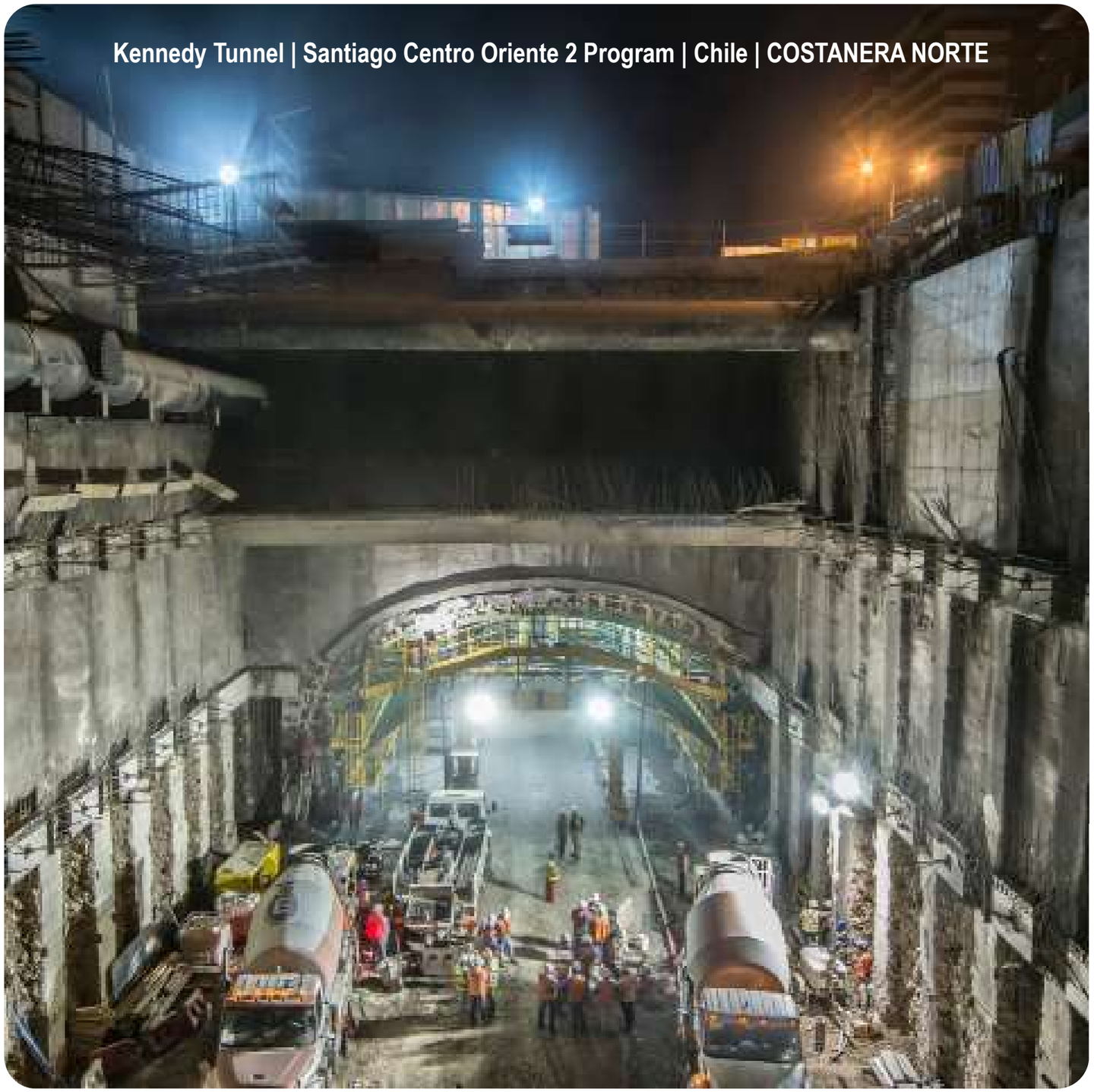


Subterra

Excellence in Tunnel Engineering

2020

Energy / Mining /Transport

www.youtube.com/subterraIng

www.es.linkedin.com/in/subterra/

@Subterra_Ing

Alto Maipo Hydroelectric Project | Chile | HOCHTIEF-CMC

1. Company Overview

1.1. Introduction

1.2. Mission, vision, values

1.3. Staff

1.4. Software tools and facilities

1.5. Quality and environmental management systems

1.6. Presence in organizations

Las Cruces Mine | Spain | COBRE LAS CRUCES

T2 Tunnel. E-65 Highway | Greece| OBRAS SUBTERRÁNEAS

1.1. Introduction

SUBTERRA is an independent private corporate group, unconnected to construction companies, suppliers of equipment or services and financial companies. Their projects are based exclusively on the rigorous analysis of each case, in order to develop technical solutions optimizing the construction costs with the maximum safe and environmental conditions, as well as compromise with the community. **SUBTERRA** is certified in ISO 9001, 14001 and 166002 management systems; and OSHAS 18001.

Since its creation **SUBTERRA** has offer services both in the design stage and during construction. As design engineering, its services include field data collection and interpretation, sophisticated support and lining calculations, functional design and security installations; and applied to all phases of feasibility, basic engineering, and detailed engineering value. In the construction phase, its services extend to the geotechnical monitoring and monitoring of slopes, tunnels and underground spaces.

SUBTERRA actually is constituted by the following companies:

- SUBTERRA Ingeniería Ltda in Chile,
- SUBTERRA Ingeniería SAS in Colombia,
- SUBTERRA Ingeniería SL in España,
- SUBTERRA India Engineering Pvt. Ltd, and
- SUBTERRA Ingeniería SAC in Peru;

that functionally act as a unique company organizing its staff and facilities to offer the best services accordingly to the specific characteristics of each project.

SUBTERRA has permanent offices in Delhi, Lima, Madrid, Medellin and Santiago, as well as several site offices; developing also projects during 2019 in fifteen countries. All of them are fully equipped with specific software tools such as FLAC 2D and 3D, UDEC, PFC, EXAMINE 2D and 3D, FAGUS, STEPS, SOLVENT, SAP2000, among others.

SUBTERRA group employs, with nine countries's technicians, is constituted for a multidisciplinary staff, from which 81 % has University degree, with more than 30 years of experiencie.

SUBTERRA has consolidated worldwide as one of the leading engineering companies specialized in the field of underground works.

P.H. San Francisco MInes | Ecuador | GNF ENGINEERING

1.2. Mission, vision, values

Vision

To be a benchmark in the Iberoamerican and India geotechnical, tunnelling and underground space engineering.

Mission

To provide geotechnical, tunnelling and underground space engineering services based on a rigorous analysis of each case, in order to develop technical solutions optimizing the construction costs with the maximum safe and environmental conditions, as well as compromise with the community.

Values

- **Excellence**
- **Innovation**
- **Social Commitment**
- **Motivation**
- **Integrity**

PH Torito | Costa Rica | GNF ENGINEERING

South Rajo Access. El Teniente | Chile | SACYR CHILE

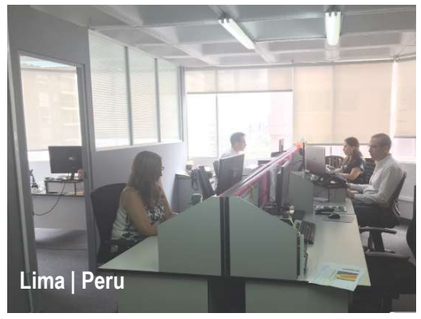
Staff | La Pirámide Tunnel, AVO 1 | Chile

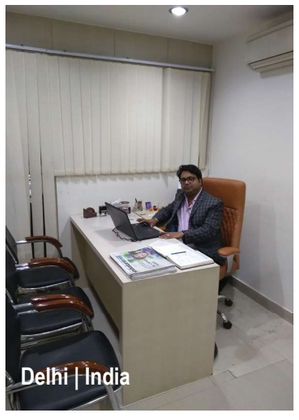
1.3. Staff

SUBTERRA has an agile structure that allow us to offer our clients a top quality services. Our multidisciplinary staff is composed by qualified people of nine countries (Argentina, Bolivia, Chile, Colombia, Guatemala, Spain, India, Peru and Venezuela).

Continuous learning is a major issue for SUBTERRA, which is why different external and internal training programs have been implemented. We also provide our staff with innovative state of the art technical tools, so that they can achieve a complete professional engagement with our clients.

In SUBTERRA we fully support the principle of gender equality thus 40% of our staff is composed by high qualified women.


Lima | Peru

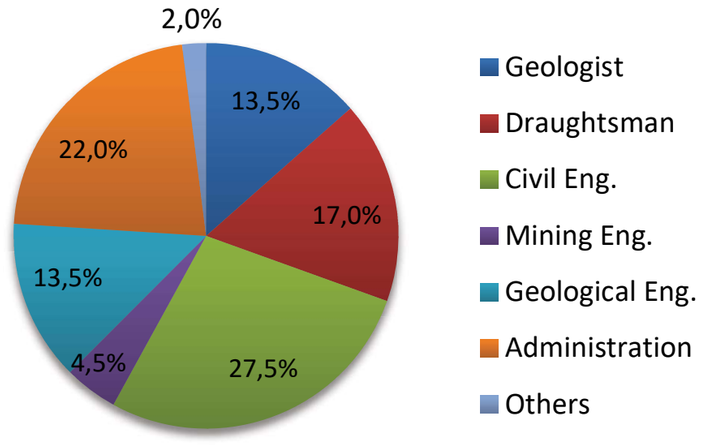

Delhi | India


Madrid | España


Medellin | Colombia

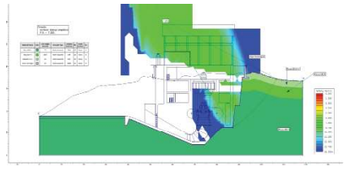

Santiago | Chile

Our team works on the projects with effort, talent and creativity.

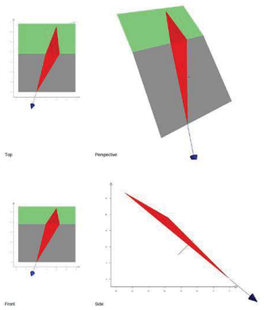


1.4. Software tools and facilities

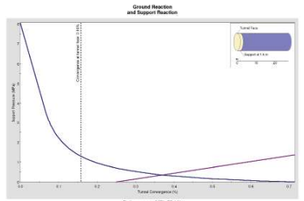
We have permanent offices in Santiago (Chile), Madrid (Spain), Medellin (Colombia), Delhi (India) and Lima (Peru), all of them are fully equipped and with the advanced technical software that allows to offer innovative solutions:



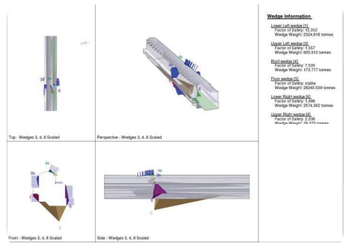
SLIDE V.6.0



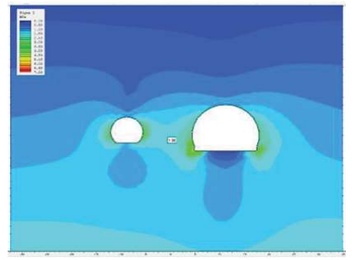
SWEDGE V.5.012



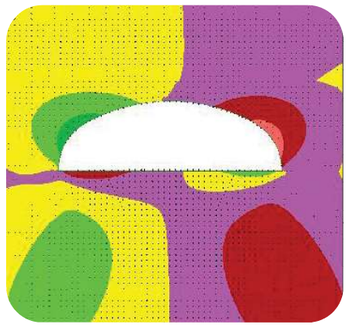
ROCSUPPORT V.3.0



UNWEDGE V.3.0

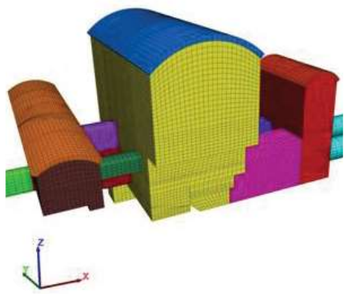


EXAMINE 2D V.7.0

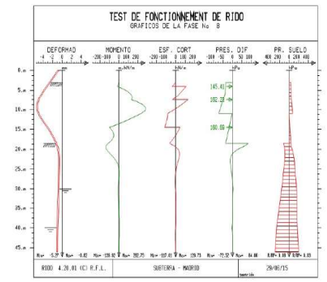


FLAC V.6.0

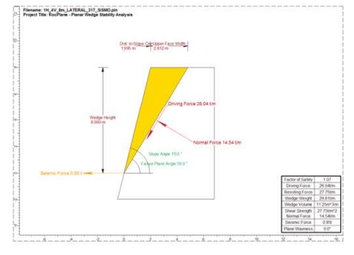
EXAMINE 3D V 4.0



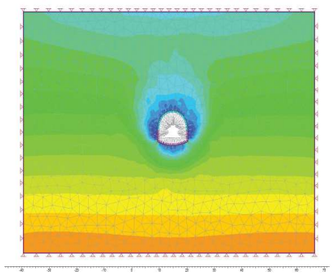
FLAC 3D V.5.0



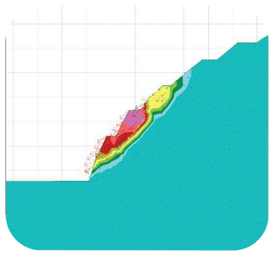
RIDO V:4.20.01



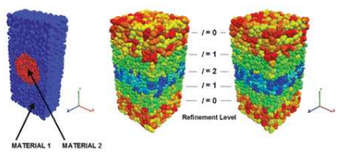
ROCPLANE V.6.0



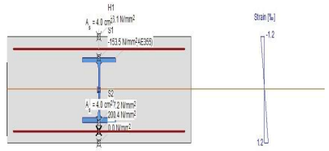
PHASE 2 V.8.0



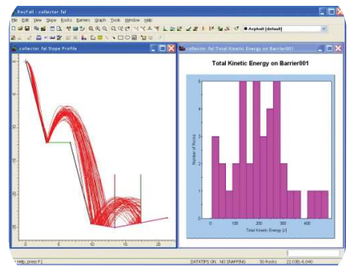
UDEC V.5.0



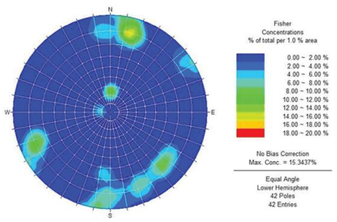
PFC2D V.4.0



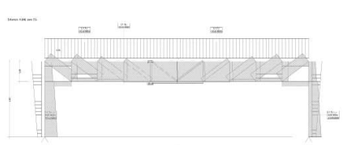
FAGUS V 6.0



ROCFALL V.4.0

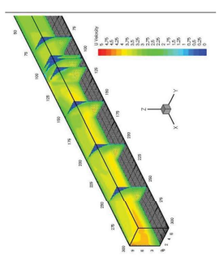


DIPS V.5.1

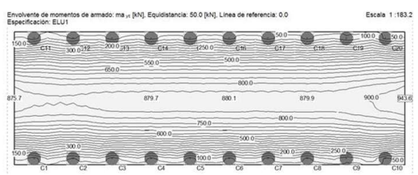


STATIK V. 6.0

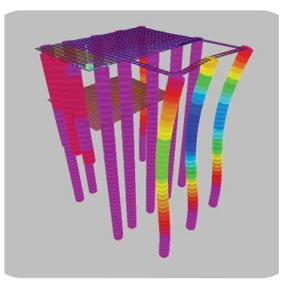
STEPS V 5.3



SOLVENT V IV



CEDRUS V 6.0



SAP2000

1.5. Quality and environmental management systems

False Tunnel Almendral | Spain | OSSA-TAPUSA

SUBTERRA INGENIERÍA is Certified in ISO 9001:2015, ISO 14001:2015, and UNE 166002 management systems R&D since 2011 (since 2018 by Bureau Veritas) and OSHAS 18001 in Chile.

This intention reflects the strong commitment with our clients in order to offer them the highest QUALITY in our projects/works, promoting in our team respect and responsibility to the ENVIRONMENT.

We express our commitment to develop our work in optimal conditions of Health and Safety.

Finally, we have an R+D+i project management system, which is so important for us.

1.6. Presence in organizations


PH Cheves Cavern | Peru | HOCHTIEF - TECSA

SUBTERRA belongs to the following associations:

- **AETOS** (Asociación Española de Túneles y Obras Subterráneas)
- **AIC (**Asociación de Empresas Consultoras de Ingeniería de Chile A.G.)
- **AMINER** (Asociación de Empresas Investigadoras, Extractoras, Transformadoras Minero-Metalúrgicas, Auxiliares y de Servicios)
- **CTES** (Comité de Túneles y Espacios Subterráneos de Chile)
- **SEMR** (Sociedad Española de Mécanica de Rocas)
- **APTOS** (Asociación Peruana de Túneles y Obras Subterráneas)
- **ACTOS** (Asociación Colombiana de Túneles y Obras Subterráneas)
- **PTTP** (Plataforma Tecnológica de Túneles)
- **EURACOAL** (European Association for Coal and Lignite)
- **TECNIBERIA (**Asociación Española de Empresas de Ingeniería, Consultoría y Servicios Tecnológicos)
- **PTES** (Plataforma Tecnológica Española de Construcción**)**

At the same time its members belong, or have belonged to the following organizations:

- **AENOR**: Comité CTN 103 “Geotecnia”.
- **COMITÉ EUROPEO DE NORMALIZACIÓN CETN TG 341 WG5:** Geotecnia.
- **ASTM**: Comité D18.02.07. Ensayos de presiometría y dilatometría.
- **COMISIÓN EUROPEA**: Coal Advisory Group (TGC1-DGXII)
- **CORDIS (Comm. Research and Development Information Services):** FP7.

SUBTERRA has personnel affiliated to the following Professional Associations:

- **CHILE**: Colegio de Ingenieros de Chile A.G.
- **COLOMBIA:** Consejo Profesional Nacional de Ingeniería
  Sociedad Antioqueña de Ingenieros y Arquitectos
  Sociedad Colombiana de Ingenieros
- **ESPAÑA**: Colegio Oficial de Ingenieros de Minas
  Colegio de Ingenieros de Caminos, Canales y Puertos
  Ilustre Colegio Oficial de Geólogos
- **PERÚ**: Colegio de Ingenieros del Perú

Leaders of the tunnel consultancy sector

2. Company activities

2.1. Professional capabilities

2.2. R+D+I activities

2.3. Safety installations

2.4. Diagnosis and rehabilitation of tunnels

Vivaceta Tunnel | Santiago Centro Oriente Program 1 | Chile | COSTANERA NORTE

Excellence in tunnel engineering

Highways and roadways

High-speed railways

Conventional railways

Hydraulic Works

Hydroelectric Works

Mining

Lo Saldes Tunnel | Chile | COSTANERA NORTE

2.1. Professional capabilities

Underground excavations

- Tunnel Design
- Excavation Method Analysis
- Tunnel Boring Machines (TBM)
- Support and Lining Design
- Subsidence Evaluation
- Portals
- False tunnels
- Caverns and Shafts
- Geotechical Assessment during Construction
- Monitoring
- Diagnosis and Rehabilitation of Tunnels
- Safety Installations (Ventilation, Ilumination, etc)

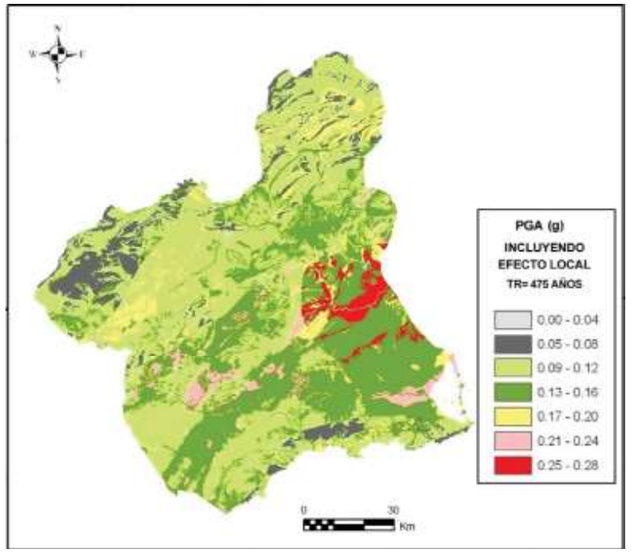
Mining

- 3D Geological Modeling
- Resources and Reserves Assessment
- Mine Feasiblity Studies
- Open Pit Designs
- Undergroung Mining Designs
- Mine Decommissioning and Closure
- Dumps and Tailings Studies
- Underground Mine Infraestructure Design (Tunnels, Shafts & Caverns)

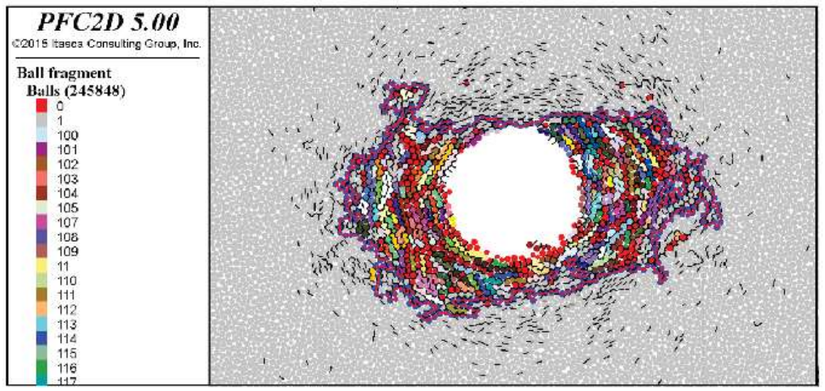
Geotechnical

- Risk Assessment
- Hidrogeology Studies
- Soil & Rock Mechanics
- Slopes & Earth Structures
- Excavation Assesment
- Aggregates and Quarries

2.2. R+D+I activities



Map of seismic accelerations | MODELRISK



Thermal effect in a gasification's borehole | COGAR

The applied research give us the opportunity to offer our clients the latest ground engineering techniques, improving our designs, enabling them to solve these complexes and challenging problems.

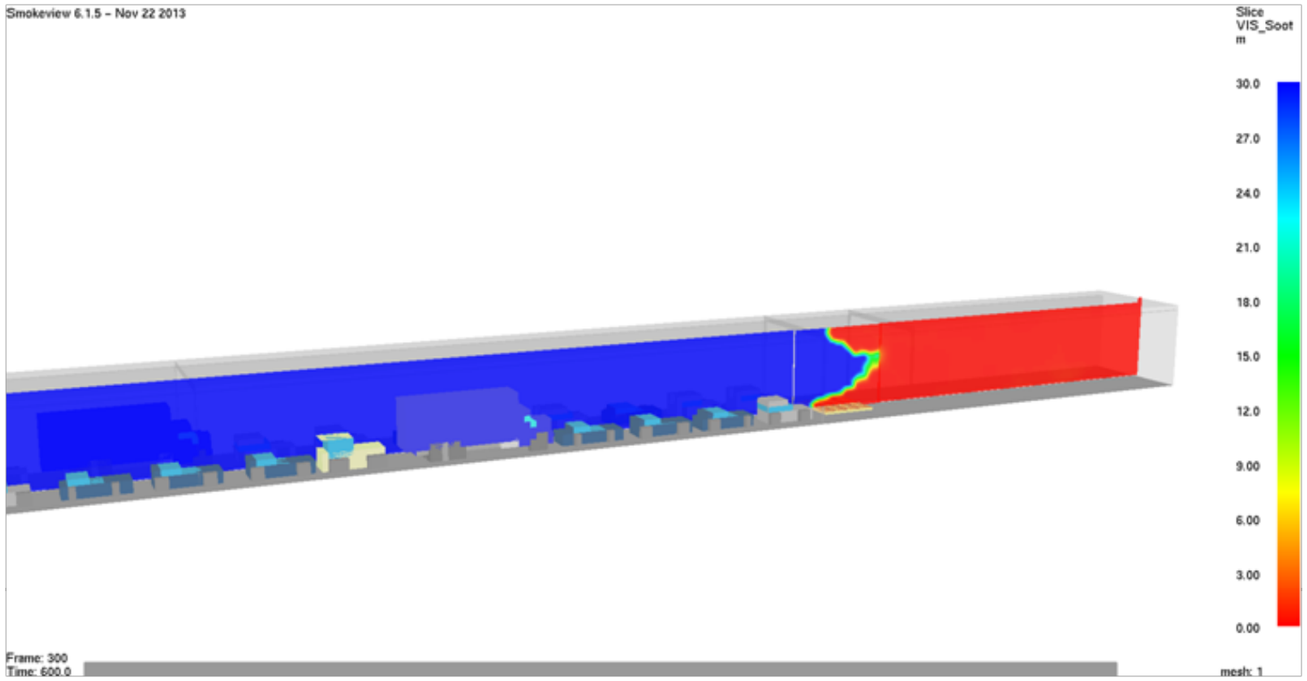
As we said before, we have a UNE 166002 system for the Research and Development projects. During the past we were registered as an innovative PYME.

In the past we collaborated in the following projects:

- Avanced tool for the standardization in the Naturals Risks's evaluation and management based in Quantitative Cartograph. "MODELRISK". INNPACTO SUBPROGRAM 2010-2014. Client: Ministerio de Ciencia e Innovación.
- Underground Coal Gasification in operating mine and areas of high vulnerability (COGAR). RFC-PR-12005 – (2013-2016). Client: Comisión Europea. DG XII.
- Smarter Lignite Open Pit Engineering Solutions (SLOPES). RFCR-CT-2015-00001 – (2015-2018). Client: Comisión Europea. DG XII.
- Investigation for the competitive improvement of the perforation cycle and blasting in mining and underground works through the definition of news techniques of engineering, explosives, prototypes and advanced tools. (TUÑEL). 2015-2018. Client: Centro para el Desarrollo Tecnológico Industrial (CDTI).
- Avanced methodology based in seismic zoning for evaluating and using the seismicity in underground works. (SYOS). 2017-2019. CONCYTEC.

We have been selected by the European Commission DGXII, by the Direccion General de Transferencia de Tecnologia y Desarrollo Empresarial of the Spanish Ministry of Science and Innovation and by Centro para el Desarrollo Tecnológico Industrial (CDTI), for the following projects:

- **A Human-centred Internet of Things Platform for the Sustainable Digital Mine of the Future (DIG). 2020-2024. RFCS.**
- **MINRESCUE. 2020-2024. RFCS.**
- **Advanced prediction for the behavior of the mass-tunnel complex, through the management and interpretation of geotechnical geological information of underground projects (KNOWTUNNEL). 2017 - 2019. CDTI.**
- **Risk Assessment of Final pits during Flooding (RAFF). 2019 - 2022. RFCS.**
- **The impact of EXtreme weather events on MINing operations (TEXMIN). 2019 - 2022. RFCS.**



Simulation of the visibility in a tunnel after reaching the steady state.

Tunnel	Country	Function	Tipology		Traffic	Length (m)	Study level	Year
Américo Vespucio Oriente	Chile	Road	Single-Bore	3 Lanes	Single- Way	8.360	Final Design	2014-16
Américo Vespucio Oriente 2	Chile	Road	Double-Bore	3 Lanes	Single- Way	5.200	Final Design	2018-19
Guayaquil Airport	Ecuador	Road	Double-Bore	2 Lanes	Single- Way	3.270	Final Design	2016
Os Campos	Spain	Railway	Single-Bore	2 Lanes	Double- Way	2.795	Initial Design	2011
O Galo	Spain	Railway	Single-Bore	2 Lanes	Double- Way	4.705	Initial Design	2011
Barro	Spain	Railway	Single-Bore	2 Lanes	Double- Way	7.792	Initial Design	2011
La Aldea	Spain	Railway	Double-Bore	2 Lanes	Single- Way	3.100	Exploitation Manual	2017
Strecht 4 Gran Canaria Railway	Spain	Railway	Single-Bore	2 Lanes	Double- Way	6.430	Final Design	2018
Xaltepec	Spain	Railway	Single-Bore	4 Lanes	Double- Way	302	Final Design	2009-10

Main references of the safety instalations projects.

2.3. Safety installations

The engineering of tunnels and underground spaces requires having modern installation systems that enable their functionality in the maximum security conditions.

Because of them, the international normative and the different nationals normative of the tunnel‘s safety systems, including the tunnel’s explotation in normall conditions like in case of fire, are increasingly demanding. It's necesary to have the following:

- Safety concept.
- Ventilation system.
- Detection and fire detection system.
- Illumination.
- Electromechanical systems.

This requirement is attended by SUBTERRA with the following services:

- **Safety installations project:** including ventilation, illumination and all electromechanical systems necessaries.
- **Exploitation manual,** of the tunnels attending its functionality, including operational normally plan, emergency plan and maintenance plan.
- **Analysis of risks,** versus different scenarios typified in the regulations for cases of accident and fire.

2.4. Diagnosis and rehabilitation of tunnels

SUBTERRA offers a tunnel's inspection services, diagnosis and rehabilitation, based in its experience in the interaction's analysis between the ground, governed by its mechanical parameters and the characteristics of the support applied to the tunnel.

Inspection of Tunnels

SUBTERRA carries out detailed surveys of the visible pathologies and the ground to be immediately behind the structure of a tunnel, which reflect its actually state, adapting the working methodology and tools to be used depending on the peculiarities of each tunnel.

The result of this inspection is a clear diagnosis of the tunnel and the state of its structure, which is understood as the support - lining aggregate. As a result a report of the status of the tunnel is issued, ranking the necessary future actions.

Structural Rehabilitation Tunnels Projects

The inspection and diagnosis of the state tunnel are the base for the performance the necessary works of the detailed engineering in order to redact a project of structural rehabilitation tunnels.

The rehabilitation tunnel is performed in order to get the suitability of the same to the new functionality (change the gage, etc) or for rehabilitating the structure of the tunnel. For it, is necessary to carry out sophisticated retrospective analyzes that reproduce the pathologies observed, using special software for stress-strain numerical calculations. Subsequently, the goodness and effectiveness of the proposed rehabilitation measures are analyzed using the same tools.

Maintenance Programs of Tunnels

Many times is possible coexisting with the pathologies existing in a tunnel, however is necessary has a control and following of the same.

For this reason, the execution of maintenance programs based on the inspection and diagnosis of a tunnel conforms a third service in the ambit of tunnel inspection and rehabilitation. It is used auscultation and monitoring techniques that allow knows in real-time the status and evolution of a tunnel, adopting in enough time, the necessary measures.

Main referencies

2010

- Inspection of Tunnels of the Jabarrella Canal (Huesca, Spain)
- Project of rehabilitation of the Son Sureda railway tunnel (Baleares, Spain)

2011-12

- Inspection, rehabilitation project and assessment during the works of the Portillo tunnel of the La Confluencia Hydroelectric Plant (VI Region, Chile)

2012

- Rehabilitation project of the Llanes Alternative railway tunnels (Altares and El Bolao Tunnels) (Asturias, Spain)

2013

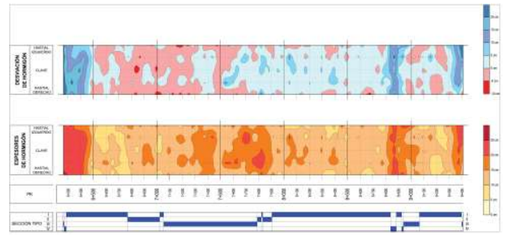
- Inspection of the Forcadiña, Sierra Pequeña and El Molino railway tunnels (Orense, Spain)

2013-14

- Inspection and rehabilitation project of the PH Pizarras's headrace tunnel (Cajamarca, Peru)

2015

- Inspection of the support's state of the highway Agaete-La Aldea's Tunnel 1. Tunnel lining and drainage review. (Gran Canaria, Spain)



Thickness isolines of shotcrete. La Aldea tunnel, Spain

2016

- Definition of the stabilization's solutions of the San Lorentzo and Belabieta tunnels in the A-15 Navarra-Gipuzkoa's Highway. (Guipúzcoa, Spain)

2016-17

- Support inspection of the Asana River's diversion tunnel. Quellaveco mine. (Peru).

2017

- Inspection and verification of the tunnel state of the Belt 1, draw point and By Pass. Antamina (Peru).
- Specialized advice in tunnels during the construction of the tunnels of the Astigarraga-Irún section (Spain)
- Inspection and verification service of CH Pangal Tunnel (Chile)

2018

- Terminal tunnel maintenance. Colca-Sigüas adduction system (Peru)

Rehabilitation PH La Confluencia, Chile

San Lorentzo and Belabieta, Spain

La Quiebra tunnel. Concesión Vial del Nus | Colombia | MINCIVIL

3. References


Albertia Tunnel | Spain | ADIF

3.1. Motorways and road projects

Since the begining SUBTERRA has participated in the design and assesment during the construction of 49 road tunnels, adding up 99.5 km lenght, in 14 countries.

Project	Tipology	Section (m²)	Lenght (m)	Constructive Method	Litology/s	Study Level	Year	Client	Country
North Costanera - South Costanera. (Tunnel: Costanera N-S)	Single-Bore	75	311	NATM	Gravels, andesites and shales	Draft	2010	GEOCONTROL CHILE	Chile
Maitenes-Confluencia Motorway. (Tunnels: T1/T2/T3)	Single-Bore	75	447/989/3.361	NATM	Andesites, conglomerate and tuffs	Detailed Desing / Assistance	2012-15	SACYR CHILE	Chile
"Santiago Centro – Oriente 1". (Tunnel: Vivaceta)	Single-Bore	92	580	NATM	Gravels	Assistance	2013-14	COSTANERA NORTE	Chile
Constructive Desing AVO tunnel under Kennedy. (AVO Tunnel)	Single-Bore	284	42	GERMAN	Gravels	Detailed Design	2013	COSTANERA NORTE	Chile
Amèrico Vespucio Oriente. El Salto–Principe de Gales (Tunnel: AVO)	Single-Bore	148	8.360	NATM. CUT & COVER	Tuffs, andesites and gravels	Tender Design	2013	SACYR CHILE	Chile
"Santiago Centro-Oriente 2". (Tunnels: Kennedy, Costanera N-S and Lo Saldes)	Single-Bore	200	1.150	NATM	Gravels	Detailed Design	2013-14	SACYR CHILE	Chile
		80	292	NATM	Andesites and tuffs	Detailed Design	2013-14	SACYR CHILE	Chile
		90	65	NATM	Gravels	Detailed Design	2013-14	SACYR CHILE	Chile
Amèrico Vespucio Oriente. El Salto – Principe de Gales. (Tunnel: AVO)	Single-Bore	148	8.360	NATM. CUT & COVER. GERMAN	Tuffs, andesites and gravels	Detailed Design	2014-15	OHL-SACYR	Chile
"Santiago Centro-Oriente 2". (Tunnel: Kennedy)	Single-Bore	200	1.507	NATM. CUT & COVER	Gravels, andesites and tuffs	Assistance	2014-17	COSTANERA NORTE	Chile
Radial NO. Chamisero 2 Tunnel	Double-Bore	80	1.590	NATM	Andesites and colluvials	Detailed Design	2015-16	COSTANERA NORTE	Chile
Radial NO. Chamisero 2 Tunnel	Double-Bore	80	1.590	NATM	Andesites and colluvials	Assistance	2016-17	GESVIAL	Chile
Los Maitenes Parque Negocios Enea Axis	Single-Bore	85	282	NATM	Pumicite	Draft	2016	ENEA	Chile
Americo Vespucio Oriente Principe de Gales- Los Presidentes (AVO 2)	Double-Bore	120	5.200	NATM	Gravels, clays	Tender Design	2016-17	OHL-SACYR	Chile
Motorways's Sector 2 Bogotá – Villavicencio. (Tunnel: Tunnel 6A)	Single-Bore	88	4.333	NATM	Quartzites, phyllites, and colluvials	Tender Design	2011	SACYR-CAVOSA	Colombia
La Quiebra Tunnel	Double-Bore	80	8.200	NATM	Quartzodiorites	Assistance	2018-20	MINCIVIL	Colombia
Motorway. Diagonal C15/C37 Axis (Tunnel: Montconill)	Single-Bore	90	615	NATM	Shales and sandstones	Assistance	2010	DRAGADOS	Spain
Elorrio Alternative. (Tunnels: Gaiztelua I and Gaiztelua II)	Double-Bore	85	594 / 1.141	NATM	Shales, Marls and sandstones	Tender Design	2011	FCC	Spain
Bermeo Alternative. (Tunnels: Ormaetxe, Sollube and Gainzadala)	Single-Bore / Double-Bore	85	950/1.150/640	NATM	Argilites, limolites, sandstones and marls	Tender Design	2011	FCC	Spain
Arequipa-La Joya Highway. (Tunnel: La Joya)	Double-Bore	90	740	NATM	Granites	Draft	2014	AYESA	Peru
Chancay Access Port. (Tunnel: Chancay)	Single-Bore	75	2.300	NATM	Gravels, clays	Assistance / Detailed Design	2014-15	T. PORT. CHANCAY	Peru
Construction Yanango Tunnel and access.	Single-Bore	100	1.062	NATM	Granites, saprolites	Assistance	2014-15	BALZOLA	Peru
Interoceànica Sur. Ollachea tunnel	Road	90	930	NATM	Andesites, sandstones, limonites, quartzites and slates	Detailed Design	2017-18	INTERSUR	Peru
"Monteagudo – Ipati" Strecth (Tunnel: Incahuasi)	Road	72	1.230	NATM	Sandstones, shales and limolites	Detailed Desing	2010	GEOCONTROL MAB	Bolivia
Rodoanel N. Strecth (Tunnel 501)	Double-Bore	180	1.100	NATM	Filites, granites and milonites	Assistance / Detailed Design	2014-16	COPASA	Brazil
Rodoanel Batches 1 to 5. Sao Paulo North Strecth. (Tunnel: Rodoanel)	Double-Bore	187	(7 Tunnels) 6.360	NATM	Granites and saprolites	Tender Design	2012	ISOLUX-CORSAN	Brazil
Chongón – Colonche Strecth. Guayaquil – Santa Elena Highway. (Tunnel: Santa Elena)	Double-Bore	92	3.000	NATM	Sandstones, shales and limestones	Draft	2014	GEOESTUDIOS	Ecuador
Guayaquil Airport Tunnel	Double-Bore	110	3.140	NATM	Limestones, shales, sandstones and conglomerates	Initial Design + Detailed Design	2016	CVA - AET	Ecuador
Amazoc-Veracruz Motorway. (Tunnel: Xalpetec)	Single-Bore	145	302	NATM	Basalts and volcanic tuffs	Detailed Desing	2009-10	ISOLUX CORSAN	Mexico
Acapulco Project Escénica Alterna. (Tunnel: Acapulco)	Single-Bore	115	3.204	NATM	Granites, schists and phyllites	Tender Design	2012	SACYR-CAVOSA	Mexico
Libramiento Acapulco (María Bonita)	Single-Bore	210	495	NATM	Gneisses	Detailed Desing	2015	MOTA ENGIL	Mexico
Jala-Las Varas Motorway. Tunnels: Las Truchas and Paso del Jaguar	Single Bore	200	870/1.100	NATM	Lahares / pyroclastic flows	Assistance	2017-18	OSSA	Mexico
Atizapán-Atlacomulco Motorway. Tunnels: Los Gallos and Cahuacán	Single Bore	215	210/115	NATM	Lahares / pyroclastic flows	Assistance	2018-19	OSSA	Mexico
Ionia Odos Motorway. (Tunnel: Kalydona)	Double-Bore	95	1.180	NATM	Sandstones and limolites	Assistance	2010	OSSA	Greece
Central Greece Motorway. E-65. (Tunnel: T2)	Double-Bore	95	3.000	NATM	Diabasas, basalts and lavas	Assistance	2010	OSSA	Greece
Tuen Mun – Chek Lap Kok Link – Northerm Connection Subsea	Double-Bore	150	2 x 4.100	WATER-SHIELD	Granites and sandstones	Tender Design	2012	OHL	Hong Kong
Struma Highway. Zheleznitsa Tunnel	Double-Bore	90	2.000	NATM	Anphibolites and gneiss	Tender Design	2016	STOSE-OSSA	Bulgaria
Kherrat Gorges (RN09). Kherrata Tunnels	Single-Bore	85	520/250/370	NATM	Dolomites	Tender Design	2016	ISOLUX-CORSAN	Algeria
Tharthri-Kilhotran Motorway. Kahaljugasar tunnel	Double Bore	90	2x4.000	NATM	-	Detailed Design	2018-19	NHIDCL	India

XALTEPEC TUNNEL (AMOZOC - VERACRUZ MOTORWAY), Mexico

The Xaltepec tunnel is part of the Motorway Project Amazoc – Veracruz, Xalapa Bypass Stretch.

One of the key issues to tackle at the time construction of the Xaltepec Tunnel is the design of the cross section, because it should embrace four lanes of 3,5 m width and a minimun gauge of 5,5 m hight (from shoulder).

This provision is a useful width of 18 m, which is equivalent to a excavation width of approximately 19 m, which can be described as an excepcional width, although there is some precedent, it's clear that this is a tunnel unique in terms of geomechanical quality of the land, the construction of this tunnel will be an important milestone.

CONSTRUCTION TUNNEL OF YANANGO AND ACCESS, Peru

The construction of the Yanango tunnel improves the current deficiencies of the current Tarma-San Ramón highway at its junction with the Yanango river, resolved by means of a suspension bridge that allows the passage of light and medium vehicles, but whose use is not allowed for heavy vehicles, which must use a ford that causes discomfort, insecurity and loss of time to users.

The tunnel, 1,012 m long and 96 m^2 of useful area, can accommodate three traffic lanes, two up and one down, as well as the berms and sidewalks included in the regulations. In its development, the tunnel is divided into three large blocks: tunnel in colluvial soil, located in the entrance portal, tunnel under the ravine in the intermediate zone and tunnel in rock in the rest. This procedure determines the support to be used in each case. The execution is contemplated, both in the entry portal and in the exit, of two false tunnels; being the exit portal, a half tunnel whose section is completed with the structure.

SANTIAGO CENTRO - ORIENTE PROJECTS (KENNEDY, COSTANERA N-S, LO SALDES), Chile

Costanera Norte has been appointed by MOPT (Ministerio de Obras Públicas of Chile) to develop the new traffic system East-West in Santiago de Chile. Detailed design and technical adduce will be camed out by Subterra.

- **Lo Saldes Tunnel**, 65 m length and 14.0 m width of excavation.
- **Costanera Norte – Costanera Sur Tunnel**, 292 m lenght, with 10,0 m width will be two lanes traffic.
- **Kennedy Tunnel**: 1150 m length, between Perez Zujovic round and Américo Vespucio link . The tunnel will be four lanes traffic and its cross section will be about 20 m wide and 200 m^2 excavation area. The excavation will be camed out by NATM.

3.2. Railway and metro projects

SUBTERRA has participated in the design and assesment during the construction of 28 railway tunnels, adding up 175 km of tunnel in 6 countries.

Project	Tipology	Section (m2)	Lenght (m)	Constructive Method	Litology/s	Study Level	Year	Client	Country
Santiago Subway L3 and L6. (Tunnel: Santiago Subway)	Double-Bore	58-185	21.397	NATM/CAVERNS/ SHAFTS	Gravels	Tender Design	2013-14	ISOLUX CORSÁN-COPISA	Chile
High Speed Railway Burgos-Vitoria. Strecth: Burgos–Prádanos de Bureba. (Tunnel): Fresno de Rodilla)	Double-Bore	77	5.250	EPB	Marly shales	Detailed Design	2009-10	CYE	Spain
South Train. Strecth 6: San Miguel - Montaña de Guaza (Arona). (Tunnel: Tunnel 6)	Single-Bore	115	2.283	NATM	Basaltic lava flows, slag and ignimbrites	Initial Desing	2010	EYSER / GETINSA	Spain
High Speed Atlántico Axis. Strecth: Vigo - O Porriño. (Tunnel: Vigo – Porriño)	Single-Bore / Double-Bore	115/77	10.000	NATM/TBM	Granites and gneiss	Initial Desing	2010	TRN	Spain
Reopening line: Manacor-Artá. Strecth 3: Son Servera-Artá. (Tunnel: Son Sureda)	Single-Bore	40	80	NATM	Limestones and marls	Detailed Design	2010	DRACOTEC	Spain
High Speed Railway Bobadilla-Granada. Strecth: Archidona-Arroyo de la Negra. (Tunnel: Archidona)	Single-Bore	138	1.053	NATM	Marls, limestones, dolomitic breccias and clays	Assistance	2010	DRAGADOS	Spain
Strecth 4. Railway Las Palmas – Maspalomas. (Tunnel: El Goro)	Single-Bore	105	2.000+4300	NATM + CUT&COVER	Basalts and agglomerates	Initial Desing	2011-12	EYSER / GETINSA / GIPIC	Spain
Strecth 7. Railway Las Palmas – Maspalomas. (Tunnel: Maspalomas)	Single-Bore	100	3.000	NATM	Phonolites	Initial Desing	2011	PROINTEC / INGENIA	Spain
High Speed Railway Galicia. Strecth: Ourense – Vigo. Strecth: O Carballiño – O Irixo. (Tunnels: Tunnel 1, Tunnel 2 and Tunnel 3)	Double-Bore	78	2.400	NATM	Granites	Initial Desing	2011	TRN INGENIERÍA	Spain
	Single-Bore	110	2.271	NATM	Granites				
	Single-Bore	110	2.278	NATM	Schists				
High Speed Railway Galicia. Strecth: Ourense-Vigo. Strecth: Cerdedo-Barro. (Tunnels: Os Campos, O Galo and Barro)	Single-Bore	110.1	2.795	NATM	Granites	Initial Desing	2011	GOC-CALTER	Spain
	Single-Bore	110.1	4.705	NATM	Granites. ortogneiss schists				
	Double-Bore	71.03	7.792	TBM DOUBLE SHIELD	Granites				
High Speed Railway Asturias. Strecth: Pola de Lena-Oviedo. (Tunnel: Pola de Lena)	Single-Bore	118	11.380	NATM	Slates and sandstones	Initial Desing	2012	PROINTEC	Spain
Corridor N–NW High Speed Railway Madrid – Galicia. Strecth: Prado-Porto. Alternative. (Tunnel: Prado Tunnel)	Double-Bore	72	7.606	NATM	Quartzites, phyllites, shales, granites and gneisses	Detailed Design	2012	COMSA/ ALDESA / COPASA / AZVI / COPISA	Spain
Corridor N–NW High Speed Railway Madrid – Galicia. Strecth: Cerdedelo-Prado. Right railway. Alternative. (The Corno Tunnel)	Double-Bore	72	8.510	NATM	Shales, phyllites, lidites, ampelites and quartzites	Detailed Design	2011-12	COPROSA -INSERSA - RUBAU	Spain
Corridor N–NW High Speed Railway Madrid – Galicia. Strecth: Cerdedelo-Prado. Left railway. Alternative. (The Corno Tunnel)	Double-Bore	80	8.510	NATM	Shales, phyllites, lidites, ampelites and quartzites	Assistance	2012-16	COPROSA-INSERSA-RUBAU	Spain
		80	8.500					ISOLUX / TABOADA	Spain
Access Ferrol Port (Briòn Tunnel)	Single-Bore	70	5.640	NATM	Schists and granites	Tender Design	2016	COPASA	Spain
San Sebastián Subway La Concha Station	Subway and Station	150	190	CAVERNA	Marls and limestones	Detailed Design	2016	FULCRUM	Spain
Dublin Subway	Subway and Station	80	7.000	EPB	Limestones and clays	Tender Design	2018	IDOM	Spain
Avant Project Detaille Troçon 2. (Tunnels: Strecth 2, Strecth 1 and Strecth 1 A2)	Single-Bore	75	600+800	NATM	Marls and limestones	Initial Desing	2013	GETINSA	Algeria
	Single-Bore	75	18.900	NATM	Limestones, calcoarenites, sandstones	Initial Desing	2013-15	GETINSA	Algeria
	9 Single-Bore / 2 Double-Bore	52	3.680	NATM	Limestones, calcoarenites, sandstones	Initial Desing	2013-15	GETINSA	Algeria
LC and LD La Meca Subway. (Tunnel: La Meca Subway)	Double-Bore	40-85	16.741	NATM/C&C/TBM/ CAVE	Granodiorites, tonalites, quartzs-diorites, gabbros, amphibolites and volcano-sedimentary units	Tender Design	2014	ISOLUX CORSÁN	Saudi Arabia
New Line Obulavaripalle – Venkatachalam. (Tunnel: Chennai)	Single-Bore	52	980+6.780	NATM	Phyllites and quartzites	Initial Desing	2010	AYESA	India
Guadalajara Subway Line 3	Subway and Stations	120	4.500	SCREENS / SHAFT / TBM	Tuffs and basalts	Detailed Desing / Assistance	2015-17	MOTA ENGIL	Mexico
Ho Chi Minh City Urban Mass Rapid Transit Line 2	Subway and Station	70	8.000	EPB	Delta deposits	Tender Design	2018	IDOM	Vietnam

DETAILED ENGINEERING OF THE STATIONS OF LINE 3 OF THE GUADALAJARA METRO, Mexico

Line 3 of the Guadalajara metro has a length of 22 km and has 18 stations, 13 of them elevated and the rest underground.

Subterra collaborates with the Concorcio Túnel Guadalajara S.A.P.I. of CV in the elaboration of the detail engineering of the Bandera, Independencia, Normal, Catedral and Mayor stations; 90 m long and 20 m wide, executed in the shelter of screen walls reinforced with micropiles.

The project is located in the Metropolitan Zone of Guadalajara (ZMG) in the Mexican state of Jalisco. The project runs from Northwest to Southeast through the Metropolitan Zone of Guadalajara, between Zapopan, the municipality of Guadalajara and Tlaquepaque.

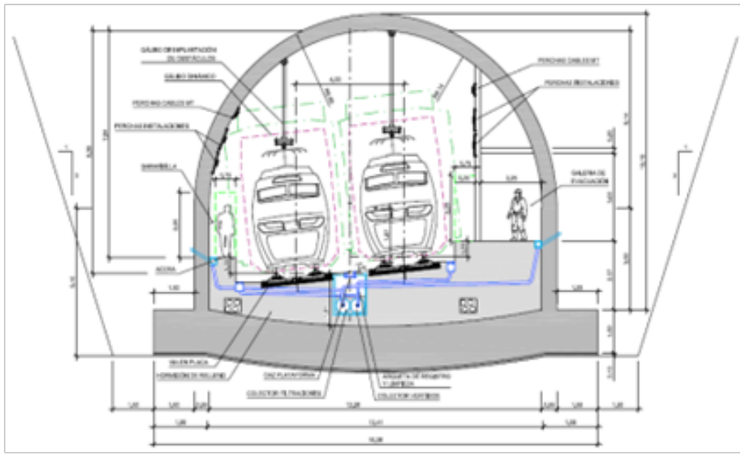
The route has an approximate length of 21,447 m and comprises a first section of air of 8,715 m that includes 7 elevated stations and is mostly developed viaduct. It is followed by an underground section of 5,337.83 m in length, which includes five underground stations and four tunnel sections between them. After the underground section, we continue with a second aerial section of 7,393.61 m in length, which, like the previous one, runs for the most part in viaduct and in which 6 air stations are contemplated.

RAILWAY TUNNELS LAS PALMAS-MASPALOMAS LINE, Spain

Railway line between Las Palmas de Gran Canaria and Maspalomas, stretch 4: Polígono Industrial de El Goro - Barranco de Guayadeque y, Stretch 7: Playa del Inglés (El Cañizo) - Estación de Meloneras (Faro de Maspalomas).

Stretch 4: is divided into three tunnels with a total length of 3 km and three false tunnels with 4 km lenght, which runs under the international Airport of Gran Canaria 10 sections have been required for the design of this stretch that includes tunnel, cut and cover and excavation between diaphragm walls. Furthermore, ventilation system was performed using extraction shafts conditioned by the arrangement of the intermediate stations.

Stretch 7: is a tunnel with 5,6 km length (2,6 km in false tunnel structure). Because of the construction of a shopping mall near the entrance portal, overlays measured from the key of tunnel to the basement of the builking range between 12 y 13,7 m.



EL CORNO TUNNEL. HIGH SPEED LINE LUBIÁN - ORENSE, Spain

The tunnel of El Corno, projected on the stretch Cerdedelo-Porto High Speed Line Lubián - Ourense, is a twin tube tunnel which has a lenght of 8,5 km.

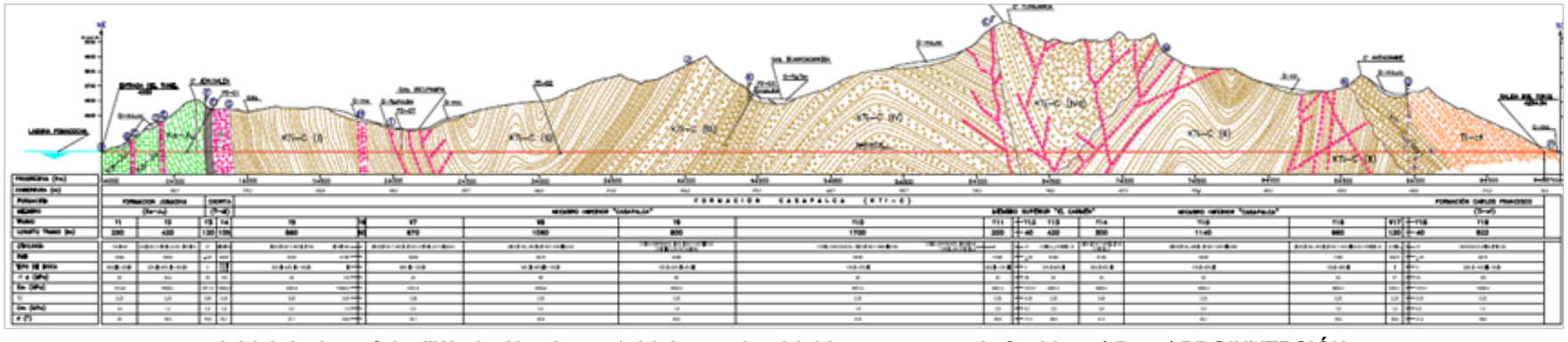
The tunnel alignment crosses at several points the current route of the railway line, which is an important milestone to consider when analyzing the stability of the tunnel.

It is designed to an Adit of nearly 800 m in order to carry out the excavation of the tunnel Corno from four diferentes faces. In addition it is designed the junction between the tunnel and the Adit in an area where the water infiltration to the excavation is high.

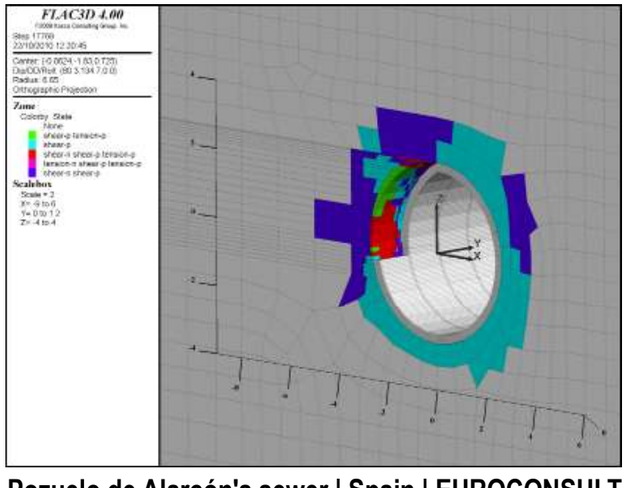
3.3. Hydraulic projects

SUBTERRA has participated in the design, wastewater and supplied of 10 hidraulic tunnels, adding up 53.5 km of tunnel in 3 countries.

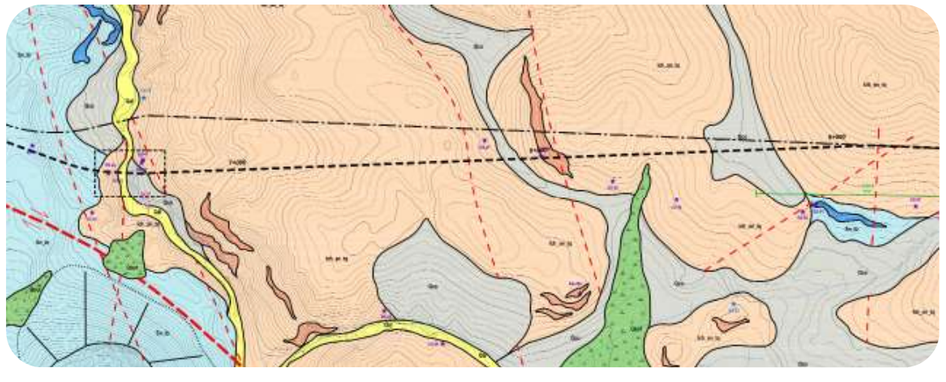
Project	Tipology	Section (m²)	Lenght (m)	Constructive Method	Litology/s	Study Level	Year	Client	Country
Chironta reservoir. Diversion tunnel	Hydraulic	70	473	NATM	Granites	Detailed Desing	2018	BESALCO-DRAGADOS	Chile
Pozuelo de Alarcón Sewer	Hydraulic	6.5	4.572	EPB	Loamy sandstone	Detailed Desing	2010	EUROCONSULT	Spain
Majes – Siguas Diversion (Tunnel: Transandino and Pucara)	Hydraulic	25	11.410+6.450	NATM	Andesites and breccias	Initial Desing and Detailed Desing	2011	COBRA-COSAPI	Peru
Llucila-Siguas Diversion	Hydraulic	25	4.600 2.500 3.100	NATM /TBM	Sandstones, conglomerates, granites and gneisses	Detailed Desing	2012-14	COBRA-COSAPI	Peru
Supply potable water to Lima (Marca 2)	Hydraulic	15	9.898	NATM/TBM	Limestones, sandstones, and conglomerates	Initial Desing	2014-15	PROINVERSIÓN	Peru
Supply potable water to Lima (Marca 2)	Hydraulic	15	9.898+10.000	NATM/TBM	Limestones, sandstone, shales and conglomerates	Tender Design	2014-15	ABENGOA - DAELIM	Peru
Harbour Effluent Tunnel. Stonecutters Island	Hydraulic	65	900	NATM + PITS	Granites	Tender Design	2011	KADEN / OSSA / CHINA RAILWAY G.	Hong Kong



Initial design of the "Works Header and driving to the drinking water supply for Lima. | Peru | PROINVERSIÓN



Pozuelo de Alarcón's sewer | Spain | EUROCONSULT



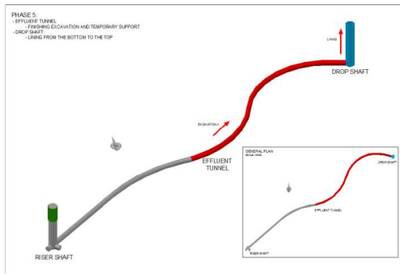
Detailed Design of the Majes – Siguas's tunnels conduction | Peru | COBRA-COSAPI.

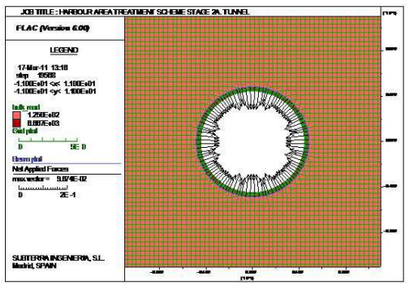
SEWER STONECUTTER ISLAND, Hong Kong

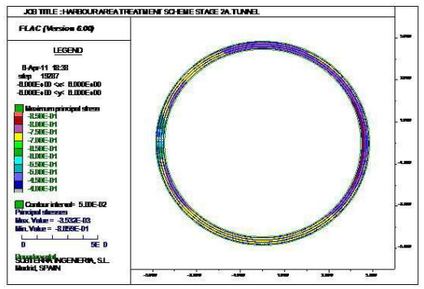
To improve the water quality of the Victoria Harbour, the Harbour Area Treatment Scheme (HATS), formerly known as “The Strategic Sewage disposal Scheme” (SSDS), was committed to be implemented in stages to provide treatment for the sewage collected frome the urban areas on bothe sides of the Harbour. It is currently developing the Phase 2A, whose main targets are the upgrading of eight existing preliminary treatment works on Hong Kong and the improving of the existing Stonecutters Island Sewage Treatment Works from the present design treatment capcity of 1,7 millillion cubic meters per day to cater for the ultimate development scenario of the whole of HATS catchment.

An Effluent Tunnel is proposed to convey the effluent from upgraded treatment facilities on Stonecutter Island to the outfall. This tunnel will be excavated by drill and blast method. It is approximately 880 m lenght, 8,5 m in inside diameter and has a 80 m deep shaft at each end.

The alignment geology of the tunnel and the shafts is composed by granite of the Lion Rock Suite (Jurassic or Cretaceous in age). The bedrock is generally medium to coarse grained with medium spaced and light to extremely narrow joints. Generally, moderately decomposed or better granite will be encountered at the tunnel level. Superficial deposits mainly comprise reclaimed fill, alluvium and marine deposits and its thickness varies between 15,0 and 25,0 meters.







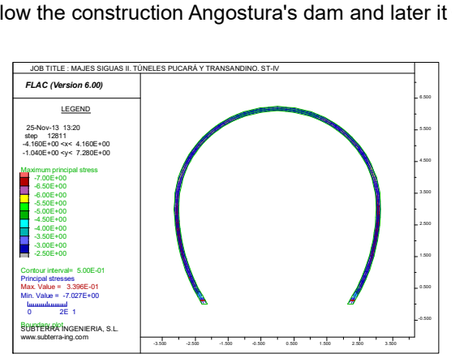
PROJECT MAJES - SIGUAS (PHASE 1), Peru

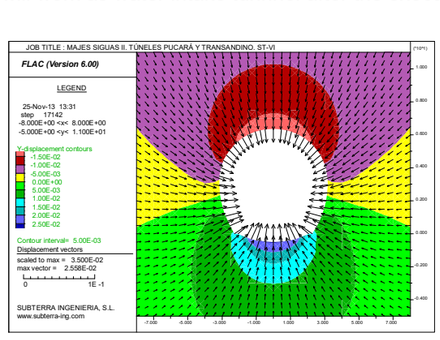
COBRA - COSAPI will be developed the “Obras mayores de afianzamiento hídrico y de infraestructura para la irrigación de las pampas de Siguas”, in Peru, a tunnel conduction will the water from Angostura dam to Chalhuanca river.

The called conduction Pucará - Transandino is formed by two tunnel: Pucará tunnel and Transandino tunnel, 6341,24 m and 9617, long respectively. Their cross section, horseshoes shape are 5,95 m wide.

Due to their length, one adit iin each has been designed, 67 and 750 m Pucará tunnel and Transandino respectively. Their cross section, square with archer ceiling are 6,5 m lenght and 6,5 m wide.

The diversion tunnel has been defined also, 394, 70 m, which will allow the construction Angostura's dam and later it will work as water intake tunnnel after the execution of a slope shaft of 45 m length.





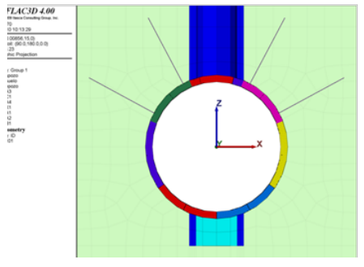
POZUELO'S SEWER, Spain

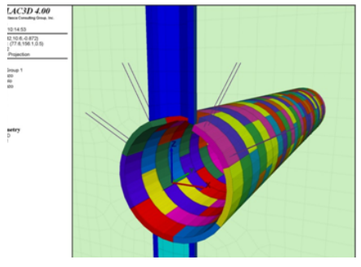
In order to be carried the rainwater to the new urban areas, the Pozuelo de Alarcón's sewer has been designed underground. For it SUBTERRA proposed the construction of a tunnel of 4,543 m length.

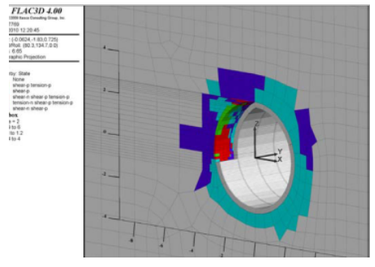
It was realized a detailed analysis of the stability of the front of the excavation by TBM and the link of the precast concrete segments.

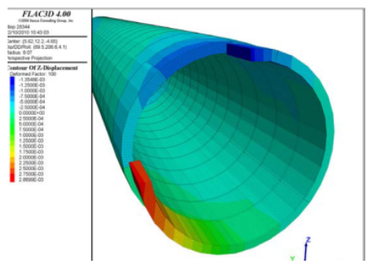
In addition, it was designed a unique connection between the sewer, the Adit, and the ventilation duct.

The lithologies affected by the Pozuelo’s sewer belong to the so-called "Material detrítico de Madrid" (clays and sands).









3.4. Hydroelectric projects

Because of the energetic demand has been increased in Latin America in the last years, SUBTERRA has been involved in the design and assesment of the construction of 33 hydroelectric plants, from Mexico to Chile, totaling 193 km of tunnel.

Project	Tipology	Section (m²)	Lenght (m)	Constructive Method	Litology/s	Study Level	Year	Client	Country
Confluencia Hydroelectric Plant Tunnels (Tunnel: Portillo / Tinguiririca)	Pass	20-35.5	9.040	NATM / RAISE BORING	Andesites, tuffs and shales	Assistance	2009-10	GEOCONTROL CHILE	Chile
El Paso Hydroelectric Plant	Pass	28	4.500	NATM	Andesites and tuffs	Detailed Desing	2011	HOCHTIEF GARDILIC	Chile
La Confluencia Hydroelectric Plant (Tunnel: Portillo)	Pass	35.5	11.290	LINING	Andesites and tuffs	Detailed Desing / Assistance	2011-12	HOCHTIEF	Chile
Itata Hydroelectric Plant	Regulation	51	70	SHAFT / NATM	Gravels y sandstones	Detailed Desing / Assistance	2013	BROTEC/ OBECHILE	Chile
Alto Maipo (El Volcán, Suelo and Alafalfal) Hydroelectric Project	Pass	13-21	22.000	NATM / TBM	Andesites, sandstones, gypsum, shales	Detailed Desing / Assistance	2013-17	HOCHTIEF-CMC	Chile
Central Hidroeléctrica Belesar III	Pumping	44	1.620	NATM / CAVERN	Granodiorites	Initial Desing	2010	SOCOIN	Spain
Los Peares III Hydroelectric Plant	Pumping	44	410	NATM	Gneisses and schists	Initial Desing	2010	SOCOIN	Spain
Edrada-San Esteban Hydroelectric Plant	Pumping	50	5.900	NATM / CAVERN	Granites, granodiorites and gneisses	Initial Desing	2010	SOCOIN	Spain
Salas-Conchas Hydroelectric Plant	Pumping	50	6.100	NATM	Granodiorites and migmatites	Initial Desing	2010	SOCOIN	Spain
Belesar III Hydroelectric Plant (Tunnel, Cavern and Shafts)	Pumping	45	1.650	SHAFT / CAVERN / NATM	Granites	Detailed Desing	2011	SOCOIN	Spain
III Hydroelectric Plant	Pumping	45	450	NATM	Gneisses and schists	Detailed Desing	2011	SOCOIN	Spain
Chira-Soria Hydroelectric Plant	Pumping	22	60	CAVERN	Basalts and ignimbrites	Detailed Desing	2012	IDOM	Spain
Chira-Soria Hydroelectric Plant	Pumping	22	5.200	NATM / CAVERN/ SHAFT	Breccias and basalts	Initial Desing	2015-16	IDOM - REDESA	Spain
Tunnel and cavern of Cheves Hydroelectric Plant	Pass	16/41	15.776	NATM / CAVERN	Tonalites, andesites, quartzites, and shales	Detailed Desing	2010	HOCHTIEF	Peru
Cheves Hydroelectric Project	Pass	16/41	15.776	NATM / CAVERN	Tonalites, andesites, quartzites, and shales	Assistance	2011-14	CONSTRUCTORA CHEVES	Peru
La Virgen Hydroelectric Plant	Pass	18	4.600	NATM	Sandstones and limestone	Detailed Desing	2011	COBRA - OSSA	Peru
Molloco Hydroelectric Project. Llatica and Soro Hydroelectrics Plants	Regulation	Soro: 8 M Ø; Llatica: 4,5 M Ø	Soro: 4124 M; Llatica: 7948 M	NATM	Quarzites, shales and sandstones; Marly Limestones; Andesites, Tobas, Dacites, and Riolites; breccias	Geotechnical Study	2014	ISOLUX-CORSÁN	Peru
Hidromanta Hydroelectric Plant	Pass	10	1800	NATM	Granites	Initial Desing	2016	JENNER RENEWABLES	Peru
Colca Hydroelectric Plant	Pass	10	545+1945	NATM	Limestones and marls	Initial Desing	2016	JENNER RENEWABLES	Peru
Hidromanta Hydroelectric Plant	Pass	10	1800	NATM	Granites	Detailed Desing	2017	INCISA – COBRA	Peru
Larreynaga Hydroelectric Plant	Regulation	16.5	2.500	NATM / SHAFT	Tuffs, andesites and basalts	Detailed Desing	2009-10	UTE COBRA OSSA	Nicaragua
Torito Hydroelectric Plant	Pass	40	3.700	EPB	Shales	Asessment	2011	SOCOIN	Costa Rica
Los Negros Hydroelectric Plant	Pass	12	3.000	NATM	Brush tuffs, volcanic breccias and andesitic lavas	Asessment	2016-17	OSSA	Costa Rica
Palanda Hydroelectric Plant	Pass	13	1.427	NATM	Granites	Tender Design	2011	UTE EDUINTER-ENWESA	Ecuador
Minas San Francisco Hydroelectric Project	Regulation	18-50	30.000	NATM / SHAFT / CAVERN / TBM	Riolites, tuffs, and intrusives.	Assistance	2012-14	GNF ENGINEERING	Ecuador
Minas San Francisco Hydroelectric Project	Pass	50-90	1.270 + 350	NATM	Andesitic tuffs	Detailed Desing	2014-16	GNF ENGINEERING	Ecuador
Delta Hydroelectric Project	Regulation	23/46	4.525	NATM / SHAFT	Slates and metatuffs	Tender Design	2012	OSSA	Guatemala
Renace 2 Hydroelectric Project. (Tunnel 1 y 2)	Pass	21	4.025	NATM	Limestones	Detailed Desing / Assistance	2012-14	COBRA	Guatemala
Renace III (Tunnel 1) Hydroelectrics Projects	Pass	21	4.750	RAISE BORING / NATM	Limestones	Detailed Desing / Assistance	2014-15	COBRA	Guatemala
El Recreo Hydroelectric Plant	Pass	15	1800	NATM	Volcanic breccias, tuffs and Dacites	Assistance	2014-15	PROACON	Guatemala
Tatatila Hydroelectric Plant	Regulation	20	1.300	NATM	Andesites,basalts,granites	Initial Desing	2012	INCISA	Mexico
Río Frío Hydroelectric Project	Pass	15	2.500/4 túneles	NATM	Fan deposits, clays, limestones and shales	Detailed Desing	2015-16	HIDROPROYECTOS	Mexico
PH-3 and PH Cuetzalin Hydroelectric Project	Pass	10	1.180 / 1.280	NATM	Sandstones, conglomerates, shales and riolitics tuffs. Cuetzalin: Basalts, andesites and volcanic breccies	Detailed Desing	2014	IMPULSA GENERACIÓN RENOVABLE	Mexico
Tatatila Hydroelectric Project	Pass	22	1.360	NATM	Andesites, basalts, granites and Granodiorites	Detailed Desing	2014-15	OHL Industrial	Mexico
Banda azul Hydroelectric Plant	Pass	12/24	7.500+6.800	NATM	Sandstones and shales	Detailed Desing	2015-16	INYPSA	Bolivia
Miguillas Hydroelectric Project. Palillada Tunnel	Pass	18	9.000	TBM / ESCUDO	Quarzites and slates	Detailed Desing	2016	ISOLUX-CORSÁN	Bolivia

HYDROELECTRIC PROJECT CHEVES, Peru

Cheves Hydropower Project is located at Huaura river, between the settlements of Sayán and Churín (Peru). Cheves Hydropower Project will divert water from the Huaura and Checras rivers, some 2 km upstream their confluence at an altitude of about 2.170 masl and back to Huaura River throught the tailrace tunnel about 1.5 km downstream at elevation 1.548 masl.

This project has been done to use the Huaura's driver resources to generate energy with an installed capacity of 168 MW divided into two Pelton units utilizing the gross head of 599 m and a flow design of 33 m^3/s.

The construction on the following tunnels has been projected:

- Transfer Tunnel: 2.580 meters.
- Headrace Tunnel: 9.915 m.
- Power House: 31,5 x 15,5 x 62,7 m (high x wide x length).
- Tailrace Tunnel: 3.700 m.
- Access Tunnel: 960 m.
- Addittunnel 1: 860 m.
- Surge Tunnel: 697 m.

The lithotypes affected by the Cheves Hydropower Project are constituted by the Chimú Formation (quartzite banks interbedded with thin quartzose sandstone strata, bituminous shale and occasional coal lenses), the Casma Group (stratified sequences of volcanic rocks, mainly andesites, with interbedded sedymentary rocks) and Churín bajo Stock (intrusive rocks with tonalite/quartz-monzonite composition).

HYDROELECTRIC PROJECT ALTO MAIPO, Chile

Alto Maipo Hydroelectric Project (PHAM) is located in the municipality of San José de Maipo, Provincia Cordillera, Región Metropolitana de Santiago, Chile. Undergroun works included in the PHAM are:

- Tunnel “Alfalafal II” of 6.250 m in length which the initial 3.250 m will be excavated with D+B method in section of 4,75 x 4,90 m (20,8 m²), and the rest with TBM of about 4,10 m of diameter (13,2 m^2).
- Tunnel “Suelo” of 1.020 m in length fully excavated by conventional methods, in a section of 4,0 x 4,0 m (13 m²).
- Tunnel “El Volcán” of 14.100 m in length of which 7.100 m will be excated with D+B method in a section of 3,80 x 4,90 (4,60) m (17/16 m²), and the rest with TBM of 4,10 m of diameter (13,2 m^2).

The area is composed of sequences of stratified sedimentary, volcanic and volcanoclastic rocks with granitoid inclusions. Covering these materials there are large deposits of Quaternary unconsolidated materials.

Also it is included the geotechnical monitoring of all underground works of the hydroelectric project.

HYDROELECTRIC PROJECT RENACE II AND III, Guatemala

Renace II Hydroelectric Project, is located inmediately downstream of the powerhouse of Renace I.

It is the second of the three elements of the cascade utlization Cahabón River, located in the municipality of San Pedro Carchá, Alta Verapaz department, Guatemala.

The tunnel will conduct an approximate length of 4,1 km.

Renace III: The most outstanding works to be performed are: Headrace tunnel about 4.750 m, with two streches, 3.600 m lenght one of them and the other of 1.150 m of middle pressure; armored section about 100 m length; surge tunnel of 275 m of depth; adit of 72 m length and headrace tunnel and the adit's gateway and exit.

3.5. Mining projects

The mining projects, as underground as open pit, are very important for SUBTERRA.

Proyecto	Tipologia	Seccion (m²)	Longitud (m)	Método Constructivo	Litologia/s	Nivel de Estudio	Año	Cliente	País
Túnel Sur de la mina Los Bronces	Exploración	20	8.125	DOBLE-ESCUDO (DSU)	Cuarzo monzonitas/ brechas/andesitas/pórfidos	Asistencia	2010	GEOCONTROL CHILE	Chile
Evaluación túneles planta proceso, PNA Fase II.	Infraestructura	52	30.000	NATM	Brechas, tobas y andesitas	Viabilidad	2010	GEOCONTROL CHILE	Chile
Túnel Rosario Oeste	Exploración	16	1.150	NATM	Rocas vulcano-sedimentarias	Asistencia	2011	COMPAÑIA MINERA COLLAHUASI	Chile
PM Chuquicamata Subterráneo. OIM y TA	Infraestructura	70	7.600 / 6.300	NATM	Granodioritas, anfibolitas y anfibolitas silificadas	Asistencia	2013-17	ASTALDI	Chile
Estudio de viabilidad de la rampa minera de interior	Infraestructura	32	1.320	NATM/SECCIÓN COMPLETA	Margas, arenas, vulcanitas y pizarras	Viabilidad	2010	CLC	España
Rampas acceso	Infraestructura	50	2 x 2.500	ROZADORA	Margas, lutitas y areniscas	Ingeniería de diseño	2015-16	GEOALCALI	España
Rampa Mina Cabanasas	Infraestructura	50	4.500	ROZADORA	Areniscas, Calizas y Lutitas	Asistencia	2015-17	ICL IBERICA	España
Rampa y galería investigación Las Cruces	Infraestructura/ Exploración	35	1200	NATM	Pizarras, tobas y sulfuros	Ingeniería de diseño	2016-17	CLC	España
Pozos de ventilación Mina Cabanasas	Infraestructura	33	900	CONVENCIONAL	Areniscas y Lutitas	Anteproyecto	2017	ICL IBERICA	España
Túnel de transporte de la Mina de Toquepala	Infraestructura	32/25	2.027	NATM	Andesita / Riolita	Proyecto Constructivo/Asistencia	2011-13	OSSA	Perú
Desvío Río Asana Mina Quellaveco	Infraestructura	25	6.500	NATM	Pórfido, granito, volcánico	Asistencia	2016-17	COSAPI-MAS ERRÁZURIZ	Perú
Rampa Exploración Romina 2	Infraestructura	22	850	NATM	Calizas	Factibilidad	2016-17	DCR Ingenieros	Perú
Túnel Transporte de la Mina Antamina	Infraestructura	30	2.600	NATM	Granodiorita y pórfido	Asistencia	2017	ANTAMINA	Perú
Túnel Transporte Coroccohuayco	Infraestructura	25	7.500	NATM/TBM	Granodioritas y cuarcitas	Factibilidad	2017	C.M. ANTAPACCAY	Perú
Mina Antamina. Túnel Side-Hill y Decantación	Infraestructura	17	940+320	NATM	Granodiorita y pórfido	Ingeniería de diseño	2018	ANTAMINA	Perú
Mina Parcoy. Túnel de Yuracyacu	Infraestructura	24	11.400	NATM	Granodioritas	Ingeniería de diseño	2018	CONSORCIO MINERO HORIZONTE	Perú
Mina las Bambas. Túnel de derivación T-6	Infraestructura	20	3.572/4.080	NATM	Calizas	Factibilidad	2018	LAS BAMBAS	Perú

OPEN PIT MINING / DUMPS	UNDERGROUND MINING
– Geotechnical assessment. Cerro Colorado Pit. Río Tinto Mines. EMED MINING. 2010. – Detailed design of the mine dumps: West, South, North, Esparragal, La Ramira, and Temporal East. COBRE LAS CRUCES (INMET). 2010-12. – Geotechnical assessment. New access South Rajo pit and dumps. El Teniente Mine. SACYR-AGUANSANTA (CODELCO). 2011-13. – Decommission study. Atalaya Pit. Río Tinto Mines. EMED MINING. 2012. – Geotechnical analysis of the tailings dams 1 and 3. XSTRATA. 2012. – Detailed design of the mine dumps: Norte, Sur y Atalaya. EMED MINING. 2012. – Geotechnical assessment. Mina Cobre las Cruces. COBRE LAS CRUCES (FIRST QUANTUM). 2012-16. – Detailed design. Inert dumps. Mina Muga. GEOALCALI. 2015. – Evaluation of the tailing dam. MATSA (MUBADALA & TRAFIGURA). 2016. – Due diligence of the tailings dam. AGUABLANCA. LUNDIN MINING. 2016. – Detailed design inpit tailings facilities. COBRE LAS CRUCES (FIRST QUANTUM). 2016-17. – Closure plan and technical expedient for the environmental remediation project of the impacted areas by mining passives. Carhuacayán Mine. AMSAC. 2017-19 – Geotechnical study of the La Parrilla open pit. IBERIAN RESOURCES SPAIN S.L. 2018.	– Basic design of the pit ramp. COBRE LAS CRUCES (INMET). 2010. – Detailed design and construction assessment of the Transport Tunnels 1 and 2. SOUTHERN COPPER). 2011 – 13. – Support optimization. Tunnel Rosario W. Cia. Min. Dña. Inés de COLLAHUASI. 2011. – Geotechnical assessment. North Manto Area. S.C. MINERA ATACAMA KOZAN. 2011-12 – Detailed design of Tibirita Mine. PACIFIC IRON. 2012. – Geotechnical assessment. Access Tunnels. Chuquicamata Subterránea. ASTALDI (CODELCO). 2012-16. – Stability analysis of a sublevel coal mine. Tipong Mine. AITEMIN. 2013-14. – Portal analysis of Access tunnel. Kusipongo Mine. KANGRA COAL. 2014. – Geotechnical assessment. Design of the crown pillar. Cerro Bayo Mine. MANDALAY RESOURCES 2014-15 – Geotechnical assessment. Nodo 3500. Andina Mine. ACCIONA-OSSA (CODELCO). 2015. – Geotechnical analysis of the crushing and Winze Picaso facilities. El Porvenir Mine. MILPO. 2015-16. – Geotechnical assessment. Cabanasas Ramp. IBERPOTASH-ICL. 2015-19. – Feasibility study of an underground exploitation for PMS. CLC (FIRST QUANTUM). 2016. – Detailed design research ramp. COBRE LAS CRUCES (FIRST QUANTUM). 2016. – Geotechnical assesment. Asana River Tunnel. Quellaveco Mine (Peru). COSAPI-MAS ERRÁZURIZ (ANGLOAMERICAN). 2016-17. – Geotechnical study of the Cobre Las Cruces's research ramp. COBRE LAS CRUCES. 2016. – Ventilation Shafts Study - Cardener Phase. ICL IBERIA. 2017-19. – Supervision for reinforcement works for the belt tunnel. ANTAMINA. 2017. – Technical-economic analysis for the transport belt of the Coroccohuayco underground mine by TBM. Antapaccay Mining. GLENCORE. 2017. – Side-Hill Tunnel. Antamina Mine. ANTAMINA. 2018. – Parcoy Mine. Yuracyacu Tunnel. CONSORCIO MINERO HORIZONTE. 2018. – Las Bambas Mine. T-6 bypass tunnel. LAS BAMBAS. 2018. – Review of the pre-feasibility system for mineral and tunnels, construction interconnection galleries. ANTAMINA. 2019. – Estudios y diseños de prefactibilidad. Desarrollos subterráneos Mina Quebradona. ANGLOGOLD ASHANTI. 2019. – Analysis of the stability of coal exploitation, method of chambers and pillars. La Gitana mine. FRONTIER COAL. 2019.

COBRE LAS CRUCES OPEN PIT MINE, Spain

The Cobre Las Cruces's aim is the explotation of the secondary copper ore reserves of a massive sulphide mineralization, embedded in volcanic and sedimentary Paleozoic rocks, hidden under tertiary sediments. The secondary copper ore reserves (HC Zone), object of the mine project, is estimated in 17.625.000 tonelates of ore with a 6,22% of pure copper, totalling of 1.096.275 tonelates of extraible copper and 978.504 tonelates of retrievable copper and commercialised like copper cathodes.
The support is formed by 140 m of Tertiary marl, under which there are a layer of sandstones, calcarenites and conglomerates with a variable thickness of 5 to 10 m, which constitutes the Niebla-Posadas aquifer. The deposit is exploited by the method of Open Pit, which will allow the removal of 97% of the copper metal contained in the reserves. The final pit will have an oval shape with 1500 m length in the East-West direction, 900 m width in a north-south direction and a maximum depth of 245 m.

SUBTERRA is the responsible of the exploitation's geotechnical following, including both open pit and dumpsites. It includes the mapping, the stability calculations and the geotechnical monitoring.

GEOTECHNICAL ASSISTANCE OF THE MANTO BLANCO SECTOR. ATACAMA KOZAN MINE, Chile

The Atacama Kozan mine is situated in the Tierra amarilla area, Chile. SUBTERRA has carried out a geomechanical characterization of the production sector called Manto Norte, which includes drilling levels at a depth of 165 and output at quota 136, Caserones Manto Norte 01, 04, 05, 06 and Manto Noreste and adjacent galleries.
The aim of this study was the improvement of a prediction model following the geotechnical and geomechanical recommendations for predicting to the potential risk associated with development the tunnels, the exploitation and the extraction sequences of the stopes. It was carry up a lithological study and a structural mapping of 13335 m of tunnel, distributed in different galleries of the mine, allowing the geotechnical characterization of the rock mass 's quality and including stability analysis of the stopes and support.
From the obtained information of the field's works was defined the used support sections in the geotechnical quality of rock mass, using empirics, analytics and numerical models.
It has used the following geotechnical software: Dips, Unwedge, Rocsupport, Examine 2D and 3D and 2D Flac.

TOQUEPALA MINE TUNNEL TRANSPORT, Peru

The project is located within the geographics area of the mining concession Toquepala mine (in the south of Peru), department of Tacna, comprising a tunnel in a straight line fromr the southwest of the pit to he existing mill site. The mine is located and altitude of 3.300 meters.
The project includes constructions of a tunnel of 2,19 km length, stretching from the projected location of the primary crushing building up the pile of intermediates, which will be connected to the transport of ore through a conveyor belt.
In adittion it is performed tow tunnels, a short mine tunnel of 155 m length and a false tunnel crossing under current rail tracks. The lithotypes affected by the tunnels are andesites, rhyolites, intrusives rock and quaternary deposits.

Finally it is made the final project of the tunnel ventilation to ensure the safety of the workers.

Guadalajara Metro | Mexico | MOTA ENGIL-SACYR

4. Clients

Yanango Tunnel | Peru | BALZOLA

COMISIÓN EUROPEA | MOP CHILE | PROVIAS NACIONAL | DIPUTACIÓN FORAL DE GUIPÚZCOA | CABILDO DE GRAN CANARIA | CONSORCIO AGUA PARA LIMA | ADIF | INTERSUR | CONVIAL | PROENERGY | INVEX | JENNER RENEWABLES | COSTANERA CENTER

GNF ENGINEERING | COSTANERA NORTE | ABERTIS | INIMA | KOROTT | ELECNOR | AES Gener | TER. PORTUARIOS CHANCAY | ABEINSA | ENEA | COBRA | ISOLUX CORSÁN | HOCHTIEF

COPROSA | TAPUSA | ODINSA | CMC | COPASA | GEOTUNEL | OBRAS SUBTERRÁNEAS | GESVIAL | ACCIONA | COSAPI | SACYR

CAVOSA | CONSTRUCTORA SAN JOSÉ | TABOADA Y RAMOS | MOTA-ENGIL | ECHEVARRIA | DRAGADOS | ALDESA | PROACON | COMSA | CHINA RAILWAY GROUP | ASTALDI

VINCI | RUBAU | IESA | INSERSA | TECSA | MAS ERRÁZURIZ | COPISA | MINCIVIL | SOCAMEX | BROTEC

AGUA SANTA | BALZOLA | ZAÑARTU | SELI | FCC | GARDILIC | GETINSA-PAYMA-EUROESTUDIOS | PROINTEC | ASISTECSA | DDQ | AXIA | SISTEMA

URCI | AITEMIN | RESTITUBO | CYE | INYPSA | AYESA | VS | GOC | INCISA | APIA XXI | CYGSA

IDOM | TRN | SOCOIN | GRUSAMAR | INGENIA | FULCRUM | ATJ CONSULTORES | EUROCONSULT | CALTER | SCHLUMBERGER WATER SERVICES | NIPPON KOEI

INZAMAC | SATAI | SAITEC | HIDROPROYECTOS | EYSER | GIPIC | IGR INGENIEROS CONSULTORES | ICEACSA | DCR | AYMA | CLC | ICL IBERIA SUR IA | MINERA LAS BAMBAS | SOUTHERN COPPER

EMED TARTESSUS | SCM ATACAMA KOZAN | C. MINERO HORIZONTE | ANTAMINA | AMSAC | COLLAHUASI | GEOALCALI | IBERIAN RESOURCES | ANTAPACCAY | RIO NARCEA RECURSOS | ASTURIANA DE ZINC | MATSA

La Confluencia Hydroelectric Power Plant. VI Region | Chile | HOCHTIEF

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