“MONTEGIGLIO CONVEYOR BELT TUNNEL” - BERGAMO (ITALY)

A TUNNEL FOR THE DEPOSITING OF A BELT CONVEYOR BETWEEN THE QUARRY COLLE PEDRINO AND THE DEPOSIT OF MONTE GIGLIO

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Abstract

This article describes the methods of construction adopted by SELI S.p.A., for the completion of a tunnel of about 9400 length, and the contextual assembly and the conduction of the conveyor belt, and the final connection of the quarry of Pedrino Hill to the depository at Montegiglio. The tunnel, that is now in progress, is being done by a TBM double shield, of about 4.80 m. diameter, and it’s lined by prefabricated concrete hexagonal 20 cm width. The execution of the tunnel is being done, for the most part, through a flysch formation that consists of an alternation of sandstone and marl layers, and finally by marly limestones at times chert-bearing. The characteristic of this project is that the ground descends at 11%, with apparently flat ground, with ascension of 1-2,15 %, and a final slant with increasing incline to 20.9 %. Another peculiarity of this operation is the nature both temporary and permanent of the conveyor belt. This article will focus particular attention on the operational method of the work, including all of its technical difficulties and we will portray the project as a technical engineering challenge.

Introduction

The “gallery of Monte Giglio” commissed by Italcementi Group in 2000 at the “Consortium Montegiglio”, is a tunnel for the housing of a conveyor belt definite for the connection between the quarry Colle Pedrino and the deposit of Monte Giglio in the surroundings of the cement supplier of Calusco d’Adda (BG-Italy).

In the first 850 meters of the tunnel excavation, realized with associated Open TBM in partnership with traditional excavators (NATM) from the “Consortium Montegiglio”, many collapses in the ceiling of the tunnel have been happened, because of the passing through very fine sands. Those

![The Project](image_url)

![Standard section of tunnel](image_url)
collapses have caused many delays in the work and many precautions have been adopted to consolidate the front of digging with a succession of umbrellas. For this reason, the Contractor in accordance with the Comissioner, has decided to change the realization technologies of the project commissioning through a specialized work to the company SELI SpA, who have submitted a proposal to do the work with a TBM double shield machine. In September 2003 the company SELI SpA, installed new equipment in the gallery, they started the excavation of the tunnel which in currently in an excavation phase.

1. THE TRACING (LAYOUT)

The gallery itself is about 9400mt which must be separated by a dislevel of 560mt from 290mt above sea level from Montegiglio to 850mt (above sea level) from the quarry of Colle Pedrino. The layout presents (leaving Montegiglio) a slope of about 850mt inclining about 11%, a false plan in rise of about 5800mt with a variable slope between 1’1 and 2,15%. It is the final remount of about 2850mt with a slope rising to 20,87 %. Between the descending and the false plan a large room was excavated in order to install there an exchange system for treins. The same room has been used to assemble the TBM at about half in the tracing, 4600 mt (from the Montegiglio entry), apart from a security service of about 8mt in diameter and 33mt in depth. (Pontida well)

2. GEOLOGICAL AND GEOMECHANICAL CHARACTERISTICS OF THE FORMATIONS OVERCOME

Within the projectation phase the characteristical geological and geomechanical formation was performed in a through and accurate manner:

- A close study with ample bibliography from literature.
- The execution of geological, hydrogeological investigations and geo-structural analysis on site.
- Research campaigns (direct and indirect) on examples withdrawn during the perforation.
- Geotechnical examples on site and from laboratories taken as examples samples withdrawn during the perforation of research.
- Geotechnical characterization of soils and rocky masses.
- Hydrological characterization through pumping samples and piezometric readings.

From studies conducted during the projectation phase and now partially encountered for the realization of the works. It results that substantial the excavation of the gallery comes about in flysch formations formed by alternatine fits of arenaric, limestone and marble, and finally by marly limestones at times chert-bearing.(see fig. 1).
Taken from one point of view geomechanical the formations resulted substantial to be of second and thin class, referring to the RMR of Bieniawsky (1989).

In the executing phase the opera of work must reduce the tied indeterminators. Throughout a rocky formation already cultivated in an underground quarry (limestone, marble). These have been researched under gynostic supplements.

The geosystimatic tomographic research conducted on various levels have highlighted some cavities not far from the projected heights. To reduce to minimum the risk of instability and danger for the work of opera it has been decided to modify the layout keeping it away for about 150 mt from the critical areas. Other research campaign supplement to detail was followed out at Colle Pedrino at the entrance area of the mountain. Necessary research to determine the contact surfaces between the superficial detrital blanket to report and of those which are rocky. According to the permission of security location towards the entrance of the mount, (of the gallery ) adjusting the final track of the layout.

3. THE WORK OF OPERA

The work itself consists in the realization of a of a about 4.80 mt (in diameter) gallery. The excavation is striked on with prefabricated elements in c.a, 20cm width. The work resides in the installation of a definite operating belt conveyor.

- TUNNEL LINING

Advancement of the TBM is made operating with the ring of definite coverings from the gallery. Pea gravel is pumped from the external (Dn 6-12 mm, about 1,5 mc/ring). The covering is made up by four prefabricated elements in c.a which converge into a ring, bee hive shape (see fig.2) The length of a single ring is even 1.3 mt, meanwhile the width is 20cm. The main characteristics of the excavation and of the covering are illustrated in the following scheme:

- Diameter of the excavation and new cutters: 488 cm
- Diameter of the estradosso of the ring: 470 cm
- Weapons: 47-75-103 kg/mc
- Volume of a complete ring: 4,244 mc
- Finished diamter: 430 cm

THE CONVEYOR BELT

The permanent conveyor belt which is used to connect the “Colle Pedrino” quarry and the deposit area of Mount Giglio is mounted and utilized during the realization phase of the to fulfil to the functions of “smarino”. It is fundamental composed, in the transitory configuration, of a structure positioned at the entry of Monte Giglio (fig. 3), of a carpentry line (fig. 4), of a external trolley (fig. 5), with a pulley- connected to a b/up which runs on the carpentry line and from the belt.

Fig. 4 - External trolley
The “resèrve de bande” set up at the entry Monte Giglio and the trolley with a pulley behind it b/up let the tunnel cover consequentially on a 200 m distance and the referred nastro be assembled. After a covered distance of the underlined 200 metres it’s necessary the excavation is stopped and the belt extended in order to be stocked up into the ”reserve de bande”.

The followings are the technical properties of the equipment:

**Belt:**
- **Width:** 800mm
- **Type:** steel cord belt
- **Tensil strength:** 3150 N/mm
- **Weight:** 28 Kg/m
- **Thickness:** 19 mm
- **Speed:** 3,75 m/s
- **Capacity max:** 200 ton/h

**Drive:**
- **Installed power:** 630 kW
- **Drive pulley diameter:** 1250 mm

**Idlers:**
- **Roller diameter:** 133 mm
- **Carrying idler spacing:** 2,0 m
- **Return idler spacing:** 4,0 m

Given the non linear of the trace and the tension conditions on the mat, waves that don’t allow strong movements. Particular attention is to be made for the correct assembling of the metallic carpentry and also to the regulating of the mat supports.

**4. THE TECHNICAL –EXECUTIVE FORMS OF THE TUNNEL**

In the carrying out of the gallery apart from the TBM type used, particular attention and characteristics assume that technology used to optimise the transport system to give provision to the material up front. The tracing slopes have made it necessary to utilize prototype trains in the areas where the slopes are superior to 2,5 % with necessary systems of material exchange on different trains in use.

- **THE TBM**

Given the instable problems of the face and the vault in the first 850m of the tunnel realization with an TBM Open, and valuating the geological characteristics and the geomechancial project of the formation across the SELI proposal, still using the TBM double shield telescopic fabricated by Atlas Copco-Robbins (Mod 1611-283), in collaboration and under supervision by SELI S.p.A (fig. 6)
Here’s a following account of the main technical properties of TBM:

**Cutters**
- Cutters diameter: 17’’ (432 mm)
- Cutters number: 32

**Head**
- Max cutterhead thrust: 8544 KN
- Cutterhead drive power: 1890 KW
- Nominal head couple: 2367 KNm
- Cutterhead speed: 0 - 10 Rpm

**Principle thrust cylinder**
- Hydraulic jack: 1380 cm

**Auxiliary thrust cylinder**
- Hydraulic jack: 2200 cm

**Hydraulic system**
- Maximum pressure: 345 bar

**Electric system**
- Motor circuit: 660 V, 3 fasi
- Principle voltage: 15000 V, 50 Hz
- Back-up power: 750 KVA

**Total TBM weight**: 390 Ton.

In order to prevent eventually damages throwing the underlined critical areas, we added to the TBM a perforer type ATLAS COPCO COP 1238 which allow the execution of exploratory survey and consolidations.

- **TRANSPORT AND EXCHANGE SYSTEMS IN THE GALLERY**

Due to the pending layout it was necessary to differenciate the road conditions within the gallery.

In the initial stretch and in the final remount, prototype trains are used (ROWA Climber). Meanwhile through the central stretch (in false plan) locomotives and classical wagon are used at a speed superior to the previous. The ROWA Climber trains (fig. 7) constituted of a motorized locomotive with three motorized wagon. They are characterized by a traction system with a vertical axis.

In particular the movement comes by friction between a couple of wheels. Friction is solidated to the body motors and a monorail is centrally solidated to the platforms.

Critical points in the productive cycle terms result without doubt to the exchange system utilized to transfer materials (segment, pea gravel etc) from one train to another. In particular two exchanges have been foreseen utilizing distinct technical solutions. The first exchange comes by means of a gantry which works on two parallel lines placed in the large room on the pending change (PK 850).

The second system of exchange (for encumbranc reasons) has been arranged in line and is located at the Pk 5600. The latter is given out troughout a mechanical power-lift (fig. 9) placed in the ordinary section of the gallery with a number of manoeuvres, entrance-exit, loading-unloading from the mount train and that of the valley.
• THE PRODUCTION

As we previously said, the production is submitted to the forms tied at the lengthening of the conveyor belt, which must have been carried out every 200mt of the gallery (3-4 days in a month) and to its conduction.

Also the daily production can be conditioned by the cycle of transporting of the prefabricated coverings up front.

This cycle partially allows to overwork the potentialities of the TBM, which has shown no difficulties in penetration within the crossed formations. After about 6700mt of gallery excavation the production parameters can be shortly accounted such as in the underneath list:

- Maximum daily advancement 34 m/gg
- Medium daily advancement**: 19.3 m/gg
- Maximum weekly production* : 162.5 m/sett.
- Maximum monthly production 702.0 m/mese
- Medium monthly production**: 580 m/mese

* From Monday to Friday considering a day stopped for the lengthening of the conveyor belt.

** The average calculated between the months of Jan-July 2004

In the fig. 10 a graphic is drawn up to show the running of the excavation of the gallery in proportion to the taken time.

Due to the peculiarity of the planometric trace (layout) and to the complex geology, the reached production targets have to be considered an exceptionally positive result, an evidence of the validity in the executive and technologic solutions we’ve carried out.

5. CONCLUSIONS

Due to the preliminary and supplement geological researches joined to the election of a TBM double shield telescopic, during the works in the gallery it has been possible till now to reduce considerably the indeterminatess to a minimum number, as like as the possible instability of the front and of the vault, despite of the particularly complex geology conditions.

Due to the technical adaptations, adopted in order to optimize the conduction of the conveyor belt, as like the outlet “réservé de bande” and the trolley with the pulley of return connected to the b/up, such as the optimization in the productive cycle, throughout the use of proto-type treins along the high-slopped distances and of some intermediate turnout systems “ad hoc”, it has been possible to strike on constantly existent production processes up to the reached excavation of the tunnel at 6700 m, assuring again the efficiency in using solutions and technologies.