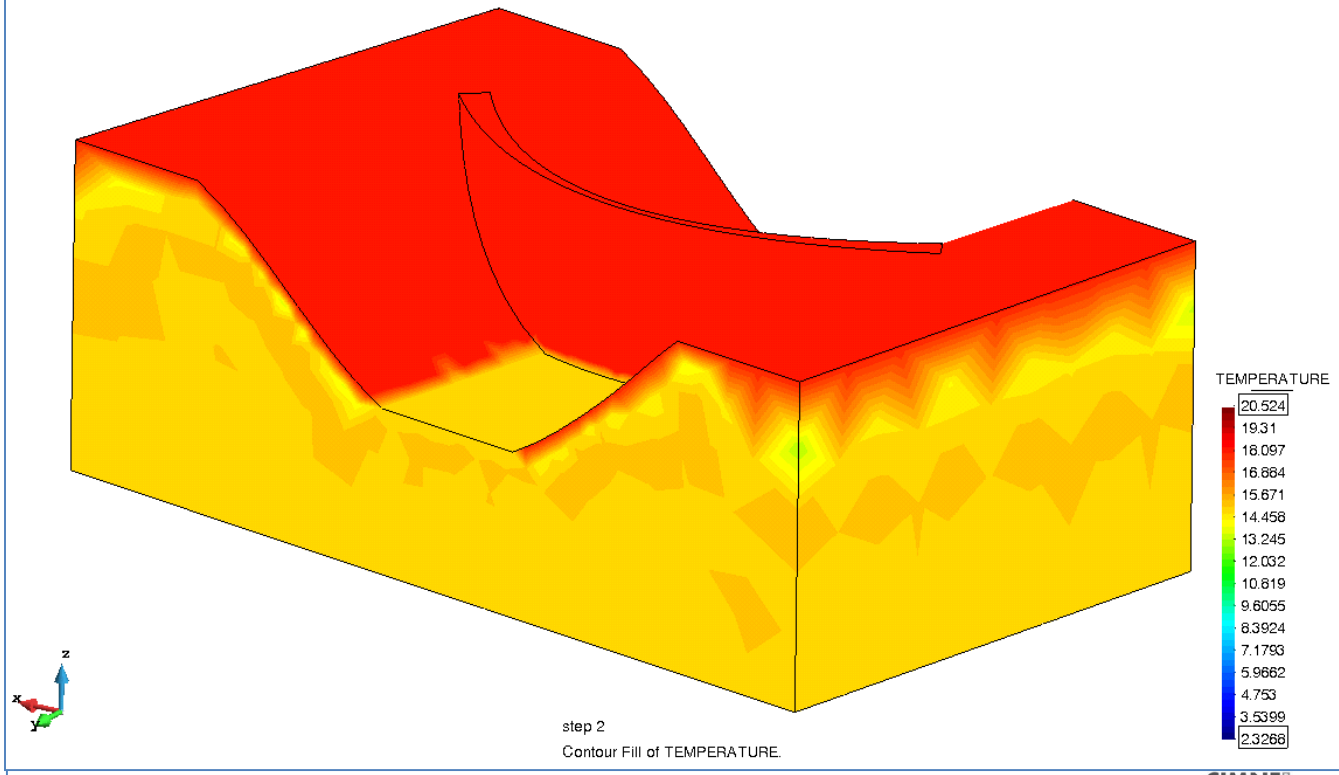


Operation phase

Level change: transient analysis

Water temperature

TEMPERATURE



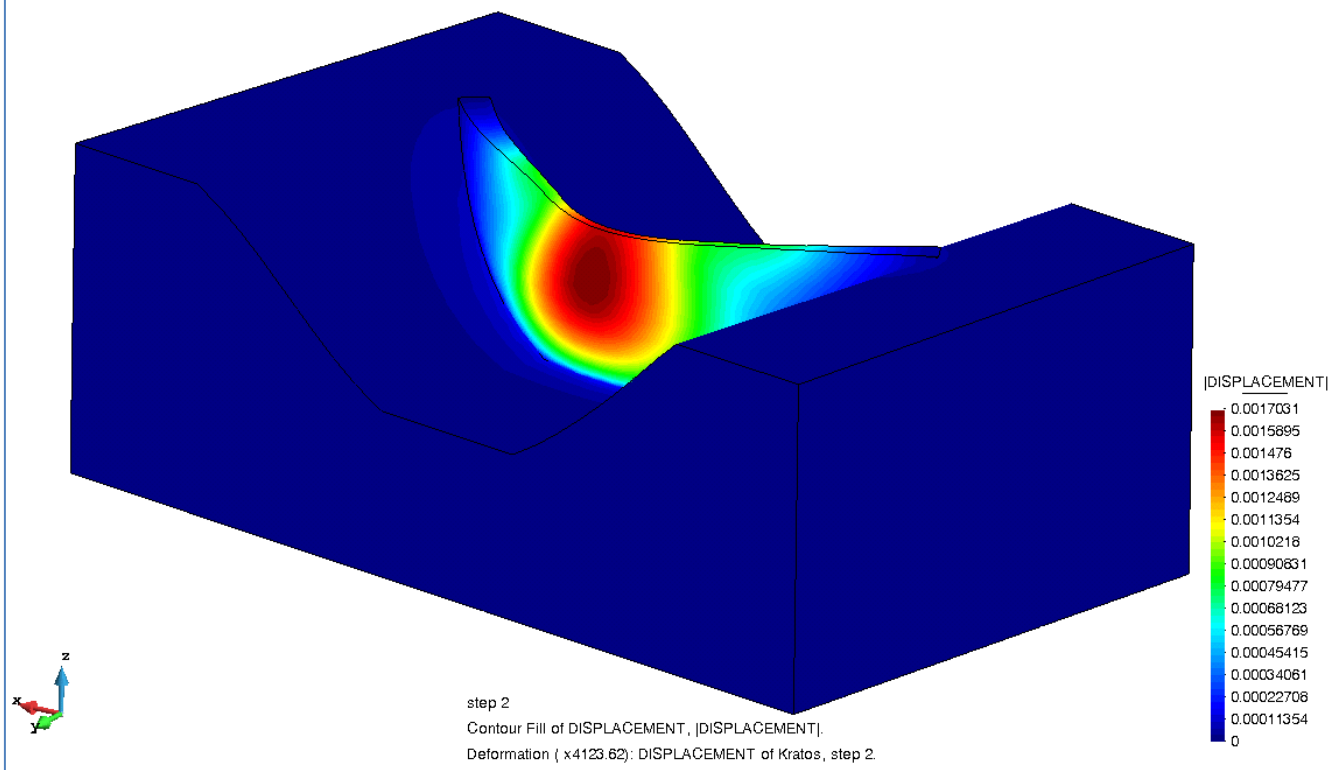
Operation phase

Level change: transient analysis

Water temperature

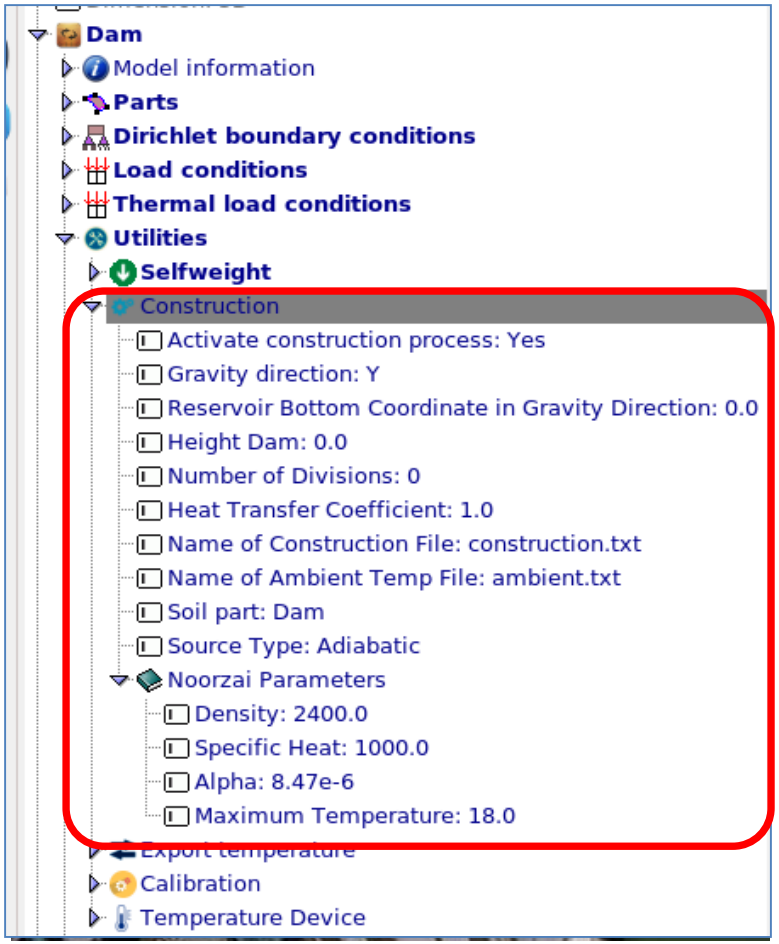
Mechanical Load

DISPLACEMENT



Construction phase

Challenges found to simulate this phase



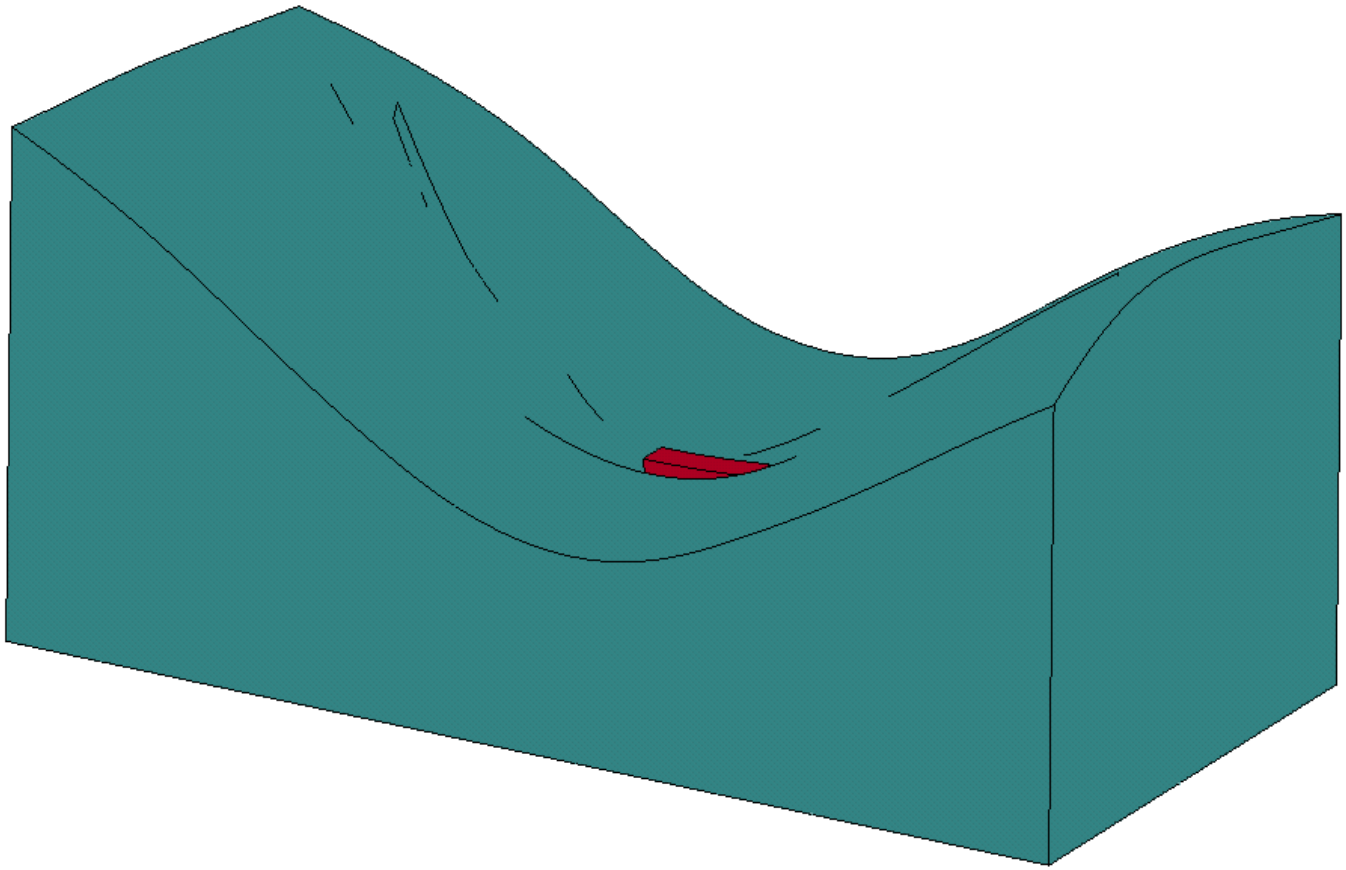
Zillergründl dam, Austria

Processes and utilities

- Building process: activate parts step by step
- Mechanical: self-weight, stresses during construction
- Thermal: heat source, thermal exchanges dam-air and inside dam (considering free surfaces)

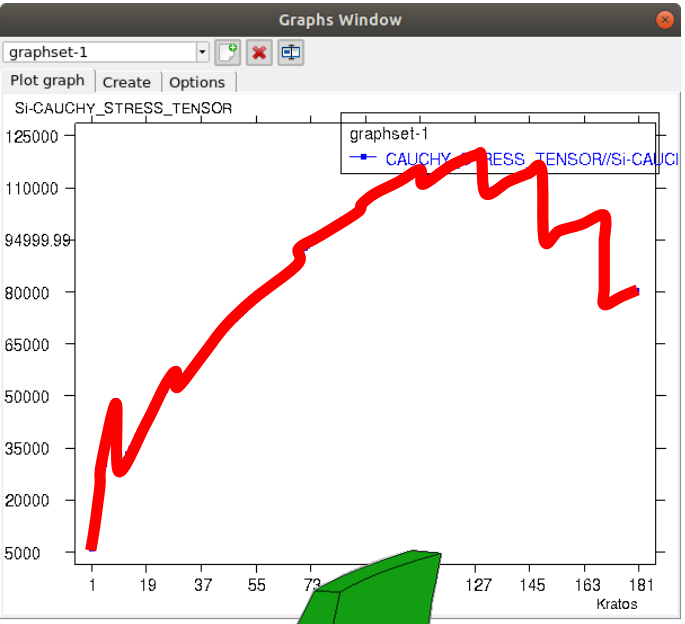
Construction phase

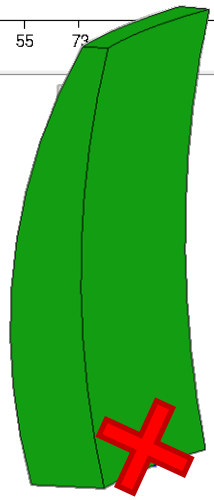
Building process: activate parts step by step



Construction phase

Mechanical: self-weight during construction (stresses)





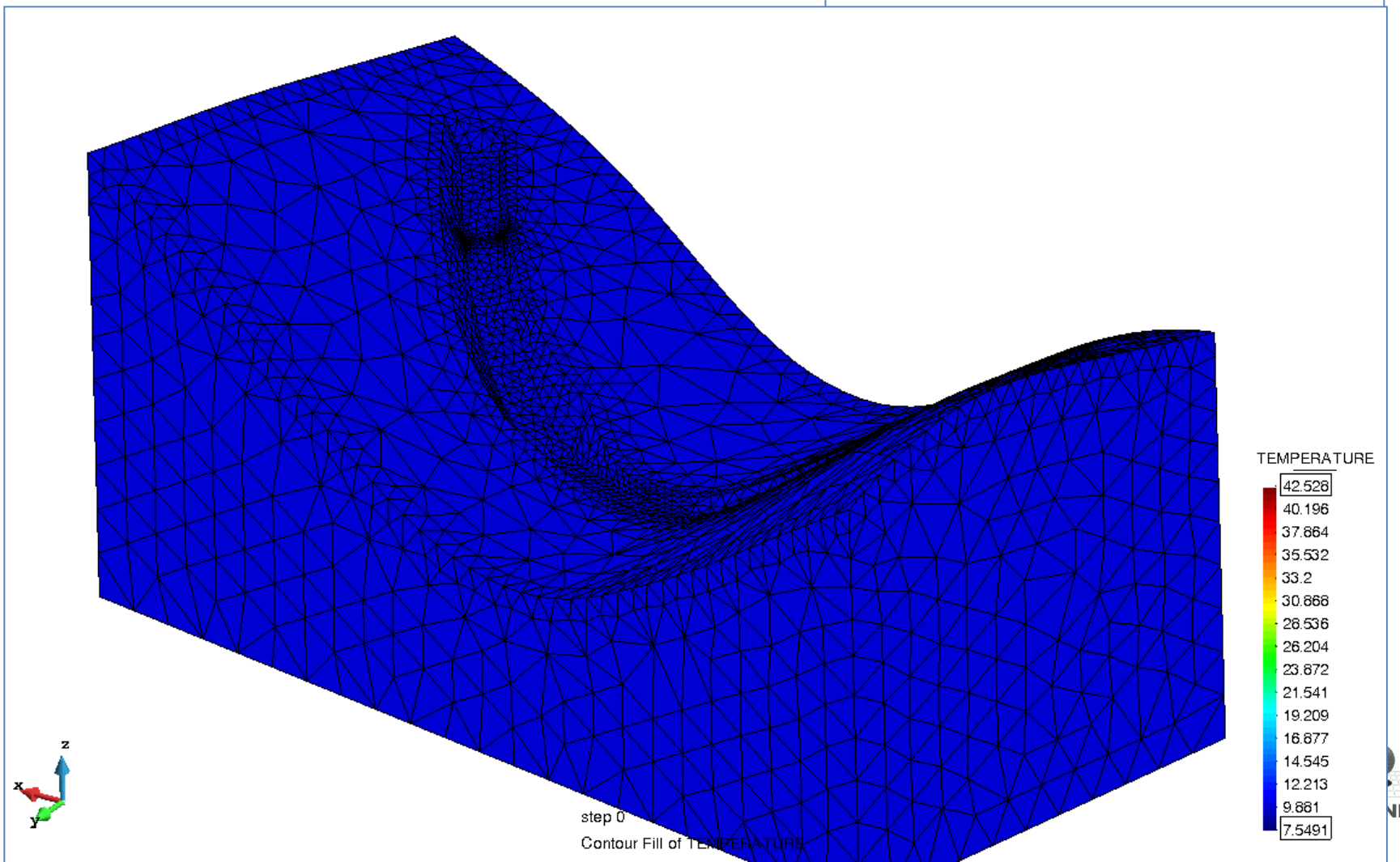
TENSILE STRESS

CIMNE

Construction phase

Thermal exchange, heat source

TEMPERATURE



What are the advantages of DamApp?

- Linked with Dagger (arch-dam generator), both applications cover, with great detail the complete cycle of Dam analysis: design, construction and operation.

- Comprehensive thermo-mechanical analysis of arch-dams. Specific loads and boundary conditions were created. Special focus on transient analysis: variable values (tables) and temporal scales.

- Construction process simulation: step-by-step building progress (parts activation), mechanical stresses (self-weight) and thermal actions (heat source, heat exchange).

In progress work

- Link construction/operating phases (grouting): self-weight stresses (neglect displacements), transfer temperature field (reference temperat.)

- Calibration of dam behavior with joint elements: during the construction and operation stages.

Acknowledgments

- Ministry of Economy, for funding AIDA, ACOMBO and NUMA projects (RETOS-COLABORACION calls)

- Lorenzo Gracia... (who laid the foundations of the Dam Application)

ARCH DAM GEOMETRY GENERATOR & DAM APPLICATION

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