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HOSE LINING OF WATERMAINS ON LARGE SCALE
The 'case' of Bosa Watermain, Sardinia, Italy

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ABSTRACT: In the region around Bosa, Sardinia, an ageing asbestos cement pipeline DN500, suppling around 8,000 inhabitants with potable water, was in need of rehabilitation. Frequent breaks and leakages repeatedly led to interruptions of the water supply, since this pipe is the only supply line in the area. The pipeline running through the Temo river valley to a dam is located in a difficult to access area with no public access roads. The mountainous terrain is also protected by numerous environmental regulations. Under these conditions, an open rehabilitation of the pipeline was impossible and ruled out from the start. A variant study was conducted considering different trenchless solutions such as sliplining with HDPE, CIPP and Hose Lining. The variant study concluded that significant technical and economic advantages could be realized using the Hose Lining system over other methods. In addition, installation risk at the site was reduced significantly using a fully factory produced and quality-controlled product. Furthermore, the construction time frame could be minimized. The network operator therefore opted for a trenchless renovation with Hose Lining and company Benassi was the successful bidder and contractor of this job. Access to the pipeline was provided via several existing manholes along the route, so that excavations could be completely avoided. After the preparation of the bypass, the existing host pipes were drained and inspected. Then, the liner was pulled in, inflated and the customized wall-mounting connectors were installed. Finally, the pressure test was carried out before the line was put back into operation. The bypass was then emptied and prepared for the next installation segment. Overall, the project was divided into six sections corresponding to three bypass segments. For each section, the same installation steps were carried out. In this way, the drinking water supply could be maintained without interruptions during the entire construction period.

1. INTRODUCTION

For years, the watermain panorama has been affected by problems relating to the poor state of conservation of the pre-existing hydraulic infrastructures.
If we look in particular at the state of the large adducers watermains, pipelines of fundamental strategic importance, their age together with their orography may have generated over time situations of disservice in the supply of water sources.
In these situations, the difficulties increase when the network operator has to face to work with asbestos cement pipelines. The extension of asbestos cement pipes in Italy is estimated to be around 125,000 km. Starting from 1916 asbestos cement pipes, with diameters generally between 150 mm and 500 mm, were in fact used for the construction of water networks; their use continued steadily from the 1950s to the 1980s due to their 'optimal' properties: the dangers of asbestos fibers were still unknown.
With the aim of including the 'trenchless technologies' within this context, there has often been talk of their use to overcome single critical situations in the context of large-scale water network reconstruction projects (for example the crossing of routes of communication). The extensive use of trenchless technologies during the execution of a large-scale water reconstruction project has been a rare condition.
The Italian network operator of the integrated water service in the Sardinia region, was able to seize this opportunity by taking care of the rehabilitation using trenchless techniques of 6 km of a DN500 watermain in asbestos cement located in Bosa (Sardinia).

The aging of the watermain, dealed to frequent breakages that involved water leaks and consequent periods of suspension of the supply in order to allow the execution of repairs. Specifically, the watermain section that was subject to rehabilitation with trenchless techniques without excavation was the one located between the Barasumene pressure divider and the Montecrispu dam, for a total length of over 6 km, within areas protected by environmental constraints without public access roads. The orography of the Temo river valley along which the watermain runs, was decisive in the choice of intervention with no-dig technologies, considering that it was practically impossible to plan maintenance with traditional techniques. . In addition to this, the presence along the path of several pits with valves and fittings of the watermain, has made possible to proceed by exploiting these access points to the pipeline, completely eliminating the need of carrying out punctual excavations.
The watermain was the only supply source of Bosa and several villages around, therefore wanting to proceed with an extensive rehabilitation project, it was necessary to study, organize and prepare an appropriate bypass system that would allow the water supply to these areas to be guaranteed for the entire duration of the work.
In the conditions just described, although even the thought of proceeding with traditional techniques was considered impossible, programming an intervention with trenchless techniques was nevertheless difficult. The daring work was completed with efficiency by the trenchless division of the Benassi Srl company, whose high degree of specialization made possible to obtain a final result of unprecedented quality characteristics.

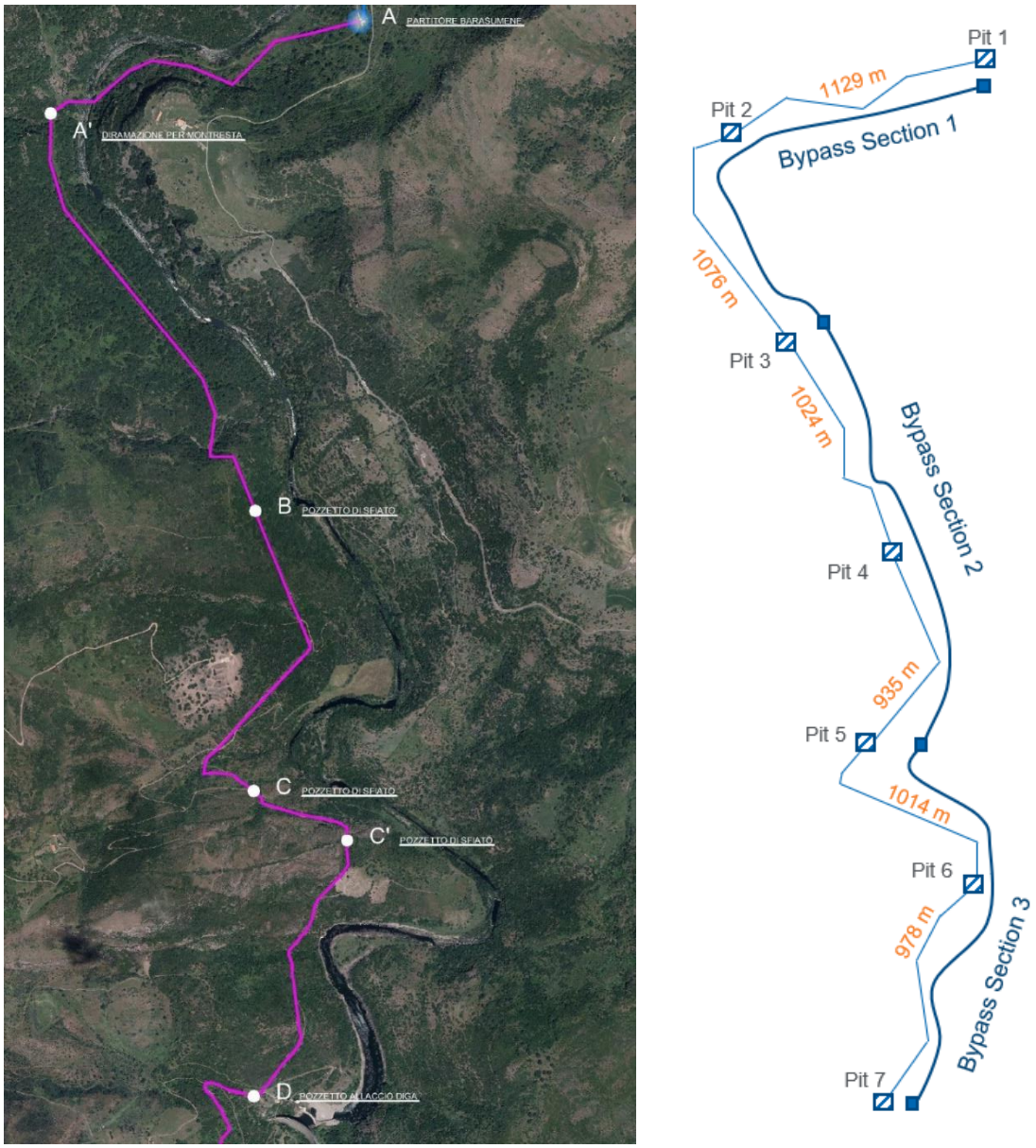

Figure 1 - Plan of the rehabilitated section and rehabilitation scheme

Figure 2 – Barasumene pressure divider (starting point) and Montecrispu dam (ending point)

2. REHABILITATION TECHNOLOGY

The trenchless technology chosen by the network operator was the Primus Line System, which consists of the use of a flexible multilayer reinforced hose liner, with the unique feature of its kind of an intermediate reinforcement layer entirely made of Kevlar® , synthetic aramid fiber that allows to reach high operating pressures, guaranteed over time, and special pieces specially developed to anchor the tubular to the ends of the restored sections named connectors.
The reinforced hose is self-supporting, i.e. able to fully absorb the internal pressure of the transported fluid, not adhering to the pipe, leaving an anular gap. Figure 3 schematically indicates the three different layers of which the hose is constituted.
The outer layer that protects the internal Kevlar® bearing core during the installation process, independently from the kind of fluid transported, is made of abrasion-resistant polyethylene (PE). The core structure is made of a seamless Kevlar® layer. The aramid fabric absorbs the traction force during insertion of the reinforced hose and the entire operating pressure. The internal layer provided for the transport of drinking water is made of polyethylene PE suitable for contact with drinking water. The flexibility of the reinforced hose allows a compact transport of thousands of meters of tubular wrapped on reel that can be inserted into the host pipe by means of an hydraulic winch, even in the presence of bends.
The second part that compose the Primus Line System is represented by specially developed fitting pieces: the connectors. Connectors for medium pressures pipes consist of an internal profiled core and an external sleeve. During installation, a two-component resin injected through a valve placed on the external sleeve, forces the the tubular into the shape of the inner core. After the hardening time of the resin, the connection is permanent and has a high strength. Each end of the connectors is equipped with a standard flange for reconnection to the host pipe or for the insertion of fittings. Furthermore, the system always allows for the supply of customized solutions for special applications, as in the case of Bosa where the configuration for anchoring to the wall of the pit has been provided for the need to insert each connector inside the existing structures saving space.

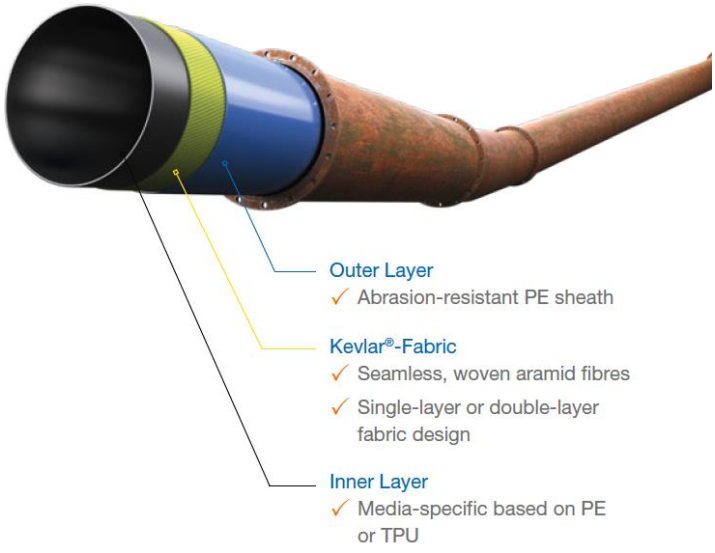

Figure 3 – Composition of the Primus Line hose liner

Figure 4 – Connectors customized for pits

3. PROJECT EXECUTION

In order to obtain the minimum impact on the pipeline and on the environment, Benassi operators proceeded operating directly and only in correspondence of existing pits sections, after removing the relative slabs, achieved by creating access tracks obtained by widening the existing paths.
Once the necessary access conditions were obtained, in order to optimize the execution of the work at the highest level and to minimize the out of service time of the pipeline, a precise organization of the intervention phases was undertaken:
- preparation of the bypass
- sectioning of the pipeline inside the pits
- preliminary video inspection operations
- insertion of the tubular and assembly of the connectors
- insertion of new special fittings inside the pits
- testing and re-put in service
- emptying and removing the bypass.

The particular and efficient setting of the bypass developed, made it possible to complete the intervention through a triple succession of the phases described above.
The bypass was created by means of the Primus Line system, taking advantage of its high flexibility in the difficult logistical working conditions.
The structure of the bypass, considering the use of about 1000 m of DN400 medium pressure Primus Line system and 1300 m of DN350 medium pressure Primus Line system, allowed to operate in 3 steps on sections of out-of-service pipeline of length equal to 2 km, and was hydraulically verified by Benassi trenchless division considering as aim to guarantee at the end of the watermain an hydraulic load value higher than, or equal to, the minimum that would have been obtained taking into consideration the original solution given by the network operator, which provided for the out of service the laying and preparation of 11 bypasses made with 1000 m of DN300 pipe.
In order to obtain optimal functionality / practicality in using the bypass system, Benassi trenchless division opted for a supply in sections having an average length of 255 m, already equipped with flanged end connectors (for a total of 9 sections: 4 DN400 and 5 DN350), each on 2 m wide drums. To proceed with the installation, protecting the material from abrasion as much as possible, minimizing the stress caused during the laying phase, a custom designed and manufactured hydraulic winder was used, towed along the track by means of an excavator.
Once the bypass had been put in service and the pipeline had been emptied, the special fittings present inside all the intermediate pits of the bypassed portion were disassembled and the inlet and outlet piping in the pits were cut with suitable equipment close to the concrete wall. The next activity was the execution, from pit to pit, of a preliminary video inspection aimed to check the absence of unsuitable conditions for the insertion of the Primus Line liner on each section (presence of internal obstacles, etc.).
Once the suitable condition has been checked in all the sections between the bypass start/end, the Primus Line liner was inserted, and the relative connectors were installed inside each intermediate pit. The high specialization of the staff together with the quality of the high-performance equipment used by the trenchless division of Benassi, have allowed the execution of single insertions with a length of 1 km. Preliminarily to each insertion, a feasibility check was carried out by the company's technicians together with the material producer taking into account the friction forces developed along the path.
Proceeding in this way it was possible to ensure the utmost care for the characteristics of the material, taking advantage of its performance linked to high tensile strength, and also to optimize logistics.

Given the type of material constituting the host pipeline, particular care was given to plan the operations on underground parts of the pipeline, carried out by duly trained personnel, as well as to the limitation of the dispersion of asbestos fibers during all phases of rehabilitation with no-dig technologies. Benassi has made available a unique equipment that allows to prevent the risk of dispersion of asbestos fibers caused by the sliding of the winch cable on the walls of the pipeline during the insertion of the Primus Line liner. The equipment in question consists of a mobile purification plant that performs the cleaning of the cable immediately at the exit from the pipe at the end of the section being renovated.
After the insertion phase of the Primus Line liner and the subsequent installation of the connectors inside all the pits of the section rehabilitated, was the time to install in series all the new special pieces placed inside the connector's finished pits. In order to guarantee a high quality of the installation, also from the point of view of the special fittings, valves and vents in cast iron produced by the German company VAG®, Viking Johnson® joints, Endress + Hauser® flow meter of the Proline Promag 400® line and finally special connection pieces in AISI 304 stainless steel were installed.
At the end of the rehabilitation activities, the testing of the renovated pipeline section was carried out between the start/end sections of the bypass and, subsequently, the reconnection to the rest of the line was performed.
Once the bypass had been emptied following the re-put in serive of the rehabilitated pipeline section, it was finally rewound for the next new laying involving the next 2 km of pipeline to be rehabilitated.

Figure 5 – Bypass laying phase

Figure 6 – Bypass installation phase

Figure 7 – Bypass view from the top

Figure 8 – Site area in correspondence of an insertion point

Figure 9 – Site area in correspondence of an arrival point

Figure 10 – Primus Line liner insertion

Figure 11 – Primus Line liner insertion

Figure 12 – Asbestos decontamination unit

Figure 13 – Use of customized equipment for the difficult logistic conditions

4. CONCLUSION

Each relining jobsite is a customized project and must be interpreted individually: working on the existing structures means find yourself operating in different conditions every time, the trenchless division of the company Benassi, specialized in the rehabilitation of watermains with Primus Line technology, has developed a dedicated procedure for rehabilitation of asbestos cement pipeline, training its staff and creating equipment dedicated to this type of solution, unique in their kind.
In the case of a large-scale trenchless projects such as the one of Bosa, this condition is amplified over the 6 km of extension of the network to be rehabilitated, consequently each operation carried out on each of the rehabilitated sections has led to a particular study related to the problems of the section itself. The trenchless division of Benassi together with Primus Lien staff is able to fully analyze the execution of complex projects such as that of the 6 km of Bosa, starting from the design and analysis of construction site problems for their subsequent resolution, guaranteeing in the implementation of an intervention of this kind the difference from any standard installation.

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