Field Works for the Binational Agua Negra Tunnel

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Paul C. RIZZO Associates Inc. is currently executing the In-depth Geological, Geotechnical and Hydrogeological Drilling Studies for the Feasibility Stage of the Agua Negra Binational Tunnel.

This Binational project, dreamed about by the entire San Juan community, is now being fully developed in the surroundings of Agua Negra’s border crossing, linking Argentina and Chile, through National Roads No. 150 in San Juan and No. 41 in the IV Region of Chile. The project is located in the Los Andes Range, on the Argentine side in the Quebrada San Lorenzo, at km. 368 of the National Road No. 150, Province of San Juan, and the Quebrada Río Colorado on the Chilean side.

The main objective of this future road work stretching 14.5 km is to allow a substantial reduction in the height of the crossing that actually exists at 4,753 m.a.s.l., to avoid approximately 50 km of mountain road with hazardous stretches and basically to make it practical for the passage of automotive and transportation vehicles of any type, during the entire year.

The stage that began on January of 2009 involves Phases I and II of the “In-Depth Geological, Geotechnical and Hydrogeological Drilling and Test Study for the Agua Negra Tunnel Project”. 
The Client is the Dirección Provincial de Vialidad (DPV) of San Juan, which by means of a Public Bid awarded the contract to the company Ecominera SA and RIZZO Associates Argentina SA (RIZZO), being RIZZO operationally responsible for the whole job and all the tests.

The geology of the Front Range presents a complex stratigraphy including metamorphic, sedimentary and igneous rocks that involve a period comprehended between the Paleozoic and the Quaternary, whose complete register is located in the Republic of Chile, west of the zone where the different alternatives of the tunnel design are projected.

Land Characteristics

The rock mass is lithologically characterized by Choiyoi Group outcrops formed by volcanic and hypabyssal rocks from the Permic and Triassic age, and superimposed on them there is a new sequence of Tertiary-period and Triassic hypabyssal and volcanic rocks named Doña Ana Formation. The geology is completed by classic sedimentary rocks from the Quaternary period whose origin is predominantly glacial and subordinately fluvial and mass removal processes.
In the places proposed to locate the different tunnel alternatives there are Choiyoi Group rock outcrops intruded by dykes, sills and rhyolite, basalt and aplite ducts. Tectonically, the most relevant element of the zone is the Río Colorado fault area that is located in the Río Colorado (Chilean side); this is a high-angle reverse fault.

There are other important regional faults that directly affect the future tunnel, like the Quebrada de San Lorenzo and the Quebrada Amarilla faults (Argentine side).

The geomorphology of the zone is characterized by the U-shaped valleys resulting from glacial erosion. The moraine glacial deposits from the Quaternary age are witnesses to the last glaciations in these valleys.

On the Chilean side, the site is characterized by rocks and deposits of similar age and lithology but with more rough slopes (35° in average).

Challenges Found in High-Mountain Areas

Given the height where works are developed, 4,300 to 4,900 m.a.s.l. on the Argentinean side and 3,680 m.a.s.l. on the Chilean side, the installation of different camps was necessary, four in total, two in each country.

In Argentina, the base Camp was placed in Arrequintin (2,950 m.a.s.l.) where the DPV has existing facilities. The camp was fully equipped for a permanent 50-person workforce to live and carry out its activities during the project. On the operational side, 4,500 m.a.s.l., another strategic camp, was set up in the Quebrada San Lorenzo, named the Argentine Meeting Point. This Camp was used for material storage, as a permanent communication center, and as a first aid center.
and shelter. This site also has the necessary accommodations to provide lodging, water, food and dry clothes for staff and equipment, should any storm isolate them, including heliport rescue capability.

In Chile, the base Camp (2,820 m.a.s.l.) was built in a flat area 25 Km from the Borehole field. The camp was fully equipped for a permanent 30-person workforce to live and carry out its activities during the project. On the operational side, 3,860 m.a.s.l., another strategic camp, was set up in the Llano de las Liebres area, named the Chile Meeting Point. This Camp was also used for material storage, as a permanent communication center, and as a first aid center and shelter. It also has the necessary accommodations to provide lodging, water, food and dry clothes for staff and equipment, should any storm isolate them, including a heliport.

All the camps were fitted with satellite communication and VHF, taking into account that the Project is carried out anywhere between 25 and 35 km from base camp, on mountain roads, and on top of that, the intense tourist movement during summer months and the desolation the rest of the year.

In order to develop the necessary operations and to comply with all the technical demands and requirements, we had to take advantage of limited space and rough slopes so as to open new roads, and to build platforms and avalanche protection berms, in order to mitigate the rough slopes around several Boreholes.

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The biggest challenge in drilling was the performance of the rigs at these altitudes where the average of performance was almost below 20 % up 4,300 m.a.s.l. and above 30% in the 9th Borehole (4,900 m.a.s.l.).

The hydrogeologic specifications required the use of pressures up of 1,2 Mpa in Lugeons tests, which was unpractical because of the fractured rock in boreholes with water levels up to 50 meters deep. For water lever under 75 meters, RIZZO had to develop a special system to perform correctly under such pressure. The system was successfully used in the 8th and 9th Boreholes.

Another important problem was the ice in the water, the systems and devices, the fuel and the machines because the frigid temperatures with averages of –15/–20 °C and the strong winds, that occasionally put the operation on stand-by and forced the field crew to go down to the Argentine Meeting Point for many hours.

Technical Project and Characterization Studies

The project required very specific studies that are not usually carried out in Argentina due to the diameter of the required drillings (HQ 4”) with total core recovery by means of NQ (63 mm). To that effect, special equipment and software had to be imported both for geophysical and hydrogeological tests.

Currently, the borings are being drilled; we have scheduled 14 wells, 10 in Argentina and 4 in the Chilean sector, thus completing a total of 6,200 meters of drilling. This task is under the authority of the company Ecominera S.A.
Geophysical Prospecting

In terms of the high demand of information required, RIZZO completed a program of measurements of Borehole profiles and 3-D Core rendering, using the latest technology relating to well-logging Geophysics for small drilling diameters. Field equipment carries out the measurement of boring trajectories (gyroscope), measurement of the boring internal diameter (caliper), structure orientation and core reconstruction virtually by means of well acoustic and optical television sets, measurement of rock density (Gamma-Gamma) and porosity (Neutron-Neutron), lithology characterization and differentiation by means of Natural Gamma, measurement of water quality (pH, Temperature, Conductivity, Redox) and measurement of vertical flows (Flowmeter). The sonic log recordings allowed us to obtain complete wave and density along each borehole, and the 4 Dynamic Modules of the Rock Mass:

- Poisson’s ratio (m)
- Rigidity modulus (G)
- Young’s modulus (E)
- Bulk modulus (K)

Each boring has a continuous control in place carried out by experienced professional personnel that perform core control and handling tasks, RQD measurements, radioactivity measurement of each core sample and routine pH, conductivity, temperature, O2 and radon saturation on sludges, methane, CO2 and radon gas at wellheads. By the end of the year, RIZZO will import for the first time into Argentina special equipment to carry out Dilatometric Tests on rocks at depths greater than 600 meters which also allows measuring the tension deformation values of rock, the “fluence” in the plastic deformation zone and finally the rock shear stress at the depths of interest.

Hydrogeological Tests

RIZZO carried out the hydrogeological tests in each boring by means of cutting-edge equipment plus other units specially developed for this project, capable of carrying out some tests with very low static levels and small-diameter borings. The experience of RIZZO’s hydrogeologist professionals allowed achieving the expected results in tests like Lugeon, hydraulic fracturing, short-term, long-term and step-drawdown pumping, drill stem tests, slug tests and repeat formation tests.
Rock Mass Dynamic Modules

Typical Pumping Test Diagram
DIAGRAMAS DE ROSA

COMPÁRRE: RIZO
POZO: S-06
FECHA: 26 - MARZO - 2009
DIÁMETRO POZO: 96.52 mm
DESENGANADO: 27.83 mm
HASTA: 148.20 mm
METRAJE: 27.83 m - 148.20 m

DIAGRAMA

Tadpole color rojo, rank 4: fracturas gruesas (2-8 cm), bien definidas, vistas en la amplitud y en el tiempo de tiempos. Pueden ser horizontales o inclinadas hasta un 40% de continuidad. El diagrama muestra la dirección de mantas real de las estructuras.

Tadpole color naranja, rank 5: fracturas bien definidas, vistas en la amplitud y en el tiempo de tiempos. Pueden ser horizontales o inclinadas hasta un 40% de continuidad. El diagrama muestra la dirección de mantas real de las estructuras.

Tadpole color verde, rank 6: fracturas finas, casi invisibles en la amplitud, pueden ser horizontales o inclinadas hasta un 40% de continuidad. El diagrama muestra la dirección de mantas real de las estructuras.

Tadpole color azul, rank 7: fracturas finas, casi invisibles en la amplitud, pueden ser horizontales o inclinadas hasta un 40% de continuidad. El diagrama muestra la dirección de mantas real de las estructuras.

Tadpole color gris, rank 8: fracturas finas, casi invisibles en la amplitud, pueden ser horizontales o inclinadas hasta un 40% de continuidad. El diagrama muestra la dirección de mantas real de las estructuras.

Nota: con los cuatro tipos de fracturas. El diagrama muestra la dirección de mantas real de las estructuras.
All the information is currently used by the Design Engineering Company that was awarded the Basic Construction of Motor Equipment.