Underwater Rehabilitation of Dams using Geomembrane Waterproofing System

presented by

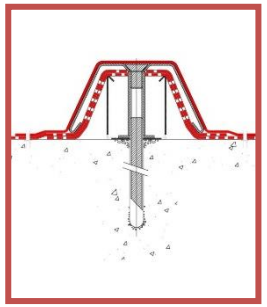
carpi

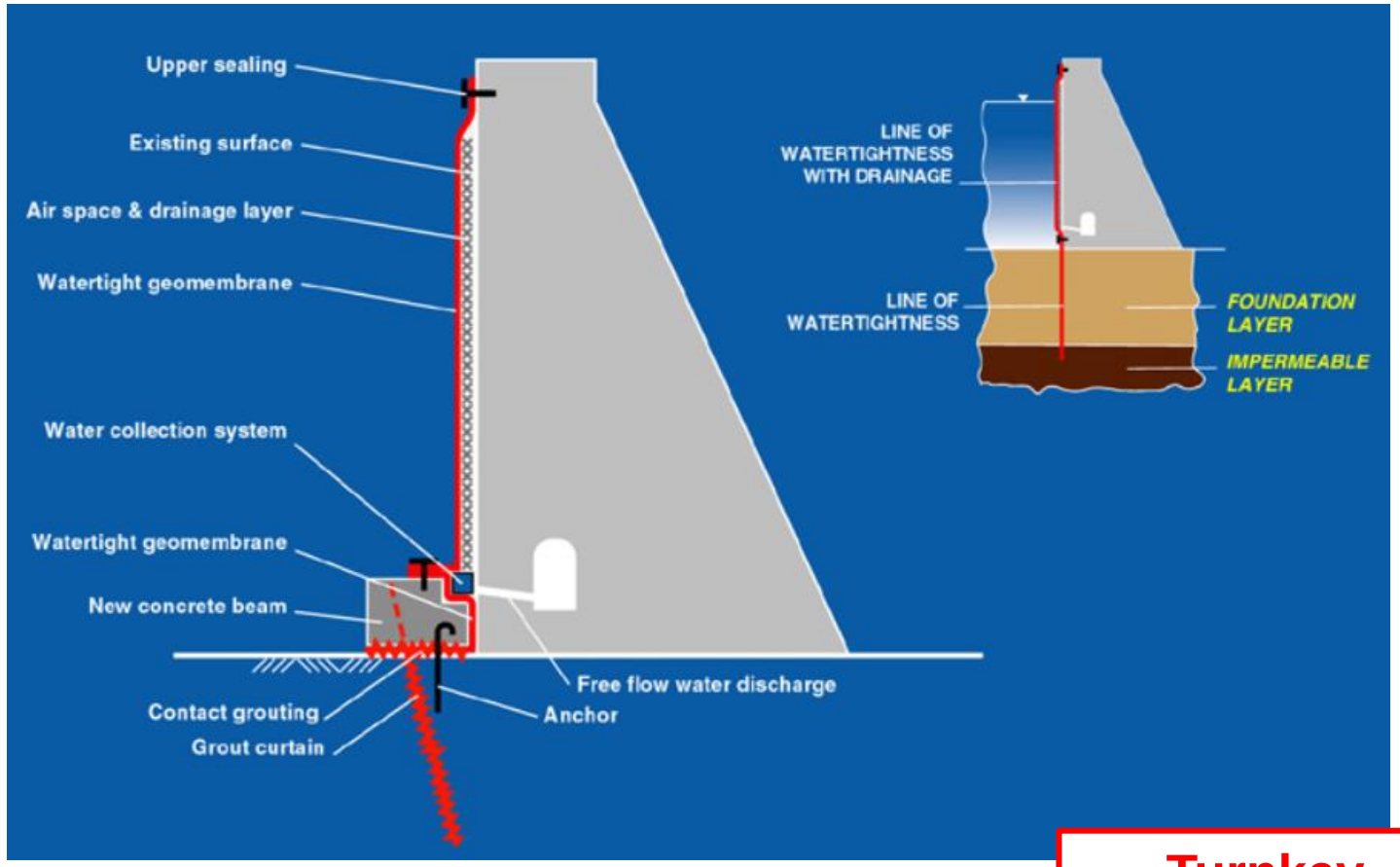
Francois Tronel
Carpi Tech, Switzerland,

PVC Geomembrane are impermeable and flexible, durable, applicable to all types of dams, low carbon imprint, cost effective

2 m wide rolls welded together to form a continuous watertight area

Waterproofing the structure upstream, with mechanical connection





Drained complex allowing for keeping the structure totally dry

Turnkey solutions by CARPI

Rehabilitation

With exposed geomembrane

Dry as well Underwater Condition

In dry – Since 1950's

In Underwater – since 1997's

(Carpi was the pioneer)

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Concrete dams, gravity

Cignana, Italy, 1988

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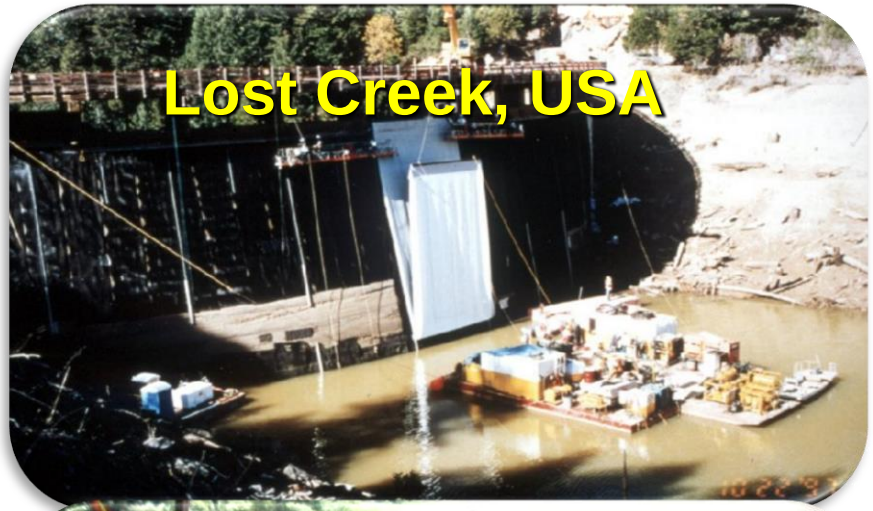
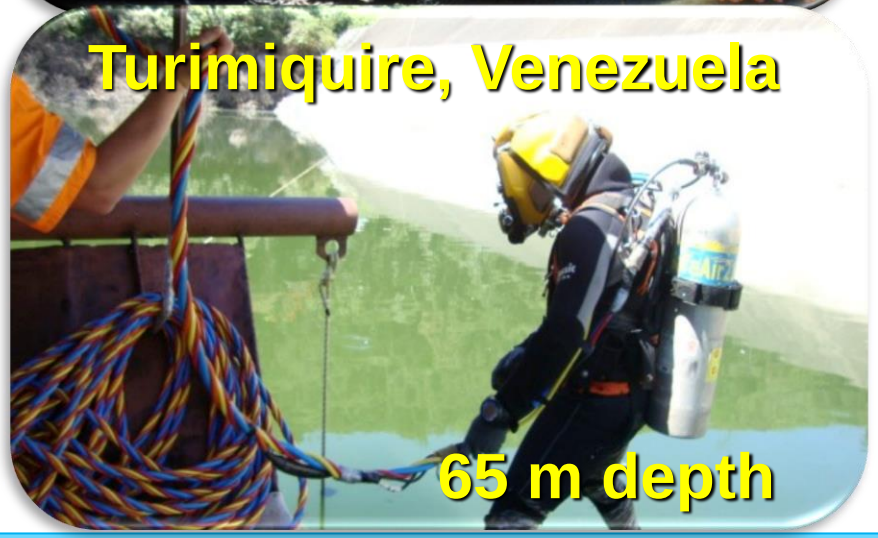
Some of the Underwater Projects of Carpi



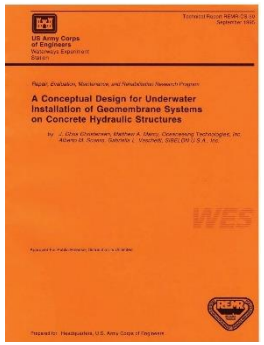


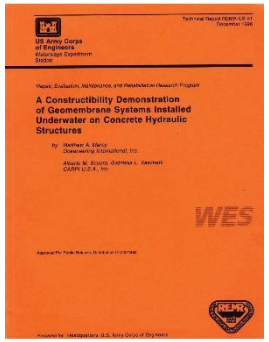
The new frontier:The underwater installation

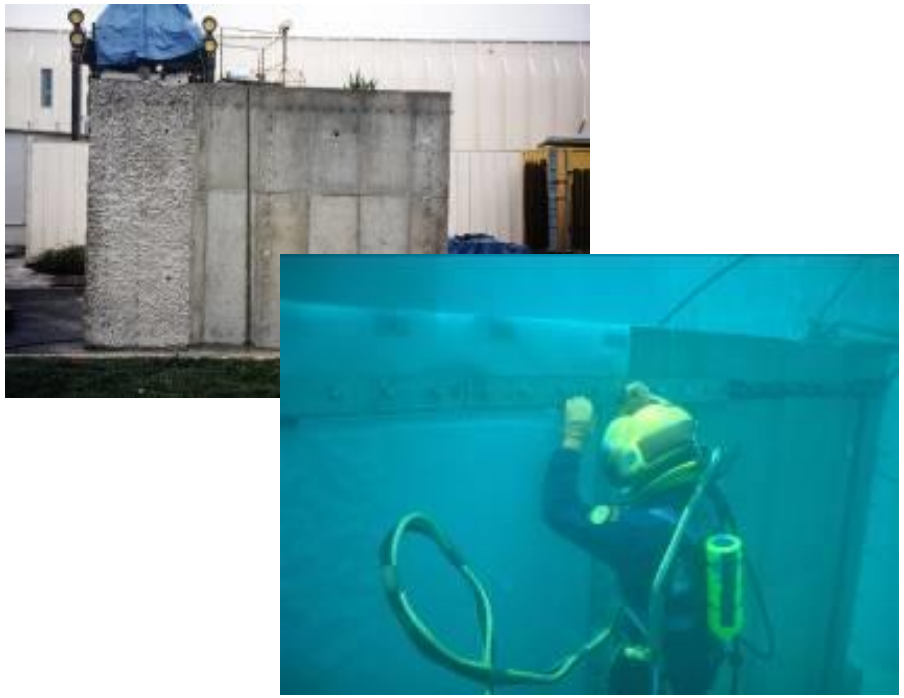
- **Water supply is not halted**
- **No impact on the social life**
- **In general, no special permit required**
- **Cost effective if considered that hydro generation, water supply and irrigation is not affected**
- **Works schedule is not heavily impacted in the monsoon period**

Underwater installation

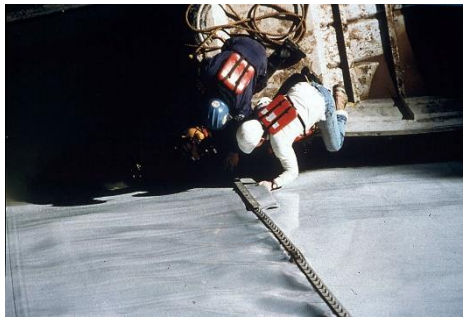
CARPI started the first study and tests under a contract for the US Army Corps of Engineers in 1995/1996





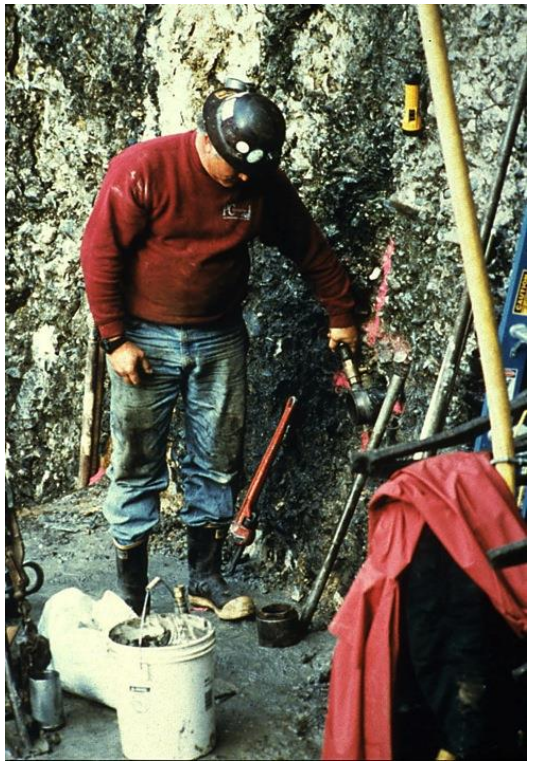


First project in USA 1997, rehabilitation fo the full face of Lost Creek arch dam, Total leakage < 0.0126 l/s



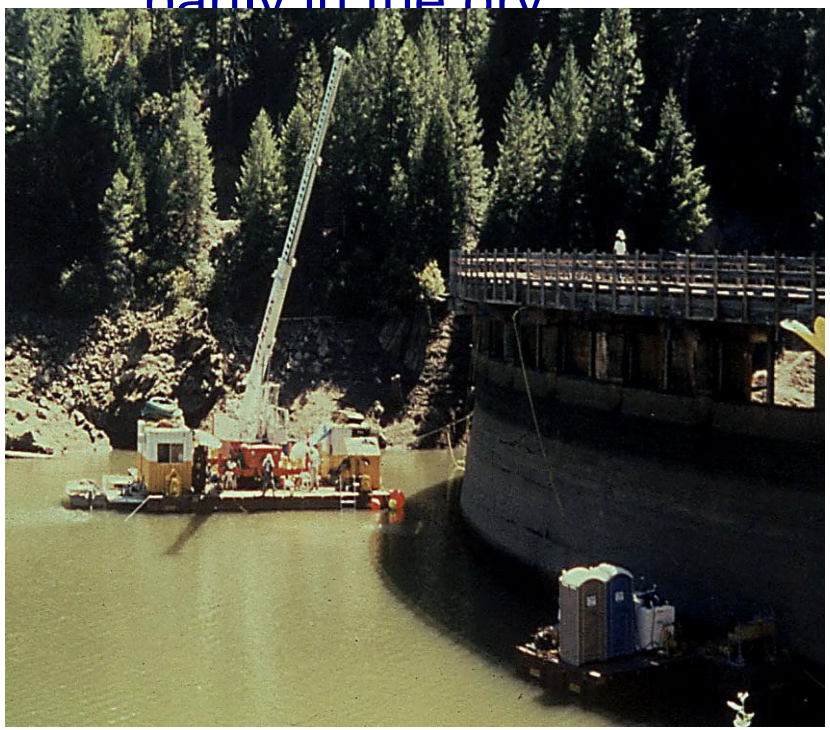
- Removal of debris from upstream face, 1 m width

- Surface preparation and installation of drainage geonet



- Drill hole from downstream to upstream to install discharge pipe for the drainage system (geonet), placed between upstream face and geocomposite

- CARPI installation equipment mounted on barge
- Installation was made partly in the dry



- CARPI pretensioning profiles used above fluctuation water level

- Prewelded geocomposite resting on the barge

- Prewelded geocomposite is anchored at top and lifted from the crest

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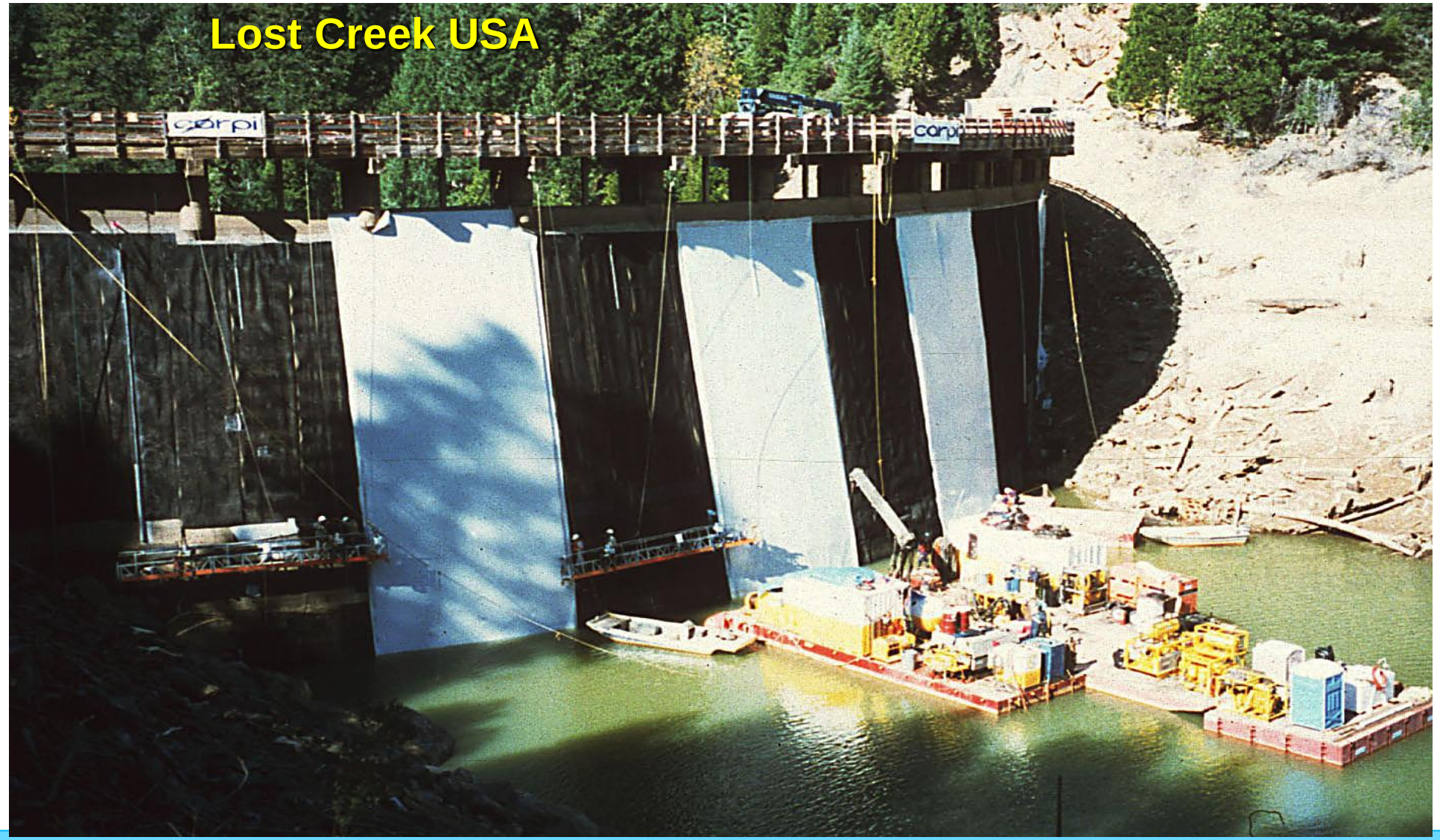
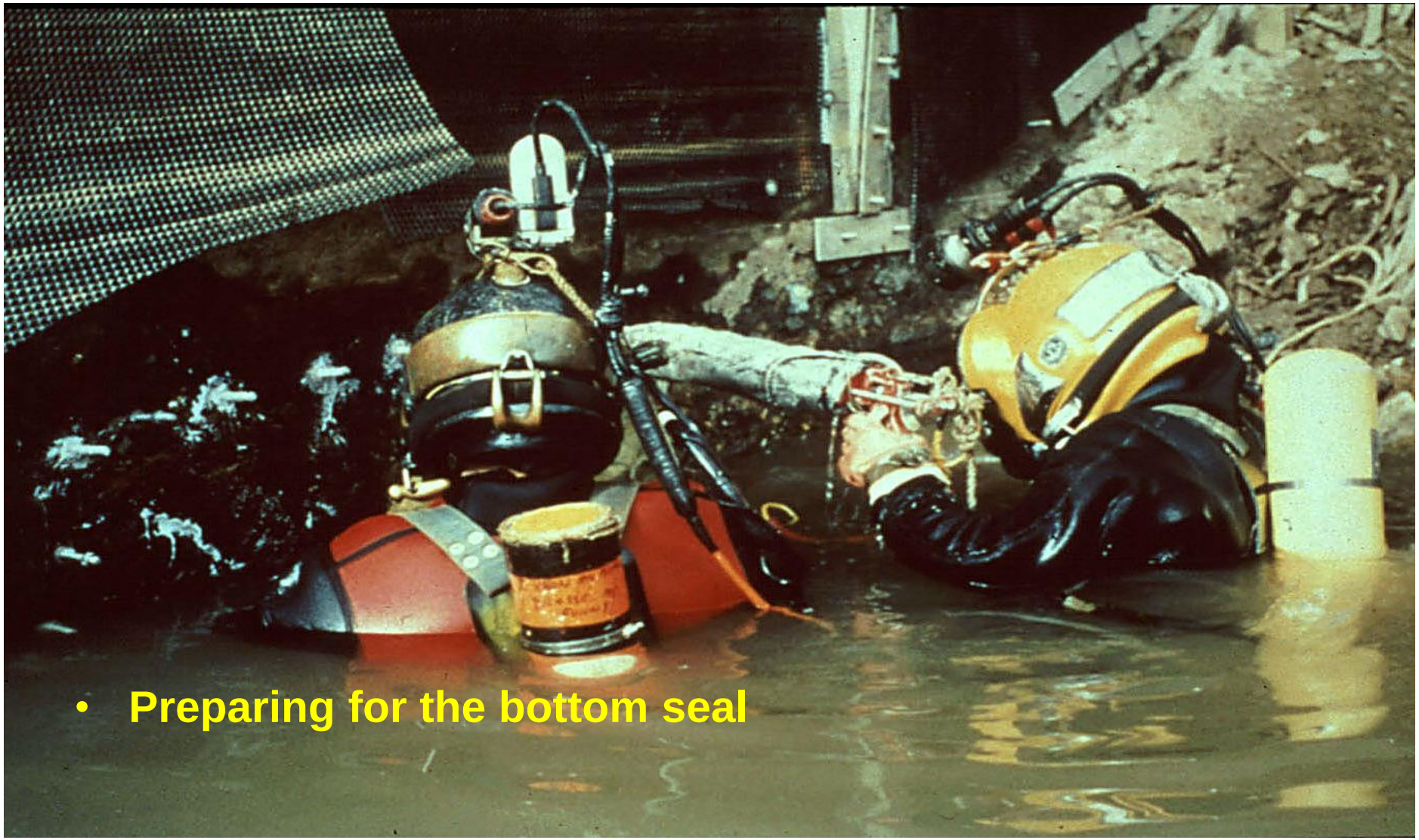


10-12 October 2022 at Jaipur, Rajasthan (India)

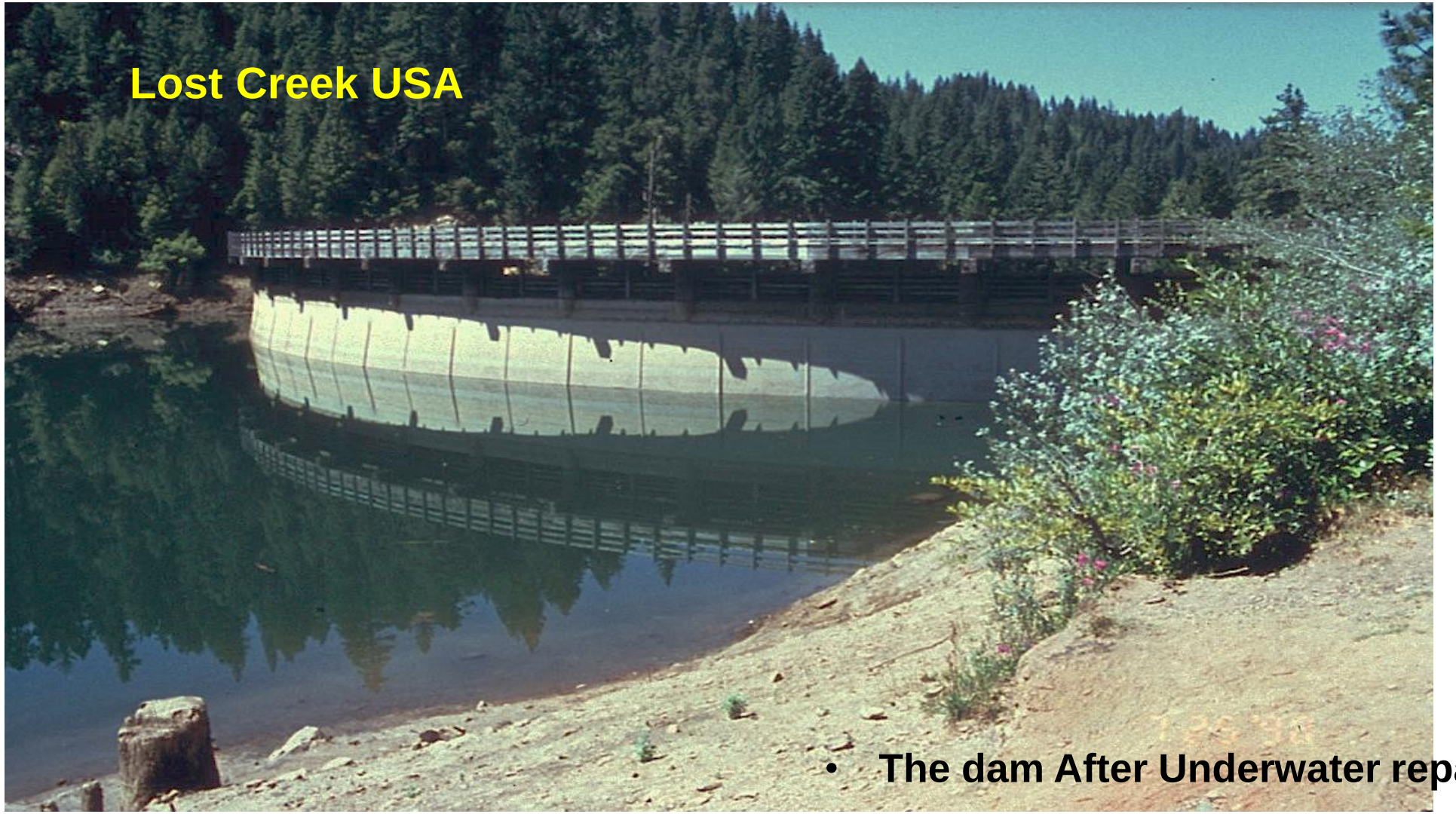


- Preparing for the bottom seal

- Fastening with face anchorage profiles in the underwater section

- Fastening with face anchorage profiles in the dry section

Lost Creek dam at completion of works in 1997



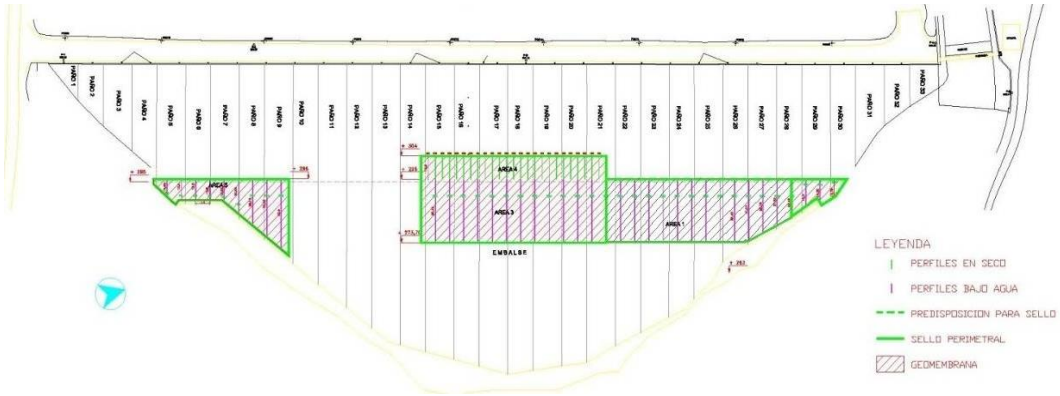
- **The dam After Underwater repair**

Lost Creek dam pictured after 10 years of operation. Seepage flows have remained at less than 0.02 l/s, well below the acceptance criteria

When California DSOD - Division of Safety of Dams, inspected the dam, the comment was that "the downstream of the dam was the driest it has ever been"

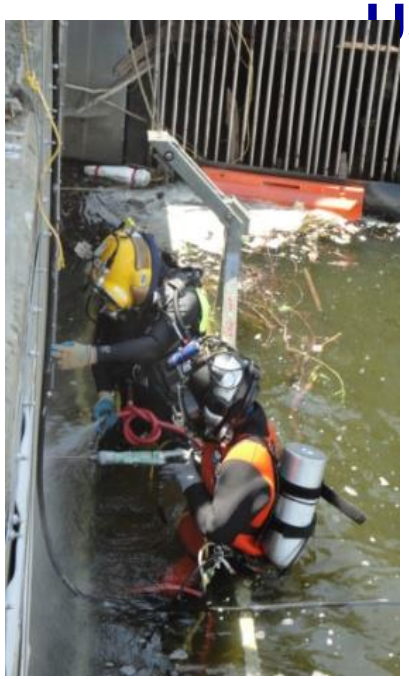
First large project in Venezuela, 2010/2011 for the rehabilitation of some 20% of Turimiquire upstream face. Maximum diving depth 65 m

Leakage reduced from 9,800 l/s to 2,400 l/s



Underwater installation

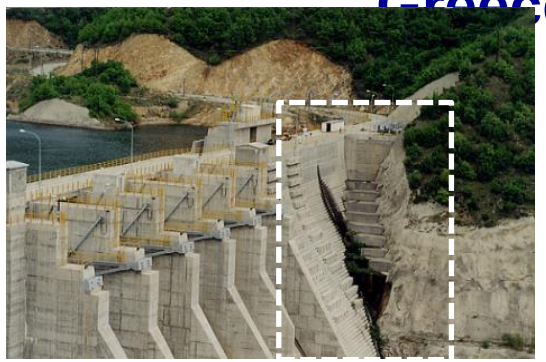
Occoquan powerhouse, USA, 2011

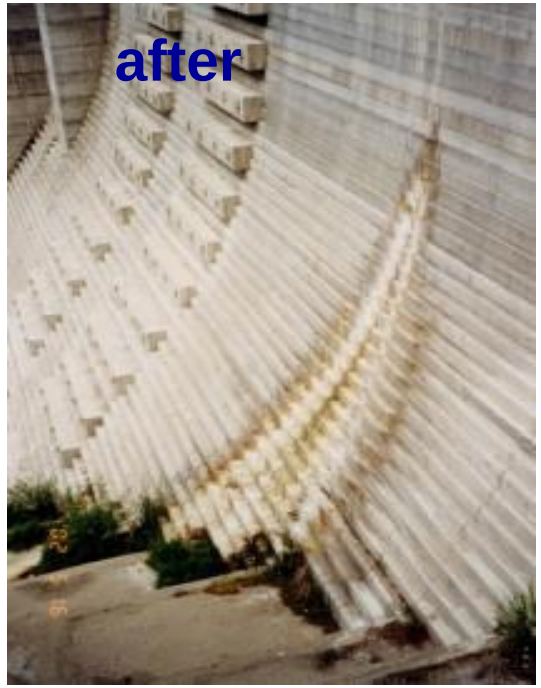


Waterproofing of wall to protect concrete and reduce potential for uplift pressure

Underwater installation

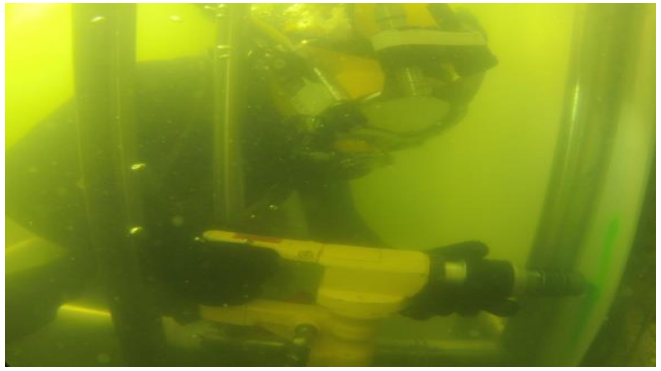
Platanovryssi 95 m high RCC dam
Greece, 2001





Waterproofing of cracks in new concrete

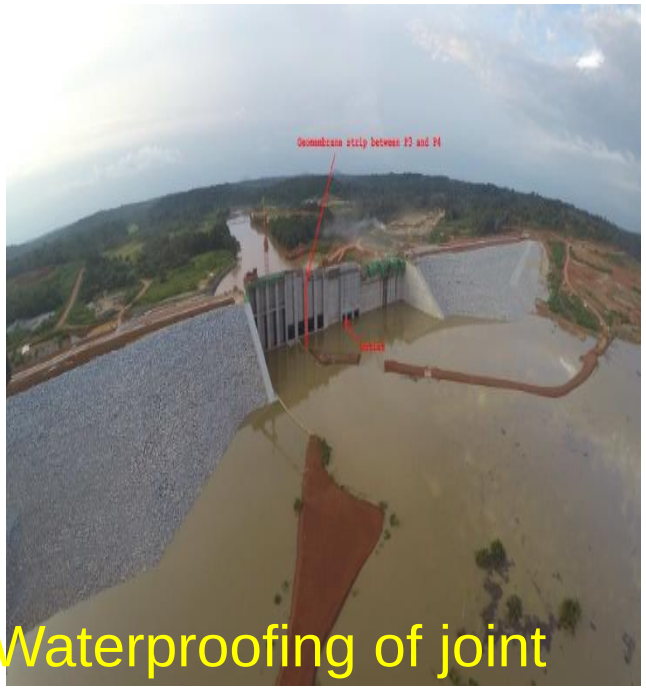
Olai gravity dam, Italy, 2013

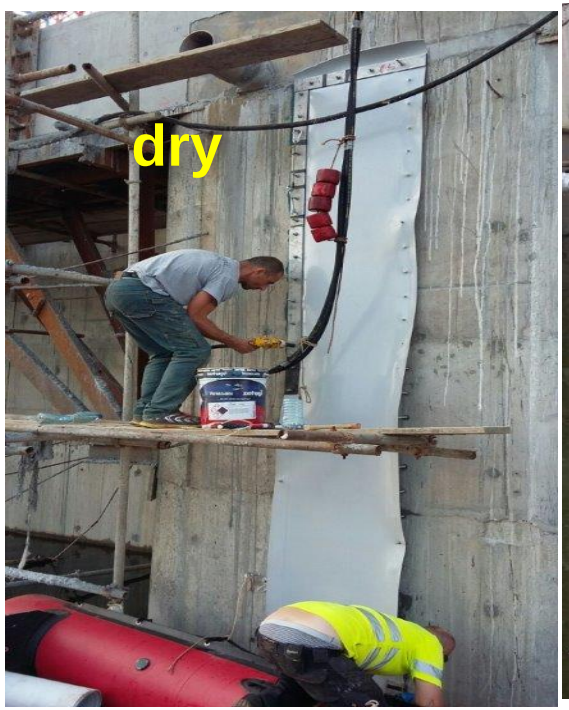


Waterproofing of joints

Underwater installation

Lom Pangar embakment + RCC dam Cameroon, 2016



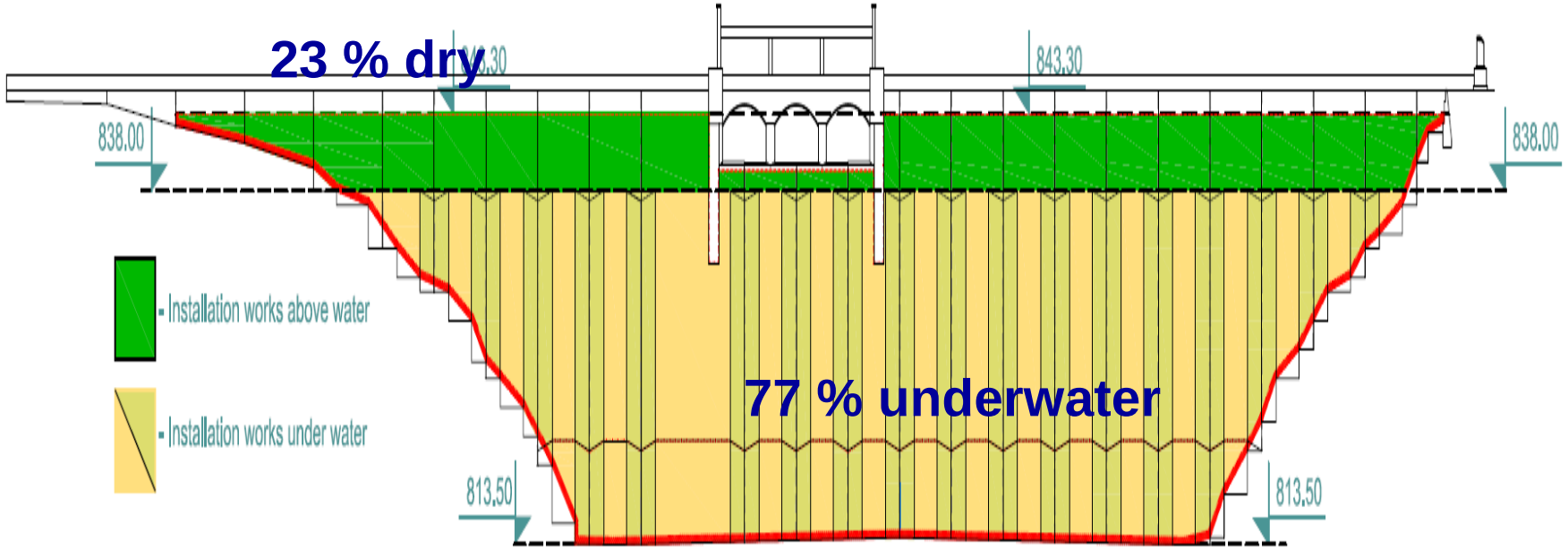


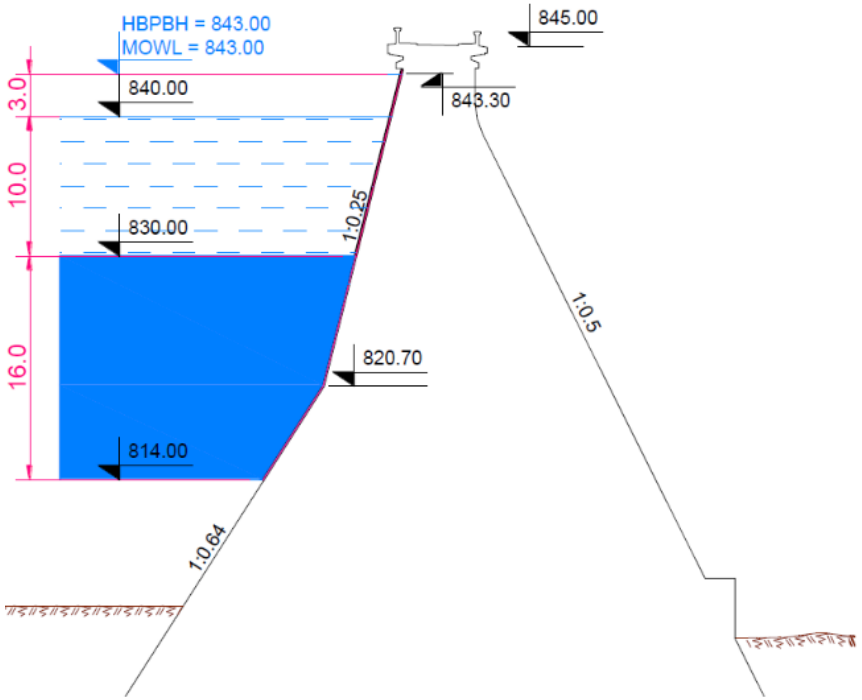
Nakai RCC dam, Laos 2016

Waterproofing of joints, holes, and cracks

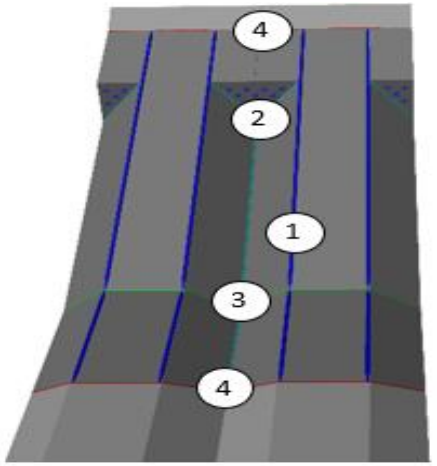
Studena buttress dam underwater installation

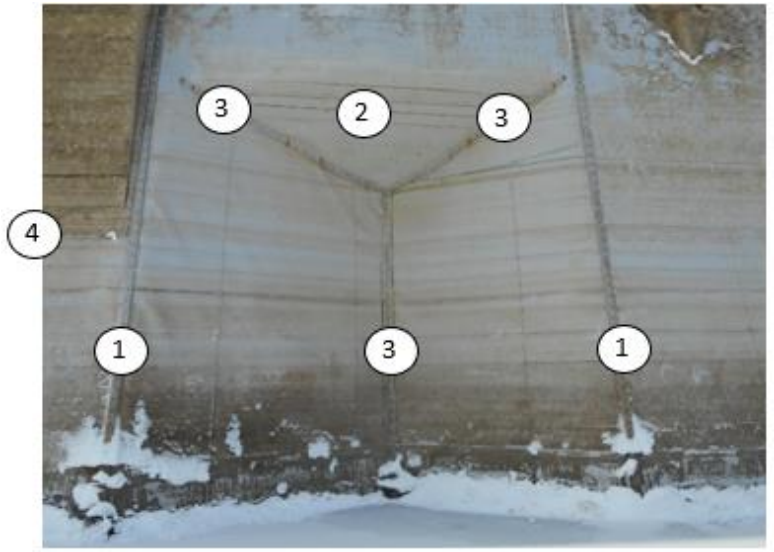
- Owned by Ministry of Regional Development and Public Works , Bulgaria
- Funds by The World Bank
- Total surface 5,200 m2
- Contract amount: 16,309,000 Euros,
- Only geomembrane works: 39 %





Very Complex Geometry



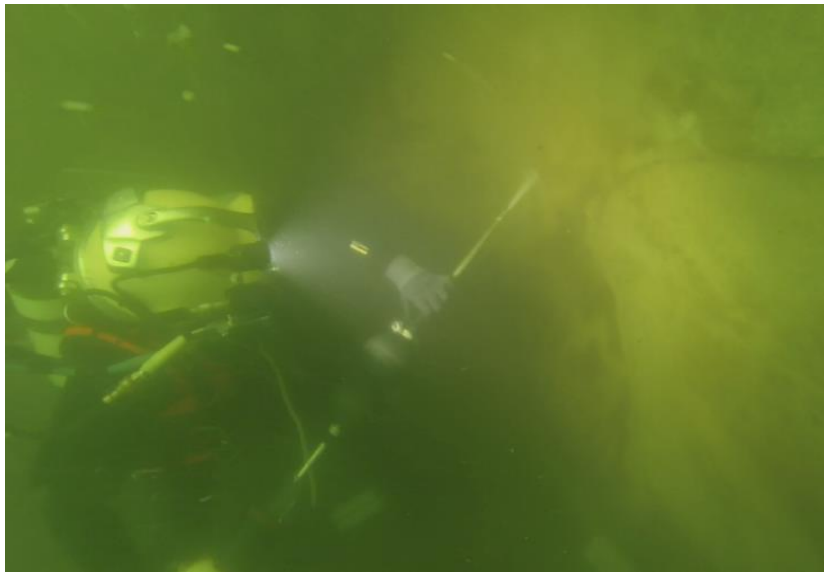


FULL FACE WATERPROOFING

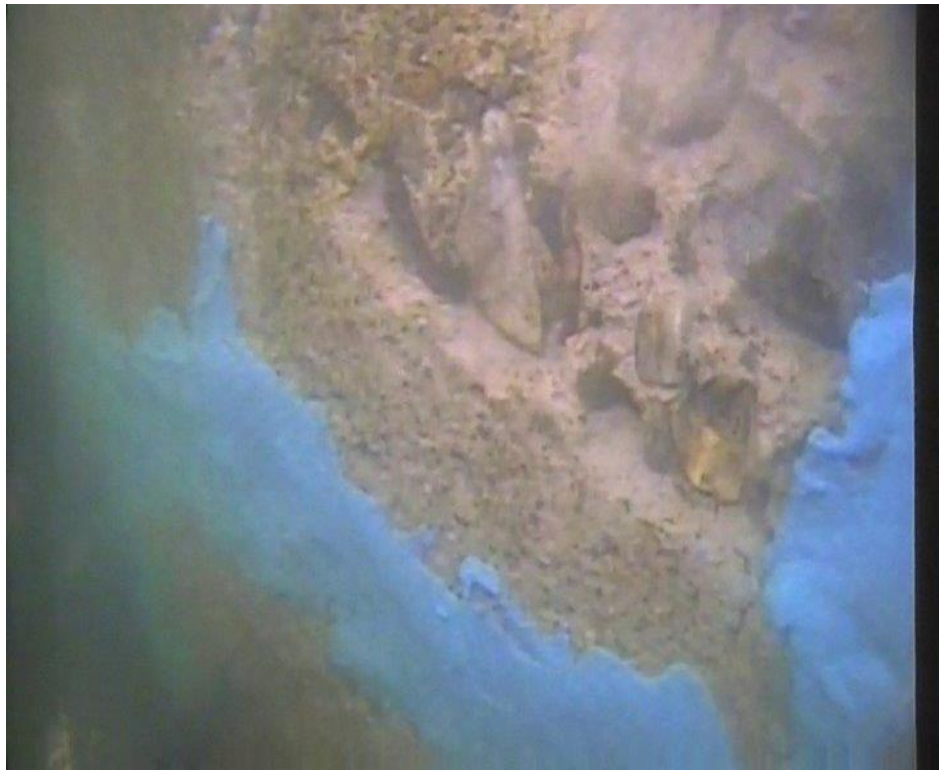
Studena gravity dam, Bulgaria 2017-2018

- Removing unstable shotcrete facing

Surface Cleaning using hydrojetting pumps



Surface levelling, Cavity Filing, Mortar resins

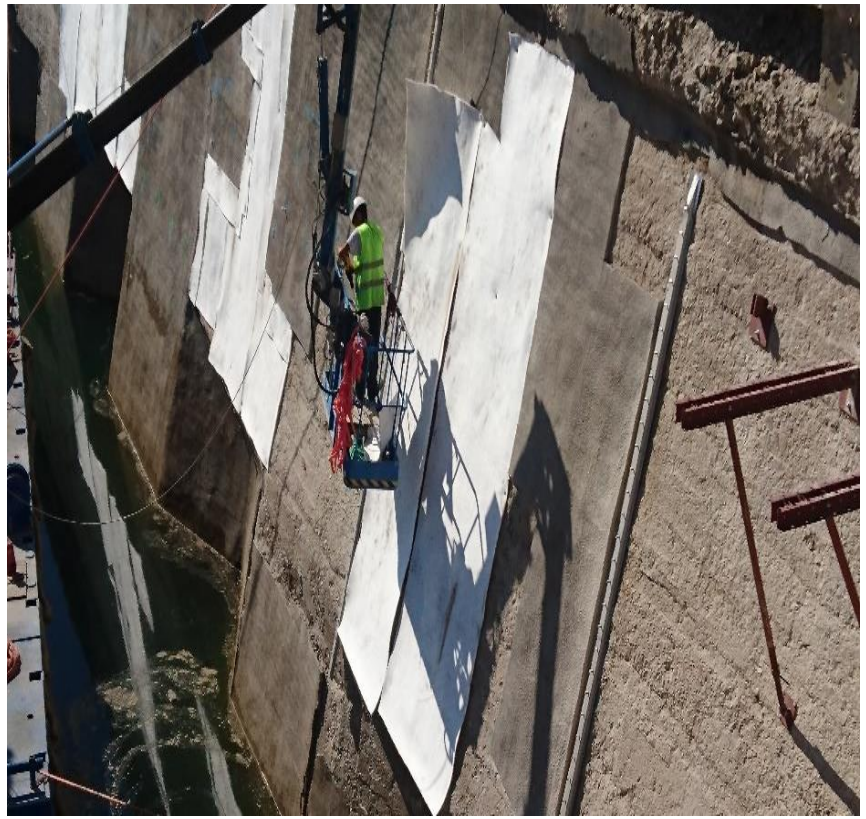


Dredging to removal deposited silt

Installation of geomembrane

Tensioning profiles

- Mockup of solution.
- Placement of anti-puncture geotextile and tensioning profiles in the dry part



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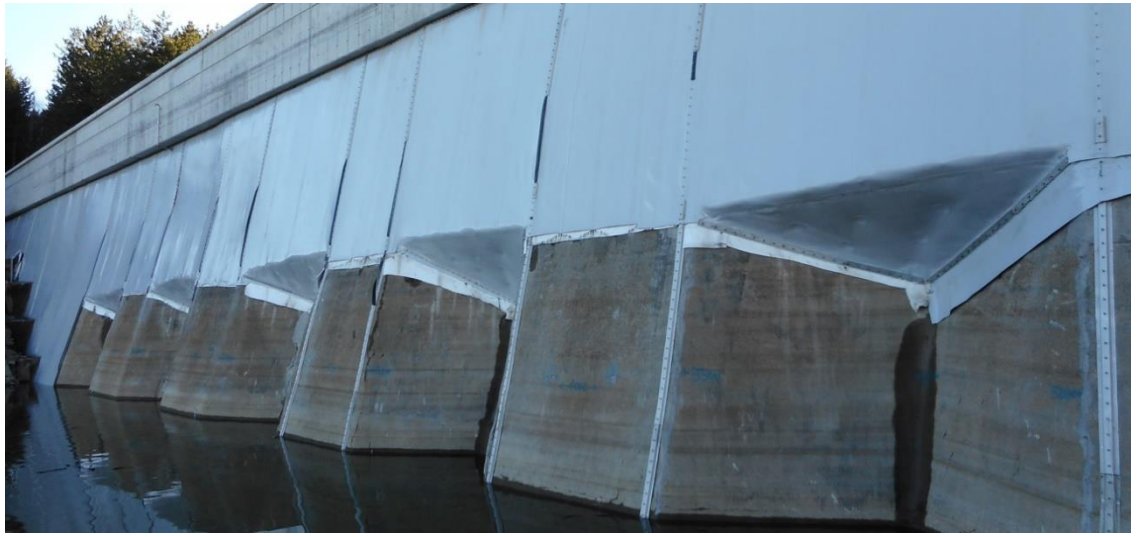

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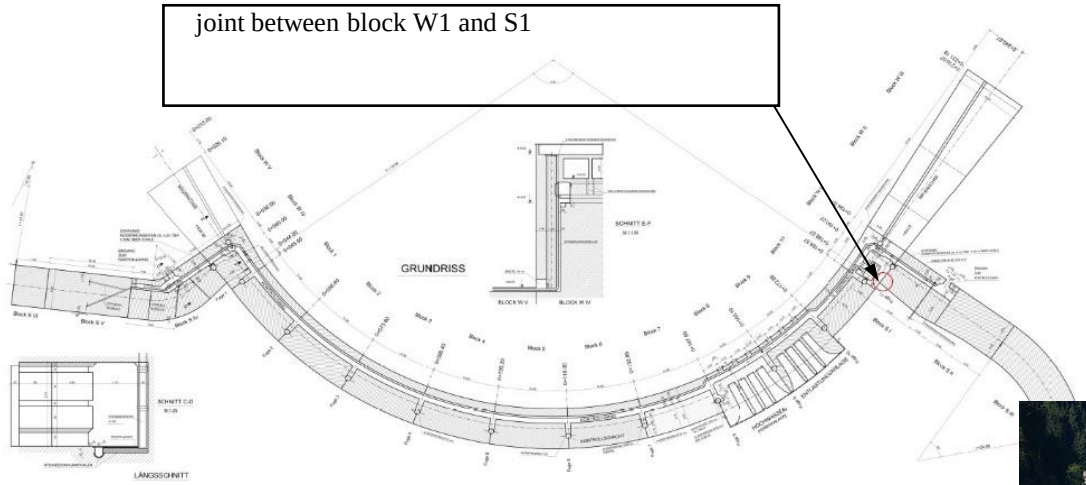
Before and after

Oker, Gravity Arch Dam
External Waterstop at Joint between Two Blocks



A SIBELON® CNT 4400, composed of a 3.0 mm thick geomembrane heat-bonded during extrusion to a 500 g/m^2 nonwoven polypropylene geotextile,

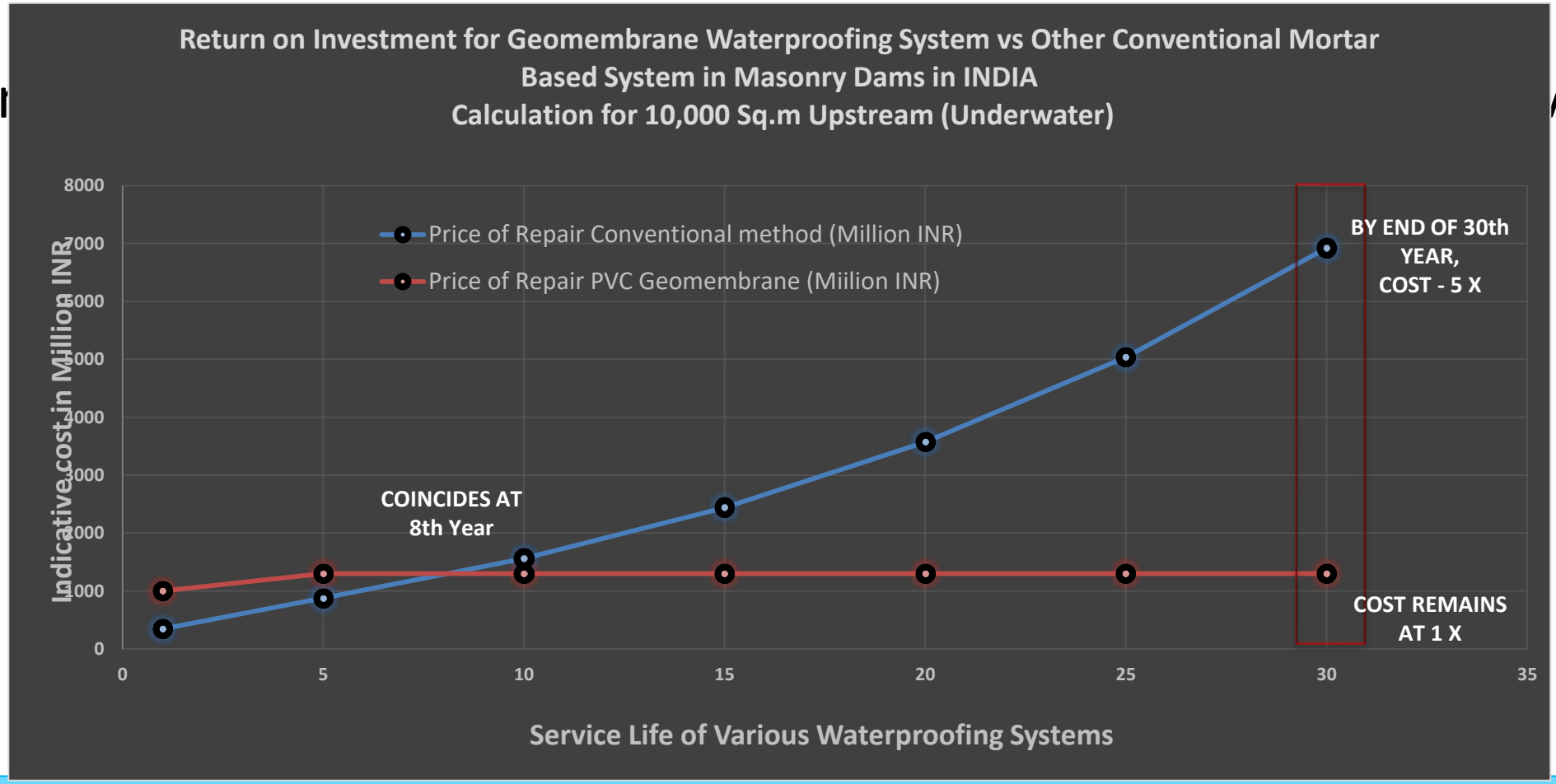
B. Sacrificial layer, providing bridging and anti-puncturing capability,

C . Waterproofing liner, SIBELON® CNT 4400 geocomposite, the same of the sacrificial layer, and

D. Watertight mechanical perimeter seal

Life Cycle of the Geomembrane System vs Conventional
Commercial Benefits

Geor ATION



New experience for underwater installation: some canals lined with prefabricated geomembrane rolls and watertigh zip

Typical use in large canals without stopping the flow:

the SibelonZip® and SibelonMat®

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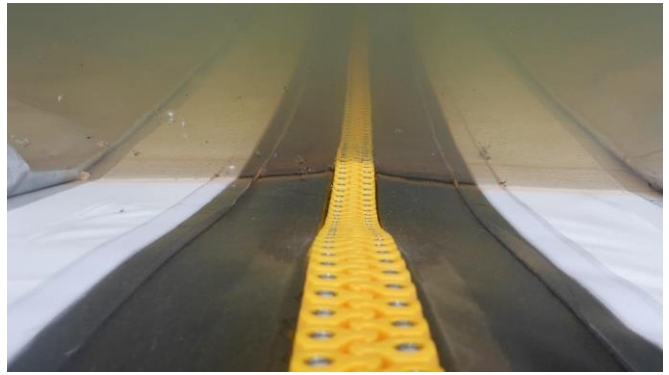
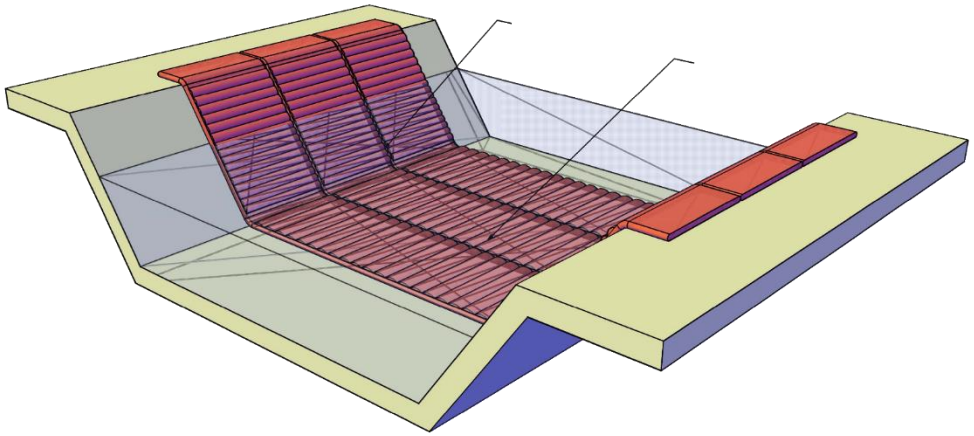
The waterproofed zip and the SibelonZip® / SibelonMat®



- Zipper connected to PVC membrane
- Prefabricated panels
- Reducing underwater manhours
- Tested up to 90m water head

- Sibelonmat: anchored mattress

→ Working underwater without stopping the flow



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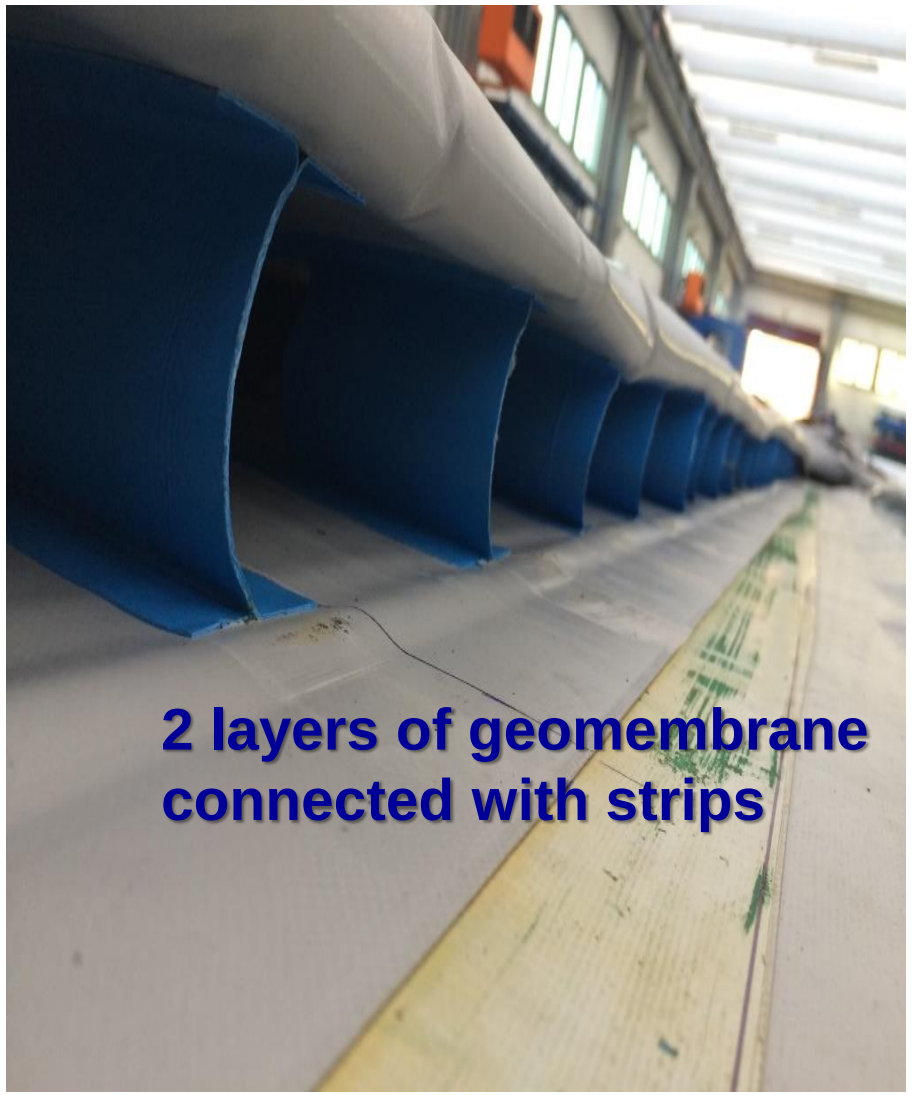

10-12 October 2022 at Jaipur, Rajasthan (India)

Ismailia canal, Egypt

- Location : France
- Type of Project : Rehabilitation - waterproofing of 50 ml of a canal bank
- Surface : 1’440 m^2
- Owner : EDF [Electricité De France]
- Designer: Carpitech
- General Contractor : Carpi Tech BV Paris Branch
- Duration : 1 month
- Period of execution : February to April 2021
- Project Manager : Frédéric WAGNER
- Site supervisor : Gabriele VALENTINI
- Status : Finalized

Concept of SibelonZip® / SibelonMat®




Unrolling machine and Underwater Installation

Panels are installed with an unrolling equipement specially developed for this application. The machine is controlled from the shore by a highly qualified operator.

Cement grout is injected in the mattress from the crest- burst resistance of the mattress is evaluate 3 bars.

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THANK YOU FOR YOUR ATTENTION