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INSTALLATION OF PRE-SUPPORT STEEL PIPES TO PROTECT AN HISTORICAL BUILDING BY A RETRACTABLE MTBM

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1. INTRODUCTION

The jobsite where this very special trenchless process has been applied is for the construction of the new railway station of Piazzale Flaminio as part of the modernization of the "Piazzale Flaminio-Riano" section of the "Roma - Civita Castellana - Viterbo" railway line, consisting of the following main parts of the work (Fig. 1):

- the station atrium, intended to allow access from Piazzale Flaminio to the quay tunnels and the underground connection to the Flaminio station of the Metro Line A
- the quay tunnels
- the two line tunnels, up to their interconnection with the existing tunnel

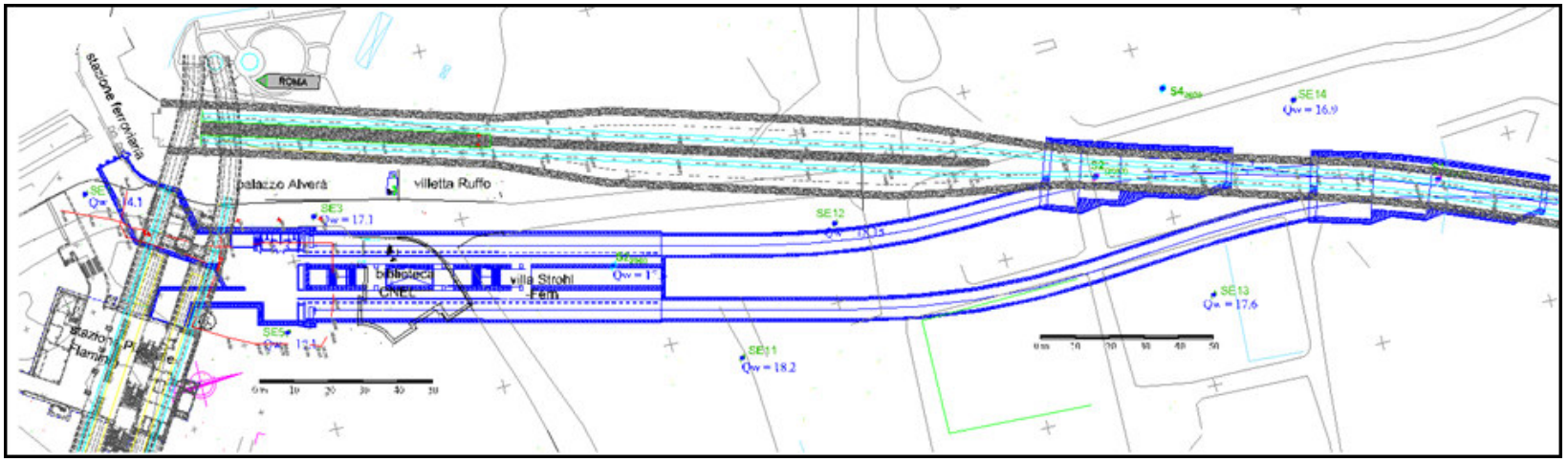

Fig. 1 – Project plan overview

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This underground work is particularly delicate due to:

- the urban context in which it is located for the interference with preexisting buildings, including those of historical value as CNEL Library (Fig. 2)
- the importance of the excavations (up to 16 m)
- the interference with the facilities of the existing Metro A station (in particular, with the quay tunnels, the line tunnels and the balancing chamber)
- the interference with archeology, finding a diverticulum of the "Flaminia Antica" Roman street (Fig. 3)

Fig. 2 – CNEL historical Library

Fig. 3 - Roman street and struts

The atrium structures are made in part with open-air excavations supported by concrete piled bulkheads, internally contrasted by means of temporary struts (Fig. 3) and partly under the floor (top & down). The bulkheads of the atrium are also adjacent to the buildings of the existing Piazzale Flaminio railway station, Palazzo Alverà, Villetta Ruffo and the former historical building of the CNEL Library.

The three arches of the quay galleries are 102 m long and are built in natural. In the initial section the station tunnels undergo the CNEL Library historical building with very low coverage (Fig. 4 and Fig. 5).

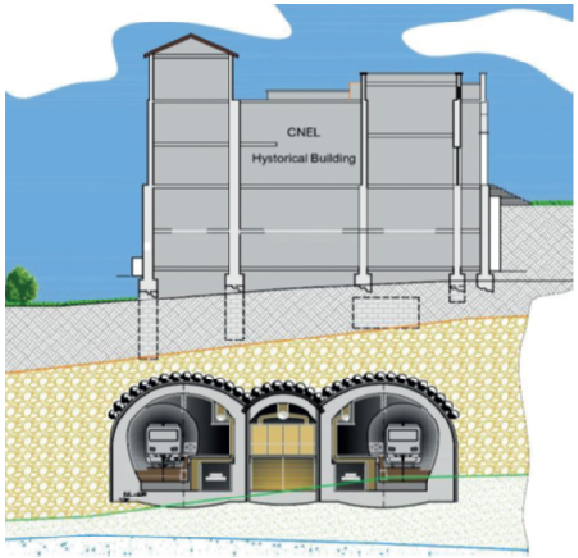


Fig. 4 – CNEL position (sketch)

Fig. 5 – CNEL position (picture)

For this reason, the ground movements induced by the construction of underground works are kept under constant control by a substantial monitoring system, which is continuously measuring and eventually automatically informing the Control Structure about movements not allowed.

In order to minimize the effects induced on the surrounding and overlying buildings, the excavation of the station tunnels is preceded by the installation of n° 36 steel pipes DN 800 mm connected to the ground and filled with concrete, to "draw" the upper contour of the three galleries, with pre-support function for the subsequent safe execution of the tunnels. The installation of the pre-support steel pipes has been performed by a Micro Tunnelling Boring Machine (MTBM) with auger soil removal.

2. PROJECT GEOMETRY AND PHASES

The n° 36 pre-support steel pipes have been installed by a leading Italian trenchless Company named P.A.T.O. S.r.l. represented here as also during the whole project period by Dr. Eng. Riccardo Miotto, Project Manager and Technical Director.

The geometry and the sequence of the drilling phases for the pre-support steel pipes are represented in Fig. 6-7-8-9-10.

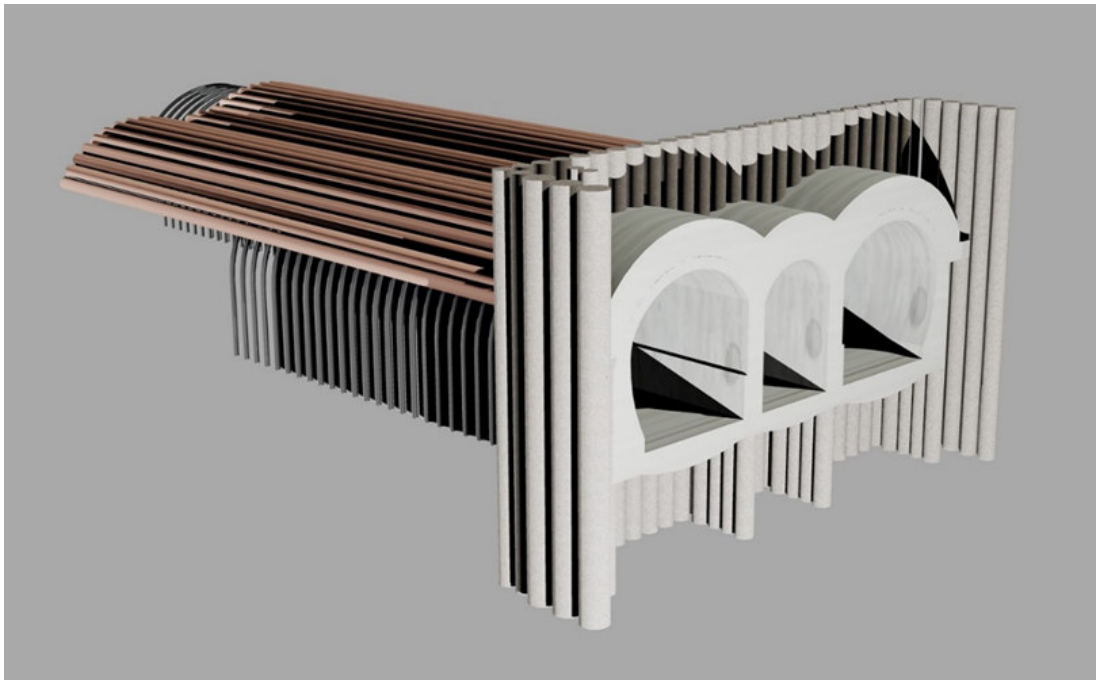


Fig. 6 – 3D geometry of MTBM works

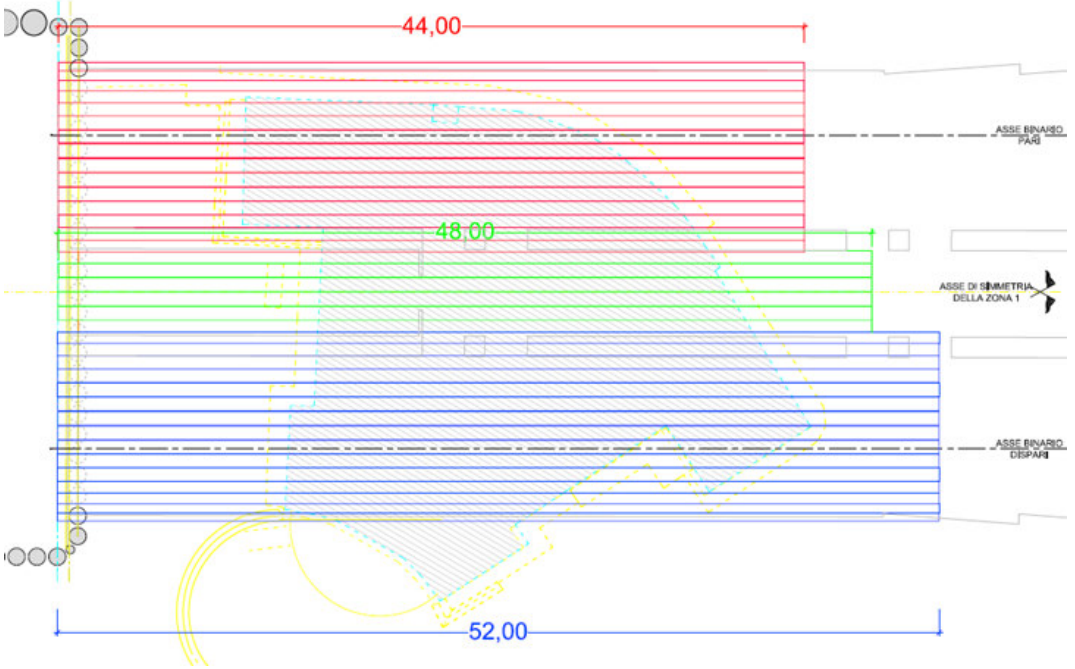


Fig. 7 – planview geometry

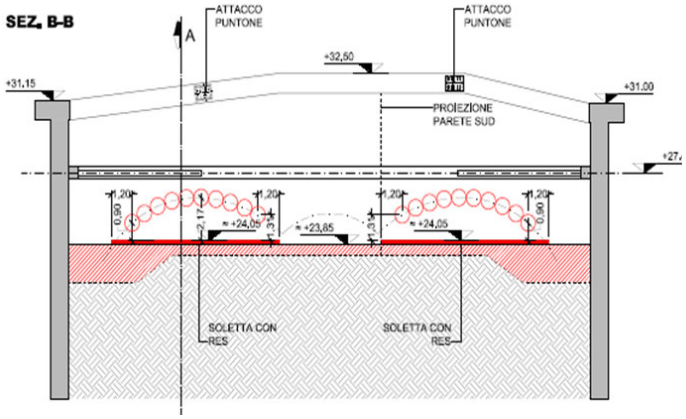


Fig. 8 – drilling phase 1

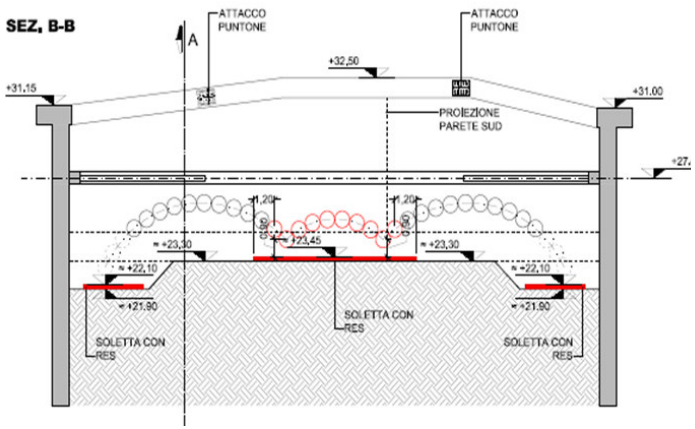


Fig. 9 – drilling phase 2

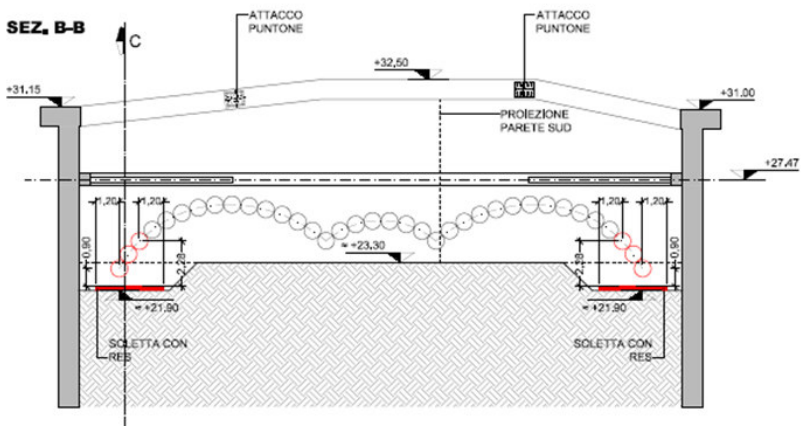


Fig. 10 – drilling phase 3

3. MAIN "SPECIAL" CHARACTERISTICS OF MTBM AND PROJECT

Considering the particular geotechnical and environmental situation, this project has been developed by a really expert Design Team composed by University professors, skilled geotechnical and structural engineers and trenchless specialists. In fact, the Micro Tunnel Boring Machine (MTBM) was designed and created ad hoc - for the first time in the world - for this project, where it was necessary to guarantee at the same time:

- **AUGER DRY SOIL REMOVAL, NOT TO "DISTURB" THE GROUND BUT ABLE TO DRILL THE FOUNDATIONS OF THE CNEL BUILDING, INTERSECTED IN SOME POINTS (Fig. 11):**

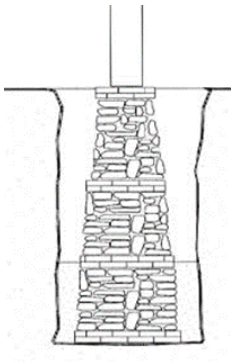
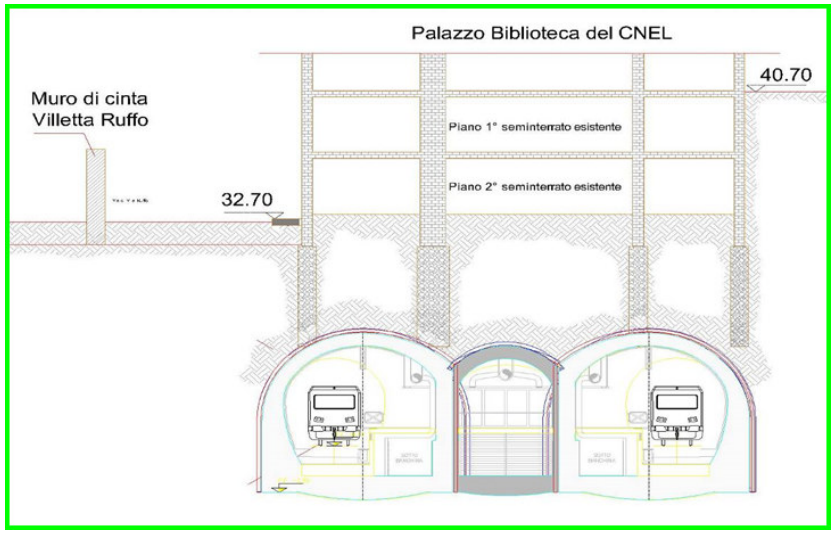


Fig. 11 – CNEL "sack" foundations



The geological situation (cemented sand with travertine concretions – Fig. 12) with also the presence of the CNEL "sack" foundations required a special cutting disc and soil removal device (Fig. 13 – 14).

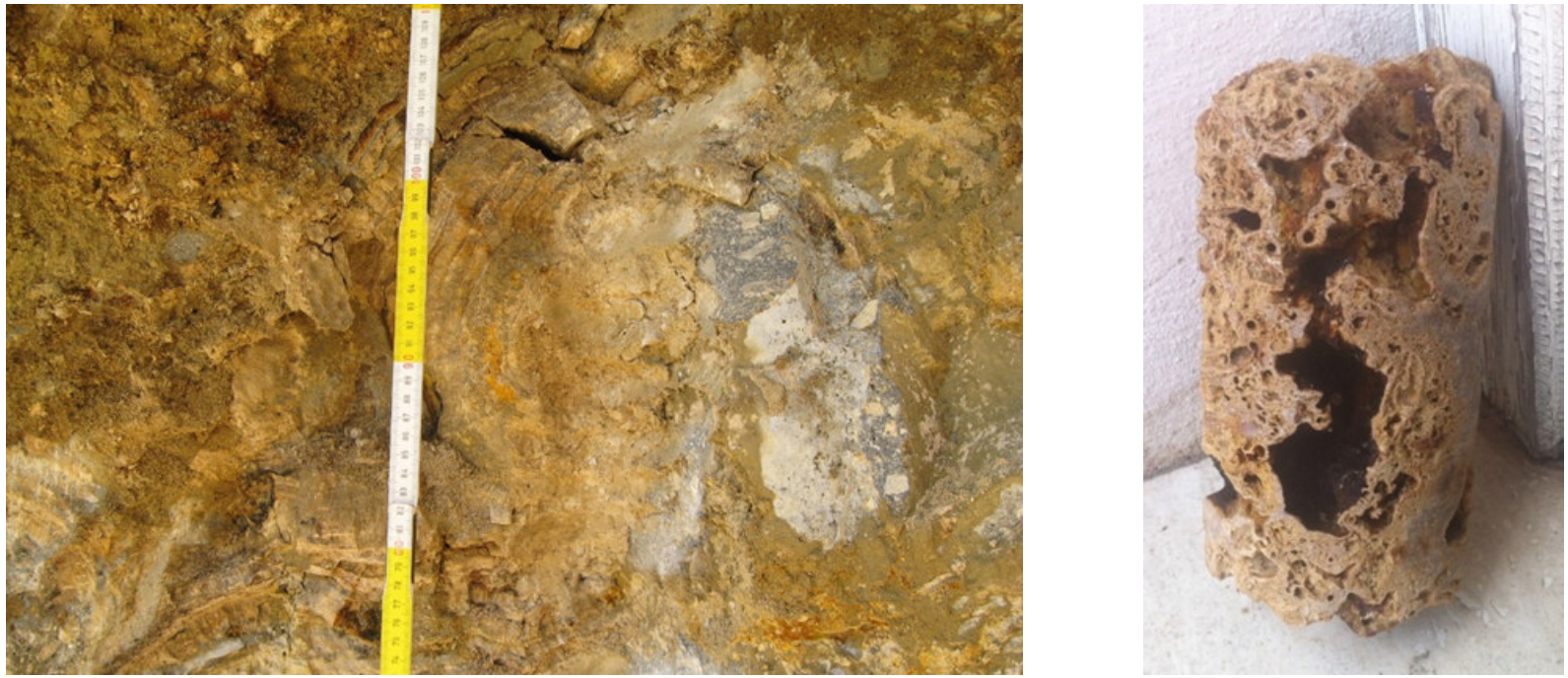


Fig. 12 – geological situation

Fig. 13 – cutting disc with auger soil removal

- **RETRACTABLE MTBM, DUE TO THE IMPOSSIBILITY OF REALIZING A MTBM EXTRACTION SHAFT EITHER FOR ARCHAEOLOGICAL AND ENVIRONMENTAL REASONS:** this project request has been satisfied producing an MTBM with a special double gripper device (Fig. 14) and a lost ring connected with the MTBM with sacrifical bolts during drilling. When finished the drilling, the MTBM is retracted back inside the steel pipe which blocks the lost ring and brakes the sacrifical bolts keeping the ring in the ground (Fig. 15)

Fig. 14 – double gripper device

Fig. 15 – Lost ring

- **<u>LASER/TARGET GUIDED AND STEERABLE MTBM</u>, ABLE TO GUARANTEE THE DESIGN POSITION OF THE DRILLING AXIS WITH A MAXIMUM DEVIATION OF 20 MM:** the geometry of this project requires a very high accuracy on the positioning of the steel pipes because they must be very close each other but not in contact. See in Fig. 16 the the laser target, in Fig. 17 n° 3 steering cyclinders and in Fig. 18 the jacking frame connected to the remote control cabin.

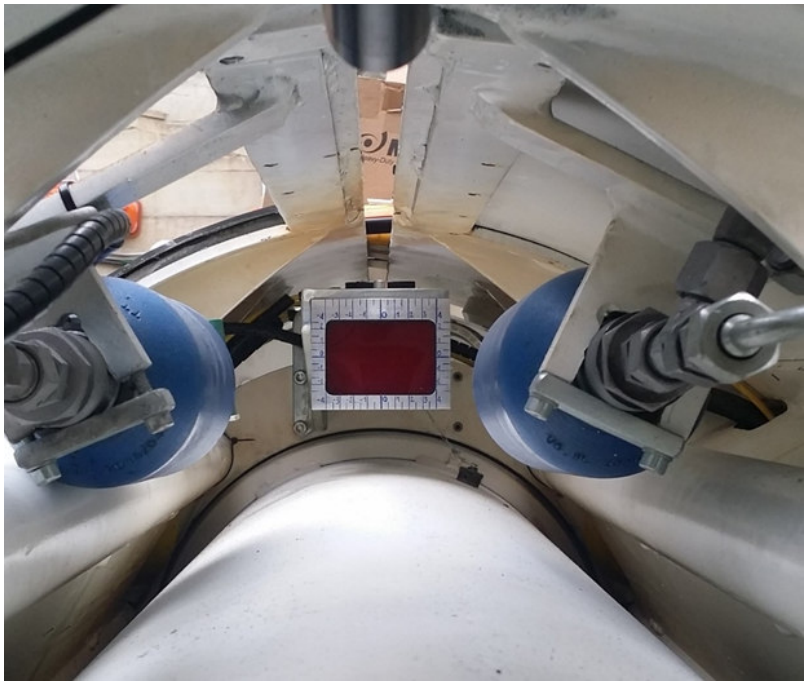


Fig. 16 – laser target

Fig. 17 - steering cyclinders

Fig. 18 jacking frame and control cabin

4. CONCLUSIONS

The n° 36 drillings were completed in a total time of n° 45 weeks (Fig. 19), including the resolution of unforeseen events, one of which was caused by an earthquake that permanently blocked the advance of one of the steel pipes, probably because of the subsidence of the intersected CNEL "sack" foundations. The problem was solved inserting a few smaller steel pipe inside the stucked one to complete the drilling length.

Fig. 19 – most of drillings completed

Every steel pipe outer annular gap has been injected with special cement grout (Fig. 20) and every steel pipe inner volume has been filled with special self-leveling concrete (Fig. 21), leaving 2 m of pipe empty for the following steel reinforcement cage connection to the crowning curb (Fig. 22 - 23).

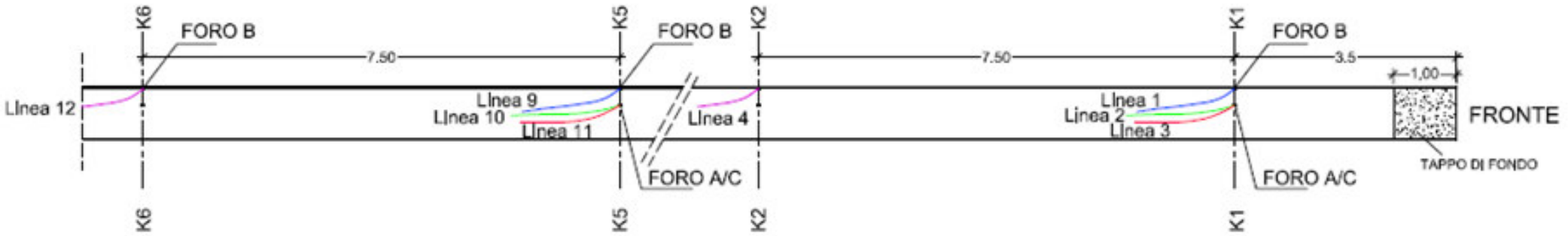


Fig. 20 – annular gap injection

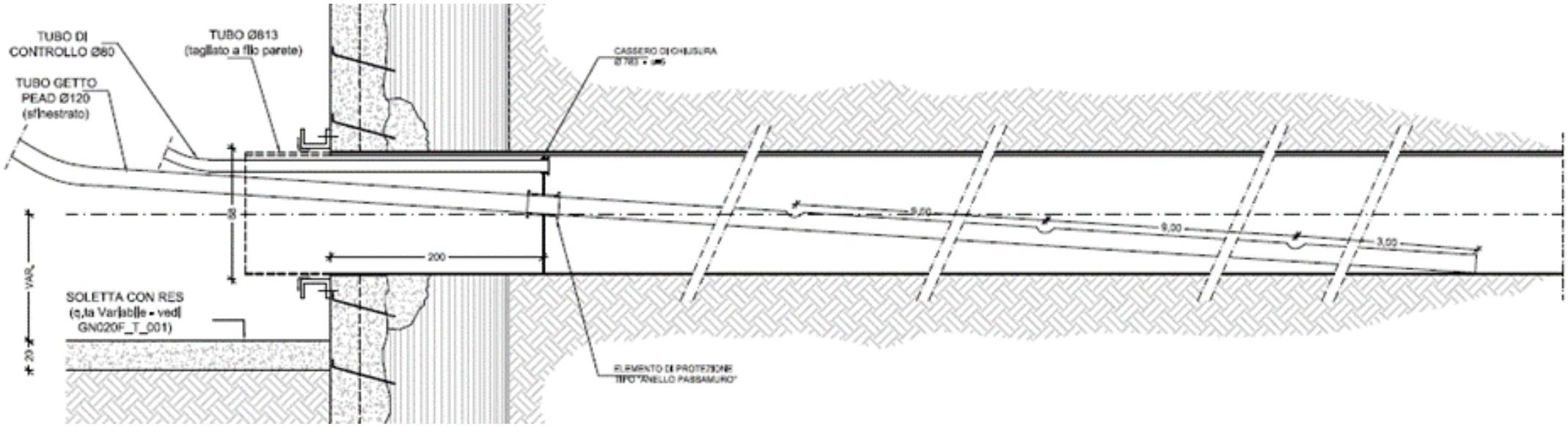


Fig. 21 – self-leveling concrete filling of the inner volume

Fig. 22 – steel reinforcement cages

Fig. 23 – crowning curb

THANK YOU FOR YOUR ATTENTION

5. REFERENCES

S.A.T.P.I. Consulting Engineers S.r.l. - DMS Engineering S.r.l. - G.P. Ingegneria S.r.l. (2016-2017) – EXECUTIVE PROJECT for: "FERROVIA ROMA - CIVITA CASTELLANA – VITERBO: PROGRAMMA DI INTERVENTI PER L'EFFICIENTAMENTO ED IL RISANAMENTO DELLA TRATTA P.LE FLAMINIO – RIANO"