ÉTANCHÉITÉ EN GÉOMEMBRANE BITUMINEUSE DU BASSIN DE STOCKAGE DES MANES

BITUMINOUS GEOMEMBRANE WATERPROOF LINING TO MANES STORAGE RESERVOIR

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RÉSUMÉ

Les demandes en eau pour l'irrigation ne coïncident pas toujours avec les précipitations. Des barrages de compensation sont nécessaires. Le bassin des Manes près de Gap à 1120 m d'altitude étanché par une géomembrane de 3,9 mm au bitume élastomère est un exemple intéressant par sa simplicité et son économie due à l'utilisation de matériaux locaux. Des fuites à la mise en eau et le mode de réparation efficace permettent de tirer des enseignements très utiles pour les futures réalisations.

ABSTRACT

Demand for irrigation water does not always coincide with rainfall and storage dams are needed. The Manes reservoir near Gap at an altitude of 1120m as been rendered watertight with a 3.9mm geomembrane impregnated with elastomer-modified bitumen is an interesting example by reason of its simplicity and low cost; it enabled locally-available materials to be used for building the dam. Leakage on first filling and repair methods yield valuable information for designing future projects of this kind.

Vue générale du réservoir / *General view of water storage reservoir*

1. INTRODUCTION

The Bayard plateau, 10km north of Gap in southern France, yields a very pure water for agriculture and domestic supply. Downstream of the viewing table on the N85 highway, is the Manes embankment dam, built in 1995, which stores heavy snowmelt flows to meet later summer demand peaks. It lies at an altitude of 1120m asl and cost FF7m to build. Its leading features are:-

- Reservoir capacity ..... 150,000 m^3
- Dam height ..... 11.5m (upstream side)
- Head ..... 10.3m (upstream side)
- Reservoir area ..... 21,500 m^2

This reservoir will be filled through a pipe from the Charance branch canal immediately above. The pipe is controlled by a float operated valve. The complete scheme comprises

- Rolled earth dam, fill volume 80,000 m3
- Intake pipe buried in dam
- Bottom outlet pipe buried in dam
- Side spillway
- Waterproof lining to the whole reservoir
- Foundation drainage system
- Access roads, consolidation works, drains and other outlets.

The Owner of the scheme is the Société du Canal de Gap, the consulting engineer is Société du Canal de Provence, the contractor for the Colétanche NTPES bituminous geomembrane waterproof lining was Société Colas Rhone-Alpes.

2. DESCRIPTION OF SCHEME

2.1. Dimensions

Full supply level is el. 1128.30m asl. Storage capacity is approximately 150,000 m^3. Dam crest level is el. 1129.50m. Maximum dam height (upstream side) is 11.50m, crest width is 4m, base width is 60m.

2.2. Typical Section

In view of the site topography, geology and locally available materials, a waterproof membrane was selected as the watertight member. The reservoir area consists of loose plastic silt at the bottom overlying moraine material. The same glacial material forms the sides of the reservoir. The shale bedrock lies very deep.

The main body of the dam will be built of this moraine material with a downstream shoulder of plastic silt. The 135,000 m^3 of excavation involves some 75,000 m^3 in the moraines and 60,000 m3 in the silt, with some 45,000 m^3 wasted. With its poor engineering properties, the silt material cannot be used for the body of the dam. It sits on rolled moraine material at the bottom. Besides these two zones, there are also:

- Bituminous geomembrane upstream facing
- Random rolled base course at dam crest
- Downstream drainage blanket
- 300-800mm rockfill toe berm at south-west end
- Toe drain in the fill above the rockfill berm
- Finger drains on downstream side of shoulder, 1m wide spaced 10m apart
- 20cm topsoil on downstream face.

2.3. Intake works

The inlet and outlet works fill the reservoir and deliver water to consumers. The incoming supply pipe from Charance canal is controlled by a float operated valve. The outgoing steel supply pipe is 800mm diameter, 7mm wall thickness, with special inside finish.

2.4. Bottom Outlet

The bottom outlet design is the same as the buried supply pipe. It will be a 600mm pipe, wall thickness 5mm, with special inside finish, buried in the dam fill at the lowest point. The upstream-end strainer is set 70cm above the reservoir floor in order to prevent clogging by fines. A 400mm dia. transition at the downstream end is controlled by two 400mm butterfly valves discharging into the outlet pool, with its outlet under the RN85 highway.

2.5. Side Spillway

The side spillway will be located on the north-east abutment. It will discharge into a side valley crossing north of the Charance canal. The valley will be regraded over its whole length to the point where it crosses the RN85 road.

3. WATERPROOF SYSTEM

3.1. Site Preparation

The work schedule was very tight and preparatory work for laying the geomembrane demanded much care. A large workforce of skilled men and reliable machinery was needed. Seamers had to be certified.
The high quality of seaming required for the geomembrane implied that

- The foundation had to be level and free from sharp stones so that the geotextile drain would properly support the waterproof member.
- Geomembrane panel sizes and layouts had to be carefully designed beforehand.
- Drawings had to be prepared showing the geomembrane storage areas on site and truck entrance and exit corridors.
- A drawing had to show trafficways for the shovel and roller in both directions.
- The various phases of the work had to be scheduled.
- A design study had to be made for joining the bituminous geomembrane to the concrete appurtenant works.

3.2. Bituminous Geomembrane

The bituminous geomembrane specification was as follows:

Minimum thickness	4mm	(4)
Minimum unit weight	4.8 kg/m^2	(4)
Tensile strength	21 daN/cm	(18)
Strain at failure	51%	(35-45)
Dynamic puncture test (Ueate)	<15	
Notched tear test N	90	
Cold fold test	<-15°C	

Figures between parentheses are the values specified in the contract. The bitumen selected was an elastomer-modified bitumen providing better resistance to sunlight, an important criterion for a membrane that will not be protected by a covering layer in a very sunny climate.

3.3. Foundation

The geomembrane lies on the upstream faces of the fill, graded and compacted with a smooth drum roller in the direction of the slope, and all sharp stones removed. A 500 g/m^2 nonwoven geotextile is provided for puncture strength. No fines were added to the surface.
The geotextile is easy to lay. The roll is carried on a core and frame, slung from the jib of a crane at the bottom of the dam or at the crest. It is dispensed by hand.

3.4. Geomembrane Laying

The rolls of geomembrane were delivered on 160mm dia. cores. They were unloaded and dispensed from a hydraulic dispenser beam slung from the arm of a Lieber 932 tracked shovel. The dispenser beam had two cones, one of which could be moved when picking up the roll. The cones were powered by the shovel's hydraulics, which also operated the reversible winding motion of the roll. The workmen therefore had only to guide the material, no pulling was needed. Sandbags were used to hold the geomembrane down while awaiting seaming, to prevent them being lifted by the wind. Seams between geomembrane strips had a 20cm overlap. They were welded with a propane flame gun and immediately flattened with a smooth roller.
Work commenced at the toe. The strips were laid in the direction of the slope and anchored in a trench not less than 50cm wide and deep dug by shovel at the crest. The bottom edge of the geomembrane facing was welded to the reservoir lining at the bottom. Joining bituminous geomembranes to concrete is very simple. The concrete is first painted with cold primer, and the geomembrane bonded to it with a suitable adhesive as well as being clamped down by means of aluminium strips plugged into the concrete every 30cm. The total area of the geomembrane was 25,000 m^2.

3.5. Protective Covering

No protecting covering was provided for the geomembrane. A fence around the reservoir will exclude extruders who might damage the lining and animals liable to drown.

3.6. Inspection and Testing

The contractor checked the bearing capacity of the reservoir floor and dam fill. After laying the geomembrane, he inspected all seams and surface condition of the geomembrane. At this large project, all reservoir lining seams and ten per cent of the dam facing seams were tested by independent inspectors using echography equipment. Flawed seams were patched with 60mm wide strips. The same simple method is used for accidental tears and proves to be entirely effective.

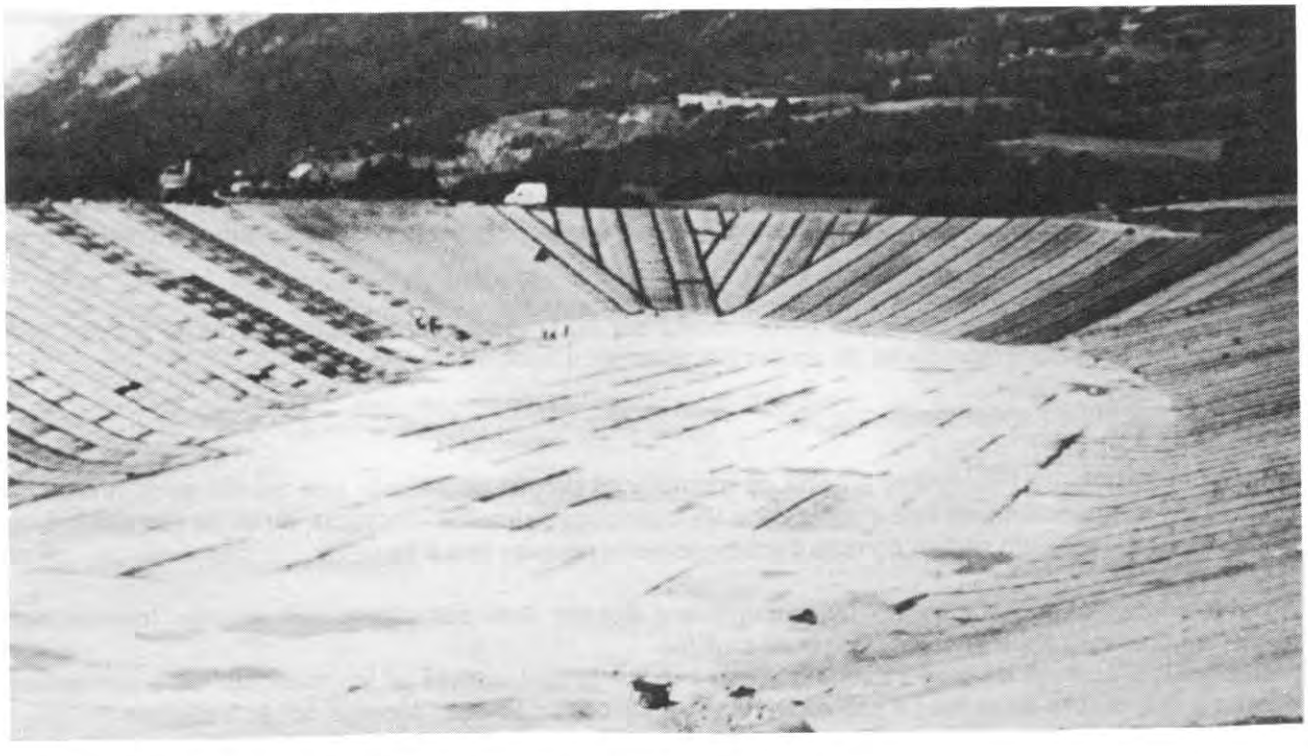
4. PROBLEMS DURING FIRST FILLING

Reservoir filling took place in October 1995. It was discovered that fines were being entrained by leakage where the geomembrane had unbonded from the bottom outlet structure, but repairs were no possible until the spring of 1996. Other minor damage was observed after the dam had remained empty over winter.
Repairs consisted of removing 700m^2 of geomembrane, making good the supporting layer, and providing drainage to the anchorage trench, which was the cause of the ravelling under the geomembrane.

5. CONCLUSIONS AND LESSONS

Waterproofing with geomembrane offers a level of reliability and safety that would be impossible to achieve by natural means. However, certain lessons have to be learnt from the experience acquired at the Manes reservoir.
1) Particular care must be exercised at the junction between the geomembrane and concrete, the underlying material must be very well compacted and the bond reinforced by clamping rails.
2) The geomembrane anchorage trench may need to be drained if the material is pervious or there is a risk of inflowing water, or alternatively the anchorage design must be amended.
3) Geomembrane-lined reservoirs must, if possible, never be left to stand entirely empty over winter, because it is important to maintain a depth of water sufficient to counteract the uplift pressure under the geomembrane.

Préparation de la couche support / *Preparation of support layer*



Mise en œuvre de la géomembrane / *Geomembrane application*