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Waterproofing the pavement support of the Cahors-Souillac section of the A20 Motorway

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The environmental constraints related to laws governing water have forced road management companies to deal with the problem of runoff water management on highway platforms from the design stage. This paper explains how Autoroutes du Sud de la France (ASF) company deals with these constraints on the construction of the Cahors – Souillac section of the A20 (Montauban/Brive concession).

1 PRESENTATION

Autoroutes du Sud de la France (ASF) is the leading toll motorway network in France, with more than 2,500 km of motorways in service.

Starting in the 1970s with the construction of the A7 and A9, ASF has acquired specialised know-how in motorway design and construction. It is one of the largest investors in France - each week, ASF builds 1 km of motorway.

Approximately 500 km remain to be built between from now to 2006, including the 22 km bypass of the city of Cahors. This project is the last phase in the construction of the A20 Montauban/Brive Motorway for which ASF obtained the concession of 7 February 1992. The A20 is part of a European North/South axis linking Paris with Spain via Toulouse which will, when completed in 2003, provide an alternative to the Rhone corridor.

The special feature of the A20 motorway is that it runs through still-pristine landscapes, for example the Causses du Quercy regional nature park, and that it has been built in ecologically sensitive areas. For example, the 46 km of the Cahors North/Souillac section run along the valleys of the Dordogne and the Rauze which are classified at European level as conservation areas (NATURA 2000). The Dordogne Viaduct also lies within the Pinsac bend which has been classified as a natural flora and fauna ecological zone (ZNIEFF).

The protection of this environment is therefore an integral part of the motorway's design and construction. The motorway section being built in the Lot exemplifies ASF's particular focus on the natural environment and its determination to ensure that its motorways fit harmoniously into their surroundings.

Along this section of the A20, there are large underground cavities and building on a karstic subsoil presented difficulties which were not, to start with, easy to solve. The karstic area comprises large underground reservoirs. These natural reservoirs lying within the limestone massifs are vulnerable and great care must be taken to avoid the risk of accidental and chronic pollution.

ASF therefore set up a special system to protect this water: a waterproof network of curved channels was built along the motorway to collect all rainwater runoff from the pavement support. This water is then channeled into large catch basins designed to stabilize and decant suspended material, trap hydrocarbons and control peak flows during storms. The basins are equipped to collect and retain all types of pollutants in emergencies following accidental discharge during exceptional storms.

Three levels of protection, corresponding to the different degrees of sensitivity of the areas located along the motorway, have been defined for this section.

In areas classed as sensitivity level 1, where there is a major risk related to the type and utilization of the sub-soil (for example, a karstic sub-soil with groundwater being used for human purposes), the system provides for full waterproofing of the carriageway, central reservation and ditches combined with a system for pre-treating chronic, seasonal and accidental pollution.

In areas classed as sensitivity level 2, in which the aquifer is less vulnerable, there is no need for additional systems to treat discharge beyond the waterproofed areas. But here too, run-off water is collected after pre-treatment of potential pollution.

In zone 3 (the least sensitive), the water collection network is sealed with fine material in the cut and made up of a concrete drainage channel or seeded ditch in the fill.

ASF paid particular attention to the design and installation of the waterproofing of these vital elements which are crucial to State's commitment to protect the environment and conserve these landscapes.

ASF, assisted by its project manager Scétauroute, entrusted the work to Eurovia and Entreprise Jean Lefebvre which held the pavement contracts for this section. They in turn called on the advice and expertise of Siplast, a manufacturer of waterproofing materials, when designing the water protection system.

The waterproofing work in the southern segment between Cahors Nord and the Sol de Roques cut-and-cover trench was carried out by Eurovia Etanchéité (Charvieu 38) and by Jean Lefebvre Géomembrane (Dijon 21) for the northern segment between Sol de Roques and Souillac. The work began in November 2000 and was completed in April 2001.

It consisted in waterproofing the curved channels in the cut areas with a bituminous geomembrane system and in waterproofing the catch basins with a high-density polyethylene (HDPE) geomembrane system.

2 COLLECTION OF SURFACE RUN-OFF WATER

The goal is to channel all run-off from the pavement into waterproof treatment basins without losses to the outside. The pavement, ditches and basins must therefore be treated and also, obviously, the hot mix-ditch and ditch-basin interfaces.

In the work described in this article the pavement support itself was considered sufficiently waterproof, first because it has a low permeability coefficient and second because the slope shape ensures rapid water run-off into the ditches without risk of stagnation.

On the other hand, special solutions were adopted for the ditches and basins.

3 WATERPROOFING THE CURVED CHANNELS

The criteria for the waterproofing were the following:

- -joining of the waterproofing to the bituminous concrete to ensure waterproofing continuity,
- joining of waterproofing to concrete structures located in the ditches - manholes, engineering structures, etc..
- maintaining topsoil in place for planting and ditch landscape integration,
- finally, climate sensitivity to enable waterproofing work to take place on schedule (waterproofing must be applied after acceptance of the pavement support and before laying of the wearing course, and scheduling is therefore crucial).

Given these requirements, the solution selected was a 3 mm thick, Asqual-certified, elastomeric bitumen geomembrane Teranap 331 TP.

4 BITUMINOUS GEOMEMBRANE TECHNIQUE

4.1 *Presentation*

Bituminous geomembranes have been used in France for over 25 years in all areas: dams, canals, industrial basins, road catch basins, controlled landfills, etc. But in contrast to HDPE geomembranes, their use in civil engineering would seem to be specific to France and a brief description of their characteristics would therefore be useful.

Bituminous geomembranes are derived from building technology where they have been used for more than 40 years, all over the world, to waterproof flat roofs. Polymer modified bituminous binders are also used in the roadworks industry.

This broad range of applications has enabled the major French building and civil engineering laboratories, such as the Centre Scientifique et Technique du Bâtiment (CSTB), the Ponts et Chaussées laboratory network (LRPC), etc., to collect a large amount of data on the behaviour and durability of modified bitumen based materials.

4.2 *Description*

Bituminous geomembranes are made up of a framework of non-woven polyester material which is primed and then surfaced with a bituminous binder - the binder provides waterproofing and weldability, the framework the mechanical properties (tensile strength, resistance to indentation, etc.) and dimensional stability (smooth surface with no irregularities due to thermal dilation).
There are two main types of bituminous binder:

-oxidized bitumen which exhibits plastomeric behaviour and whose utilization temperature lies between 0 and 70°C,

-SBS elastomeric bitumen which exhibits elastic behaviour and whose utilization temperature lies between –20°C and 80°C.

Given the location of the site and the winter scheduling of works, SCETAUROUTE recommended an SBS elastomeric bitumen membrane whose utilisation temperature range was suited to the requirements of the site.

4.3 *Installation*

Edges were assembled by welding with a propane blowtorch and manual taping. The blowtorch flame can reach temperatures of 600°C to 1,000°C and the bitumen softens at around 100°C. The welder therefore need only adjust their speed to achieve a high-quality weld.

Patches applied during the initial construction or for subsequent repair use the same technique : torch welding.

Finally, one of the advantages of bituminous geomembranes is that they can be welded onto concrete structures, steel and bituminous concrete, using the same torch welding technique.

In terms of resistance to chemicals and specifically to hydrocarbons, the bituminous geomembrane + protective topsoil complex provides resistance for over 7 days which is in line with the site requirements and the operation of the curved channels.

4.4 *Conclusion*

The choice of this material for the site was based on its simple welding technique, its low sensitivity to weather conditions and compatibility with the different surfaces encountered in roadwork.

5 CURVED CHANNEL WATERPROOFING WORK

The Teranap 331 TP bituminous geomembrane is supplied in 1,900 kg rolls which are 4 m wide and 100 m long.
Earthmoving work on the curved channels was performed with a grader using a 0/20 coarse gravel over which the geomembrane is laid.

The rolls are delivered by forklift or 15-ton crane truck and then laid using a wheeled excavator traveling over the motorway pavement under construction. The excavator is fitted with a variable width (from 3 m to 7.5 m) beam made up of elements which can be disassembled and transported by crew cab.

On the southern - sensitivity level 1 - segment, the width of the curved channel profile to be waterproofed is uniformly 4 m. After positioning by a surveyor, the rolls are simply unrolled longitudinally without lengthwise joints. The crosswise joints at the ends of the rolls are hot-welded, respecting the direction of water run-off flow. Length treated: 7,920 linear meters.

On the northern - sensitivity levels 1 and 2 - segment, the width of the curved channels varies in accordance with 4 standard profiles (5.30 m, 3.90 m, 6.60 m and 4.70 m), requiring the use of geomembranes in widths of 4 m, 2 m and 1 m. In sensitivity level 1 areas, the geomembrane rises 1.50 m above the water stream on the bank side and in sensitivity level 2 areas it stops at the final wearing course level. Surface treated: 88,000 m.

Depending on the area, either the geomembrane is attached to the concrete drain and inspection structures of the drainage network by hot welding it onto concrete previously primed with a bituminous Siplast Primer (70 structures in the northern segment) or, alternatively, the concrete structures are cast directly onto the geomembrane (50 structures in the northern segment).

The part of the geomembrane which is in contact with the outside bank of the curved channel, where the slope is steepest, is overlaid with a geotextile of uniform 2 m width in the south and variable width, according to area, in the north. This geotextile (Enkamat 7009 C100 or WD110) holds the 15 cm deep bank side topsoil in place.

The horizontal part of the geomembrane on the pavement side is covered by 0/20 coarse gravel which forms the upper base course of the motorway's emergency lane. An overall hot mix layer serves as a wearing course and ensures continuity of water run-off flow into the lateral ditches.

On the southern segment, the average laying speed is 500 linear meters per day.

In the north it is approximately 3,000 m²/day. Work in this zone is more complex due to the varying width of the profiles to be covered and the need to fasten the membrane in order to prevent it from sliding on the banks which have variable slopes of up to 1-in-1. This fixation requires numerous perforations in the rock (every 1.5 m).

6 WATERPROOFING THE BASINS

Run-off water is present only very briefly on the pavement and in the ditches, but it can be retained in the catch basins for long periods of time.

In ditches, soil retention is a problem and erosion and soil wash-out (a rapid phenomenon) during storms must be prevented. In basins, the problem is quite different: banks are planted and the water level varies. The problem here is the risk of soil displacement in the tidal range area.

A system has therefore been introduced to hold the soil on the banks; this system is separate from the geomembrane and made up of a three-dimensional geotextile in conjunction with a reinforcement grid.

This being the case, the criteria for geomembrane selection are less stringent and a choice of several types (polypropylene, HDPE, elastomeric bitumen geomembranes) is possible.

The geomembrane selected was a 1.5 mm, Asqual certified high density polyethylene because of its excellent resistance to chemical attack.

Its underside and surface are protected by two geotextiles and soil is held in place by a geocontainer.

Concrete structures provide ditch-to-basin waterproofing continuity. On the ditch side, the bituminous geomembrane is welded onto the concrete to ensure inflow of water without losses. On the basin side the HDPE geomembrane is generally attached by mechanical fastening. Connections between different types of waterproofing were therefore not an issue.

7 BASINS WATERPROOFING WORK

A total of 37 basins with an average surface area of 2,300 m_ (ranging from 1,100 to 2,900 m_) were waterproofed over the motorway section as a whole.

The waterproofing was structured as follows:

- a Bidim S 61 or Datex TH 300 geotextile,
- a 1.5 mm thick HDPE geomembrane,
- a Bidim S61 or Datex TH300 geotextile,
- a three-dimensional Enkamat 7010 H20.20 PET 90P geotextile.

The basins of the southern segment, which lie in a karst area, are reinforced with a 1 m wide Agrunet 450 type geogrid positioned in a 3 m per side perpendicular mesh.

Each basin is very carefully gridded for the joining of the geomembrane edges.

All longitudinal geomembrane joints are double welded. Welds are systematically inspected under pressure (0.2 MPa).

Geomembranes are mechanically clamped to the concrete effluent inlet and outlet structures by means of a stainless steel or aluminium reglet. In some cases no joints are required, as effluent flows directly onto the membrane protected by rip-rap.

Ten centimetres of topsoil are then laid on the bank and a 30 to 40 cm layer of as-dug material is applied to the bottom of the basins.

In areas without rock outcropping, the topsoil banks are immediately planted to ensure harmonious integration of the site into the landscape.

8 CONCLUSION

As the "builder" of the motorway, ASF has devoted a major part of its activity to designing systems to reduce environmental impact along the route.

The "duty to safeguard the natural heritage" incumbent on each of us under the law of 10 July 1976 (Article 1.), applies to the entire Montauban-Brive section of the A20. The design and construction of this motorway required considerable attention to environmental constraints and in particular to the impact of the various types of pollution likely to affect karst areas.

Co-ordination between project manager Scétauroute, the Siplast company and Eurovia and Jean Lefebvre made it possible to implement specific waterproofing solutions.

Attention to the natural environment and respect for it have enabled ASF to build an environmentally safe motorway.

Figure 1. Installation of HDPE geomembrane on a basin.

Figure 2. Installation of elastomeric bituminous geomembrane in the channels

Figure 3. installation of soil protection

Figure 4. Basin with its soil protection

Figure 5. Installation of the three-dimensional geotextile

Figure 6. the site.