A UNIQUE EXAMPLE OF CLOSE FIT LINING TECHNOLOGY FOR THE RENEWAL OF WATER PIPES ALONG THE BRIDGE PONTE PUNTA PENNA IN TARANTO

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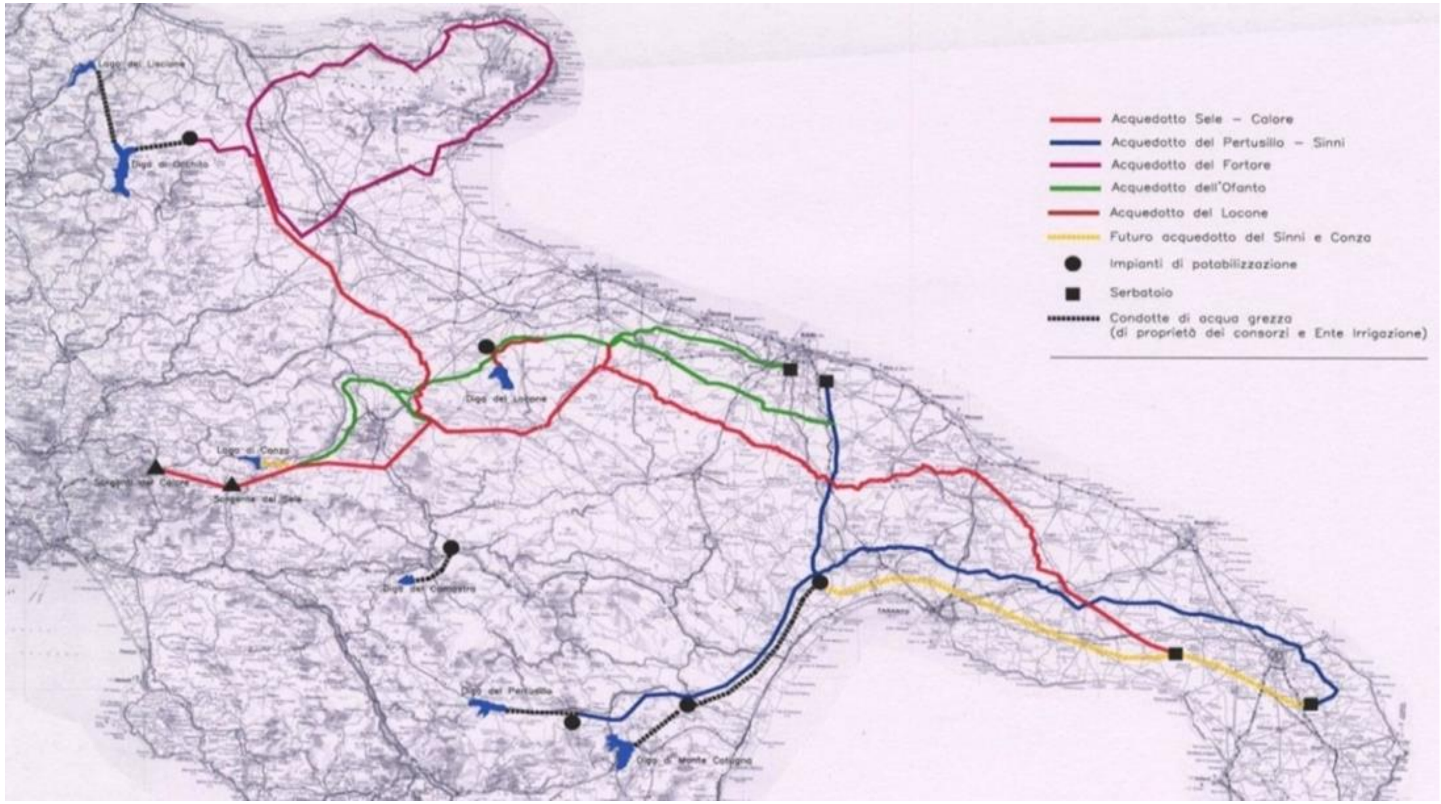
AQP cares about one of the most complex system in the world for drinkable water regarding its transport and distribution, characterized by different hydraulic devices, transport capacity and state of age - maintenance.



250 districts

25.000 km of pressure pipes: 5.000 km for supply and 20.000 km for distribution

It provides drinking water to 4 million citizens.

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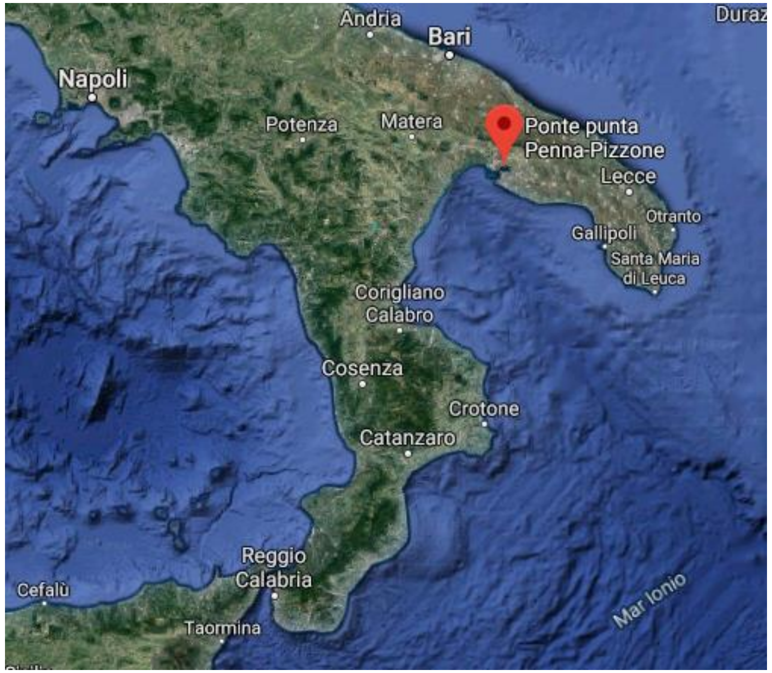
Geographical context in which the bridge is located.



Ponte Punta Penna: one of the longest bridge in Europe that connects two coasts.

The pipelines were built at the same time as the bridge, which was inaugurated on 30 July 1977.

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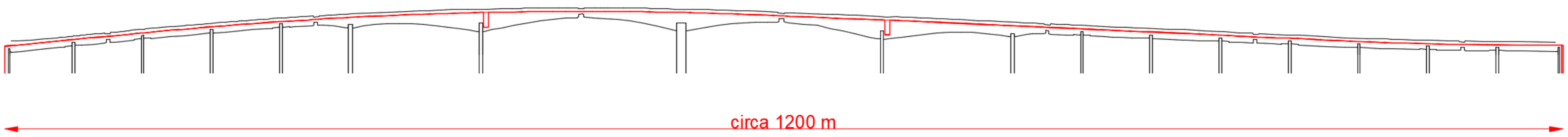
Length = 1200m Spans = 14 High = 47m



Material = steel

DN = 500mm

N.Pipes = 4

Water Flow = 500l/s

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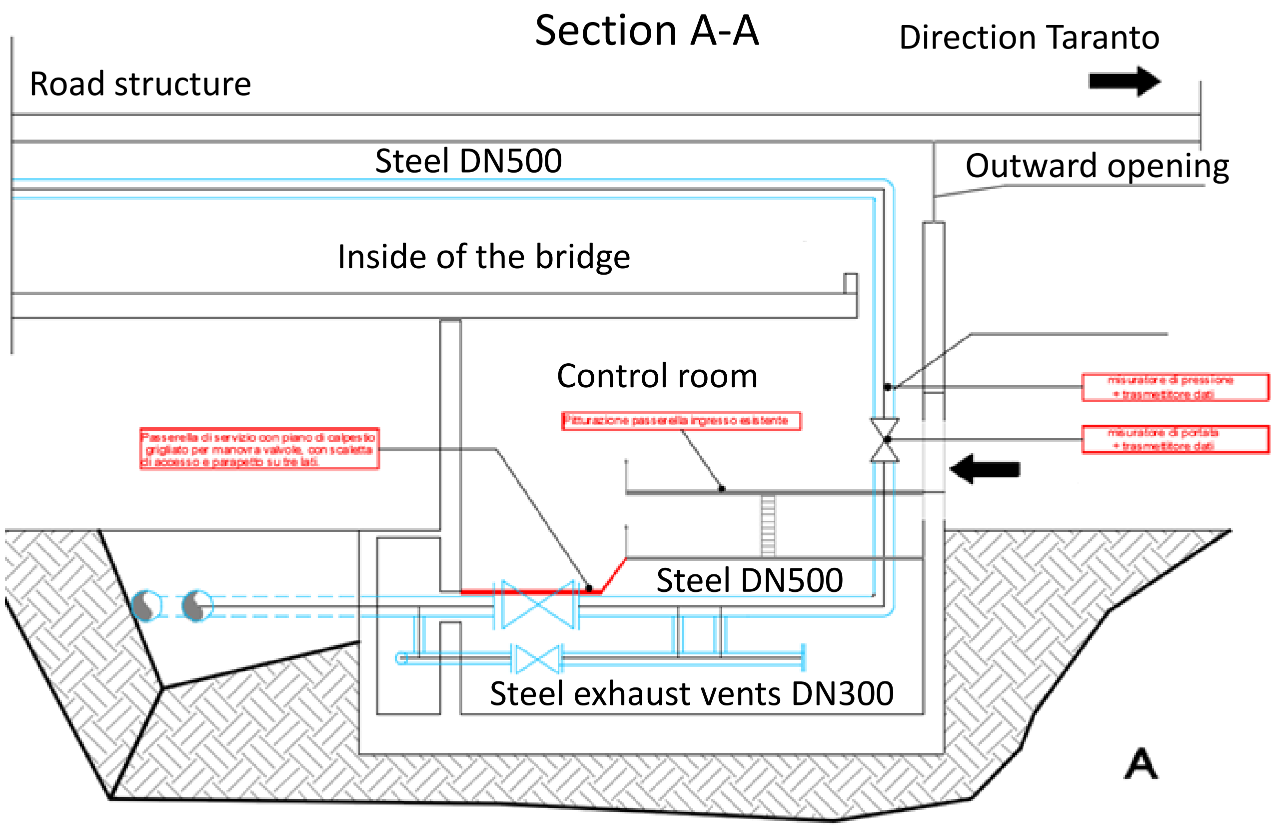
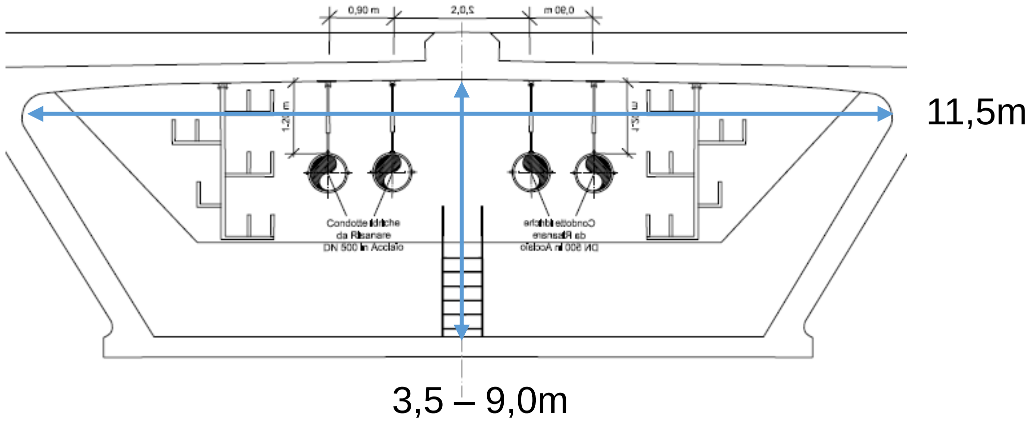


The distance between the height of the body's footsteps and the lower generator of the pipes varies according to the internal height of the body and is between 2.0 and 6.8 m.



The pipes are located at a distance of approximately 1.20 m from the roof slab.

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Status of fact and project solution

The inspection of the pipes in 2010-2011 pointed out

widespread advanced state of oxidation

severe steel deterioration

Rainwater entering from the overlying road structure

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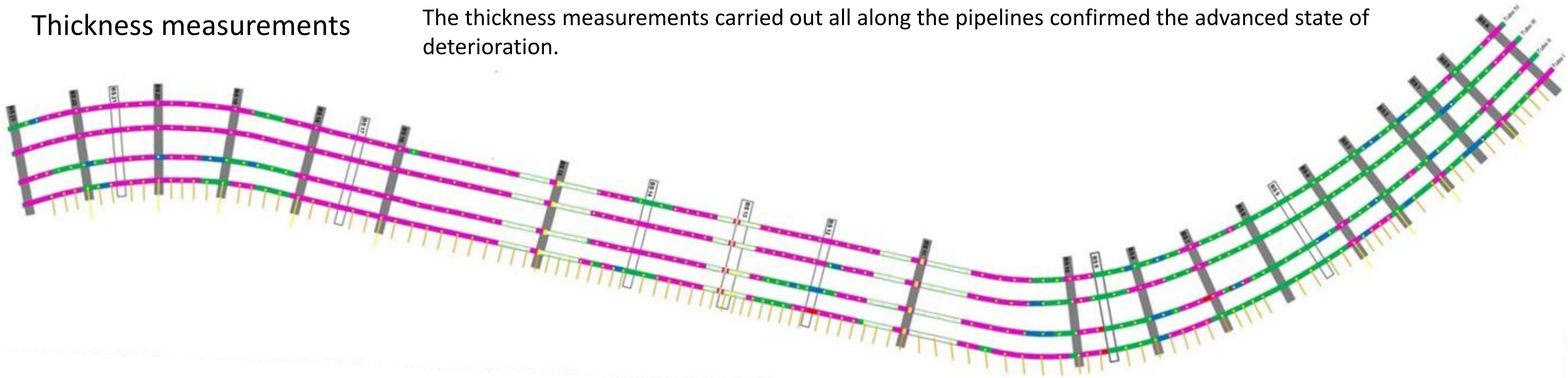
Thickness measurements

The thickness measurements carried out all along the pipelines confirmed the advanced state of deterioration.



- Pipe section with remaining thickness 7,5 - 8,0 mm
- Pipe section with remaining thickness 6,0 - 7,5 mm
- Pipe section with remaining thickness 4,2 - 5,9 mm
- Pipe section with remaining thickness 1,8 – 4,0 mm
- No measurable, no particular problem

→ the reduction of the wall amounted to 3 up to 4 mm and locally even up to 6 mm

Necessary to restore the structural properties of the pipes

The rehabilitation had to fulfill the following essential needs and it was also influenced by logistical and evinromental aspects:

- To guarantee the structural resistance and to give the pipes an adequate response to corrosive agents and environmental deterioration
- To limit the pipeline off-duty time and meet minimum service levels
- Presence of only two pedestrian access points to the deck of the bridge located at the opposite ends of the pipes
- The working enviroment inside the bridge does not allow the transit of large mechanical vehicles
- It was not possible to replace the existing pipelines from the surface, so as not to affect the structure of the bridge

→ NO DIG TECHNOLOGIE

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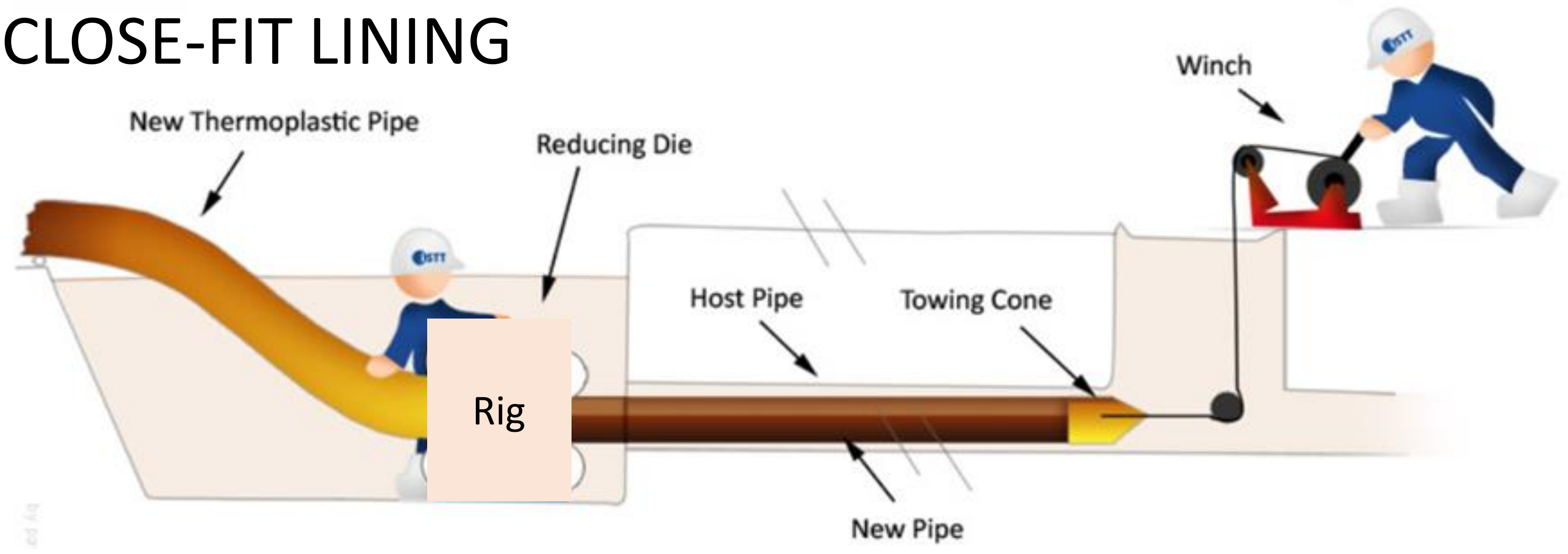
CLOSE-FIT LINING



Insertion of a new tube, composed of high-strength polyethylene, into each of the four pipelines. The new pipe is temporarily deformed and subsequently restored into the required shape and size to adhere perfectly to the interior of the existing pipe.

Avoidance of a significant reduction of the hydraulic section and obtainment of a new pipeline that guarantees its own structural resistance, independent of the support of the existing pipeline.

Advantages

Health and Safety

Reduction of the risks for all the work carried out by the workers inside the bridge

Environmental

No production of about 470 tons of existing pipe

Technical

Better resistance to corrosion of the working life cycle by 80 years

Citizen Discomfort

Maintenance from the outside. Minimum Out-of-use times of the pipelines

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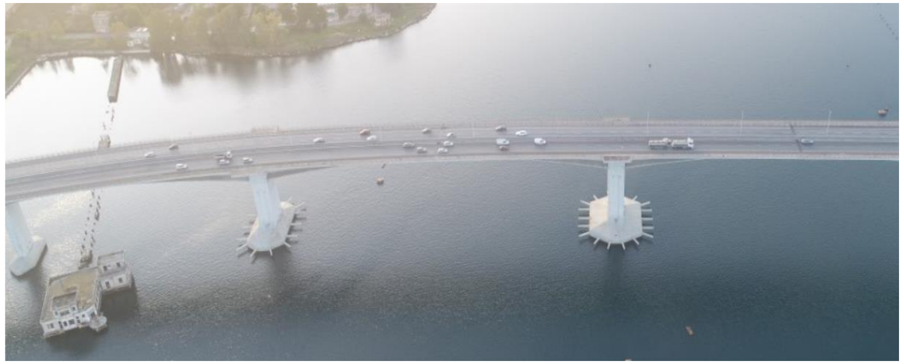
Major critical issues found

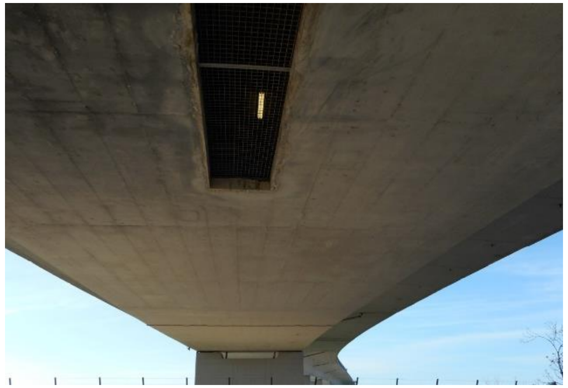
1. Steel pipes hanging inside the bridge

2. Inability to create new enterings in the bridge

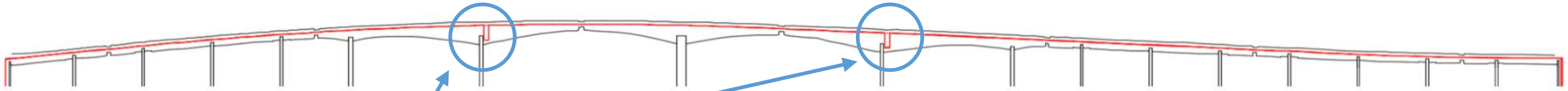


3. Insertion point of the piping

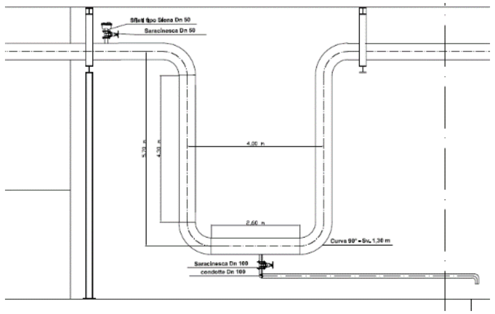
4. Winch positioning area



5. Pipes insertion length



6. Omega-shaped strokes



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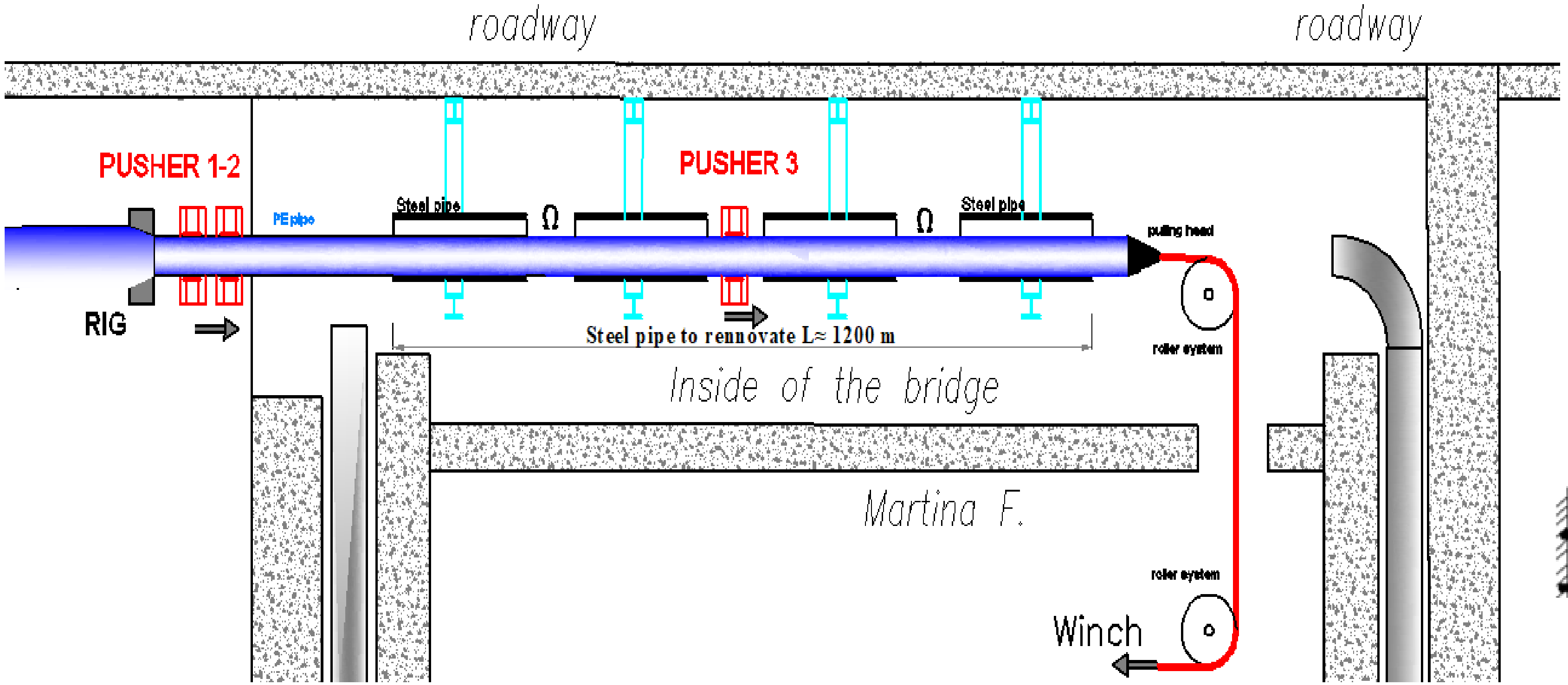
Crucial point: THE STUDY OF THE FORCES

The maximum friction force was expected to be registered at the point where the new pipe would have been inserted into the existing tube completely.

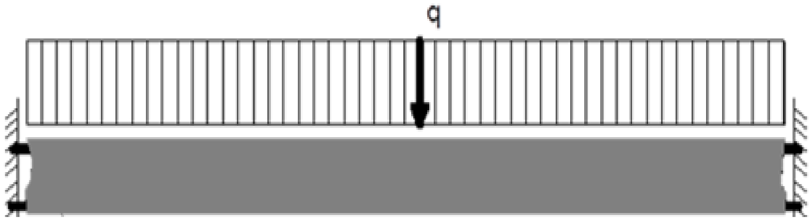


Minimum pipe thickness dimensioned:

$$q = W_{water} + W_{PE} + W_{steelpipe}$$

Additional verification for the case of serious corrosion phenomena on the existing pipe.

Detachment of an entire portion of the steel pipe between two adjacent supports, about 10,5 m apart



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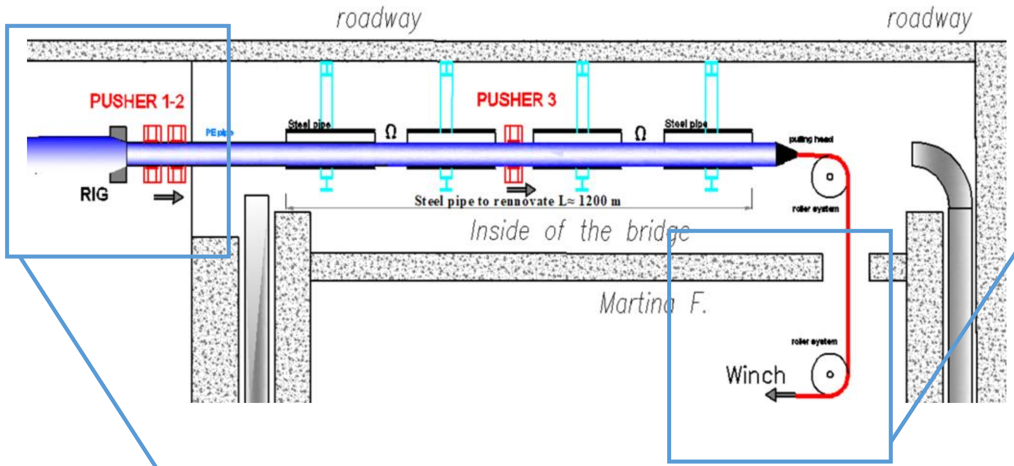
FORCES ACTING ON THE EXISTING PIPELINE



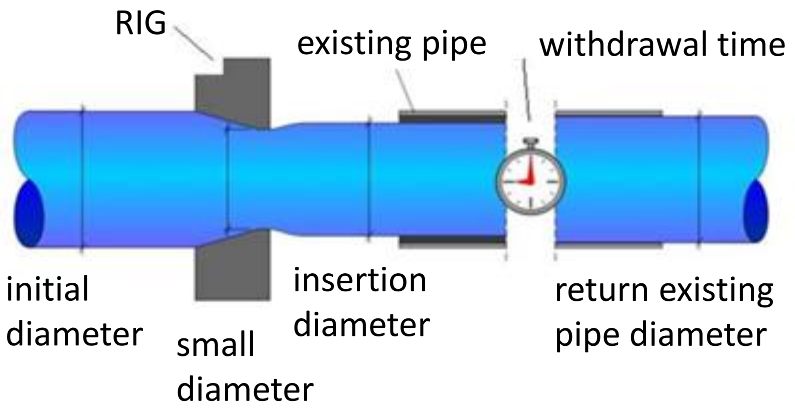
total force guaranteed by the winch

$$F_{tot.} = fs * (F_{RIG} + F_{IMM})$$

fs: safety factor

FRIG: force through RIG

FIMM: existing tube friction force



Pusher: helpin the draft, not pushing

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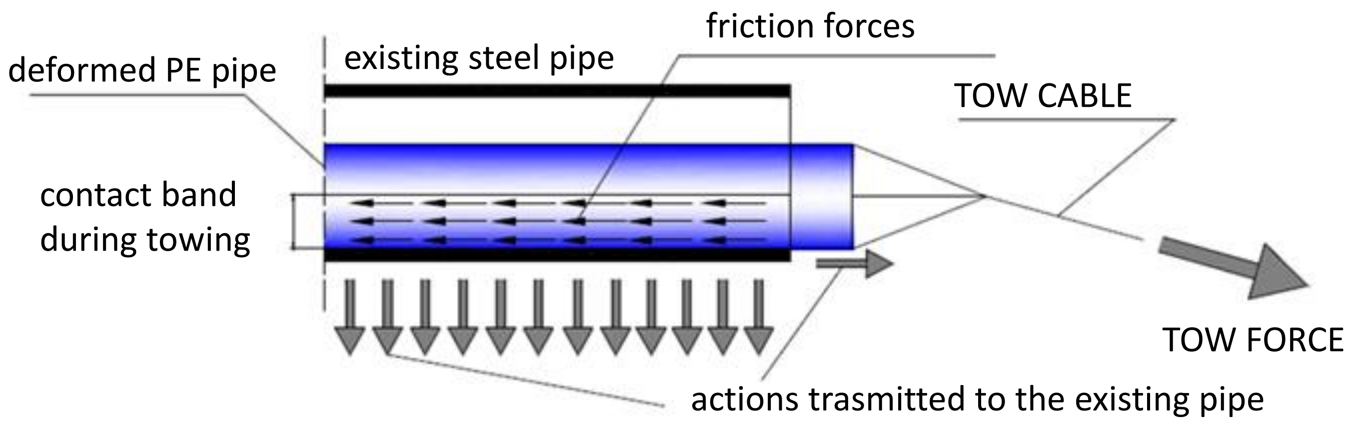
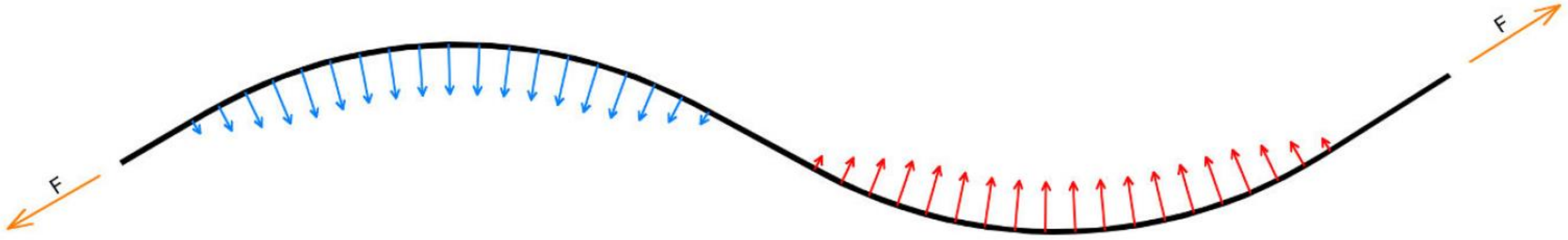
FORCES ACTING ON THE EXISTING PIPELINE

Longitudinal forces: TOW-FRICTION FORCE



Transverse and vertical forces: PLANE ALTIMETRIC DEVELOPMENT OF THE BRIDGE



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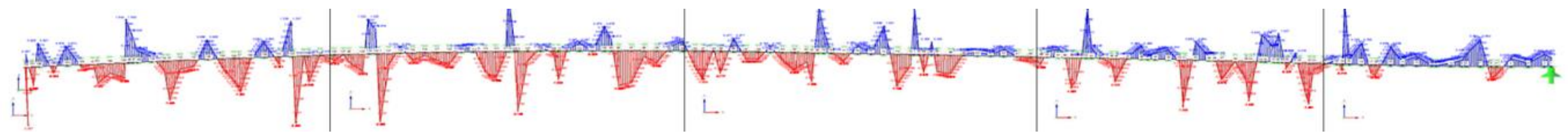
Knowing the Plano-Altimetric Prospect of the four pipes

3D FEM Model

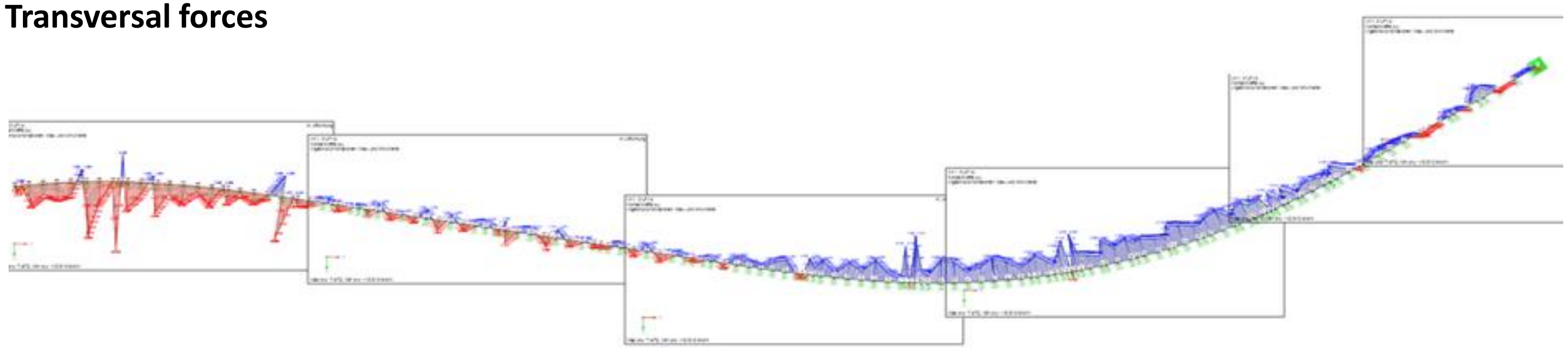
Stress Simulation

Three types of forces were considered: longitudinal forces deriving from friction and the pulling force respectively and transversal forces from the plane-altimetric course of the bridge.

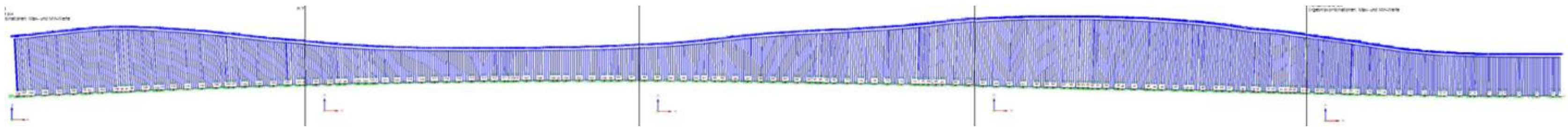
Vertical forces



Transversal forces



Longitudinal forces



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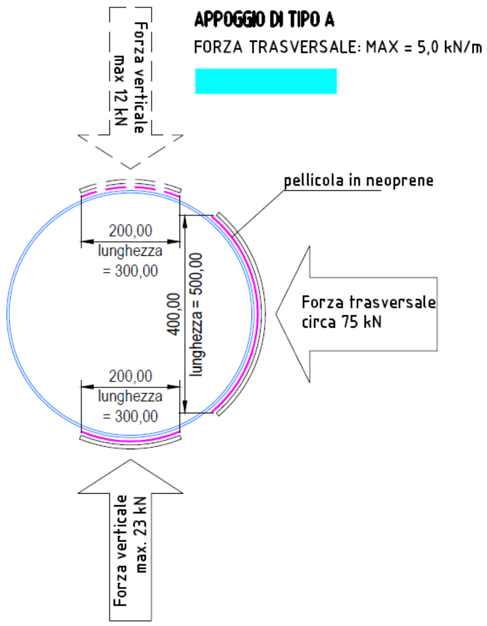
Not continuous ground support

On the basis of the 3D model, three types of supports were calculated: one for highly stressed areas, one for medium forces and one for straight sections.

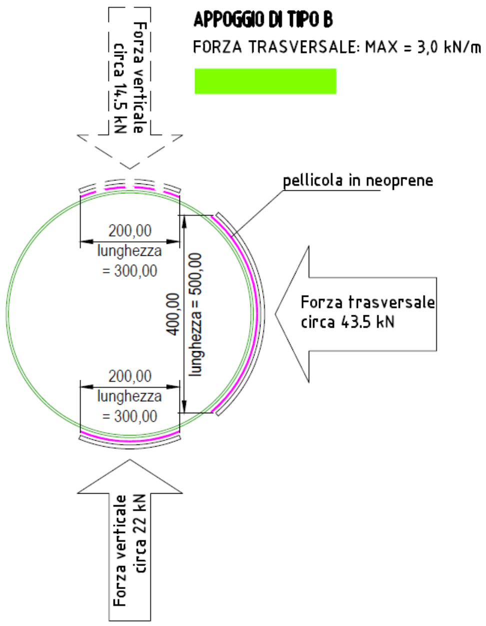
N°		
69	tipo B	S2
70	tipo B	S4 S2
71	tipo B	S4 S2

N°		
79	tipo C	S4 S3
80	tipo C	S4 S3
81	tipo A	S3 2xS5 S3 2xS5

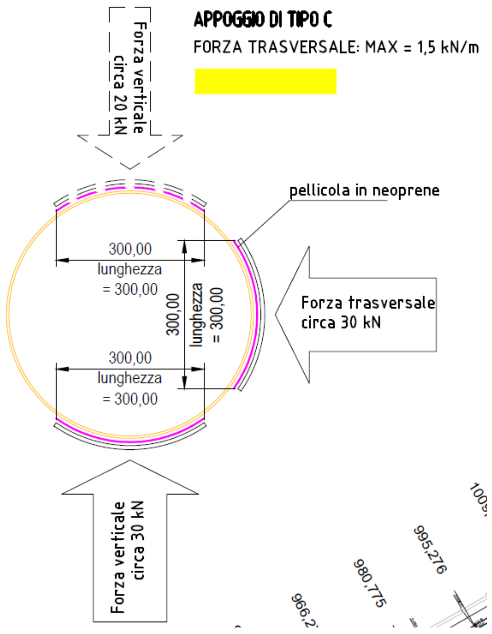
Highly stressed area



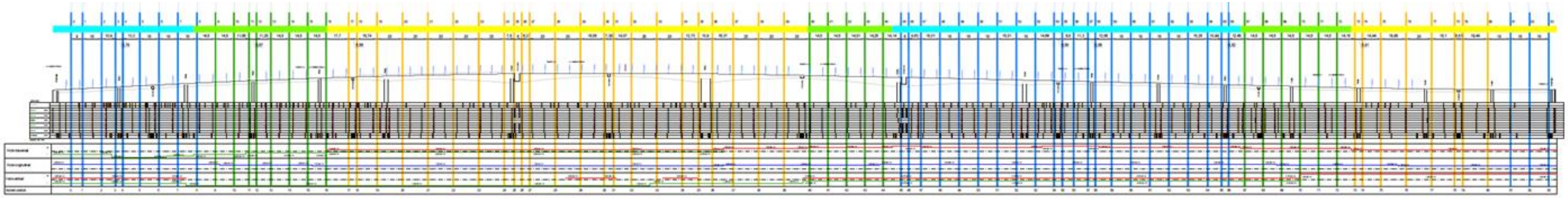
Medium stressed area



Low stressed area



85 shoring systems were installed



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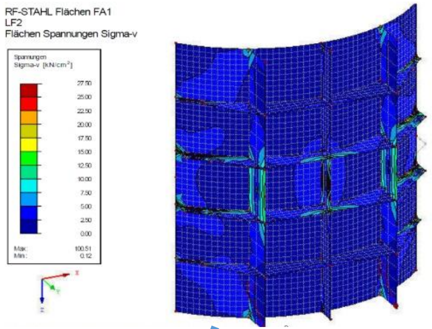
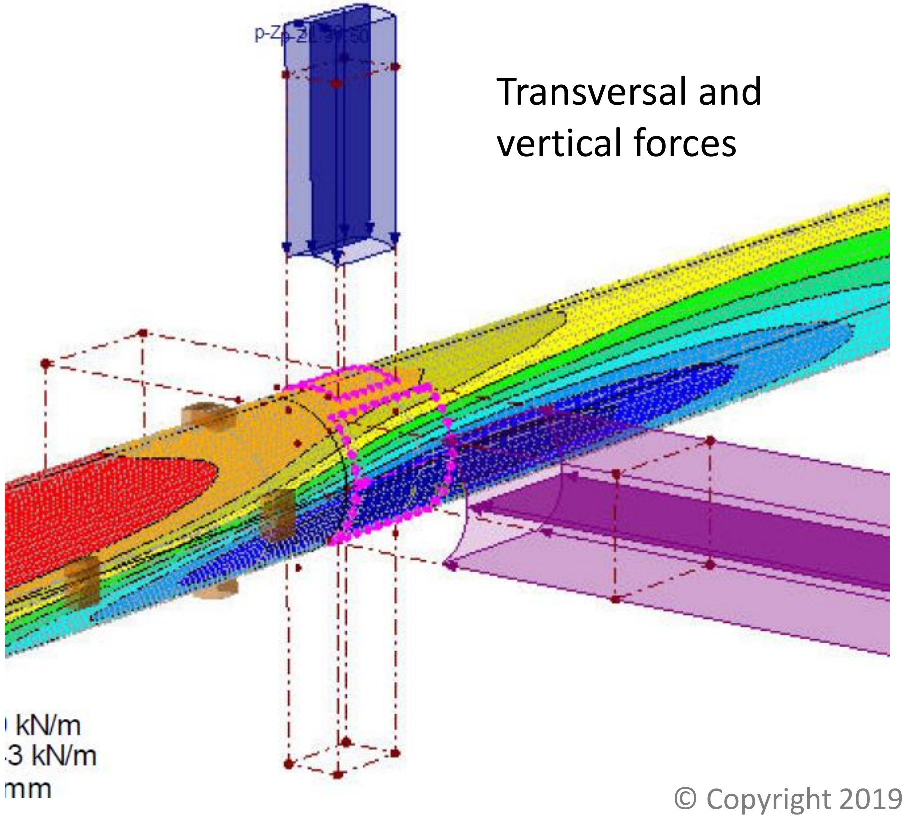
Specific design of structures for each section in order to avoid local concentration of loads

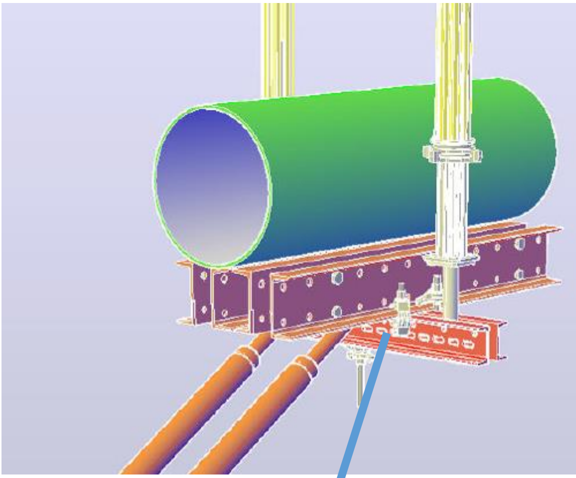
Saddles with steel plates and temporary support to distribute force





Transversal and vertical forces

Longitudinal forces



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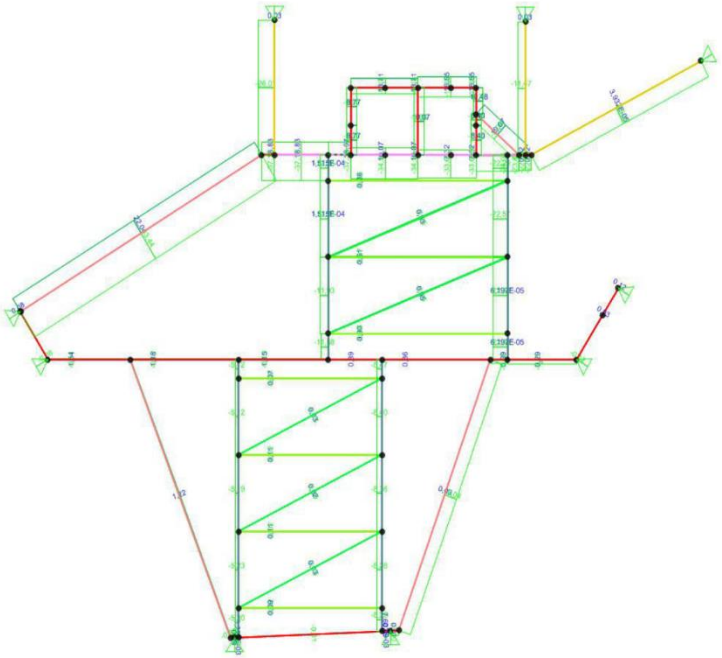
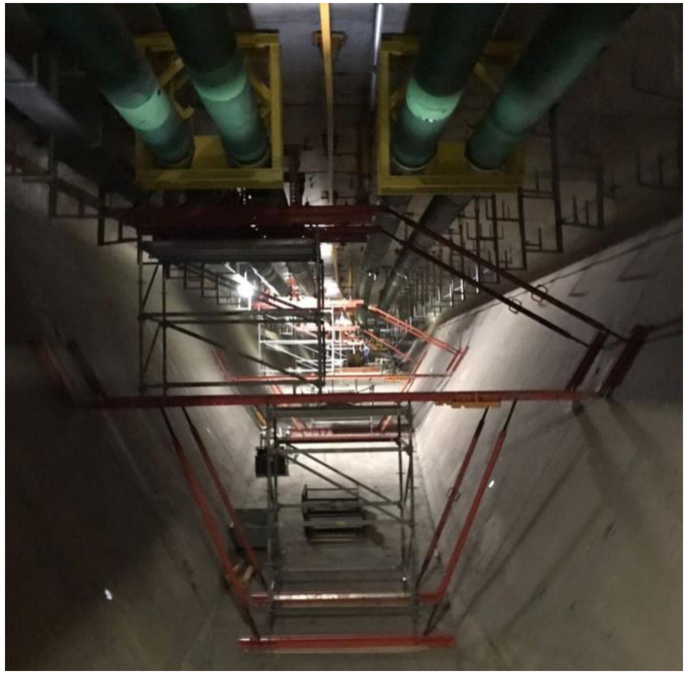
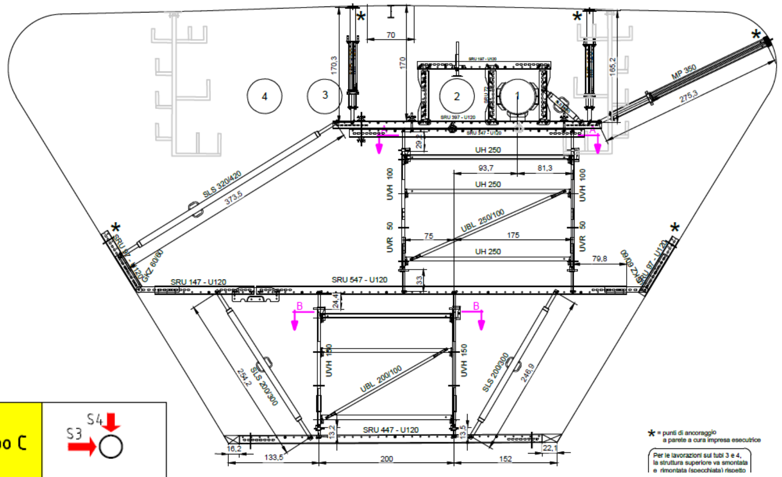
A prop for the longitudinal force and two others to avoid a vertical resultant on the existing pipeline were placed every 50m in order to counteract the longitudinal force.

69	tipo B	S2







79	tipo C	S3 S4

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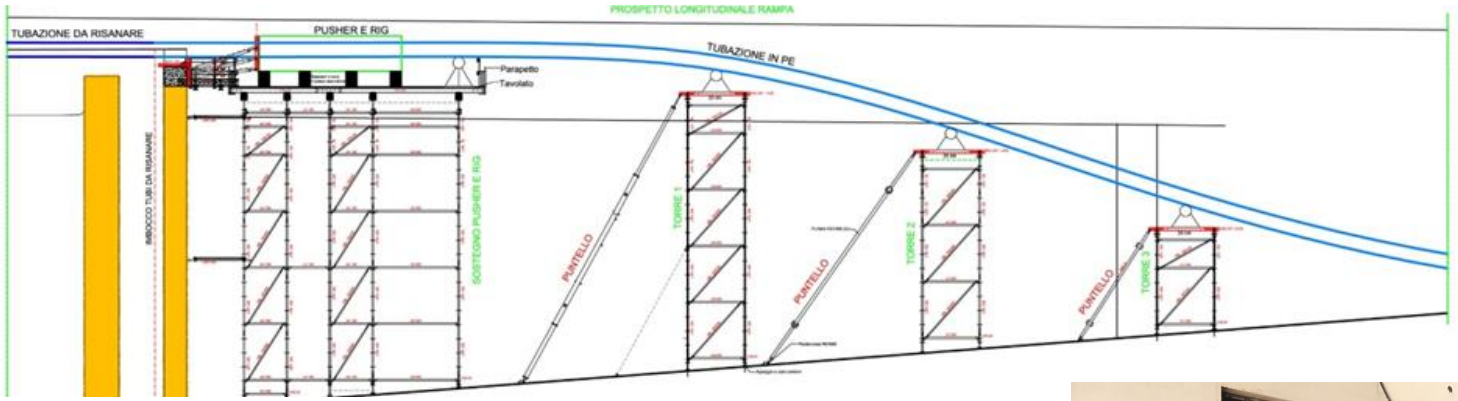
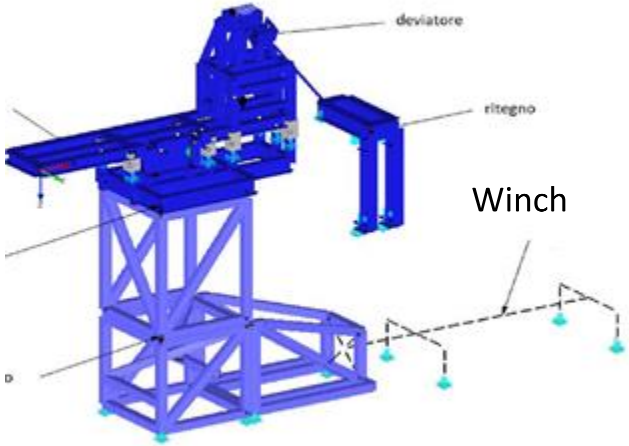
Temporary support structures to ensure that the pipeline reaches the required insertion height

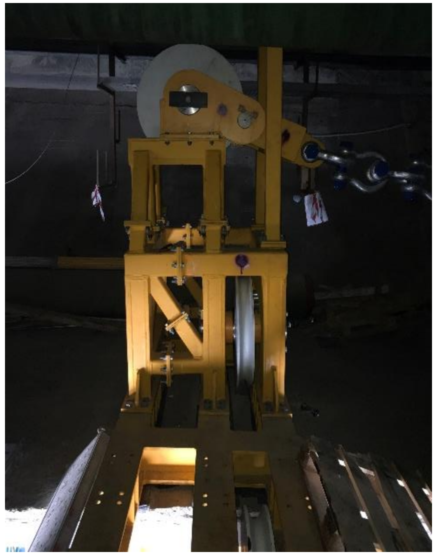


Design of a system of pulleys, allowed the cable to be diverted until it was aligned with the axis of the pipe to be repaired.

The winch was equipped with a system of ropes and bottle pulls for these pipes.



Winch



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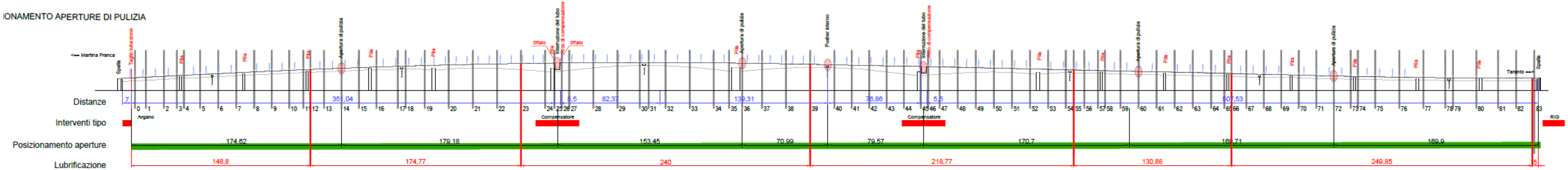
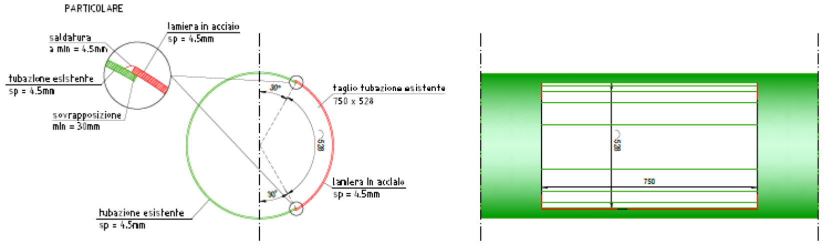


Preparatory works to ensure the best possible installation result were undertaken. Those included the mechanical cleaning and the insertion of a test tube inside the pipeline to detect possible obstacles.

The cleaning was alternated with the calibration of the pipe to verify that the internal section was constant and free of protrusions and deformations



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PE pipe bars (L = 20m) are joined by mirror-head welding.
4 sections of approximately 400 m each have been prepared on special rollers arranged along the local road network. In this way, the number of welds carried out during the insertion phase has been reduced to 3.

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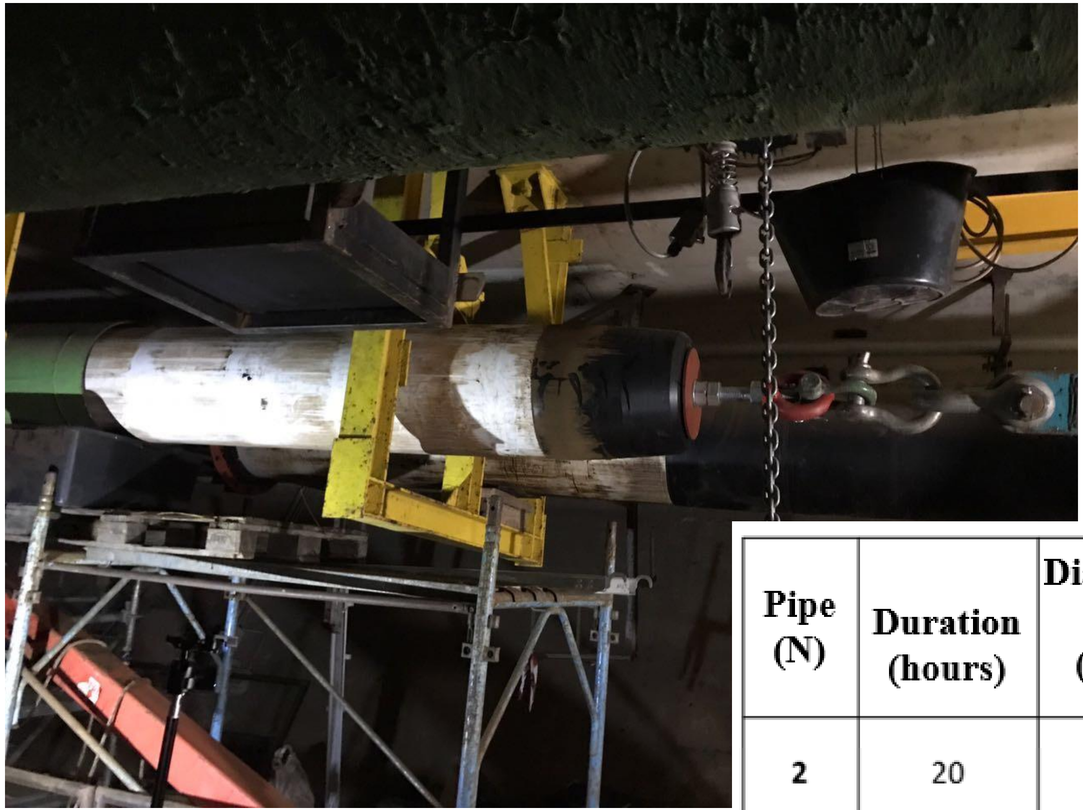
The four new pipelines, after being welded piece by piece on site, brought to the entry point of the bridge and reduced in diameter through a rig, were pulled to the other end of the bridge

The final Project

The final Project



The insertion and pulling phase of the approximately 1,200 m of new PE pipeline was carried out seamlessly, with an estimated time for the completion of the relining of an entire pipeline of about 20 hours. In the execution phase, the forecasts were substantially complied with.

Pipe (N)	Duration (hours)	Diameter RIG (mm)	Diameter PE Pipe (mm)	Diameter Reduction (%)	Temperature PE pipe (C°)	Max. Towing Force (KN)	Lengthening (%)
2	20	440	500	12	17 - 24	500	4,0
3	14	450	500	10	10 - 20	500	2,1

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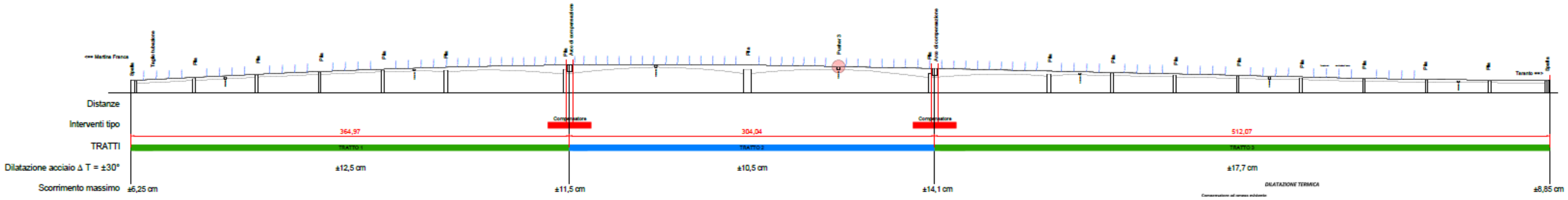
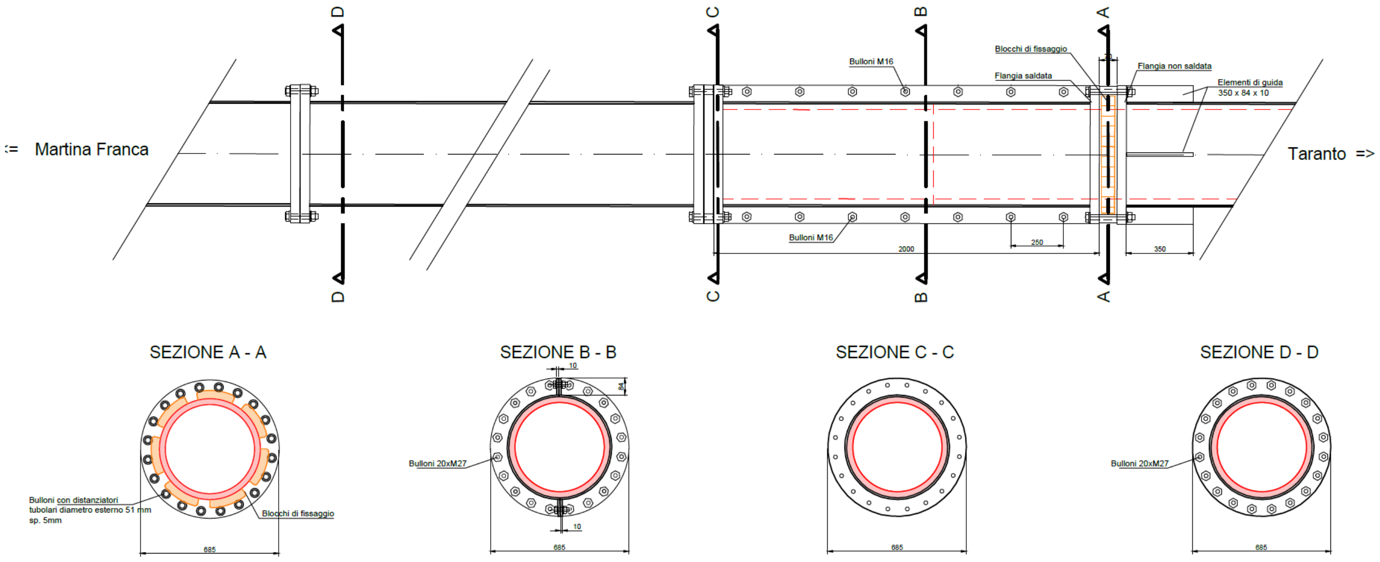


The rehabilitation was completed by the following activities:

Stopping the pulling force and depletion of the retreat phase.

Locking the PE pipe and restoring hydraulic connections.

Reconstructing the structural continuity of the original pipeline.



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Thank you for your attention