Over 65 years shaping pathways underground

PROJECT BOOK

SUBWAY
OSSA, founded in 1952, is a leading company in the underground construction sector specializing in four business areas: Construction, Energy, Mining and Services.

Both in underground excavations by traditional method (NATM) and in tunneling with TBM, OSSA is a solid underground works partner for important industrial and construction groups internationally. At OSSA we are highly committed to Quality, Health and Safety, and Environment, and we invest in Research and Development Projects at an international level. We promote a culture of respect and teamwork among our team.

OSSA has vast recent experience in high speed railway tunnels with over 75 km of high speed rail tunneling projects, leading the Spanish market in this specialty, and also in underground power plants, having built over fifteen underground plants with some of the largest underground caverns in the world. As a recent highlight, we have built more than 10 km of tunnels for the Santiago de Chile Metro.

Internationally OSSA has executed works in Hong Kong, Taiwan, Chile, Peru, Colombia, Panama, Costa Rica, Brasil and Guatemala and is recently focusing its tendering activity in North America, Central America, Asia and Great Britain.

After 65 years of success, our strategy is to continue expanding internationally, and to support large civil engineering and mining industry clients at all levels, contributing our vast technical expertise and our equipment fleet, while prioritizing health and safety and innovation in all our projects.
SAFETY

Safety is OSSA’s main asset from the time when its operations began, demanded by the specialisation required for the works carried out underground.

The company’s staff have a high degree of professionalism and specialisation, which has been achieved after many years of training and the transfer of know how. Working in confined spaces with the presence of gas, dust, noise, low visibility and the use of explosives means that OSSA’s safety department is the most relevant in the company.

The use of cutting-edge, innovative techniques in the field of underground works requires the continuous training of the company’s human resources.
The section has a length of 1,312 ml and requires a PV-19 ventilation shaft to be constructed in the centre of the section to allow access to the line tunnel being built. The project includes a gallery for 4 No. 301 ml routes.
### Location and Additional Information

Construction of 2,223 m long tunnel, with a cross section between 64 to 75 m², linking an underground station 120 m long and 172 m² in section, called Lo Cruzat, with another open-cut station of the same length, called Plaza Quilicura. For the excavation of the tunnel, three circular attack pits of 15 m diameter and about 20 m depth are used. For the excavation of the Plaza Quilicura station, 154 piles D. 1,200 mm, 17 to 24 m deep, are executed. The walls of the excavation are supported by walls between mesh piles and shotcrete with cable anchors of different lengths.
The location of Los Leones station is both a terminus and an interchange between Line 1 and Line 6. The project also includes the civil work for the entrances to the station:

- One called LOS LEONES NORTH, located at the intersection of Av de Providencia and Calle Suecia that provides access to the Line 6 station
- The other called LOS LEONES SOUTH, located at the intersection of Calle Suecia and Av Nueva Providencia, which is the connection between Line 6 and Line 1
- Both entrances are connected by a 120m long underground tunnel

The following works have been carried out: excavation, reinforced concrete structure, pillars, perimeter walls, beams, slabs and surfacing. Also include the mechanical, electrical sanitary and telecommunications installations including terminations in ceilings, walls and floors. Furthermore, the external works of urban planning, surfacing and landscaping have been carried out.
In order to comply with the current accessibility regulations, Metro has set up elevators in all existing stations. This contract includes 26 elevators in 9 stations.
Secondary lining and drainage of the previously executed tunnels between the Colectora Industrial Station and Ventilation Shaft PV 19b. The application of concrete has been carried out using formwork trolleys. Access for equipment and materials is provided by three vertical shafts linking the tunnel required to be lined with the surface. Consequently, vertical elevating devices needed to be installed in the three access shafts. In order to complete the lining within the scheduled timeframe, two concrete application units were required.
### Stage 1A. Package 01. Lima Subway (Peru)

**Owner:** UTE Dragados - FCC - Cosapi - Ansaldo - Impregilo

<table>
<thead>
<tr>
<th>Status</th>
<th>Start: 03/2015</th>
<th>End: 06/2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Subway Tunnel</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Peru</td>
<td></td>
</tr>
<tr>
<td>Province</td>
<td>Lima</td>
<td></td>
</tr>
<tr>
<td>Place</td>
<td>Lima</td>
<td></td>
</tr>
<tr>
<td>Budget (Excluding VAT)</td>
<td>22,387,000 €</td>
<td></td>
</tr>
</tbody>
</table>

**Location and Additional Information**

The work involves excavating 3 vertical ventilation shafts with an excavation diameter of 16.5 m and a tunnel with an excavation length of 2,243.8 m and an excavation cross-section of 68 m², with primary support by NATM, in compacted gravels with sand and silt insertions at the crown and invert in various stretches.

The support consists of reticular trusses and shotcrete with fibres. In the stretches with fines at the crown 89 mm-diameter micropile umbrellas are being executed.

**Geography**

- **Cross section:** 68 m²
- **Length:** 2,244 m

**Geology and Geotechnical Data**

- Conventional methods for the excavation and supports according to NATM

**Tunnel Equipment**

- Model L2C 2-boom jumbo
- Model PM-500 shotcrete robot
- Backhoe loader
- Front loader
- Telehandler
The work consisted of constructing section 3 North of the new Line 3 of the Santiago Subway. There is one station in the section, named Hospitales, being attacked from a circular shaft 25 metres in diameter, which was already constructed. There is also a shaft named Inglaterra, already constructed, which provided access to the tunnel between stations during the works. At both ends of the station a ventilation tunnel approximately 30 m in length has been executed, communicating with a ventilation shaft 5 m in diameter, which, in turn, connects with the outside, with a mean length of 25 m.

The main work units executed were: Hospitales Station, 120 m long with a cross-section of 150 m²; 75 m of ventilation tunnel with a cross-section of 75 m², 437.1 m of tunnel between stations with a mean cross-section 65 m², and 2 ventilation shafts with a diameter of 5 m and a total length of 60 m.
**CONSTRUCTION DATA SHEET**

**SUBWAY**

**Project**  
CONSTRUCTION OF CIVIL ENGINEERING WORKS - TUNNELS, LINK BETWEEN LINE 6 AND LINE 3. SANTIAGO (CHILE) SUBWAY

**Owner:** Metro de Santiago

<table>
<thead>
<tr>
<th>STATUS</th>
<th>START: 08/2014</th>
<th>END: 08/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE</td>
<td>Shaft, connecting gallery and linking tunnel</td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>Chile</td>
<td></td>
</tr>
<tr>
<td>PROVINCE</td>
<td>Santiago de Chile</td>
<td></td>
</tr>
<tr>
<td>PLACE</td>
<td>Santiago de Chile</td>
<td></td>
</tr>
<tr>
<td>BUDGET (EXCLUDING VAT)</td>
<td>8,688,751,296 CLP</td>
<td></td>
</tr>
</tbody>
</table>

**GEOMETRY**  
Cross section: Tunnel between 40 and 64 m². Shaft 90 m².  
Length: 1,536 m. Shaft 33 m.

**OVERBURDEN**  
33 m

**METHOD OF TUNNELING**  
Mechanical equipment for excavation and support according to the NATM

**GEOLOGY AND GEOTECHNICAL DATA**  
Gravels, fines and mixed soils with fines and gravels

**TUNNEL EQUIPMENT**  
Shotcrete robot  
Backhoe loader  
Front loader  
Telehandler

**LOCATION AND ADDITIONAL INFORMATION**  
The project consists of constructing an ellipsoid shaft with an open area of 12 x 8 m and a depth of 33 m, and then an 18 m connecting gallery, from which 791 m of tunnel are to be excavated to link up with Line 6 and 745 m to connect with Line 3 of the metro.
### Construction Data Sheet

**Type**

**Subway**

**Project**

**Constitution of Tunnels, Stations and Inter-Station Tunnels Section 2. Line 3. Santiago (Chile) Subway**

**Owner:** Metro de Santiago

**Project Photos**

---

<table>
<thead>
<tr>
<th>Location and Additional Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The works consist of constructing section 2 of the new Line 3 of the Santiago Subway. There are three stations in this section, named Vivaceta, Conchalí and Chacabuco, being attacked from three circular shafts over 25 metres in diameter, which are already constructed. The stations are each 120 m long with a mean cross-section of 150 m². There are also two construction shafts named Teniente Mery and Pantaleón Vélez, already constructed, which provided access to the tunnel between stations during the works. At both ends of each station a ventilation tunnel approximately 30 m in length has been executed, communicating with a ventilation shaft 5 m in diameter, which, in turn, connects with the outside, with a mean length of 25 m. The main work units executed were: 360 m of stations with a cross-section of 150 m², 146.8 m of ventilation tunnel with a cross-section of 75 m², 1,463 m of tunnel between stations with a mean cross-section of 65 m², and 6 ventilation shafts with a diameter of 5 m and a total length of 160 m.</td>
<td></td>
</tr>
</tbody>
</table>

---

| Status | Start: 07/2015  
End: 07/2016 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>Subway Tunnels</td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td>Chile</td>
</tr>
<tr>
<td><strong>Province</strong></td>
<td>Santiago de Chile</td>
</tr>
<tr>
<td><strong>Place</strong></td>
<td>Santiago de Chile</td>
</tr>
<tr>
<td><strong>Budget (Excluding VAT)</strong></td>
<td>36,284,000 €</td>
</tr>
</tbody>
</table>

| Geometry | Cross section: Tunnel between stations: 65 m²  
/ Station: 150 m² |
|----------|-------------|
| **Length** | Tunnel between stations: 1,463 m  
/ Station: 3 x 120 m |
| **Overburden** | Medium |

<table>
<thead>
<tr>
<th>Method of Tunneling</th>
<th>Conventional methods for the excavation and supports according to NATM</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Geology and Geotechnical Data</th>
<th>Silts and gravels</th>
</tr>
</thead>
</table>

| Tunnel Equipment | Putzmeister PM 500 shotcrete robots  
Atlas Copco L2C jumbos  
Manitou  
Caterpillar model CAT 312/315 excavator  
Caterpillar model CAT 950 and 924 loader |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONSTRUCTION DATA SHEET</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>SUBWAY</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Project photos</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Project**

CONSTRUCTION OF CIVIL ENGINEERING WORKS, SHAFTS, GALLERIES AND TUNNELS

SECTION 4 - LINE 6. SANTIAGO SUBWAY (CHILE)

**Owner:** Metro de Santiago, S.A.

**Type:**

- **Project photos**

** Status**

- **Start:** 06/2013
- **End:** 06/2016

**Structure**

- Tunnel, Stations and Shafts

**Country**

- Chile

**Province**

- Santiago de Chile

**Place**

- Santiago de Chile

**Budget (Excluding VAT)**

- 64,006,511 €

**Location and Additional Information**

The main works executed were: excavation of 2 stations, 120 m each; 3 rectangular shafts with pile walls, 30 m each, with cross-sections of 20x46 and 48x46. 3 circular shafts were also executed, one 25 m in diameter and 23.2 m deep, another 15 m in diameter and 24 m deep and the other 12 m in diameter and 25.8 m deep. Access and connecting galleries was also excavated, as well as 2,391 m of tunnel between stations.

**Geometry**

- **Cross section:** 68 m² / 180 m²
- **Length:** 2,391 m

**Overburden**

- Low

**Method of Tunneling**

- Excavation with mechanical excavation. NATM System

**Geology and Geotechnical Data**

- Silts and Gravels

**Tunnel Equipment**

- Putzmeister PM500 concrete spraying system
- Jumbos Atlas Copco L2C
- Manitou
- Caterpillar model CAT 320 backhoe
The scope of the works carried out can be summed up as:

- Partial execution of the excavation and support of Nuble Station and its access galleries. The station comprises a cavern 120 m in length with a cross-section of 168 m², involving a maximum excavation width of 17.20 m and a maximum height of 12.6 m. It is being executed in four phases using the Self-Supporting Vault method.
- Stub tunnels for the initial sections of the tunnel between stations, 9 m long with a cross-section of 65 m², constructed from the east and west tunnel portals of Nuble Station.
- Tunnels between stations with a 65 m² excavation cross-section and a length of 195 m from the eastern stub tunnel towards the Marathon shaft and 150 m from the west stub tunnel.

All the excavations are being carried out with mechanical equipment and application of supports following the New Austrian Method.
The main works executed were: excavation of 3 stations; 2 rectangular shafts with pile walls, one 34.5 m deep with a cross-section of 46x44 and the other 26.8 m deep with a cross-section of 45x27. 3 circular shafts are also being executed, two of them 15 m in diameter with depths of 22.3 m and 24 m, and another 12 m in diameter and 23.1 m deep. Access and connecting galleries were also excavated, as well as 4,116 m of tunnel between stations.
### C824 Tunnel, Hong Kong

**Owner:** MTR (Mass Transit Rail Corporation)

**Start:** 08/2010  
**End:** 12/2013

**Budget (Excluding VAT):** 149,445,693 €

#### Construction Data Sheet

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location and Additional Information</strong></td>
<td><strong>Construction Data</strong></td>
</tr>
<tr>
<td>Construction of high speed train tunnels. Double tunnels of 2.6 Km each, with a cavern for track changes and two tanks of 90 m and 45 m respectively at the end points of the section. The tunnel section is of 70 m² per tube. Excavation is carried out by alternating backhoes with hammers and jumbos. Some measurements: 21,000 m³ of shotcrete, 24,000 m of bolts, such as Swellex MN24, 115t of metallic trusses and 101,000 m³ of reinforced concrete.</td>
<td></td>
</tr>
</tbody>
</table>

#### Type

| SUBWAY |

<table>
<thead>
<tr>
<th><strong>Status</strong></th>
<th><strong>Start:</strong> 08/2010</th>
<th><strong>End:</strong> 12/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>High speed tunnel</td>
<td></td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td>China</td>
<td></td>
</tr>
<tr>
<td><strong>Province</strong></td>
<td>SAR Hong Kong</td>
<td></td>
</tr>
</tbody>
</table>

#### Project

| **Budget (Excluding VAT):** 149,445,693 € |

| **Geometry** | 1 underground shaft of 250 m² and 90 m in depth  
1 underground shaft of 680 m² and 45 m in depth  
Double tunnels of 67 m² with 345 m² cavern and bifurcation |
| **Overburden** | Height |
| **Method of Tunneling** | Shaft excavation with secant piles wall in the upper floor area and drill and blast in the inferior rock area |
| **Geology and Geotechnical Data** | Tuffs with quartz veins and sandstone |
| **Tunnel Equipment** | Atlas Copco XE3CJumbos, L2C, CAT 320 backhoes, PM 500 Robojets, Manitou platforms, GH cranes |
### Duplication of the Añorga–Rekalde Section of the Bilbao–Donostia Metropolitan Railway

**Owner:** Euskal Trenbide Sarea (ETS)

#### Status
- **Start:** 08/2009
- **End:** 09/2012

#### Structure
- **Type:** Subway Tunnels
- **Province:** Guipúzcoa
- **Country:** Spain
- **Place:** San Sebastián

#### Geometry
- **Cross Section:** 45,41 m²
- **Length:** 710 m

#### Overburden
- **Method of Tunneling:** NATM. Mechanical excavation
- **Geology and Geotechnical Data:** Calcareous limonites

#### Equipment
- **Budget (excluding VAT):** 27,452,333 €
- **Tunnel Equipment:**
  - Roadheader
  - Shotcrete robot
  - Two-boom jumbo
  - Backhoe loader
  - Telehandler

#### Location and Additional Information
The works involve constructing a 2,168 duplication of the line by a bypass based on a 710 m tunnel and 250 m of false tunnels, construction of a metal viaduct over the N-I and elimination of a level crossing. The building of two rail diversions and the demolition and construction of a new station have also been necessary.

Further works carried out were the demolition and replacing of roads and tracks, walls, covering over of part of the Añorga drainage channel and diversion of a large number of affected services. The works include track laying, track superstructure and track electrification.
These works involved constructing a 1,671 m duplication of the line by a bypass based on a 258 m tunnel and 262 m of false tunnels.

The Irubide tunnel is 258 m long with a 45.41 m² cross-section. The excavation was carried out following what is known as the New Austrian Method, using mechanical drilling with a roadheader. The support was by means of rock bolts, sprayed concrete with fibres and metal trusses. The tunnel was waterproofed with geotextile and PVC sheets. The lining consisted of a 35 cm thick concrete ring round the whole perimeter.

It was also necessary to construct 4 walls and divert a large number of affected services, notably including the junction of the N-634 with the N-1 and the Añorga drainage channel. The works include laying the track and complete electrification of the track.
## Construction Data Sheet

### Project

**FMB (Bilbao Subway) – Line 2. Ariz–Basauri**

**Owner:** Dpto. de Transporte y OOPP del Gobierno Vasco

### Status

- **Start:** 12/2006
- **End:** 11/2011

### Geometry

- **Cross section:** 62 m²
- **Length:** 2,108 m

### Structure

- Tunnels

### Overburden

- Medium

### Country

- Spain

### Province

- Vizcaya

### Place

- Bilbao

### Budget (Excluding VAT)

- 64,392,394 €

### Location and Additional Information

- Tunnel for the double track Ariz – Basauri branch of the Bilbao Metro. Includes shafts equipped for raise boring, jet grouting treatment, walls, pile driving, etc.

- The length of the worksite is about 1.5 miles (2.37 Km) and runs through an urban environment.

- Works comprise the construction of two underground stations in caverns measuring 110 m in length and 190 m² each section, where concourses, platforms and technical rooms were built. They also include the implementation of access to the stations, such as emergency ventilation systems and ventilation systems under platforms.

- 11,230 m³ of shotcrete, 70,000 kg of steel fibre, 90,000 ml of Swellex rock bolts, 500,010 kg of roof trusses, 221,000 m² of electro-welded wire mesh, 12,000 ml of micro piles.

### Tunnel Equipment

- Heavy roadheader. Jumbo has two booms and service plataform Atlas Copco PARA

### Method of Tunneling

- Mechanical equipment

### Geology and Geotechnical Data

- Marls, limestones, sandstones and lutites (Lower Cretaceous)
### Type

**CONSTRUCTION DATA SHEET**

**SUBWAY**

#### Project

**NEW MIRIBILLA STATION**

*Owner: Bilbao Ría 2000 S.A.*

| STATUS | **Start:** 04/2005  
**End:** 12/2008 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE</td>
<td>Cavern, Shaft, Tunnel</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>Spain</td>
</tr>
<tr>
<td>PROVINCE</td>
<td>Vizcaya</td>
</tr>
<tr>
<td>PLACE</td>
<td>Bilbao</td>
</tr>
<tr>
<td>BUDGET (EXCLUDING VAT)</td>
<td>13,447,941 €</td>
</tr>
</tbody>
</table>
| LOCATION AND ADDITIONAL INFORMATION | Construction of the New Miribilla Station, shafts and roadways: access, ventilation and emergency.  
Vertical Shaft up to about 48 m depth from top and 135 m² section. 90 m long extended tunnel of cross section = 40 m².  
457 m³ steel fibres reinforced shotcrete, 534 m bolts B - 500S Ø = 25 mm, 2,396 m bolts Swellex Mn24, 644 m fiberglass bolts Ø = 22 mm and 1,864 m² wire mesh. |

| GEOMETRY | **Cross section:** Variable  
**Length:** 1,072 m |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERBURDEN</td>
<td>48 m</td>
</tr>
<tr>
<td>METHOD OF TUNNELING</td>
<td>Mechanical, drill and blast and raise boring</td>
</tr>
<tr>
<td>GEOLOGY AND GEOTECHNICAL DATA</td>
<td>Marls, limestones, sandstones and lutites (Lower Cretaceous)</td>
</tr>
<tr>
<td>TUNNEL EQUIPMENT</td>
<td>Jumbo has two booms. Ripper hammer. Raise borer. Wet - mix Aliva AL - 285 = 9 - 21 m³/h</td>
</tr>
</tbody>
</table>
**NEW LLAMAQUIQUE LOCAL RAILWAY STATION**

**Owner:** Renfe

### Project Data Sheet

<table>
<thead>
<tr>
<th>Type</th>
<th>SUBWAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>NEW LLAMAQUIQUE LOCAL RAILWAY STATION</td>
</tr>
</tbody>
</table>

#### Project Photos

- Construction of New Railway Station of Llamaquique, two 85 m length platforms and auxiliary facilities included.
- The station is built under reinforced concrete slab between diaphragm walls with clamshell wall excavator until 17 m depth.
- Reinforcement works to Fresno tunnel of 99 m long and 60 m² cross section.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry</td>
<td>Cross section: Variable</td>
<td>Length: 19 m</td>
</tr>
<tr>
<td>Structure</td>
<td>Cavern</td>
<td></td>
</tr>
<tr>
<td>Overburden</td>
<td>Max. 20 m</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Spain</td>
<td></td>
</tr>
<tr>
<td>Province</td>
<td>Asturias</td>
<td></td>
</tr>
<tr>
<td>Place</td>
<td>Oviedo</td>
<td></td>
</tr>
<tr>
<td>Budget (excluding VAT)</td>
<td>16,071,482 €</td>
<td></td>
</tr>
<tr>
<td>Tunnel Equipment</td>
<td>Clamshell wall excavator</td>
<td></td>
</tr>
</tbody>
</table>

#### Location and Additional Information

- Construction of New Railway Station of Llamaquique, two 85 m length platforms and auxiliary facilities included.
- The station is built under reinforced concrete slab between diaphragm walls with clamshell wall excavator until 17 m depth.
- Reinforcement works to Fresno tunnel of 99 m long and 60 m² cross section.

**Owner:** Renfe

**BUDGET (EXCLUDING VAT)**

- 16,071,482 €
### Project: FMB (Bilbao Subway) - Line 2. San Inazio–Plaza Lutxana

**Owner:** Dpto. de Transporte y OOPP del Gobierno Vasco

<table>
<thead>
<tr>
<th>Type</th>
<th>Project</th>
<th>SUBWAY</th>
</tr>
</thead>
</table>
| Status | Start: 01/1998  
End: 10/2000 | Geometry | Cross section: 65 m²  
Length: 1,050 m |
| Structure | Tunnel, cavern and tank | Overburden | 40 m |
| Country | Spain | Method of Tunnelling | NATM. Top-Heading and Bench. Mechanical excavation |
| Province | Vizcaya | Geology and Geotechnical Data | Marls, limestones, sandstones and lutites (Lower Cretaceous) |
| Place | Bilbao, Erandio, Barakaldo | Tunnel Equipment | Road header (Heading) and ripper hammer (Bench). Wet - mix Robojet Meyco and Meyco GM - 090  
\( \eta = 6 - 7 \text{ m³/h} \) |
| Budget (Excluding VAT) | 21,131,742 € | Location and Additional Information | Work involved executing a double track tunnel of 65 m² gauge and 1,050 m, of which 254 m were excavated after a previous injections campaign was carried out to reduce land permeability.  
A 70 m cavern with a variable section (135 m² max) was constructed, 430 m of single track tunnel with 35 m² gauge and a 30 m section under line 1 with 3 m coverage.  
A 180 m, one track tunnel was also excavated in a trench protected by pile wall. A vertical shaft of 46.5 m in depth and 68 m² gauge with a connecting tunnel section to the shaft of 62 m in length.  
7,436 m³ steel fibres reinforced shotcrete, 59,651 m bolts, Swellex and fiberglass bolts, 42,747 Kg steel ribs and 60,810 Kg wire mesh. 9,537 m³ concrete lining H - 250. |
**PROJECT:** FMB (BILBAO SUBWAY) – LINES 1 AND 2. SARRIKO–DEUSTO SECTION

**Owner:** Dpto. de Transporte y Obras Públicas del Gobierno Vasco

<table>
<thead>
<tr>
<th>STATUS</th>
<th>Start: 10/1990</th>
<th>End: 02/1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE</td>
<td>Cavern Shaft Tunnel</td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>Spain</td>
<td></td>
</tr>
<tr>
<td>PROVINCE</td>
<td>Vizcaya</td>
<td></td>
</tr>
<tr>
<td>PLACE</td>
<td>Bilbao</td>
<td></td>
</tr>
<tr>
<td>BUDGET (EXCLUDING VAT)</td>
<td>9,602,743 €</td>
<td></td>
</tr>
</tbody>
</table>

**Geometry:**
- **Cross section:** 62 m²
- **Length:** 932 m

**Overburden:** Medium

**Method of tunneling:**
- NATM. Top-Heading and Bench. Drill and blast
- Mechanical excavation

**Geology and geotechnical data:**
- Marls, limestones, sandstones and lutites (Lower Cretaceous)

**Tunnel equipment:**
- Jumbo has two booms and service platform Atlas Copco Boomer

**Location and additional information:**
Two railway tunnels of Bilbao Subway, stretch: Sarriko-Deusto. Excavation and support systems.

The design includes the construction of 110 m long cavern with 18 x 13.5 m of cross section. Concrete segment lining and extrados shotcreting.

Two access ramps and ventilation systems.