Politecnico di Torino

Dams & Reservoirs DAY 2025

Water and Energy security for Europe

ITCOLD

ITYP

OPEN DAY ON DAMS



Dams and environment: engineering solutions for the future

Dams and hydropower plants

Design case hystories

TORINO , 28 maggio 2025

Andy De Paola – Geotecna Progetti

GEOTECNA PROGETTI

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ITCOLD – II Concorso Fotografico

Geotecna Progetti and dams - Structures designed in the years

Dams – Multidisciplinary structures

Hydraulic

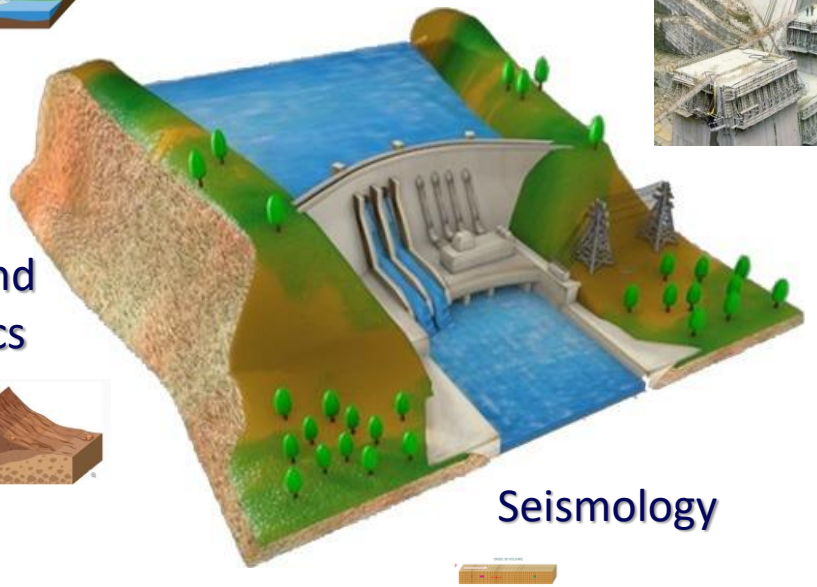


Hydrology



Structures and Materials





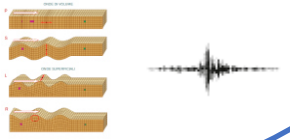
Environment



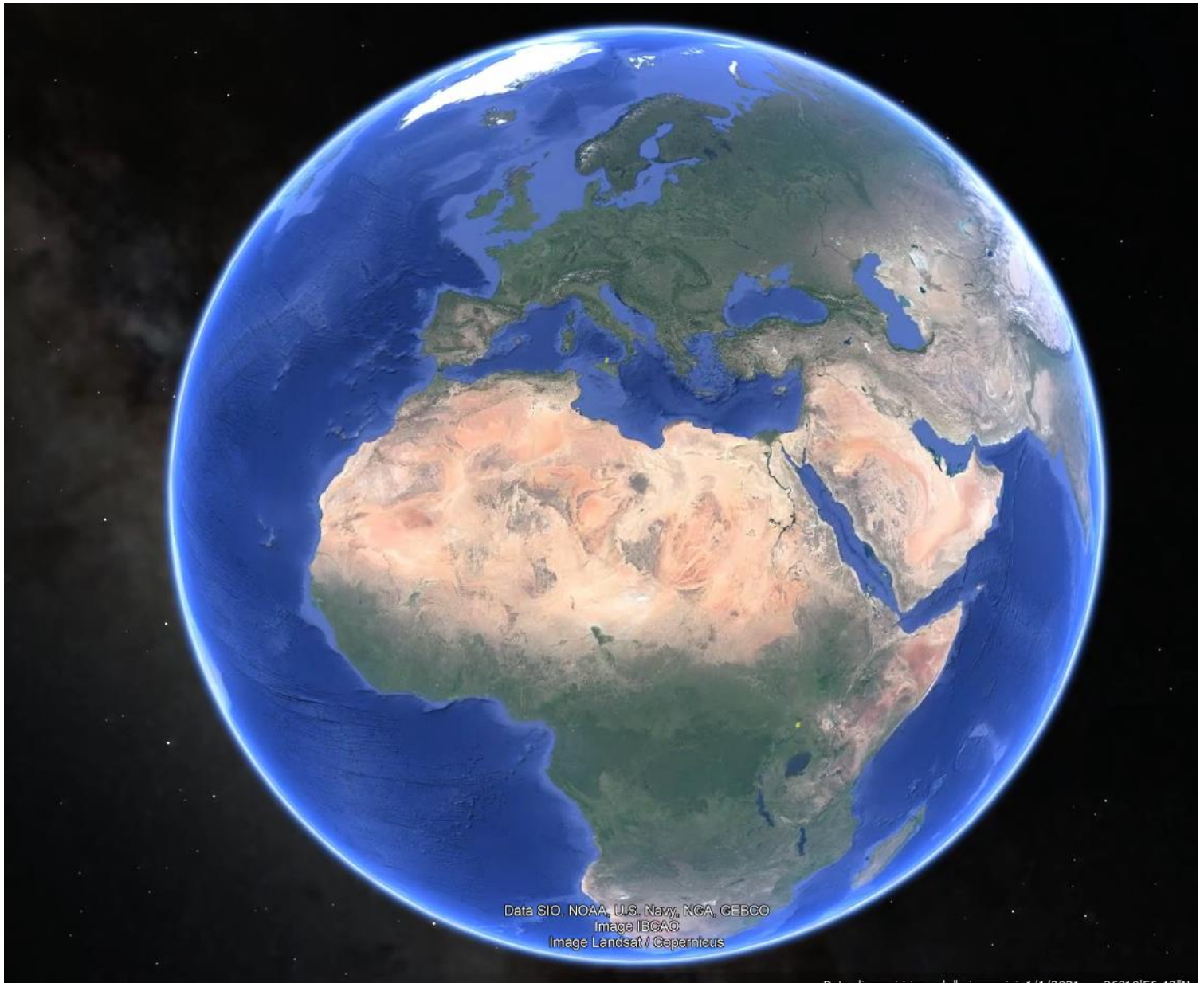
Geology and Geotechnics



Seismology



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STRUCTURES PRESENTED

ROSAMARINA DAM

- *Location: Caccamo (PA) – ITALY –* **EUROPE**
- *Services:* Detail design, Construction Consulting and Instrumentation Data Interpretation
- *Activity period:* **1980-2016**
- **COMPLETED WORK**

HYDROPOWER PLANTS HPP1 – HPP2

- *Location:* Pader, Gulu and Kitgum Districts – UGANDA – **AFRICA**
- *Services:* General design for Concession and Financing, Detail Design and assistance during construction
- *Activity period:* ***2016*-2021**
- **COMPLETED WORK**

GUAYUBIN DAM

- *Location:* Guayubín River, Santiago Rodríguez Province – DOMINICAN REPUBLIC – **AMERICA**
- *Services: Basic Design,* Detail Design and assistance during construction
- *Activity period:* **2020-2022**
- **WORK IN PROGRESS**

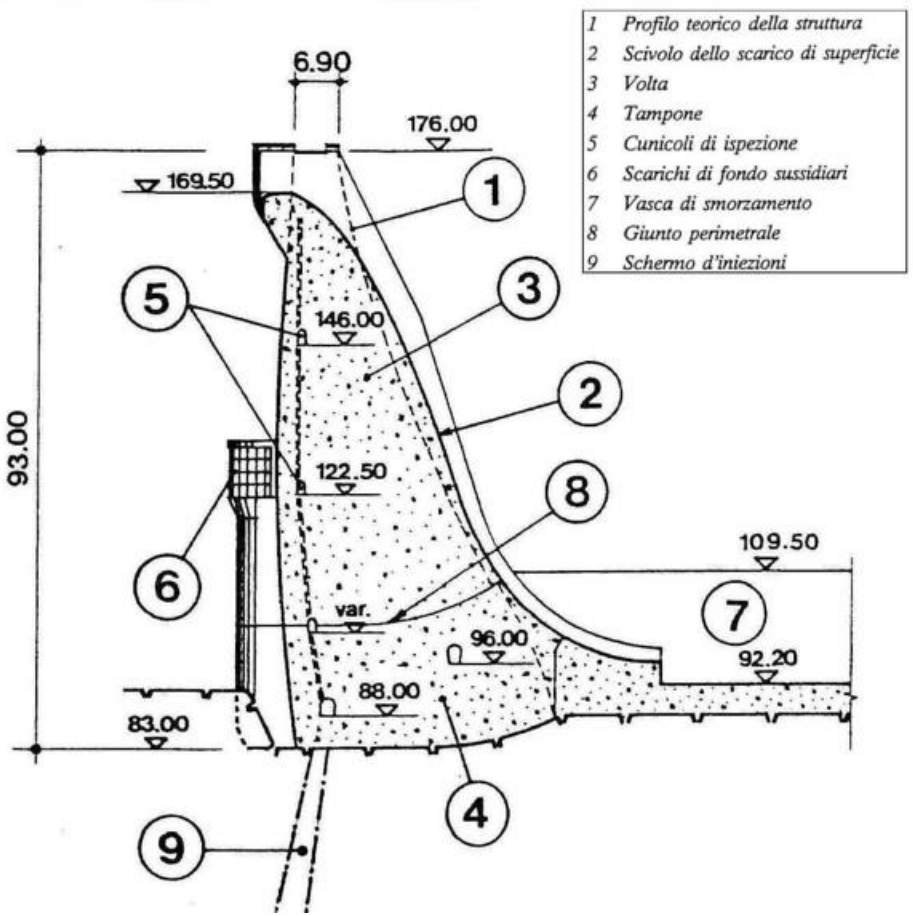
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ROSAMARINA DAM

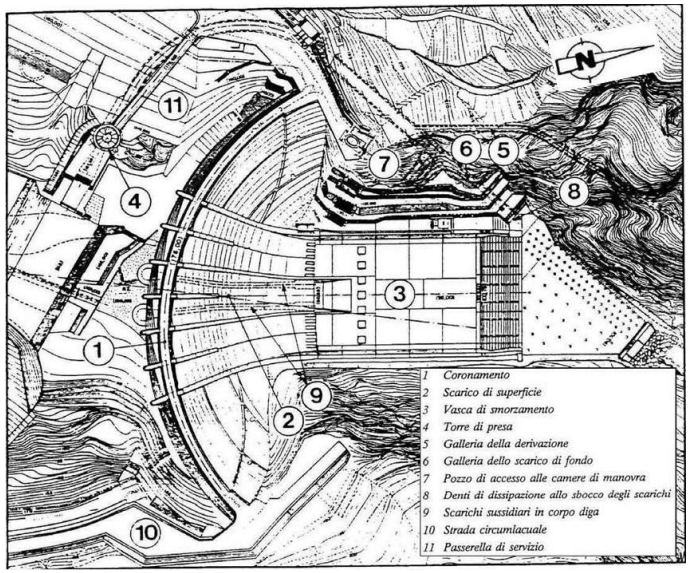
- *Use: Irrigation, Potable Water, Industrial Use*

Geometry and Main Data of the Dam

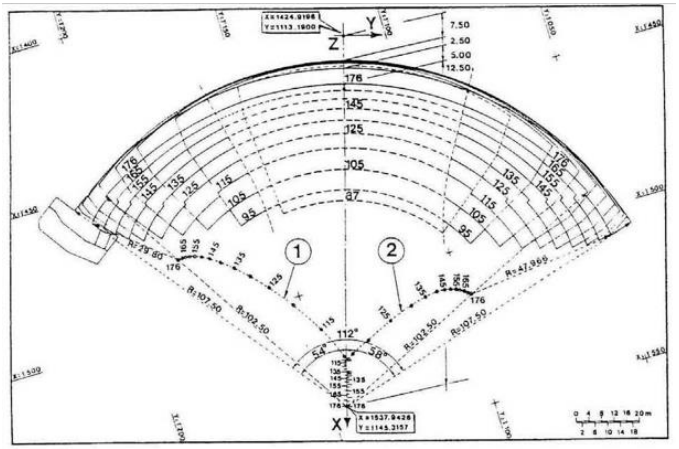


Central sector - Typical section

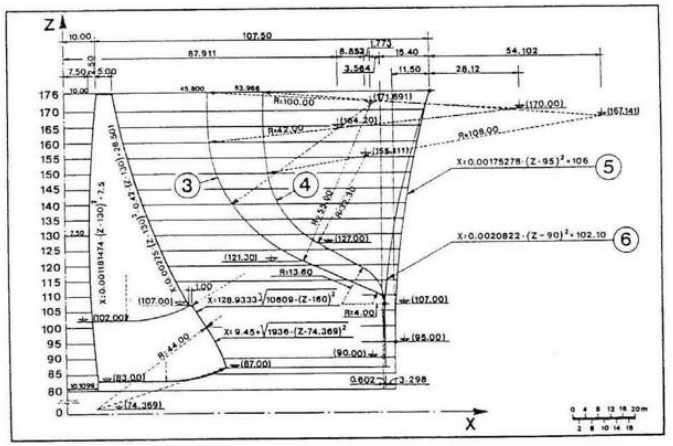
The structure has a symmetrical arch geometry formed by arches with variable thickness.



The dam is of the **arch-gravity type**, with a maximum height of 93 m, crest length of 200 m, crest thickness of 6.90 m, and base thickness of about 42 m.



1-3 Centri pulvino intradosso spalla destra
2-4 Centri pulvino intradosso spalla sinistra
5 Centri volta di estradosso
6 Centri volta di intradosso

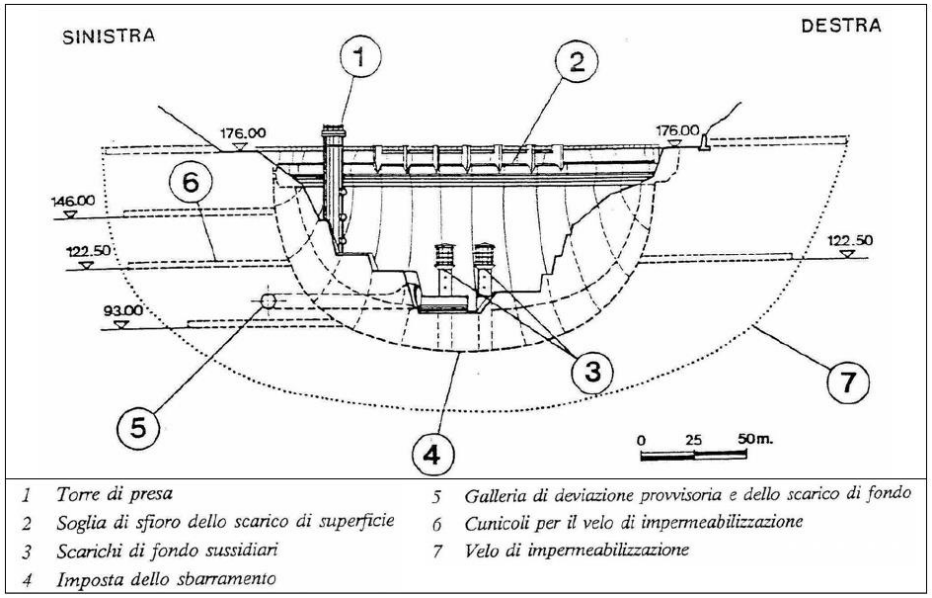


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ROSAMARINA DAM

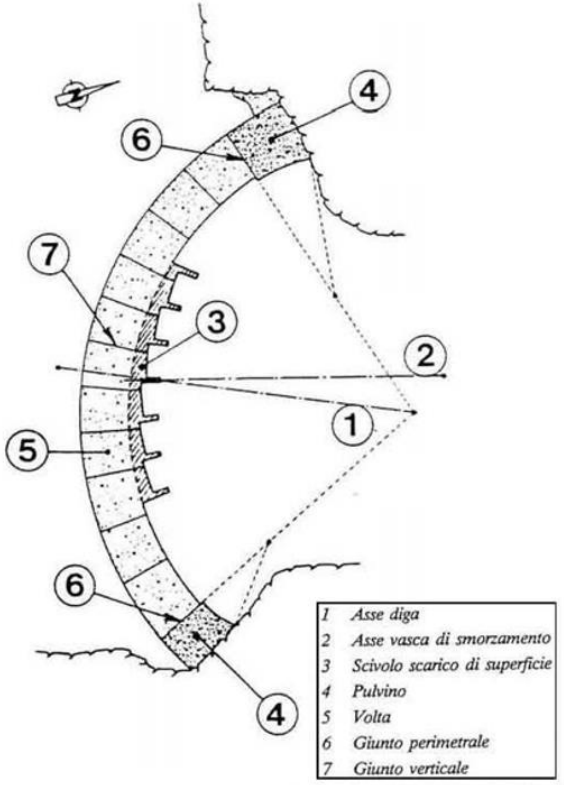
Construction Joints

For the construction, the dam body was divided, with transverse joints, into 12 blocks about 14 m wide at the crest and about 20 m at the base.



1 *Torre di presa*
2 *Soglia di sfioro dello scarico di superficie*
3 *Scarichi di fondo sussidiari*
4 *Imposta dello sbarramento*
5 *Galleria di deviazione provvisoria e dello scarico di fondo*
6 *Cunicoli per il velo di impermeabilizzazione*
7 *Velo di impermeabilizzazione*

The arches were anchored to the rock through a thrust block, which is connected by a perimeter joint; at lower levels, the block gradually transforms into a thick buttress.



1 *Asse diga*
2 *Asse vasca di smorzamento*
3 *Scivolo scarico di superficie*
4 *Pulvino*
5 *Volta*
6 *Giunto perimetrale*
7 *Giunto verticale*

Spillway

The spillway is integrated into the dam body and consists of a threshold with 6 openings with total length of 72 m.



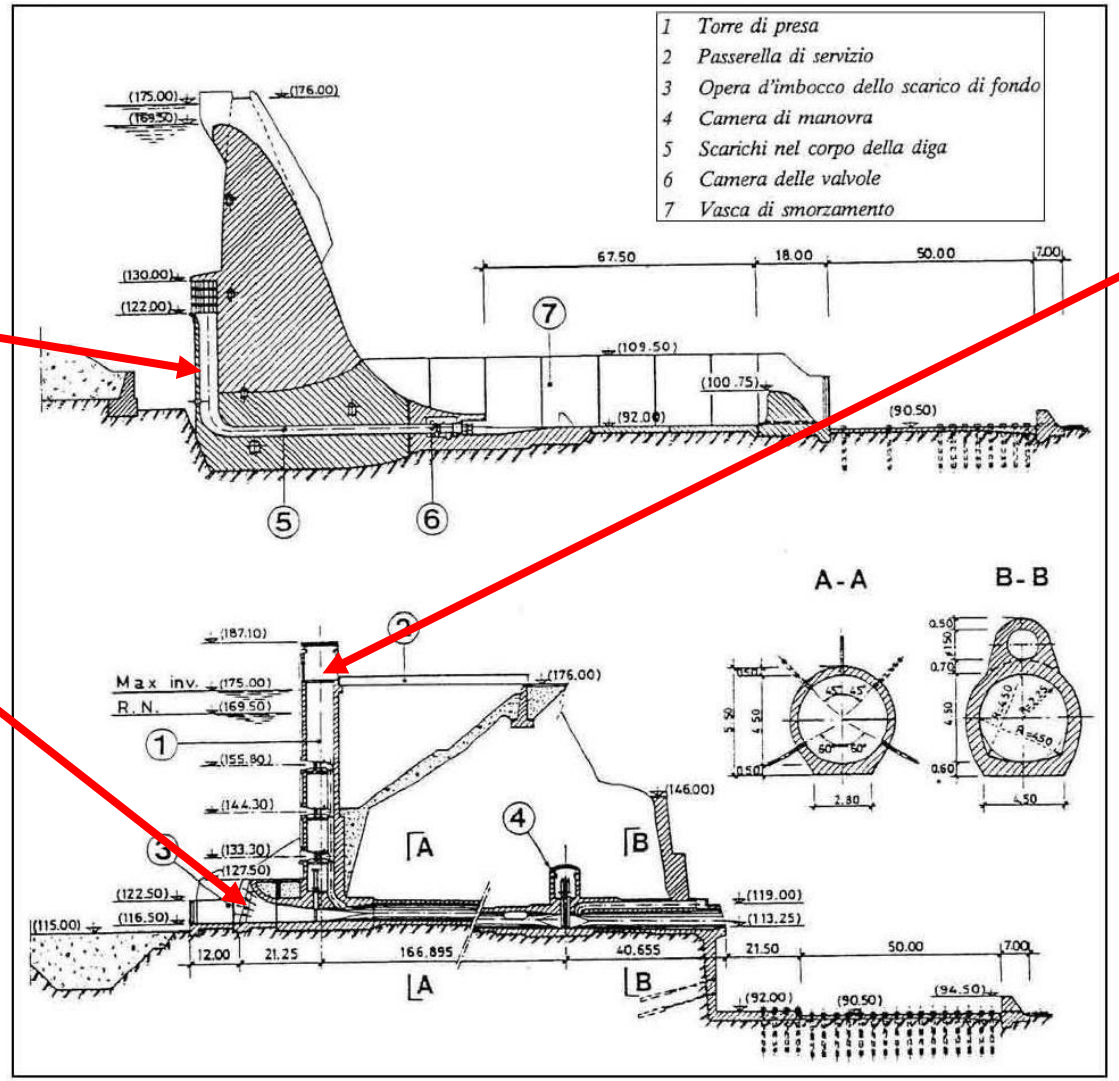
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ROSAMARINA DAMS

Bottom Outlets and Derivation Works

The **bottom outlets** consist of:

- two auxiliary conduits inside the dam body
- a tunnel



The bottom outlets, together with the spillway, are capable to **discharge flows higher than the flood with 1000 years of return period.**

The **intake tower** of the bottom outlet on the left side also includes the **intake structure**, consisting of a vertical pipe inside the tower.

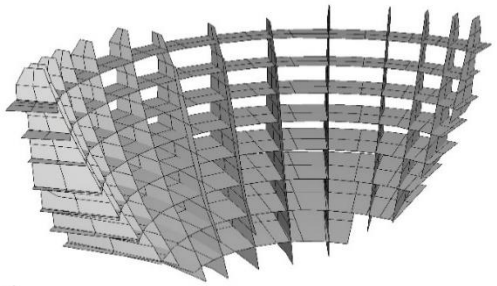
This vertical pipe is connected to a tunnel about 1000 m long, which then divides into the irrigation and potable water network systems supplied by the reservoir.

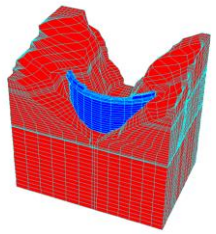
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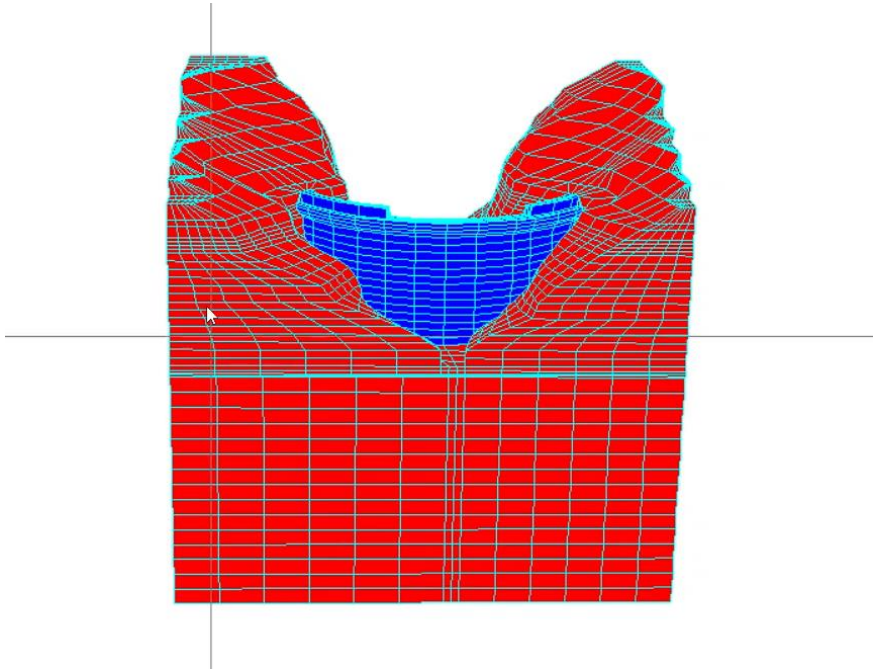
ROSAMARINA DAM

Stability Analyses

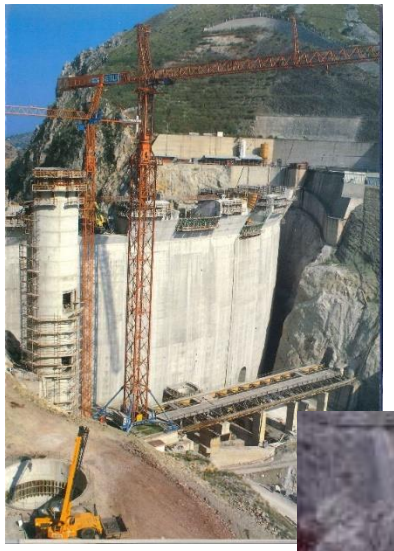
The dam's behavior was verified through different calculation methods.
In an initial analysis, the structure was modeled using a mesh with 8 arches and 14 cantilevers.







Construction Works







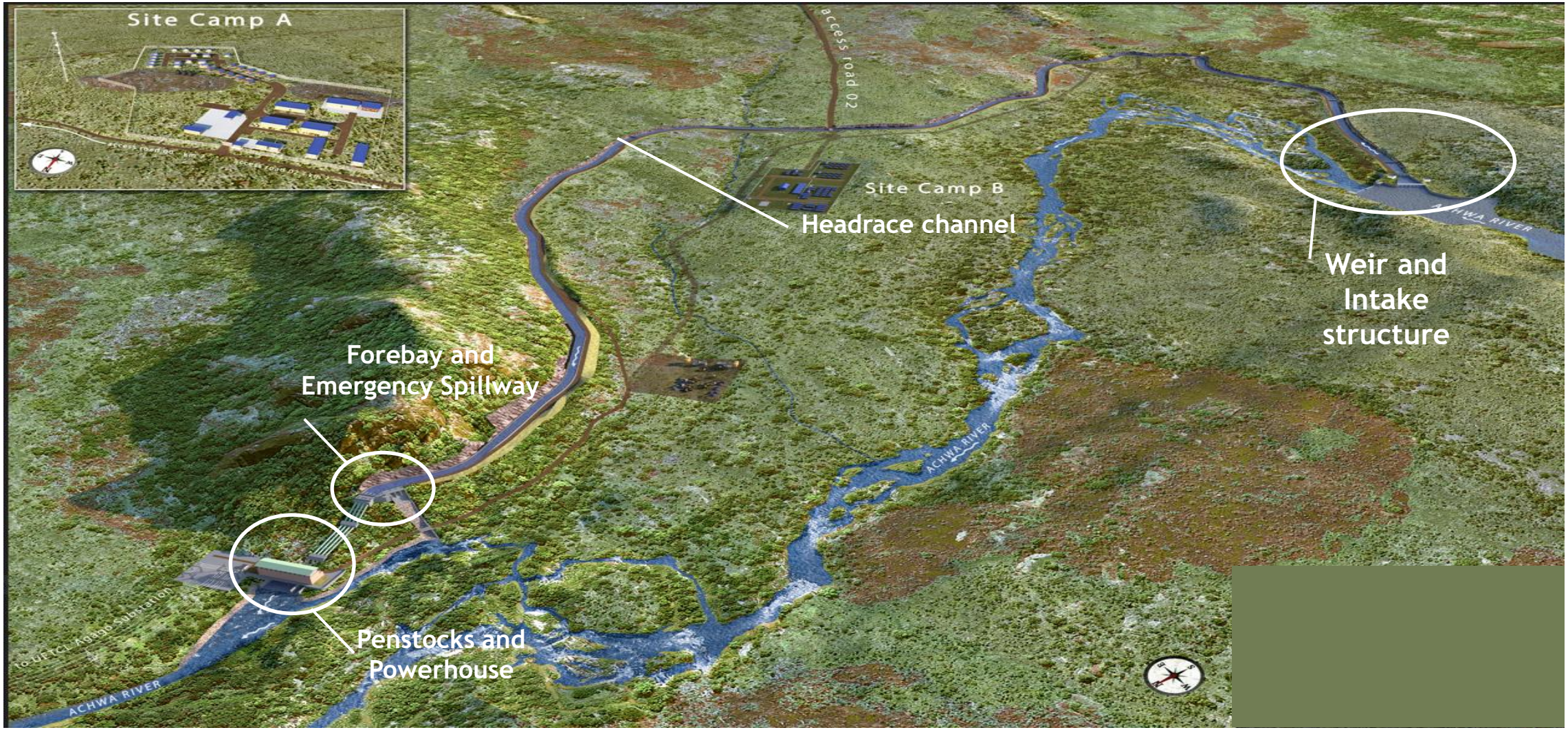
Finally, a 3D finite element model (FEM) was developed, considering a large volume of foundation rock along with the structure.

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HYDROPOWER PLANTS HPP1 – HPP2

- Use: Hydroelectric

Achwa HPP1 and HPP2 are two run-of-river hydropower plants, each with a capacity of approximately 43 MW.

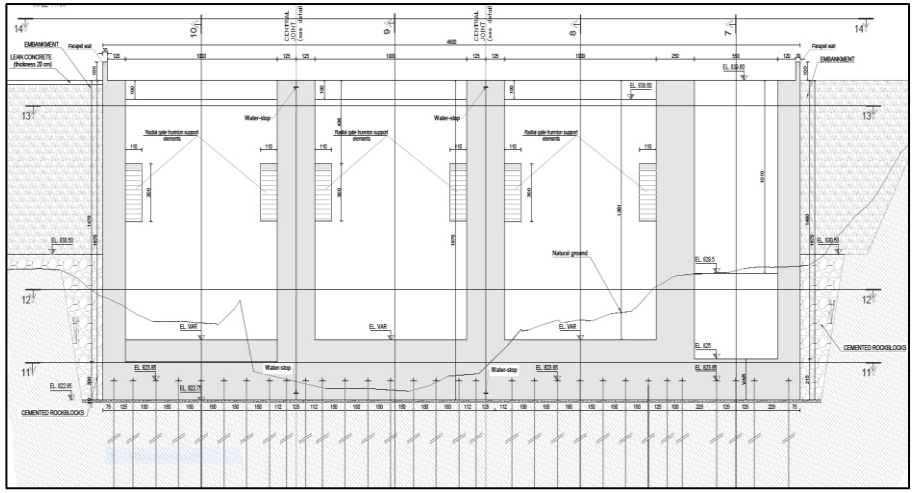


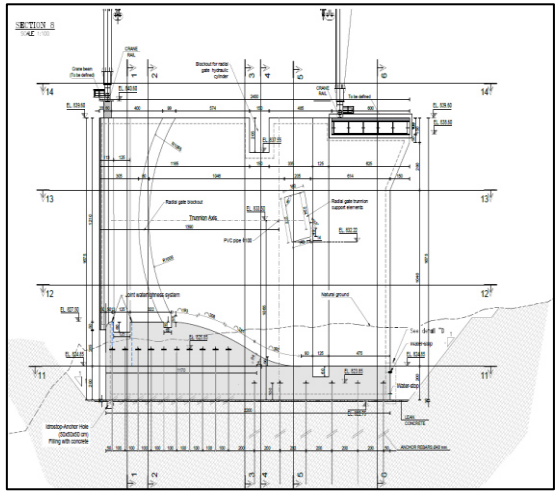
Lay-out impianto

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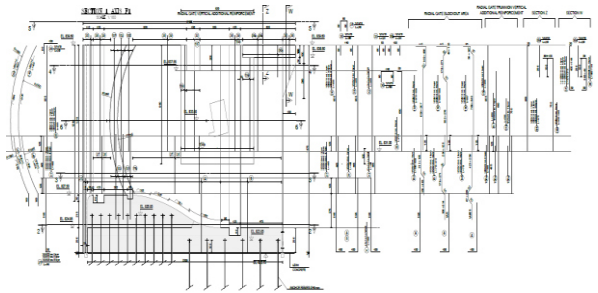
HPP1 – Rapresentative structure - Weir

The **weir of the HPP1** Plant is a reinforced concrete structure, **about 15 m high and 46 m long**, with three openings guarded by three large radial gates. The structure creates a reservoir of about 3 million cubic meters, **qualifying it as a large dam.**

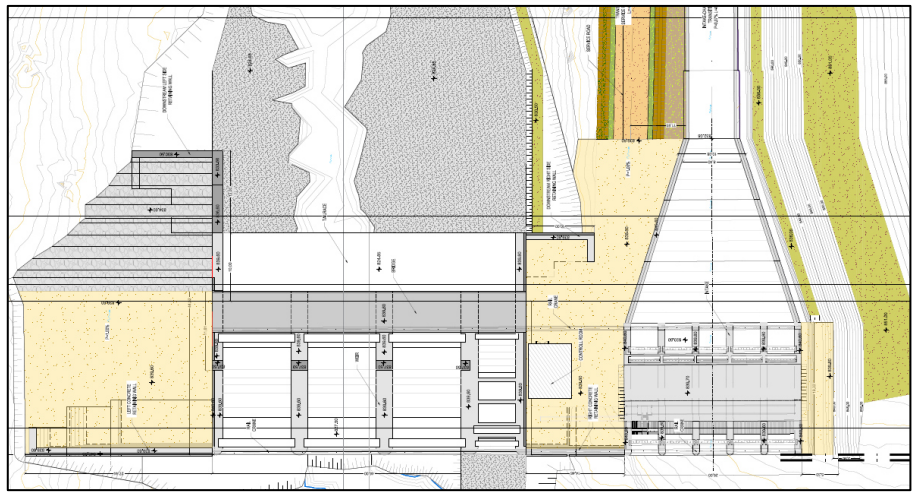




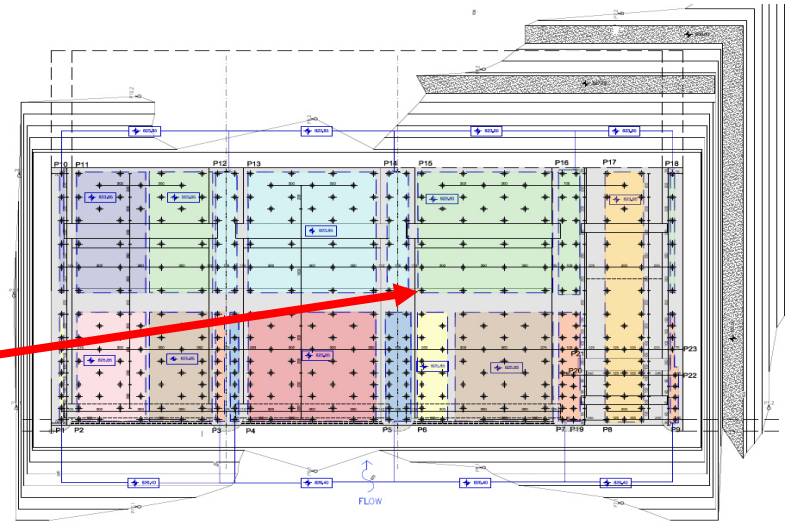
HPP1 Weir transversal and longitudinal sections



As a global improvement of the foundation rock mass and as an additional contribute against sliding and toppling,
A grout curtain has been realized to prevent significant water flows through the foundation rock mass.



HPP1 - Weir and Intake – General plan



HPP1 - Weir – Anchor rebars plan layout

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HPP1 – Weir and intake







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HPP2 – Weir, intake and channel











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HPP1 – Forebay





HPP2 – Forebay



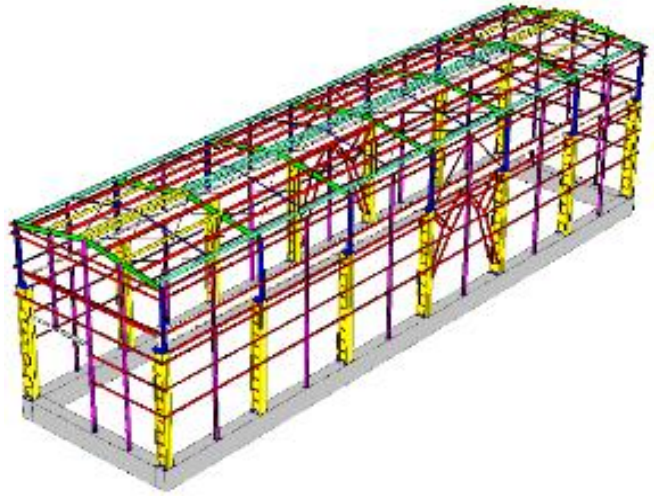


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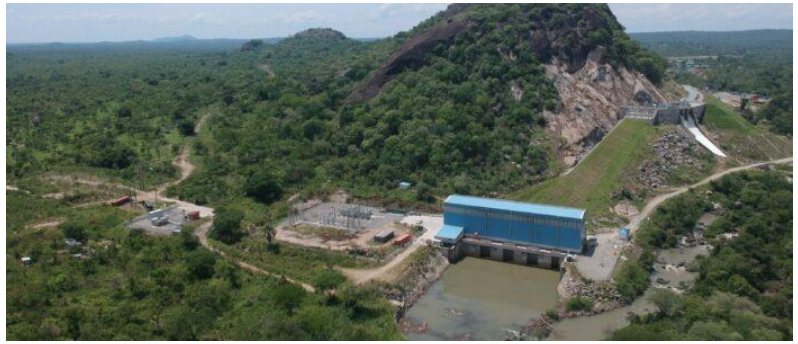
HPP1- HPP2 – Penstocks and Powerhouse







Powerhouse – Modello FEM









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GUAYUBIN DAM

- Use: Irrigation and hydroelectric

The numerical aspects that I will illustrate in a synthetic form below have been subject of a speech that i have presented at the World Conference on Earthquake Engineering 2024. Anyone interested can contact me via e-mail to receive the article.

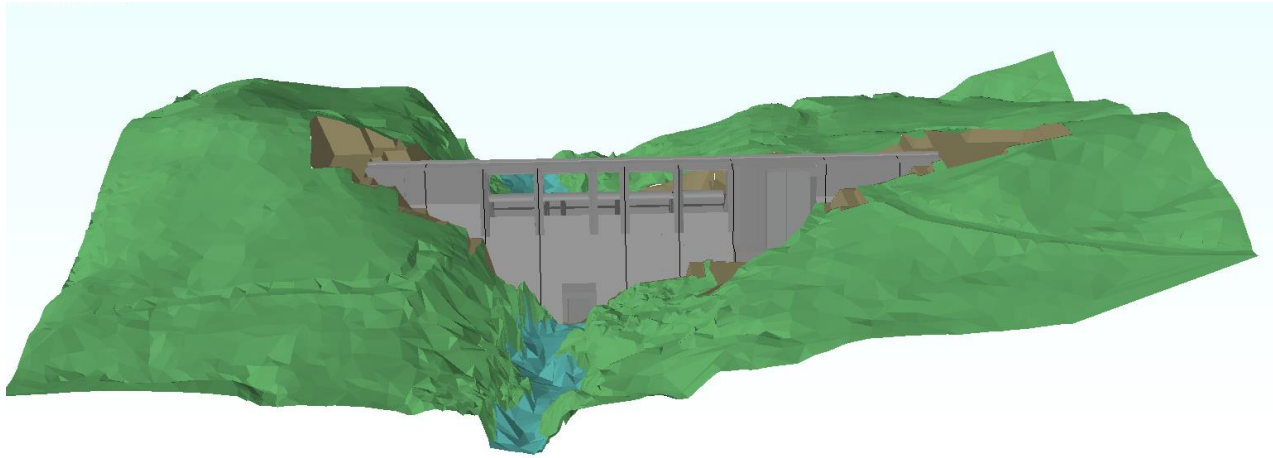


Dam work site – In construction

Principal characteristics of the dam

The structure is a conventional concrete gravity dam divided into 9 independent blocks of width ranging from 11.30 m to 25.20 m, for a total longitudinal extension equal to 153.50 m.

The spillway, in the central part of the dam, consists of five 15.00 m wide openings, guarded by gates.

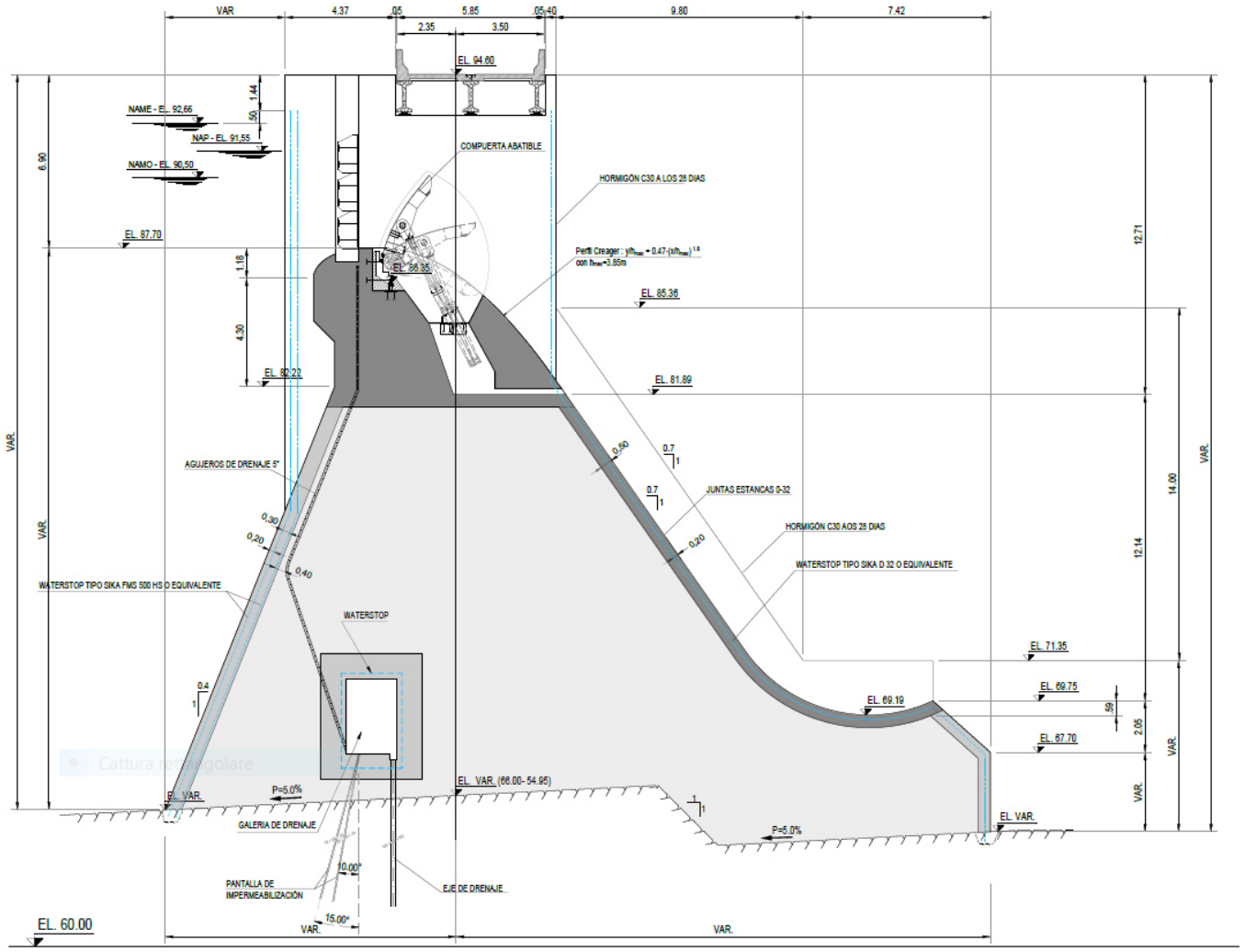


3D Model (Revit)

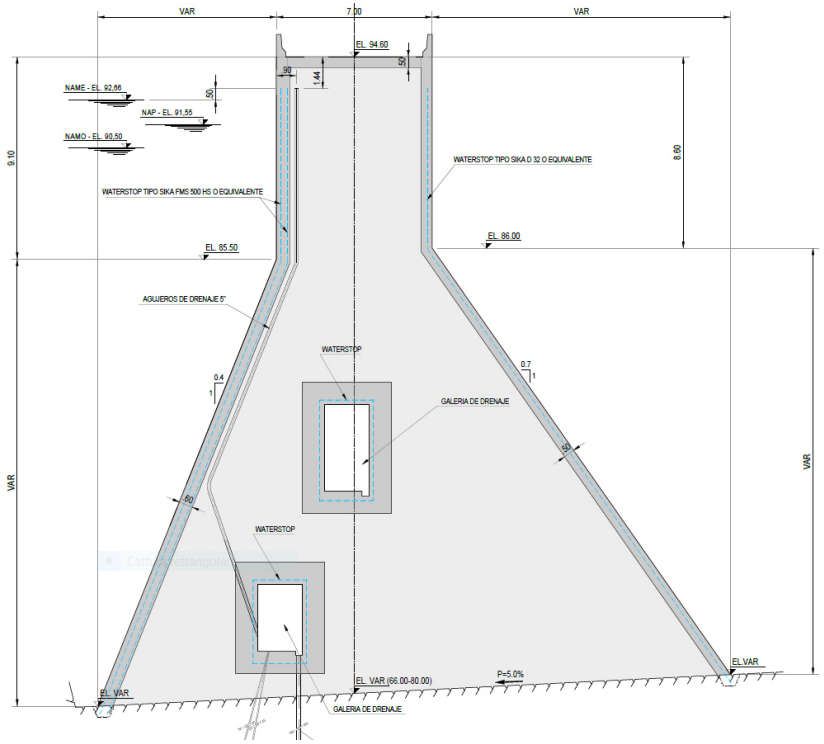
The Structure is located in a region with very high seismicity

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GUAYUBIN DAM



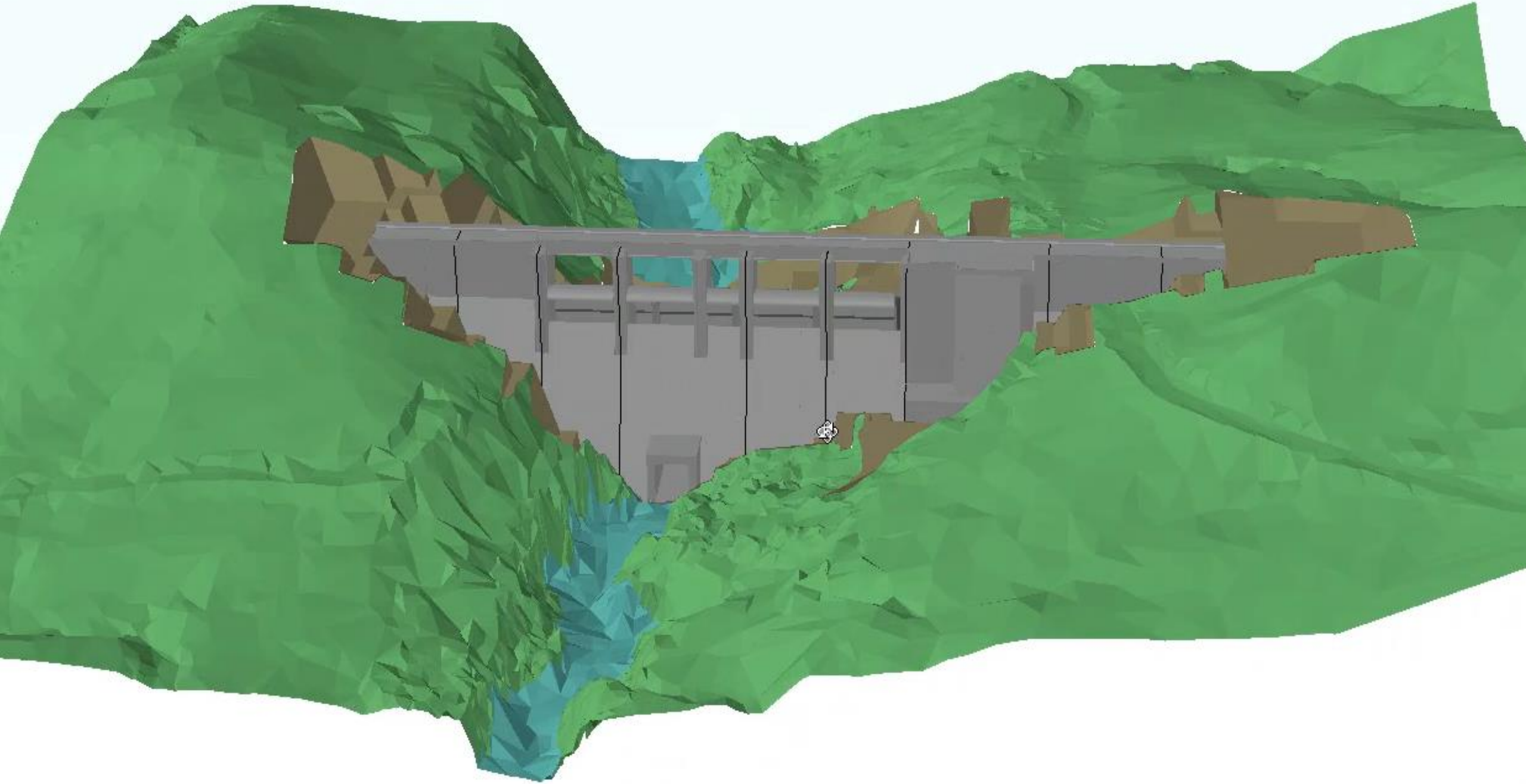
Central sector - Typical section



Lateral sector - Typical section

Maximum height: 42,60 m
Slope of the upper face: 1 V: 0,40 H
Slope of the downstream face: 1 V: 0,70 H

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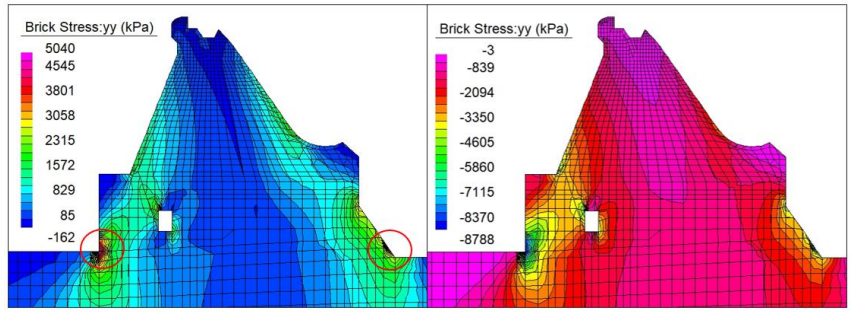


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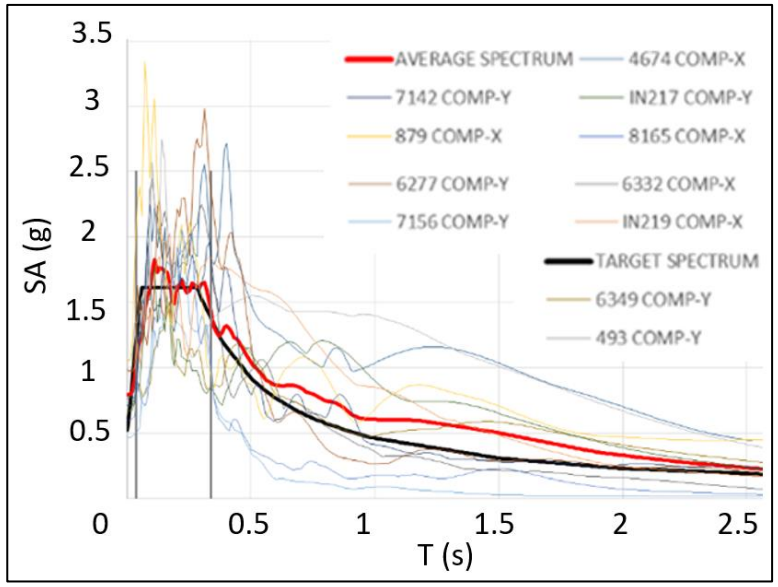
GUAYUBIN DAM – NUMERICAL ASPECTS

The verifications have been developed considering the criteria of the **U.S. Army Corps of Engineers (USACE)**

The analyses developed using various numerical methods and methodologies **of increasing complexity**

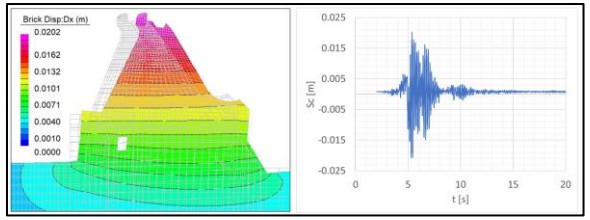


Time-history dynamic analyses have been performed using suitably selected accelerograms scaled to the site-specific response spectra values.



The analyses were performed in Safety Evaluation Earthquake (SEE) and Operating Basis Earthquake (OBE) conditions.

Design Earthquake	Return period T (years)	PGAh (g)	PGAv (g)
OBE	144.3	0.179	0.099
SEE	5750	0.776	0.484

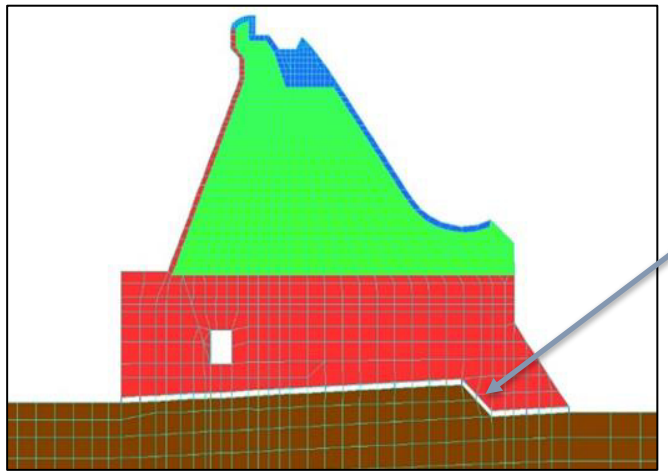


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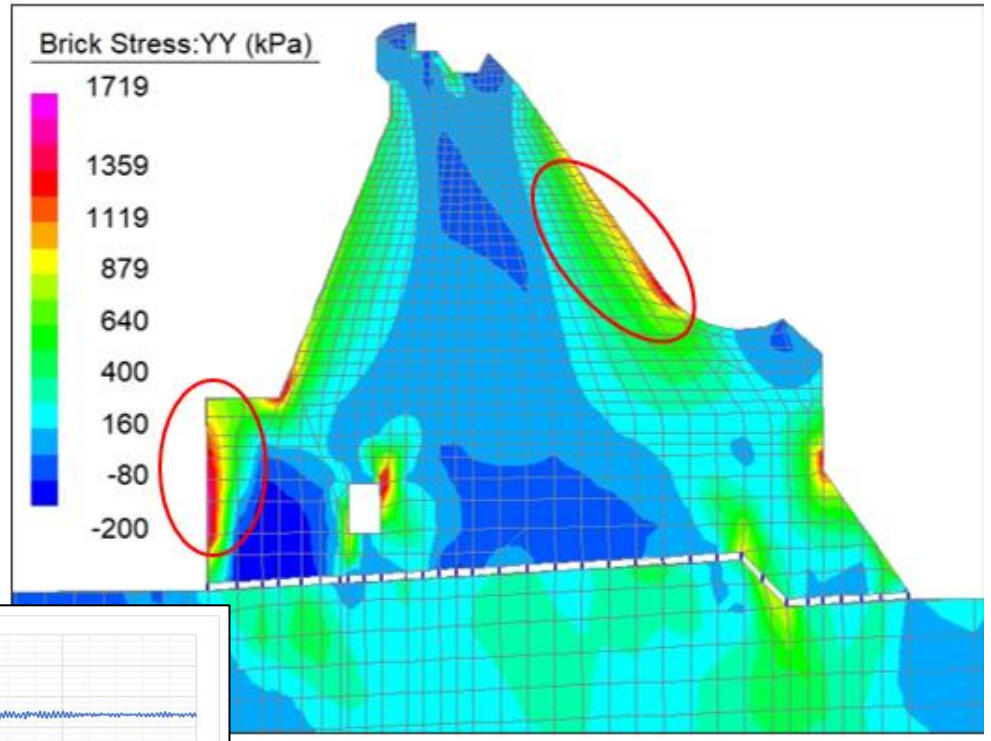
GUAYUBIN DAM – NUMERICAL ASPECTS

Analysis of the dam with the FEM Method - Nonlinear time history dynamic analysis

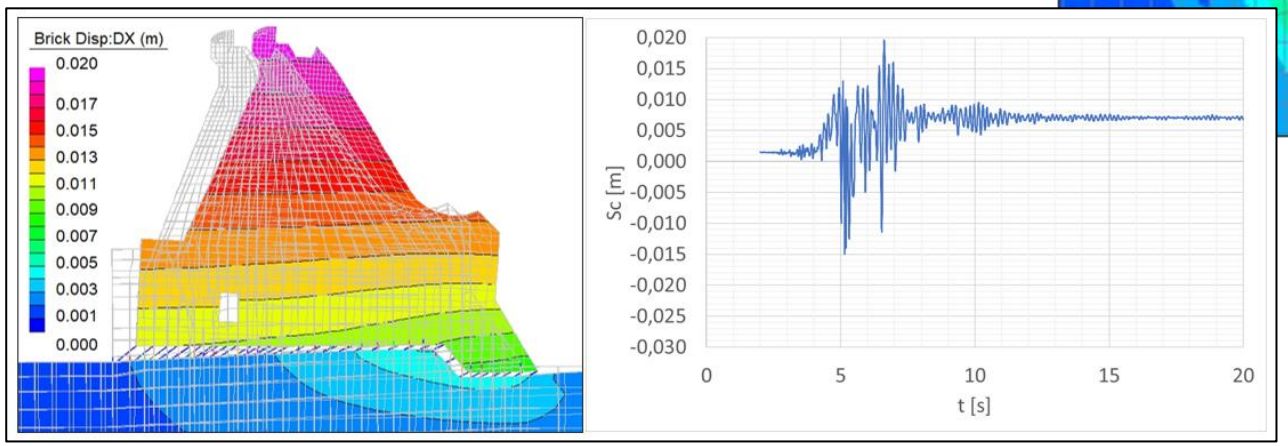
Non-linear time-history dynamic analyses have been performed, in order to evaluate more precisely the tensile stress values at the dam toes and the possible permanent displacements.



Contact points

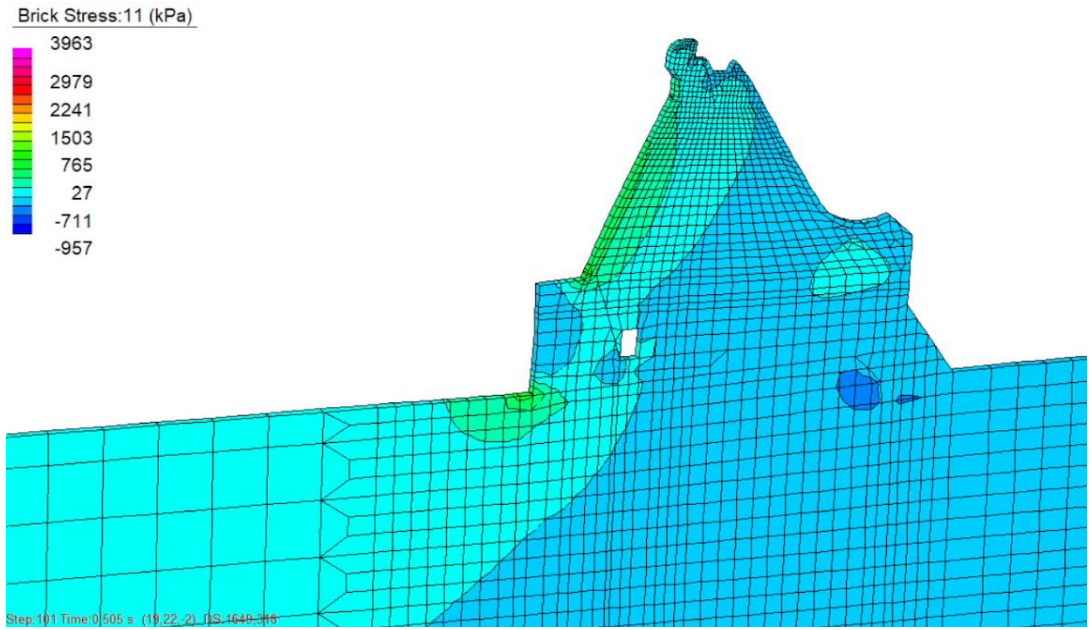


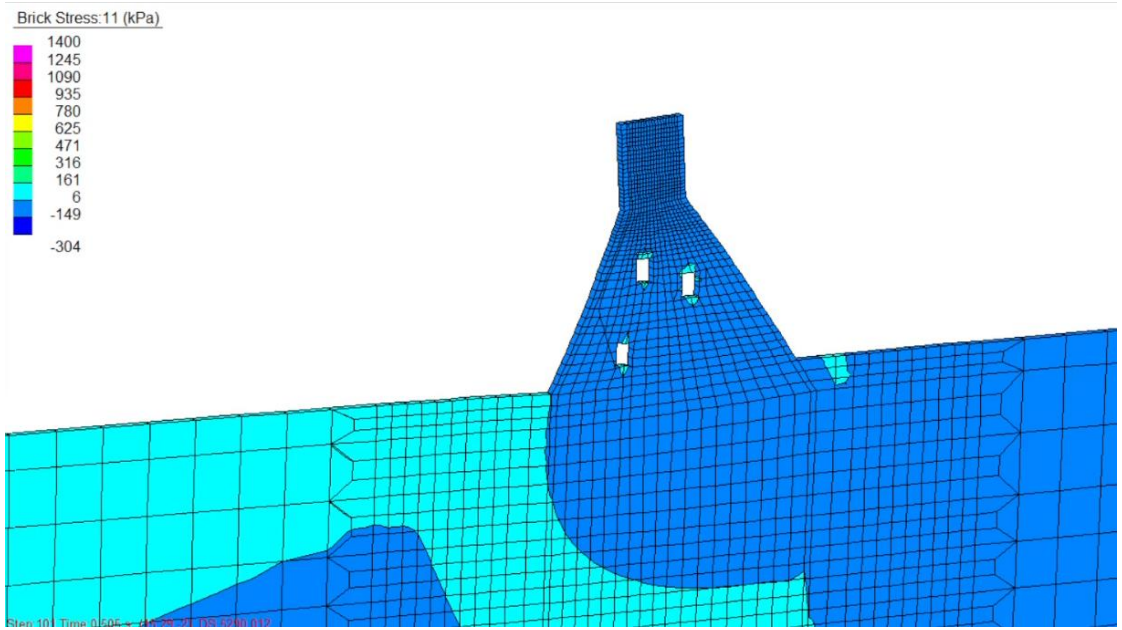
It is possible to **exclude the formation of continuous** fracture surfaces between the upstream and downstream faces.



Max displacements at the dam crest: 2 cm
Residual displacements at the dam base: 0.7 cm

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Thank you!