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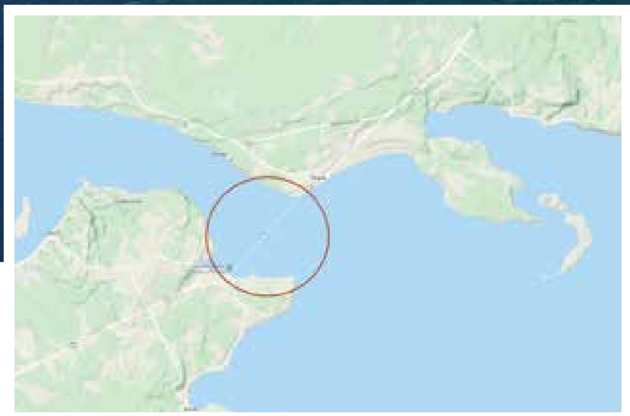
FEATURE STORY

TREVI FOUNDATIONS Chacao BRIDGE: SOUTH AMERICA'S Longest SUSPENSION BRIDGE



COMPLETE VIEW OF THE CHACAO CHANNEL, JACK UP BARGE AND SERVICE PLATFORM

PROJECT DESCRIPTION

The construction of the Chacao Bridge aims at connecting the continent with the Chiloé Island, located 1.100km south of Santiago de Chile, in the Los Lagos Region, 48km away from Puerto Montt and only 5km away from Pargua.

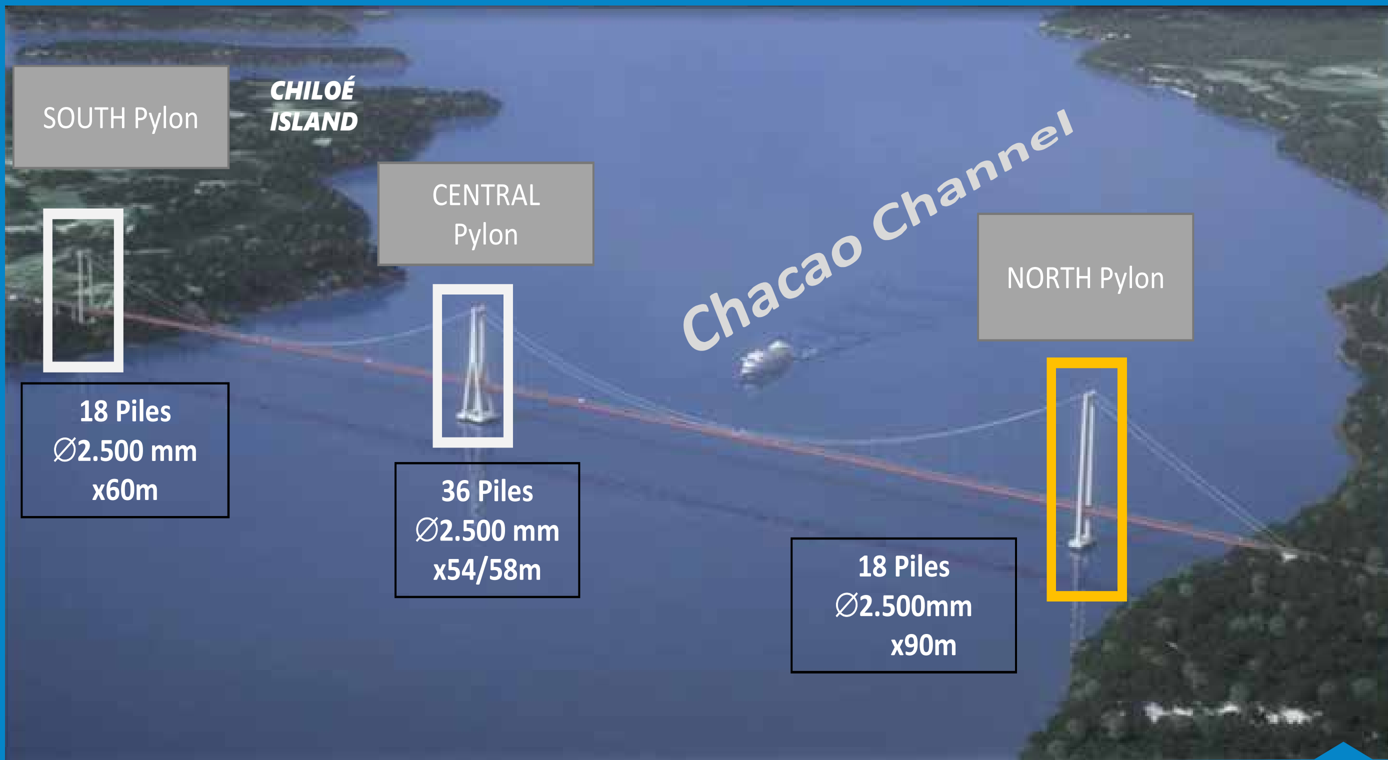
The idea of a fixed connection between Chiloé and the continent has long been one of the main concerns of the Roads Direction (Dirección de Vialidad) and the Public Construction Ministry (Ministerio de Obras Publicas MOP). Since the 1970s it has been regarded as a possible connectivity solution for the Chacao Channel.

However, connection studies started only from the 1990s onwards, including the possible construction of a tunnel and the analysis of different bridge types. As a result, MOP decided the suspension bridge was the most feasible option, from all points of view.

In 2012 and 2013, the project was consolidated through the traditional fiscal public construction system, with the creation of an international bid registration. In December 2013, the contract was awarded to the Consorcio Puente Chacao (Chacao Bridge Joint Venture), an entity formed by four international companies headed by the Korean Hyundai.

Three years later, the design of the Chacao Bridge was recognized with the "Be Inspired" award in the category "Bridges Innovations," which consolidated these MOP Roads Direction's initiative as an "avant-garde" project worldwide.

Continued on page 29



CHACAO CHANNEL, SIMULATION OF THE FUTURE BRIDGE UNDER CONSTRUCTION

Trevi Chile SpA (Trevi), a recognized leader in the foundation industry, was selected by the consortium to carry out the foundations of the bridge piles.

Route 5 is the longest highway in Chile, stretching from Arica to Quellón in Chiloé, hence connecting the country throughout a 3353km long highway. However, when reaching the end, the road is interrupted between the continent and the Chiloé Island by the Chacao Channel, where all traffic runs, via a 30 to 45 minute ferry trip.

The bridge under construction will connect the missing part, expediting the main transportation to/from Quellón at the southern tip of Chiloé.

Once the project is completed, there will be no interruption between the continent and the Chiloé Island. The country will be permanently connected from Arica in the north of Chile to Quellón in the Chiloé Island, through Route 5, which will be extended for 190km. The bridge will cut the time required to cross the channel to just three minutes. This is a major improvement considering the actual trip time of about 30 to 45 minutes that the ferry takes to cross the channel, without taking into account the extreme weather conditions the channel faces throughout the seasons.

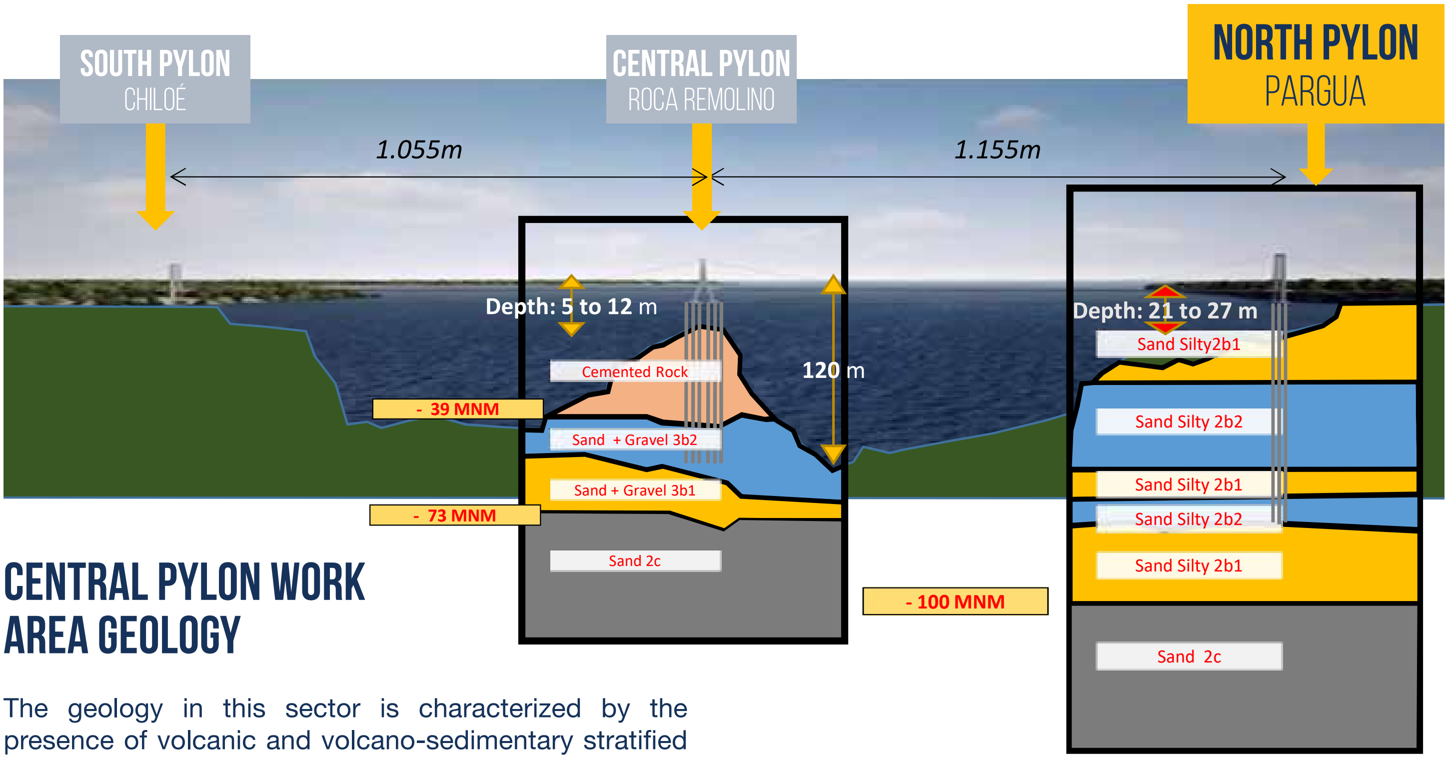
The design and construction of the Chacao Bridge project is the largest project MOP has ever awarded, and its completion will bring more than simply territorial integration to the inhabitants of the Chiloé Island.

The project, under the responsibility of the MOP´s Direction of Roads, will directly affect the over 160 thousand inhabitants of Chiloé and the archipelago´s interaction with the rest of the territory, allowing a higher development of its economic, educational and health structures, along with touristic and socio-cultural activities. The bridge will be a milestone that, together with the project for the Ruta 5 dual road and the archipelago roads system intervention, will consolidate a necessary road infrastructure aimed at helping the development and improvement of the quality of life of the Chilotas (Chiloé's inhabitants).

The length of the bridge will be 2,574m and will consist of three main pylons, one in the middle of the channel and two on each side, namely the north pylon on the continent side and the south pylon on the Chiloé's side. The lights between the central and north piles will stretch for 1,553m, while the ones between the Central and South Piles will cover a 1,055m length, thus becoming the longest suspension bridge in South America.

We are going to talk about the Central Pylon, whose foundations are already finished. Trevi is currently working on both north and south pylons.

Continued on page 31

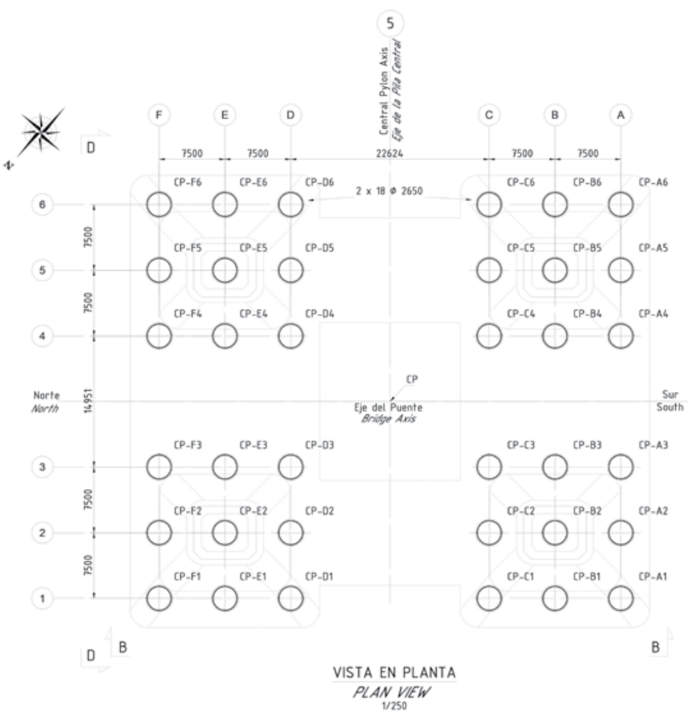


CENTRAL PYLON WORK AREA GEOLOGY

The geology in this sector is characterized by the presence of volcanic and volcano-sedimentary stratified sequences of Oligocene-Pliocene age.

The alignment of the main structure of the bridge in the Chacao Channel coincides with the rock outcrop called Roca Remolino, where the central pylon is located.

The generalized profile of the central pylon is defined with a tuff of volcano-sedimentary origin formed by gravels and cemented sands up to -31m (roca remolinos aka swirling rock) and then fine to medium-grained sand with some rounded, dense and moderately cemented gravel, while, at a depth up to 65.6m, there is poorly-graded coarse and grained sand.



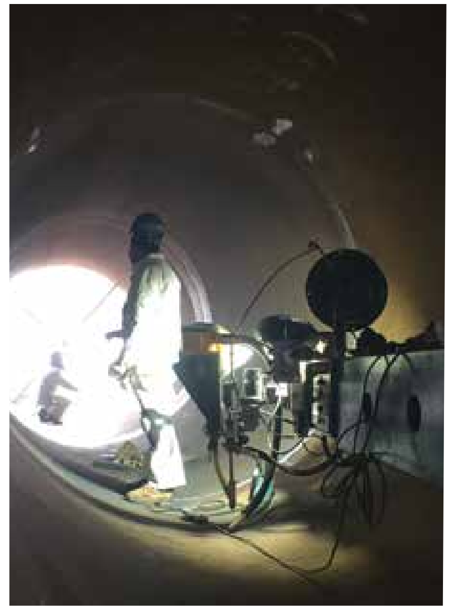
TREVI'S SCOPE OF FOUNDATION WORKS

Trevi was chosen for the execution of the bridge foundations, including the central pylon (already completed), as well as the north and south pylons, currently under construction.

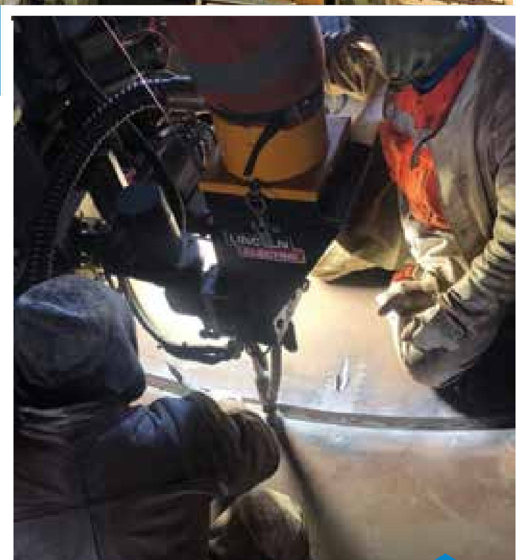
The foundation works of the central pylon consisted in the execution of 36 piles with 2.5m wide diameters and lengths of 54m for type one piles and 58m for types 2 and 3 approximately, each of them excavated from a jack up barge.

Continued on page 33

VIEW OF THE CHACAO CHANNEL, JACK UP AND SERVICE PLATFORM



WELDING PROCESS OF THE PERMANENT STEEL CASING



SUBMERGED ARC WELDING (SAW) FOR THE STEEL CASING

Ocean currents were among the challenges Trevi had to face during the execution of the central pylon. They were the about 528cm/s on the marine surface and 192cm/s on the sea bottom, caused by the change of tidal streams. Moreover, weather conditions were harsh, with strong winds ranging between 18 and 23m/s (65-83km/h), an average temperature of 11°C and torrential rains throughout the year, with an average precipitation of 2000mm per year.

Notwithstanding the above, the main technical challenge Trevi had to overcome was the size of the piles, along with the length, diameter and weight of the permanent steel casings and the reinforcement cages, which involved the use of heavy machinery in the limited space available on the jack up barge. Therefore, logistics and project management as a whole were undoubtedly another great challenge.

In addition to the casing installation, drilling works and concrete casting on the central pylon, Trevi was in charge of the assembly of the reinforcement cages and the welding of steel casings.

Using a modern welding system – mounted inside a sliding welding workshop equipped with special equipment dedicated to the rotation of the long casing sections during welding – all the sections of the casing were assembled despite their different thicknesses, in order to install the permanent casing on each pile. All welding stages were subject to strict quality tests before being to be installed. The main contractor, Hyundai, purchased the steel casings.

Reinforcement steel cages were completely assembled on site, in a steel cutting and bending workshop that added up to two assembly lines already built for this purpose.

REBAR CAGES AREA

Each rebar cage section was initially pre-assembled and then verified by the contractor's quality control team, which checked all the joints to see if they matched perfectly, due to the very strict tolerance allowance. The main contractor´s quality control department inspected the whole construction process, before allowing elements to be installed. The contractor also provided the steel reinforcement bars.

The works carried out for the central pylon were the following:

- 36 piles with a 2500mm width diameter and a 54m or 58m length
- Total volume of concrete cast on piles: 10,713 m^3
- Steel rebar used for the reinforcement cages: 2,256t
- Steel used for the steel casings: 3,447t, and 24m and 28m length.

The construction process of the piles was adapted ac-cording to the soil/rock conditions of the site and the extreme working conditions of the Chacao Channel.

- Initial phase of Ø3,000mm temporary casing installation
- Pre-drilling using a Ø2,750mm auger
- Permanent casing installation and driving to the final position
- Removal of the Ø3,000mm temporary casing
- Drilling down to design elevation with Ø2.500mm permanent casing
- Installation of reinforced steel rebar cages
- Concrete casting on pile

Due to the limited available space on the jack up barge, only the service crane and the drilling rig remained on board at all times, and as a consequence, the other heavy equipment and material such as Vibrohammer, temporary casing, drilling tools, etc. were loaded/ unloaded from the barge to an auxiliary platform at every pile

Continued on page 36

CARGO SHIP TRANSPORTING TOOLS AND ACCESSORIES

DRILLING EQUIPMENT

JACK UP VIEW

CATAPULT FOR THE STEEL CASING LIFTING

cycle. Permanent casings and reinforcement steel cages were also transported when required. This highlights the level of coordination of the cargo ships used to meet the production performance requirements.

EQUIPMENT USED

In order to carry out the works offshore, Hyundai, the main contractor, provided a 50m x 28m barge fitted with four long support legs (jack up) Pioneer III, with a 3,600t capacity along with a fixed platform, where the concrete batching plant was located.

The jack up housed: a 400t service crane provided by the main contractor and the Soilmec SA-40 drilling rig with a 423 kNm torque, capable of drilling up to 4,000mm wide diameters and mounted on a Soilmec SC-120 crane, plus a 450m3 polymer plant for the production and treatment of the drilling polymer mix to stabilize the boreholes. The Vibrohammer PVE 200, provided by Trevi, was also part of the equipment.

Other auxiliary equipment was arranged by Trevi in order to achieve the production requirements set for the project. These included a guide frame for the casing alignment and a catapult for the unloading of the steel casing from the transportation vessel to the jack up.

The Chacao Bridge project is currently in progress and the central pylon is completed. The completion of the central pylon is the main object of this article. The works for the north and south pylons have already started and Trevi is the awarded subcontractor for their execution.