



## **THE NEW TECHNIQUE OF WATERPROOFING HYDRAULIC BASINS WITH STRUCTURAL BITUMINOUS MEMBRANE IN WORK**

### **THE 'MBSM' PATENT OF CEA COOPERATIVA EDILE APPENNINNO AND PAVENCO PAVEMENT ENGINEERING CONSULTING**

Contrary to what is more widely known, the use of binders and bituminous conglomerates is not limited only to applications in the road field, but, over the years, has also involved hydraulic engineering, especially in the construction of artificial reservoirs and the fronts of dams. The bituminous mixtures for this type of application are designed with the main purpose of providing protection to the concrete or earth structures of which the reservoir is made up and guaranteeing the waterproofing of the surfaces in contact with water. As it is easy to imagine, if on the one hand the type of materials does not differ much from traditional applications in the road sector, the greatest complexities are encountered in the installation phase. The paving techniques, conceptually, it is the same as that for road infrastructures as the material must be laid at high temperatures (contained between 140 and 160 ° C depending on the class of bitumen) and immediately compacted to reach the project density. However, the inclination of the paving surfaces and the reduced space for maneuvering imply the use of specific machinery and equipment that are in the possession of very few construction companies worldwide. Since the 1950s, the company Ing. Giuseppe Sarti & C. SpA has developed highly specialized technical-organizational skills and has equipped itself with special milling machines, rollers and pavers to carry out waterproofing works on dams, lakes and canals both at national and international level. In May 2014, Cooperativa Edile Appennino (CEA), which boasts over thirty years of experience in national and international international for the execution of civil works, infrastructure, aqueducts and gas pipelines, has purchased the company branch of the company Giuseppe Sarti & C. Spa, inheriting its know-how, management and equipment.

During 2016 the Technical Director of CEA Ing Leonardo Sarti and the road paving technologist Ing. Fabio Picariello of the company Pavenco Pavement Engineering Consulting srl, assisted by a team of technicians, developed a new technology for waterproofing the hydraulic reservoirs that takes the name of Modified Bitumen Sealing Membrane (MBSM). The MBMS is an in situ application of modified bitumen and selected aggregates that takes place by means of a machine specially designed and built in the CEA workshops. Starting from the road experience on which the CEA company and the Pavenco company have been working for some time, the team of designers developed the idea of re-adapting the classic multilayer treatments for road pavements to the field of waterproofing on sloped surfaces of hydraulic basins. If the technology itself, therefore, does not represent a constructive novelty, the application on slope is a real innovation which is, today, protected by a registered patent.

### **MBSM TECHNOLOGY**

MBSM is a structural bituminous membrane built on site and is composed of modified bitumen and aggregates that are spread simultaneously to form a covering and waterproofing layer of the facing surface.



The waterproofing action is carried out by the bituminous binder with the addition of polymers such as styrene butadiene styrene SBS which improve its rheological characteristics by enhancing elasticity, ductility, cohesive power and mechanical behavior at high and low temperatures. The bitumen is spread at temperatures between 175 and 190 ° C and, thanks to its modified nature, it adheres to the existing surface forming a continuous veil. The aggregates which are applied by gravity by an automatic grit spreader, in turn adhere to the still hot bitumen to create the structural lithic skeleton.

The waterproofing treatment can be applied on the layer to be waterproofed multiple times according to the degree of coverage and protection to be achieved. Laboratory studies have shown that the overlapping of three layers of MBSM are comparable to a 3 cm bituminous conglomerate layer from the point of view of resistance to mechanical impact actions.

The machine, which is able to move autonomously on the inclined face, consists of an automatic horizontal levelling platform on which, in addition to the stripping bar and the grit spreader, also the aggregate hopper and the heated bitumen tank are located. The laying of hot bitumen and the spreading of the aggregates takes place simultaneously and is managed by a control console located in the cockpit. In the configuration of the prototype created, the machine is able to tackle slopes up to 1: 1.7.

The composition of the MBSM is from time to time studied in the laboratory following a preliminary investigation on the state of the facing to be restored. Based on the state of degradation of the facing, it is



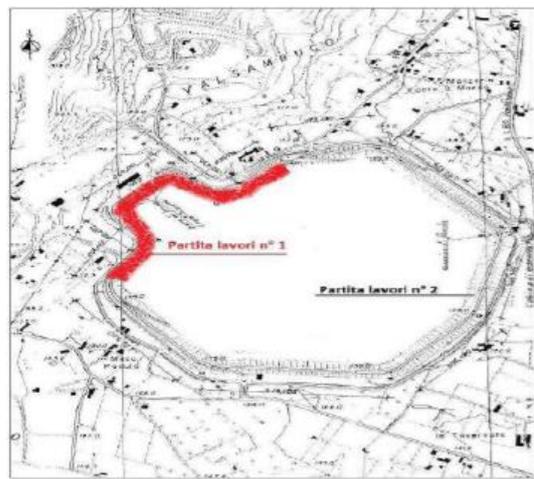
therefore possible to vary the granulometric curve, the petrographic nature of the aggregates and the quantity of bitumen necessary to create the waterproofing. An excess of bitumen could lead to instability of the mixture and the risk of percolation at high temperatures, while a defect of the same would be insufficient to maintain adhesion with the aggregates.

### Application in the Enel - Presenzano basin

The first application of the MBSM membrane by CEA took place in the Presenzano (CS) water basin, where one of the most important hydroelectric plants of ENEL spa resides, as part of the "Restoration work on the seal of the upstream face". The 'Domenico Cimarosa' is a power plant located in the Volturno valley between the provinces of Caserta, Isernia and Frosinone, and is a closed-cycle plant for a total of 1000 MW, consisting of two basins with a capacity of approximately 6 million cubic meters each. and a relative difference in height between them of about 500 m. The water supply, collected in the upstream basin, takes place through penstocks made with tunnel excavation, while the discharge is carried out in the downstream basin.



Valley basin of the central ENEL of Presenzano 'D. Cimarosa '



Sector of the basin affected by the works with MBSM

After 30 years of operation, following the water losses attributable to the degradation of the bituminous conglomerate covering and the joints between it and the concrete works of the intake works, Enel has provided for the complete removal of the seal layer in bituminous mastic and the remaking of the bituminous conglomerate layer on the inclined faces (slope 1: 2).

For the execution of this first batch of work, the complete emptying of the basin and the accumulation hoppers was carried out. Due to the particular construction geometry of the plant in correspondence with the mouths, it would have been extremely difficult to proceed with the traditional operations of milling and laying the new bituminous mantle which would have required not only the use of winch wagons but also



cranes to support the machinery. The application of MBSM, on the other hand, has proved to be optimal as the machines do not require any support as they can move independently on the inclined wall.

Before the waterproofing activities, the surface of the wall was cleaned and the existing sealant was removed with hydrodemolition at 2500 bar until the existing bituminous conglomerate was scarified for about 1 cm. All the cracks on the surface were clogged and restored with bituminous sealant.



*The cleaning operations of the facing*



*Cracks in the facing visible after hydrodemolition*

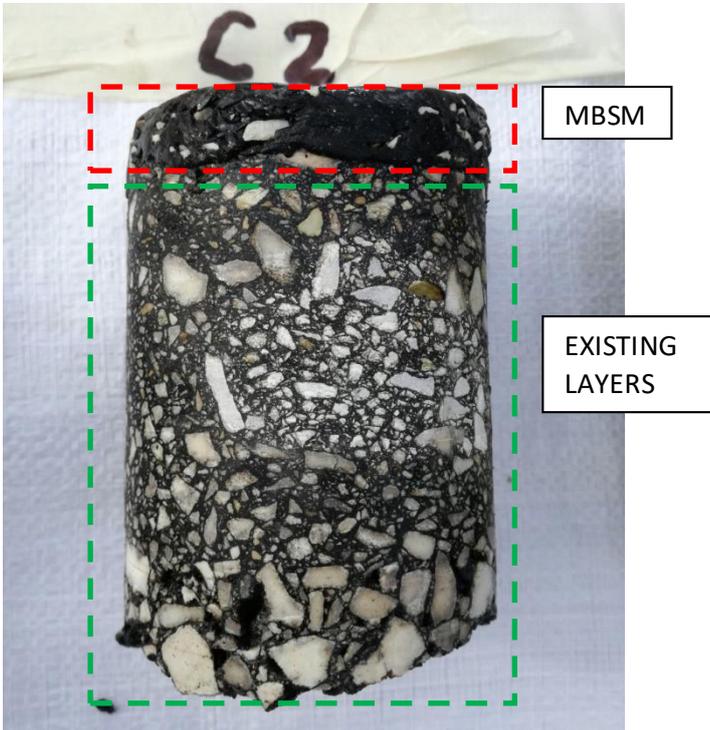
For the present work, the MBSM membrane was performed in two superimposed layers in the following sequence:

- 1st layer: bituminous binder coat modified at the rate of 2 kg / m<sup>2</sup> + limestone aggregate coat with size 8/10 at the rate of 9 liters / m<sup>2</sup>
- 2nd layer: bituminous binder coat modified at a rate of 1.8 kg / m<sup>2</sup> + limestone aggregate coat with size 3/6 at a rate of 6 liters / m<sup>2</sup>



After each application, rolling is followed to form the perfect mesh between grit and bitumen, obtaining complete densification of the membrane.

The post-operam controls demonstrated the perfect adherence of the membrane to the surface and the total absence of residual voids.



*Waterproofing package sample*



*Aspect of the surface after the first MBSM application*



*Aspect of the surface after the second MBSM application*

### **Application in the Enel - Edolo basin**

In 2018, the MBSM technique was applied on behalf of Enel in the Edolo basin, in Lombardy, where the intervention carried out on the upstream face has reduced the leakage of the basin from 20% of total leakage (29-01-2015) to 7.1% of total leakage detected on 03-05-2018.



*Edolo basin, Enel*



## CONCLUSIONS

The patent registered by CEA introduces a revolutionary innovation in the field of waterproofing of reservoirs. Borrowing from the consolidated experience of the road engineering sector, high-performance modified bitumens are used to create a structural membrane on site which, compared to a traditional sealing layer, provides:

- greater resistance to thermal variations
- greater stability and cohesion with the support
- greater adhesion
- greater resistance to oxidation and aging.

property	Characteristic values
Consistency at intermediate operating temperatures	Pen > 45 (45-80)
Consistency at high service temperatures	R&B > 70 ° C
Fragility at low operating temperatures	Fraas < - 14 ° C
Deformation recovery	Elastic Return at 25 ° C > 85%

*Main characteristics of the binder*

MBSM technology, due to its waterproofing and resistance characteristics, is a valid alternative to traditional construction practices, allowing a considerable benefit both in terms of construction times and in terms of site logistics. The application in the Presenzano hydraulic basin has sanctioned the debut of a technique that can replace the applications of bituminous conglomerate and mastic membranes on an inclined face.

CEA, accompanied the precious collaborations with Universities and research laboratories, intends to develop new technologies and implement research projects to bring innovation to the construction of hydraulic basins, a consolidated sector on techniques of undoubted effectiveness but certainly implementable.