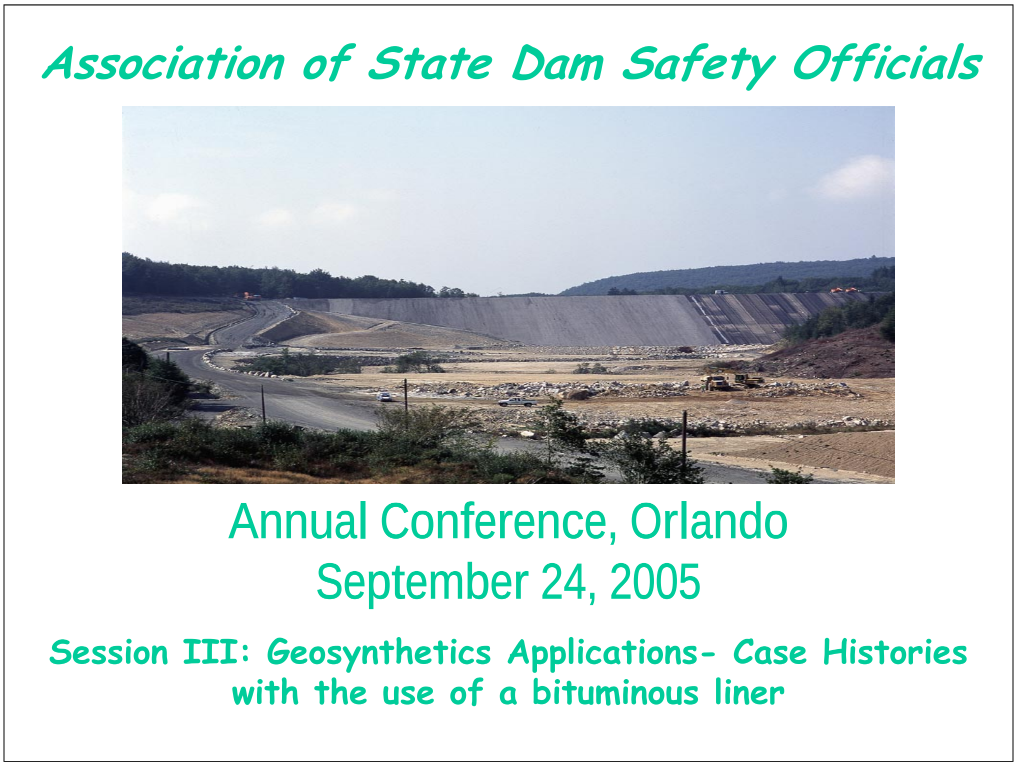
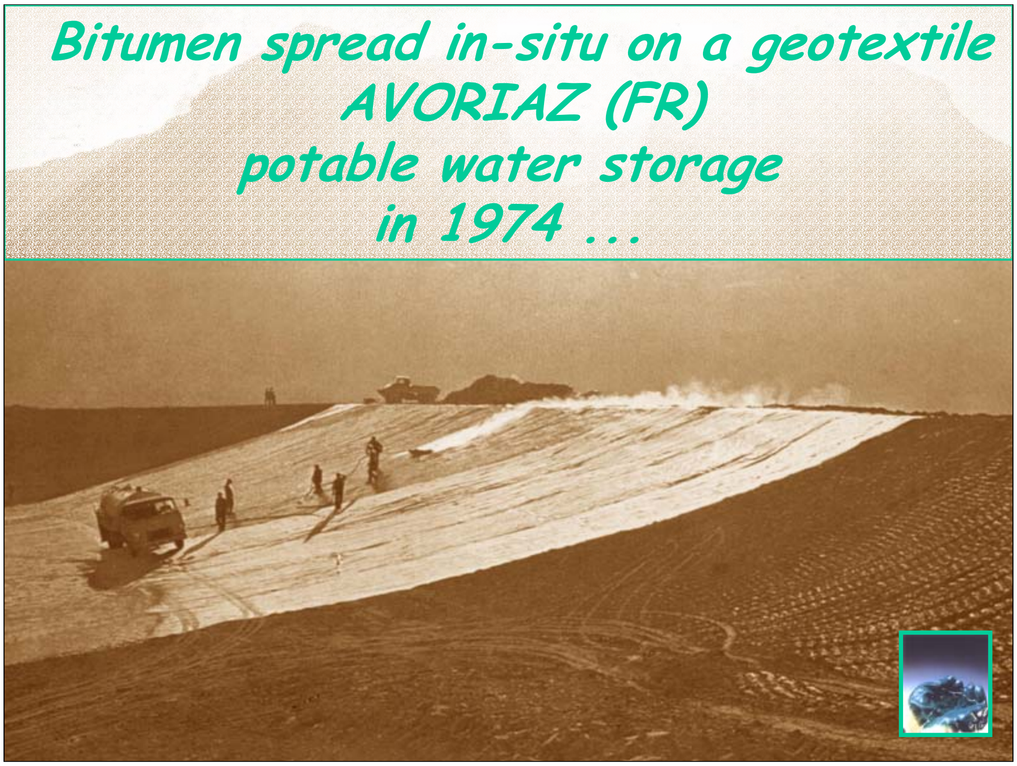


I will speak about some works we did in dam construction with our bituminous geomembrane. Please, before starting, let me remind you that the use of asphalt to watertight dams or canals is 3,000 years old, as we can find works on the Euphrates and Tiger rivers.



The concept came from the USA between 1947 and 1951 - it was bitumen spread on the soil without any reinforcement. The origin of Coletanche in France dates back to the beginning of the 70s, with Coletanche in place and the construction of ponds in Castelet in 1973, or in Avoriaz in 1974. At the outset, " in situ " Colétanche was produced by spraying hot bitumen at 200° C onto a polyester geotextile laid on the soil. Now, this technique seldom used due to :

•safety of workers,

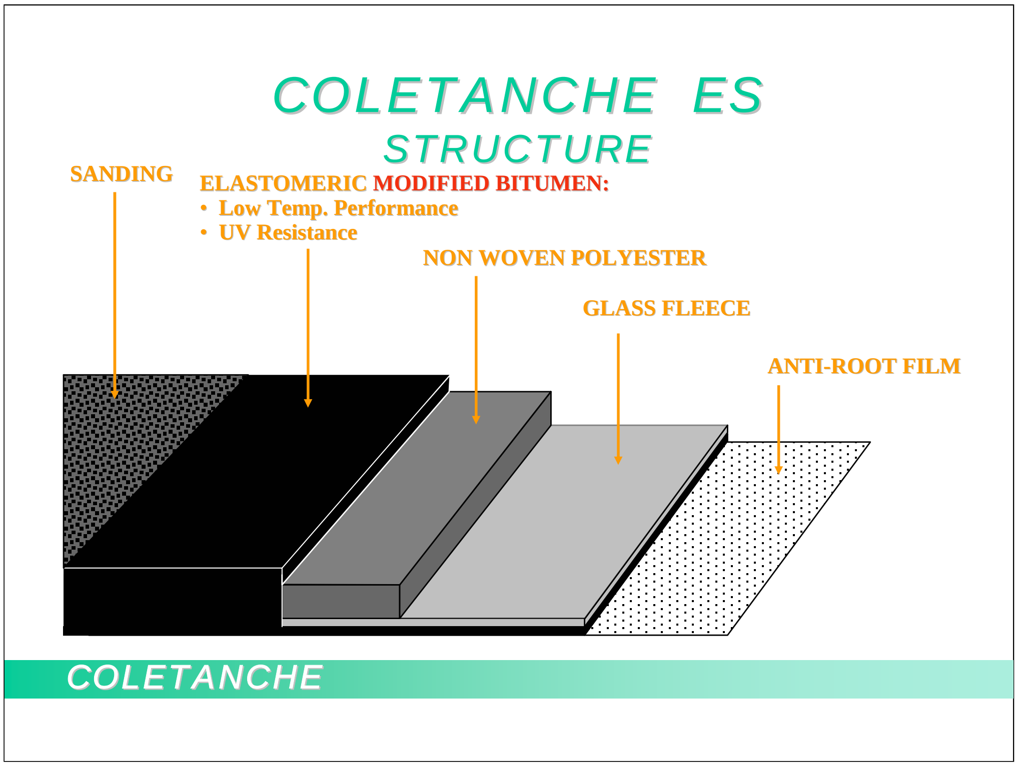
•sensitivity to wet conditions during application

•large bitumen consumption especially on slopes more than 3H by 1V.

Advantage: no welding

So we preferred to prefabricate in a plant "P" for prefabricated was added at the name of Coletanche NT to become Coletanche NTP.

The Shell company, our mother company, till 1996, was very active till this date to push the use and test Coletanche.



Coletanche NTP or Coletanche ES both have the same structure. The impregnation for Coletanche ES is done with SBS modified asphalt.

Coletanche NTP is impregnated with blown bitumen pen 100.

Fabrication line : Control room

The control cabin which includes, in particular: video monitoring the production, in receiving all the information of follow-up of production.

And finally the metal cooling platelet, with the installation to roll the geomembrane at the end.

The weight of each roll is 2 tons. Please note the Kraft paper on 20 cm or 8 inches that is removed on the site to ensure a clean surface to do a good weld. The bright face for Terphane, the anti-root face.

The factory applies a Quality Plan (QC/QA) following a specifications contract with an official external control company called Asqual.

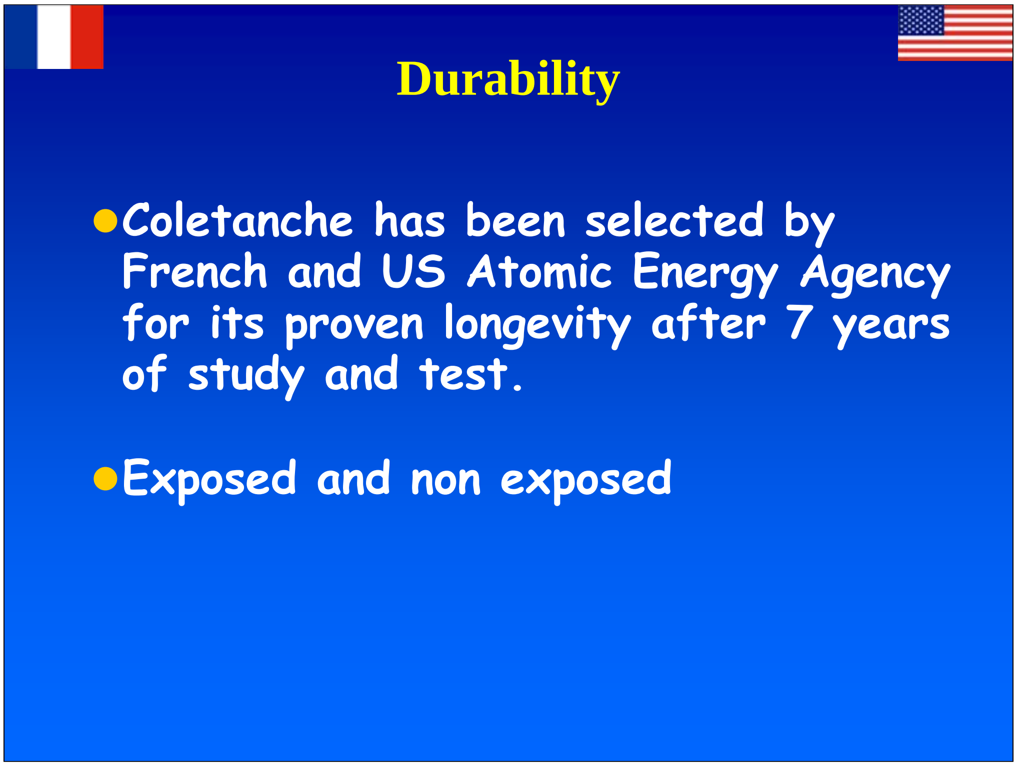
Each roll is controlled in cutting a strip of 20 inches at the end of the fabrication line. Half goes to the lab, the other half is stored during 12 years.

Tests are carried out:

1 - on every raw material (geotextile, asphalt, etc.)

2 - on finished products:

- Thickness
- Mass per unit area
- Width of the roll
- Tear resistance
- Elongation at break
- Static Puncture



Bituminous geomembranes age extremely slowly. Nuclear Safety Agency in USA and in France found a very low bio-degradation by microbial attack after 7 years of study. Numerous papers are available on the subject. Alonso et al. (1993) published a review of 20 hydraulic structures in France that are waterproofed with bituminous geomembranes. After 19 years, the watertightness was good.

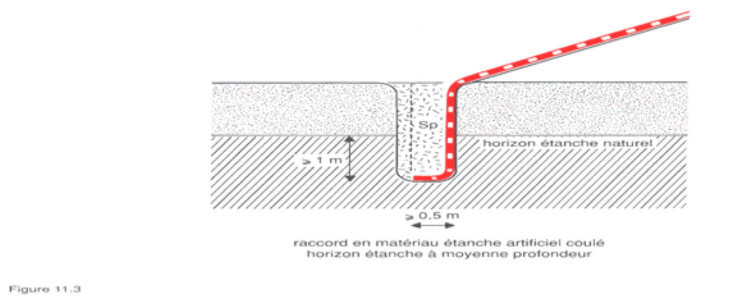
These are examples to show what we are able to put directly on the GMB without any protection and how we can work on it.

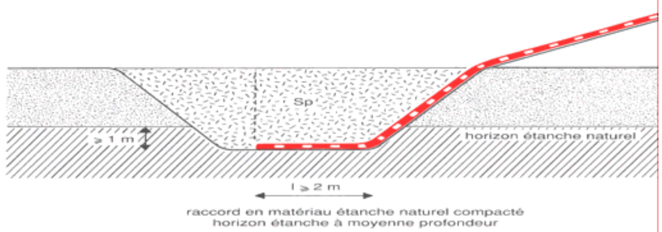
Work to cut flow after a hurricane.

Usually we use NTP 3 or ES 3 for this kind of exercise and especially in dam construction. Thickness 4.6 mm or 224 mils reinforced by geotextile of 300 gr/m2 inside.

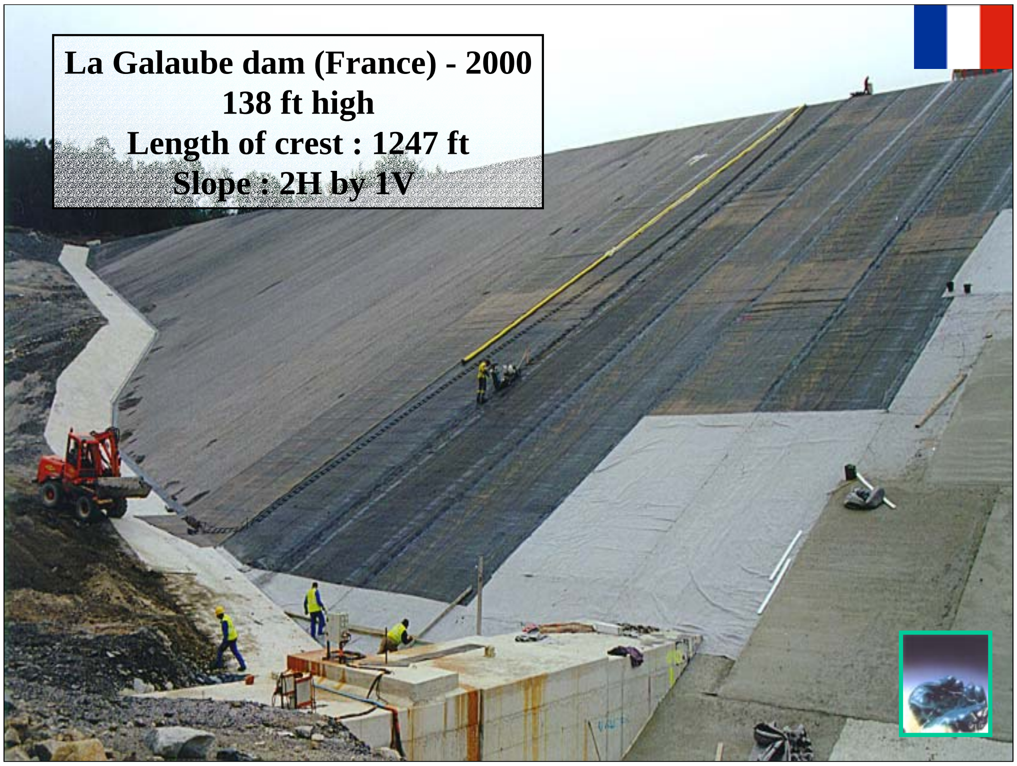
The same watertightness everywhere in the construction. Very appropriate for permanent weld under water.

Anchorage in the Watertight Horizon





Don`t forget to anchor the geomembrane in the watertight horizon



This is the highest dam we did with our bituminous geomembrane, 5 years ago. As it is completely and permanently monitored, we can say that it is working well with the client satisfactorily. This dam will constitute a reserve of more than 8 million cubic meters intended to serve drinking water and irrigation the south-west part of France and to regulate the shipping canal du Midi joining the Mediterranean Sea with the Atlantic Ocean (classified at the World patrimony). The cost of the project exceeds the $20 million US. Several solutions were envisaged while taking in account of the requirements of:

Security

Geological constraints:

Quality of the soil of foundation

Availability of the materials

Geographic constraints:

Access by small mountain roads with structure not designed for heavy trucks and with a lot of sharp curves.

Hydraulic constraints:

Evacuation of the over flood, extraction in the toe, drainage system at the rear of the dam - there were also environmental constraints and financial constraints, of course.

The solution of the arch was abandoned for geophysical and geological reasons.

Two other solutions were kept as gravity dam:

Barrier BCR, given up because need to bring materials of better quality asking for extracting materials outside the site with pollution of the environment for the transportation

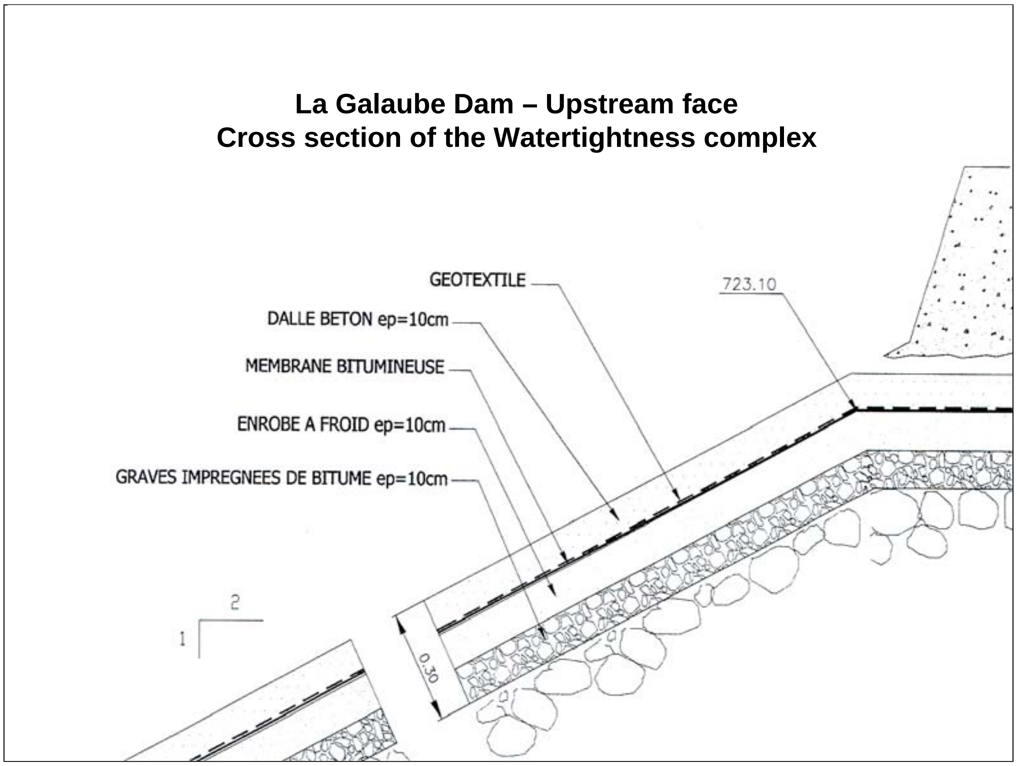
Earth Dam with materials taken in the bowl without impact at the exterior of the site that presents a high security level.

Two envisaged solutions for the watertightness: -

By Clay core but material not available on the site – therefore, transportation cost important

By geomembrane on the upstream face

The competition was between PVC and bituminous geomembrane. The bituminous geomembrane was chosen on a financial point of view.



It is constituted about 800,000 m3 of the mica-shale taken on the site. This dike leans upstream on a baseboard in reinforced concrete,

based on the not altered granite (diorite). Length in crest is of 380 meter or 1246 feet and slope is 2 for 1. Maximal height above foundations is of 43 meters or 141 feet.

The watertightness of the dam is prolonged in foundation by a veil of injection realized through the upstream plinth.

Work is completed by:

- A lateral flood sluice sized for 80 m3/s.
- A low level intake,
- A gallery under backfill, divided in a hydraulic gallery,
- A work of downstream release.

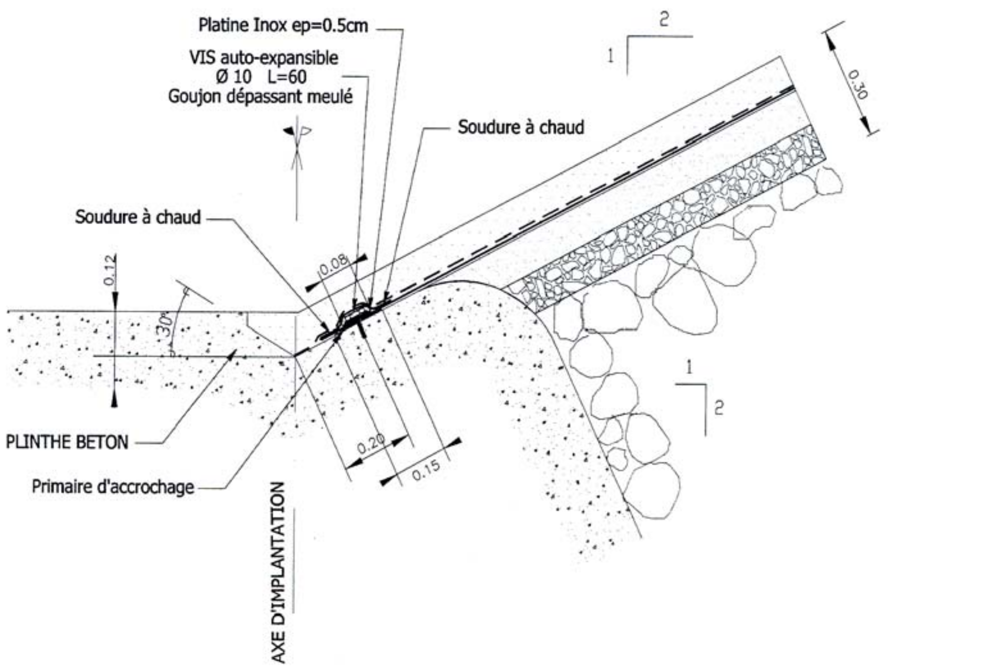
CROSS SECTION OF WATERTIGHT MASK from high permeability to low

4 inches or 10 cm of coarse gravel 0/20,,

4 inches or 10 cm of cold mix asphalt 0/10

A bituminous geomembrane

4 inches of concrete with fibers pour on a geotextile of 600 gr/m²



La Galaube Dam
Detail of bonding Coletanche and concrete

Look at the round form of the concrete. We have to intervene very early in the design to check details like this. In foot and on all the edges of the mask, BGM is fixed to a beam in reinforced concrete, based and anchored in the cliff. This baseboard assures continuance between

the waterproofness of the foundation and banks. The mode of fixation of the geomembrane is sealed by a primer (asphalt/solvent) and heated. Perenity assured by stainless steel bar screwed in the baseboard.

La Galaube Dam
Compaction of backfilling - July 2000

COMPACTION OF THE MASK

First of all, the mask is compacted by means of two compactors in static roller of 4 tons each. These compactors are towed since the crest by two hydraulic shovels fitted out with winches. Please note the width of the crest of 6 meter or 20 feet. The minimum being 5m. Or 16 ft.

We needed room for the equipment and storage of rolls.

La Galaube Dam- Upstream face - July 2000
Laying 0/20 crushed limestone with leveling by laser

COARSE GRAVEL 0/20

Then a layer of crushed gravel 0/20 of minimal thickness 10 cm or 4 inch is implemented. This layer assures a first leveling of the surface of the slope and its lock before the spreading of the following layer. For it, 5 000 tons of gravel crushed 0/20

Once stored and moistened, 5 000 tons of gravel crushed 0/20 is transported by dumper, which dumps their load since the height of the crest.

La Galaube Dam- Upstream face - July 2000
Laying 0/20 crushed with leveling by laser apparatus

The spreading and the leveling of materials is made by means of 2 bulldozers. Their guide is assured with a turning laser.

La Galaube Dam- Upstream face - July 2000
Compaction of 0/20 and impregnation with bitumen emulsion

The compaction is regulated by a permanent control of obtained densities measured in the gamma-densimeter.

La Galaube Dam- Upstream face - July 2000
Impregnation with bitumen emulsion

TACK COAT

A layer of priming with asphalt emulsion at the rate of 1,5-kg/m ² is then laid. The distributor truck is set up on the crest and the emulsion is spread in the lance with sometimes more than 100m of flexible pipes.

La Galaube Dam- August 2000
Compaction of cold asphalt 0/10

COLD MIX ASPHALT

A layer of 10 cm in thickness of cold max asphalt 0/10 comes then, of which role is:

To assure the fine geometrical level of the upstream before the installation of the geomembrane

To constitute a half-permeable building material allowing to limit leaks through the mask, in case of accident during construction

The formulation of this cold mix asphalt permits to obtain a nearby permeability of 10^{-6} m/s. 5 000 tons of cold mix asphalt were made on the site. The laying is identical to that of the coarse gravel. The precision of the obtained level is of ± 2 cm or 0.8 inch.

La Galaube dam- August 2000
Compaction of cold asphalt 0/10

Compaction of cold asphalt

La Galaube Dam- August 2000
Control of compaction of cold asphalt 0/10

Control of the compaction of cold asphalt given the permeability of the layer.

La Galaube dam - August 2000
Surface aspect of cold asphalt 0/10

-

La Galaube Dam
septembre 2000

Identification
of
COLETANCHE NTP3
rolls

Every roll arrives on the site with this label. This way, the consultant has the data sheet of the test done in the factory for following QC/QA.

I have to say that we learned a lot in working for capping radioactive wastes. Now, we know what is a stringent QC/QA and how we have to follow it. We were controlled by 2 consultants. We apply the same type of QC/QA for every construction of dam – security comes first.

La Galaube Dam- September 2000
Laying *COLETANCHE NTP3*

Waterproofness by REINFORCED BITUMINOUS geomembrane for an area of 240 580 sq.ft. The GMB COLETANCHE NTP 3, of unit mass is 5,5-kg/m^2, and of a thickness of 4,6 mm or 184 mils. As on the construction site, was not accepted horizontal weld, it was necessary to make the rolls according to a precise "calpinage" drawing.

Some Coletanche rolls exceeded 100 ml or 328 ft and a weight of more than 3 tons (standard roll of are 65 m or 213 ft and 2 tons).

GMB presents the following qualities:

- High Resistance to tensile strength ,
- Waterproofness and durability due to its main constituent, the asphalt,
- High Resistance to tears, puncture and deformations,
- Maintain of its high resistance qualities with the time.

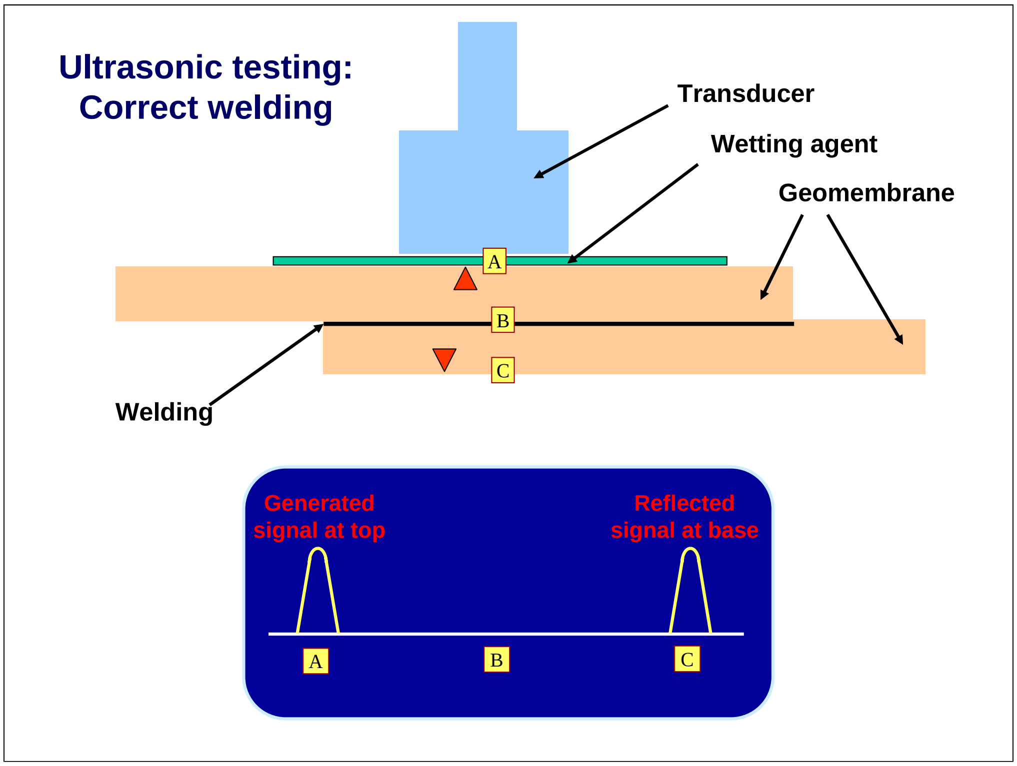
Rolls are unrolled by means of a horizontal hydraulic beam managed by the driver of the excavator. Work is done with total safety in mind on slopes. An overlap of 20 cm is respected to allow weld. To avoid any creeping, the geomembrane is anchored in crest of the dam.

La Galaube dam - October 2000
COLETANCHE NTP3 **- Control automatic of joints by CAC 94**

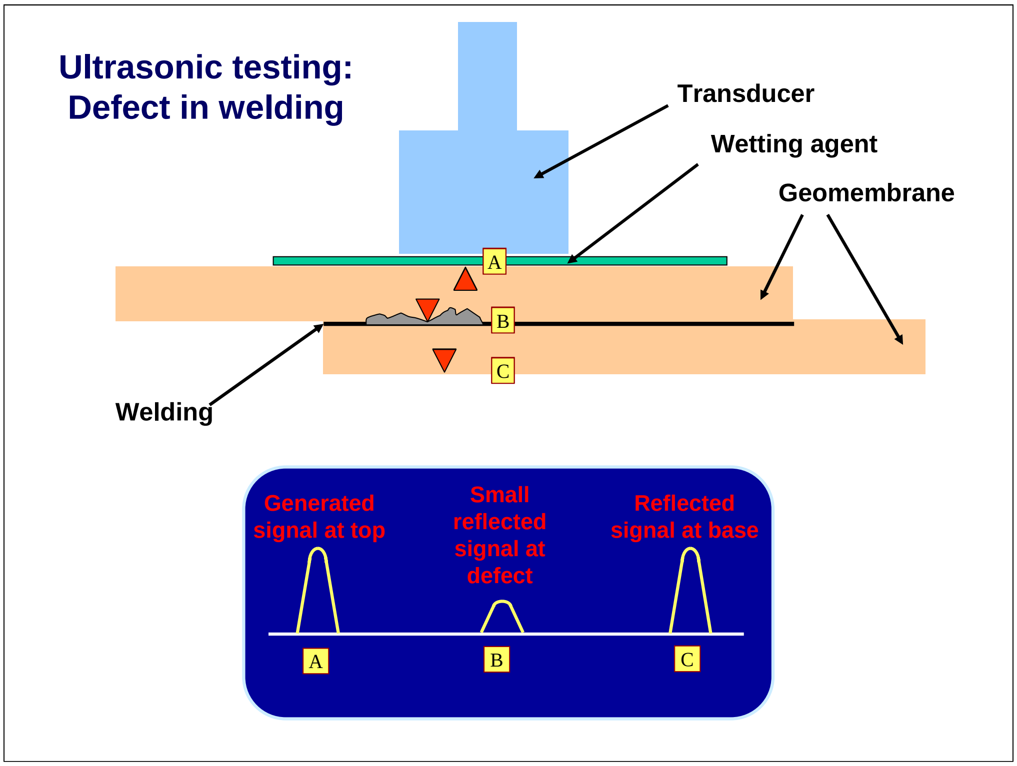
-

La Galaube Dam - October 2000
***COLETANCHE NTP3* – Automatic control of seams by CAC 94**

The control of welds is realized with a machine of non-destructive control called CAC 94. System uses 24 sensors with ultrasounds allowing checking in continuous a width of weld of 21 cm. The data of control of every sensor are then transferred on a computer PC. Software establishes a graph showing the area to repair. This control is unique in the geosynthetics world. It represents a complete scan of the seam.



The CRT screen reveals two traces as the testing progresses, and with a good seam - ultrasound signal shown on CRT only at Generation 'A' and Reflection at base 'C'.



Where a defect is present, at "B", a secondary smaller peak is revealed as shown.

La Galaube Dam - October 2000
Laying concrete on the top of Coletanche

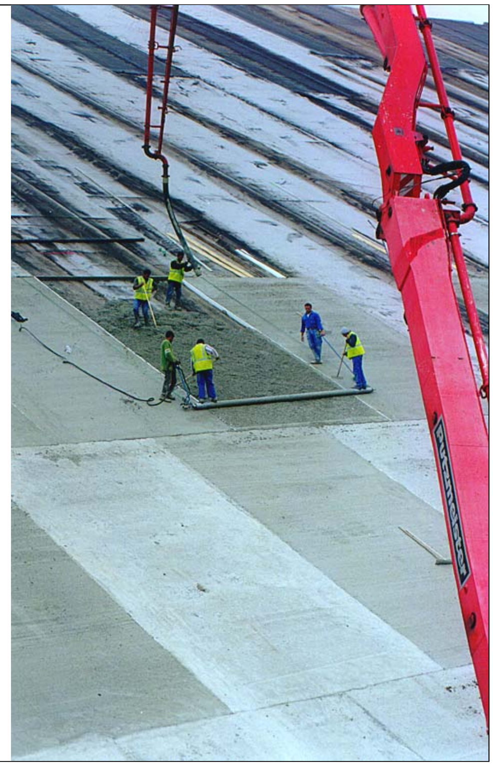
This covering to avoid trunk or vandalism is realized with concrete paving stones flowed in place on a device anti-puncture constituted with a non-woven geotextile of 600gr/m². Paving stones have a minimal thickness fixed to 10 cm and are provided with a device anti-fissuring, constituted with polypropylene infinitive long fibers. The choice to pour in place of the big paving stones (5 m x 10 m) with opened joints presents several advantages:

On the aesthetic plan: level of water not constant, filling in easier,

Drainage under is assured with the geotextile and opened joints

La Galaube Dam
October 2000

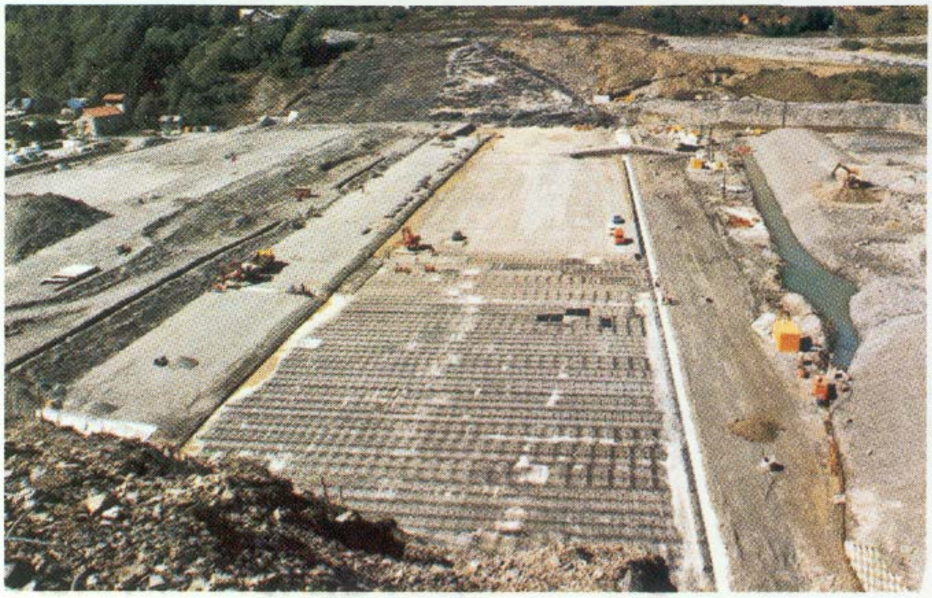
Laying of mechanical protection in concrete



The concrete is brought on foot by truck and pumped until 60 meters or 200 ft of distance. Concrete is poured to fabricate paving stones one by two into aluminum formwork. Then, the realized paving stones serve as formworks for the following paving stones. Joints between concrete paving stones situated in the drawdown zone are performed with Tixophalte, asphaltic formulation bituminous with elastomer added with allowing solvents its operated to cold, on vertical support and under the water.

2 years after

In spite of work done in the rains and winds of autumn, (advantage of GMB) the short delay of 5 months was respected. Work was so ended for the end of November 2000, allowing the Owner to fill a large part before cold weather and snow.

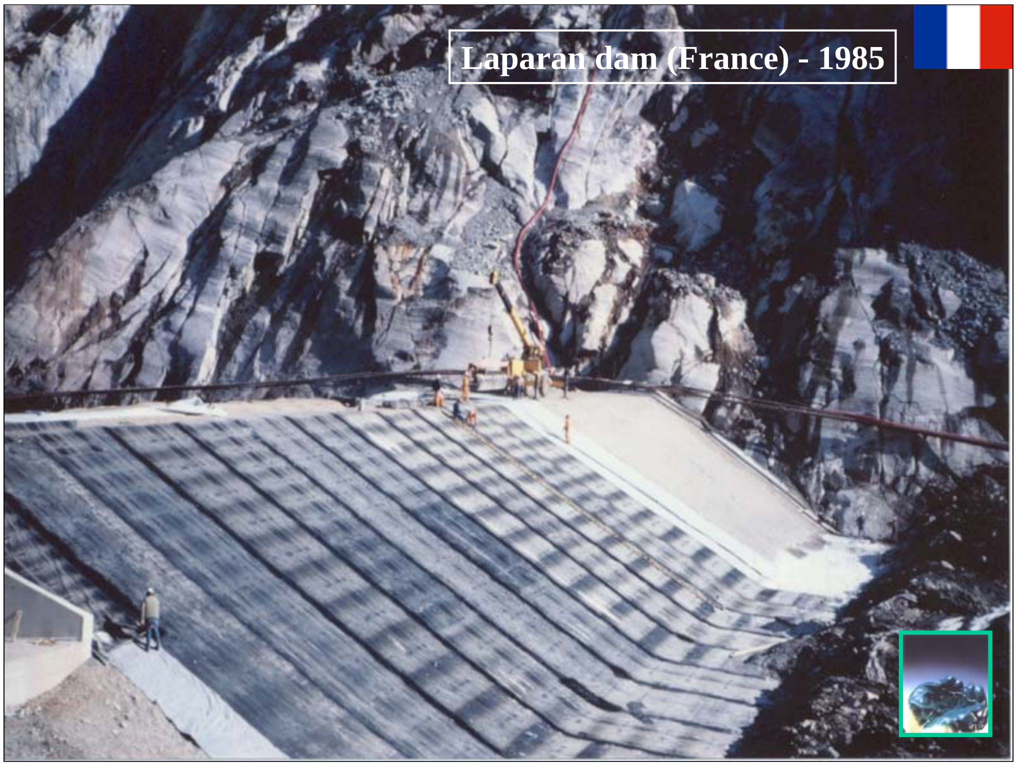

Protection of the foundation of the supporting mass of the Vernet dam, E.D.F. development, Grand-Maison site (France).

Le Verney dam – Work done for Electricity of France

BMG on the total horizontal area of the base of the rockfill dam to improve the watertightness of the base, by a better link with the cut off trench and on the bank. They used NTP 4 the thickest geomembrane5.6 mm or 225 mils, for its special high puncture resistance. We are the sole supplier of French railways for more than 25 years. We did similar railroads work in Nebraska for BNSF. GMB applied directly under ballast. Upstream face watertight by asphalt concrete.

Height = 26 m. or 85 ft. ,Paper in the International High Dam in New Delhi in 1979. Another dam Alesani did the subject of a paper presented in the International Conference of high dam in Rio in 1979. All are working well.

Work completed, reservoir full.


Laparan dam (France) - 1985

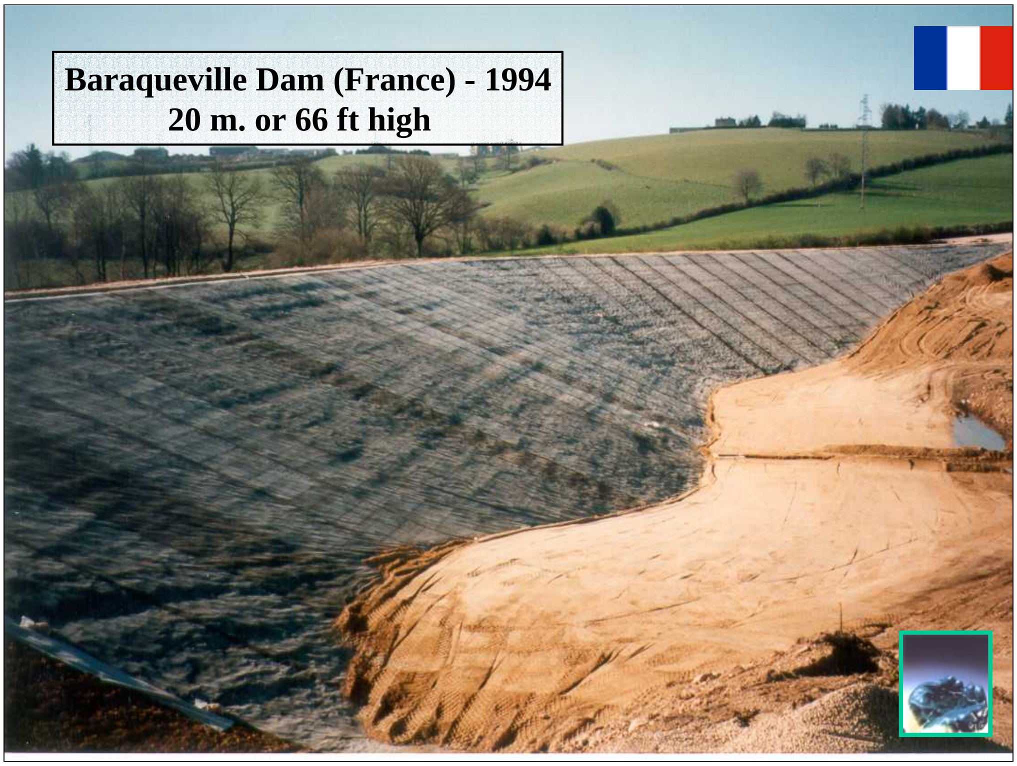
-

Work done at 1650 m of altitude in the Alps.

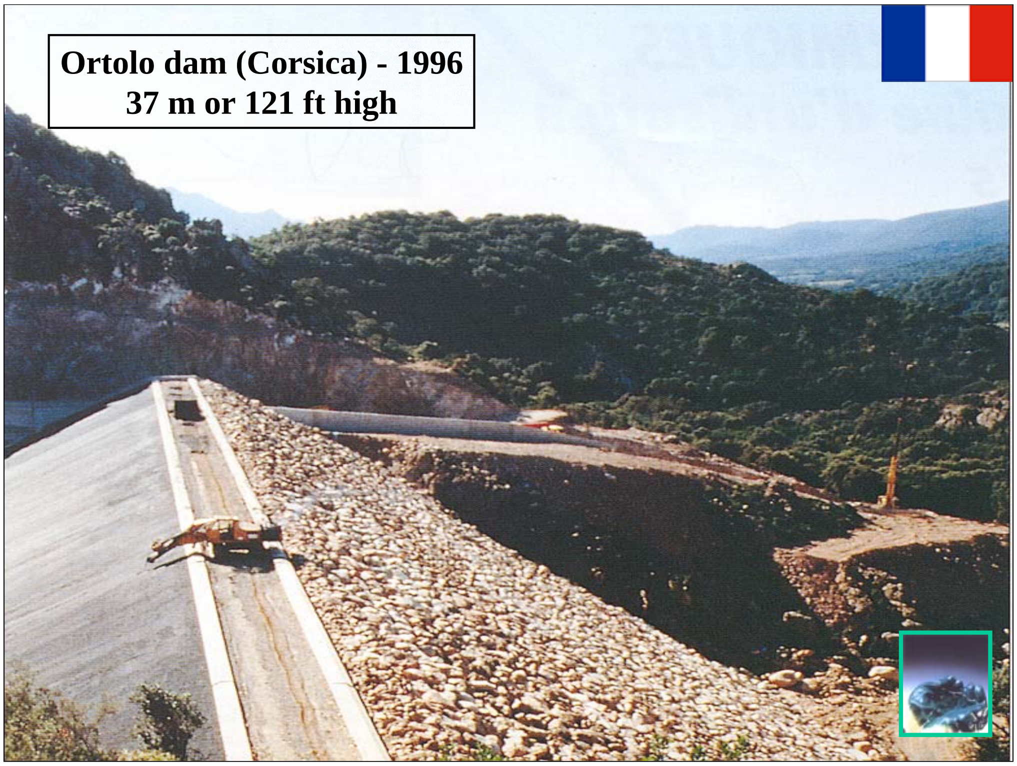
Length of the crest 640 m or 2100 ft, height = 15 m or 50 ft, facing GMB 6 000 m2 or 64 500 sq. ft. In this region, we did Naussac in 1981 and Mas D'Armant in 1981. As the level is constant, we put a protection with concrete slab white for a question of aesthetic (tourist region) tied up with stainless steel rope at the crest on 2 meters.

Precast concrete slabs for aesthetic reason and protection against tree trunks and vandalism

-



30% cheaper than with a core watertight. Just protected by gabion filled with local rocks (respect of environment) at the top because the level is constant too.


Ortolo dam (Corsica) - 1996
37 m or 121 ft high

-

A dyke on Arctic Circle
by -13°F

Coletanche ES can be put in place till –31F

Barrage Anglier
(Canada)
by –13° F
(Qc, Canada)
Mars 2004

-

A special mention for this project - the cofferdam was built in ice after a lot of other solution.

-

Pose of covering material without geotextile. By – 13F, it is better to pose one geosynthetics at the place of 2 or 3. When there is wind it is worse.

-

Dam at St. Jovit, Mont Tremblant (Qc, Canada) 2003

-

All the works, we did with Coletanche are still working well in spite of a very (I will say no at all) poor maintenance, in all the cases after more than 30 years of service for some. The results show a great reliability in dam construction in using GMB. The ease of laying, welding and absence of wrinkles permit an installation without defects. Now in Quebec, there is no anymore rockfill dam watertight without the use of BGM.

Please note that HDPE is not used in Europe due its stiffness and high thermal expansion coefficient. The important wrinkles make difficult the covering and the quality of the watertightness by formation of cracks during compaction the covering materials.