

LARGE URBAN EXCAVATIONS



URIEL & ASOCIADOS

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- **Geotechnical Engineering at U&A goes further than simple geotechnical analyses on which to base projects or designs**
- **U&A carries out specialized geotechnical consultancy both, during the design period and along the construction phase, adding value and reducing costs and risk simultaneously**

In the design and construction of large excavations in urban environments, U&A has developed activities as diverse as the following:

1. Geological-Geotechnical Investigations and Submission of Geotechnical Reports (usually in several successive stages)
2. Hydrogeological study
3. Integrated conception of excavations, foundations and control of ground water.
4. Design and calculation of earth retaining systems (pile walls, diaphragm walls, ground anchors...)
5. Design of ground water control schemes (water table lowering, tied-down rafts, buoyancy rafts, drainage blankets...)
6. Design and supervision of ground anchor load tests.
7. Monitoring (excavation-induced movements of the excavation and surrounding buildings, control of flow rates and pore water pressures, ...)

EXAMPLE BROCHURE

- The following pages briefly describe some selected examples where U&A has been deeply involved in the design and construction of large excavations. Practically all the examples shown were located in urban areas.
- Two main types of projects are included.
 - The first group refers to railway and metropolitan subway projects. U&A has participated in a considerable number of such projects since 2000, when the extension of the Madrid subway began. Some other projects, the most recent ones, refer mainly to High Speed Railway Lines. As mentioned in other documents of the information submitted, U&A has also been involved in the geotechnical supervision (peer review) of hundreds of kilometers of HSR lines and station projects designed by others. These jobs are not included in these pages.
 - The second group covers the design and construction of urban shopping malls in urban areas which required large and deep excavations, larger than those of conventional railway or subway stations. U&A has been in charge of the geotechnical investigation, design and construction control of a very large number of such malls, in different places and under very different geotechnical circumstances.

EXAMPLES LOCATION



LIST OF SELECTED RAILWAY/SUBWAY JOBS INVOLVING LARGE EXCAVATIONS IN URBAN AREAS

EXCAVATION OF RAILWAY LINES AND STATIONS (INVOLVING PILE WALLS, DIAPHRAGM WALLS, GROUND ANCHORS...)				
Year	Title	Client	Location	Remarks
2012	Geotechnical Assistance during the excavations of a tiedback, deep pile wall in Sotiello (High Speed Railway. North Axis. Spain)	GEOCONTROL, S.A. (Civil Engineering Consultant)	Asturias	Design check of the retaining system. Design, supervision and interpretation of the tests carried out on the ground anchorages
2012	Geotechnical Assistance during the construction of Zamora HSR Station. Madrid-Galicia. Spain.	ROVER ALCISA, S.A. (Construction Company)	Zamora	Analysis of geotechnical issues during the construction of the HSR Station
2011	Geotechnical Consultancy. Design of the cut & cover solutions for a new downtown railway Station. City of León.	MBG INGENIERÍA Y ARQUITECTURA, S.L.-TECOPYSA (Civil Engineering Consultants)	León	Geotechnical Assistance for the design of the excavation of the new Railway Station. Design of anchored diaphragm walls through very permeable soils below the water table. Design of measures to counteract uplift and seepage
2010-2011	Geotechnical design of the new HSR line crossing of the city of Murcia. Geotechnical design of the new Station.	ADIF (Spanish Railways Administration)	Murcia	The solution involved the excavation of the 8 km long new line and the Station between anchored diaphragm walls. Difficult soil conditions. Subsiding alluvial soils high below a high water table. High seismicity area
2009-2012	Geotechnical Assistance during the construction of the HSR line between Pontevedra and Cerponzos	U.T.E. CERPONZONS (Joint Venture of several Construction Companies)	Pontevedra	The tasks carried out have involved the design of different geotechnical solutions for the execution of excavations, pile or micropile walls and other soil retaining systems. A considerable part of the new line runs close to existing buildings
2009	Geotechnical Consultancy on the cut & cover design of a railway line across the town of Langreo (Tender Phase)	FCC (Construction Company)	Asturias	
2005-2006	Geotechnical Assistance. Design of tunnels and cut & cover solutions to eliminate several railway grade crossings in the Town of Coles (Ourense)	U.T.E. PORTAS TR-SEG (TECNICAS REUNIDAS-SEG) (Joint Venture of Engineering and Construction Firms)	Pontevedra	Design of short tunnels below the water table in urban environment
Before 2005	Geotechnical design of a railway station, shopping mall and hotel. Málaga	Jacobs-Sereland (Engineering Firm)	Málaga	Design of the excavations for the new HSR Station. Slurry walls and tiebacks below the water table. Foundations of the Station and additional buildings (hotel and shopping mall)
Before 2005	Geotechnical design of a HSR Station in Zaragoza City	Pondio (Engineering Firm)	Zaragoza	Design of the excavations and foundations of the new Railway Station
Before 2005	Geotechnical Consultancy. Madrid Subway. Extension of Line 7. Elaboration of Tender documents. Segments: Gregorio Marañón-Guzmán el Bueno; Guzmán el Bueno-Virgen de la Paloma; Virgen de la Paloma - Peña Grande	FCC (Construction Company)	Madrid	Analysis of the project and preparation of geotechnical documents for the Tender Phase, including new and modified Stations
Before 2005	Geotechnical Consultancy. Madrid Subway. Extension of Line 9. Elaboration of Tender documents. Segment Pavones-Vicálvaro	FCC (Construction Company)	Madrid	Analysis of the project and preparation of geotechnical documents for the Tender Phase, including new and modified Stations
Before 2005	Geotechnical Consultancy. Madrid Subway. Extension of Line 4. Elaboration of Tender documents. Segment Esperanza-Gran Vía. Connection with lines 8 and 10	FCC (Construction Company)	Madrid	Analysis of the project and preparation of geotechnical documents for the Tender Phase, including new and modified Stations

LIST OF SELECTED SHOPPING MALL JOBS INVOLVING LARGE EXCAVATIONS IN URBAN AREAS

GEOTECHNICAL DESIGN AND CONSTRUCTION OF COMMERCIAL CENTERS INVOLVING DEEP EXCAVATIONS SOLVED BY MEANS OF PILE WALLS AND DIAPHRAGM WALLS					
Location	Approximate plan area (m ²)	No of basements / Excavation depth (m)	Method of excavation	Foundations	Remarks
Talavera	12000	4 (19 m)	Diaphragm wall + tiebacks	Drilled Shafts	Sea level 2 m below ground surface. Partial top-down construction
Eibar	> 10000	3 to 7 (>20 m)	Segmental tied-back panels	Footings	
Salamanca	> 10000	6 (> 20m)	Diaphragm wall + tiebacks	Footings	Wall excavated with trenchcutters (Hydrofraise)
Cartagena	36000	5 (19 m)	Diaphragm wall + tiebacks	Footings	Water level at 4.9 m below ground surface
Córdoba	> 10000	4 (15 m)	Diaphragm wall + tiebacks	Footings	Expansive soils
Jaén	> 10000	4 (15 m)	Diaphragm wall + tiebacks	Drilled shafts	Special measures needed to control creep in the anchors "fixed" length
El Ejido	30000	5 (20 m)	Diaphragm wall + tiebacks	Raft	
Elche	33000	4 (17 m)	Diaphragm wall + tiebacks	Footings	
Badalona	16000	5 (18 m)	Diaphragm wall + tiebacks	Raft	
Albacete	10000	5 (18.70 m)	Diaphragm wall + tiebacks	Drilled shafts	
Gerona		4 (15 m)	Diaphragm wall + tiebacks	Footings	Enlargement of an existing mall. Interface and connection between buildings solved
Coslada	30000	5 (18 m)	Diaphragm wall + tiebacks	Footings	Not finished
Tarragona	16000	6 (> 20 m)	Diaphragm wall + tiebacks	Raft	
Mataró	10000	6 (18 m)	Diaphragm wall + tiebacks	Driven Piles	Not finished
Guadalajara			Diaphragm wall + tiebacks		Analysis of tiebacks failure. Design of the reinforcement

Excavations of an anchored deep pile wall in Sotiello (High Speed Railway. North Axis. Spain)

Client: Jacobs Sereland

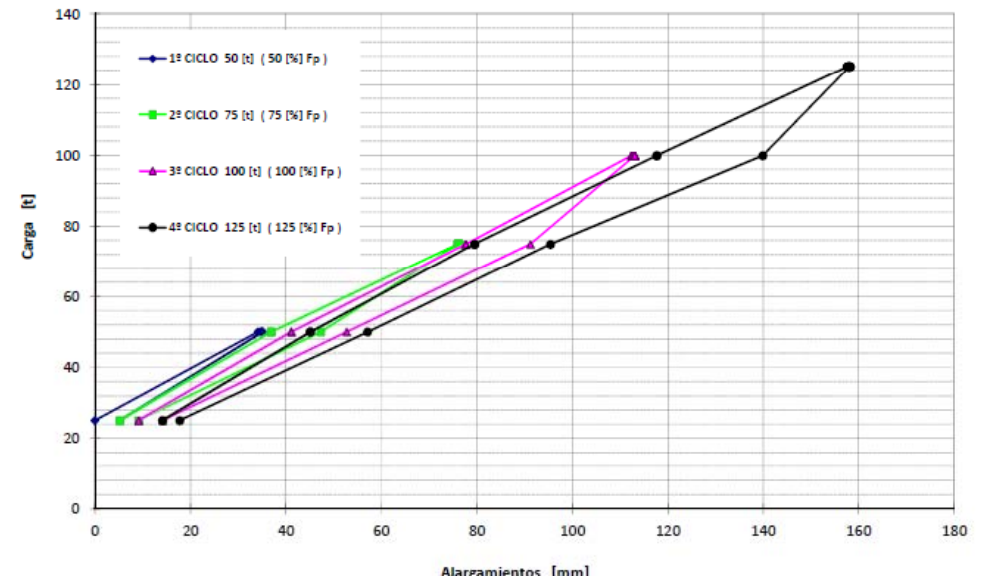
- **SOTIELLO. 25 M DEEP PILE WALL + TIEBACKS.**
- **URIEL & ASOCIADOS TASKS: CHECK OF THE RETAINING SYSTEM. DESIGN, SUPERVISION AND INTERPRETATION OF THE TESTS CARRIED OUT ON THE GROUND ANCHORAGES**



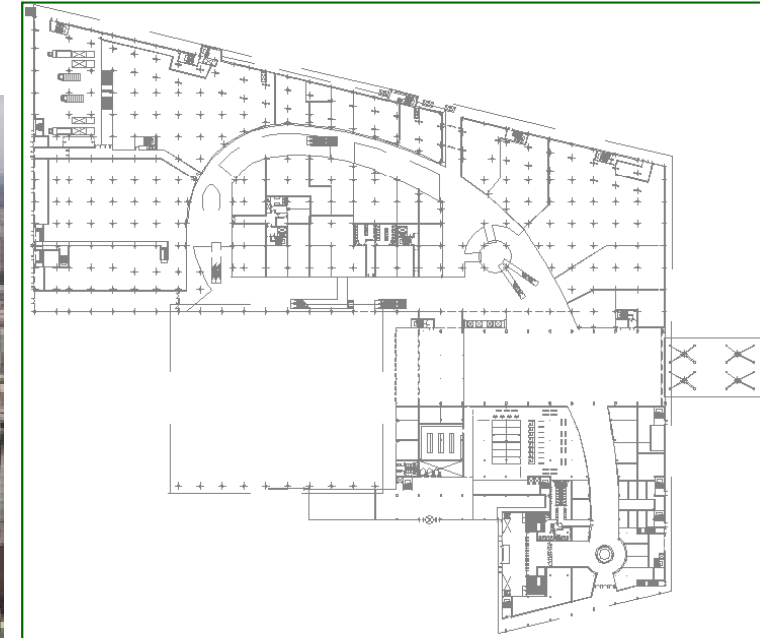
ANCLAJE: 30. Fila 2ª

Se hizo un 5º escalón. No se representa porque se perdió el origen de alargamientos

CICLOS DE CARGA. RELACIÓN CARGA-DEFORMACION

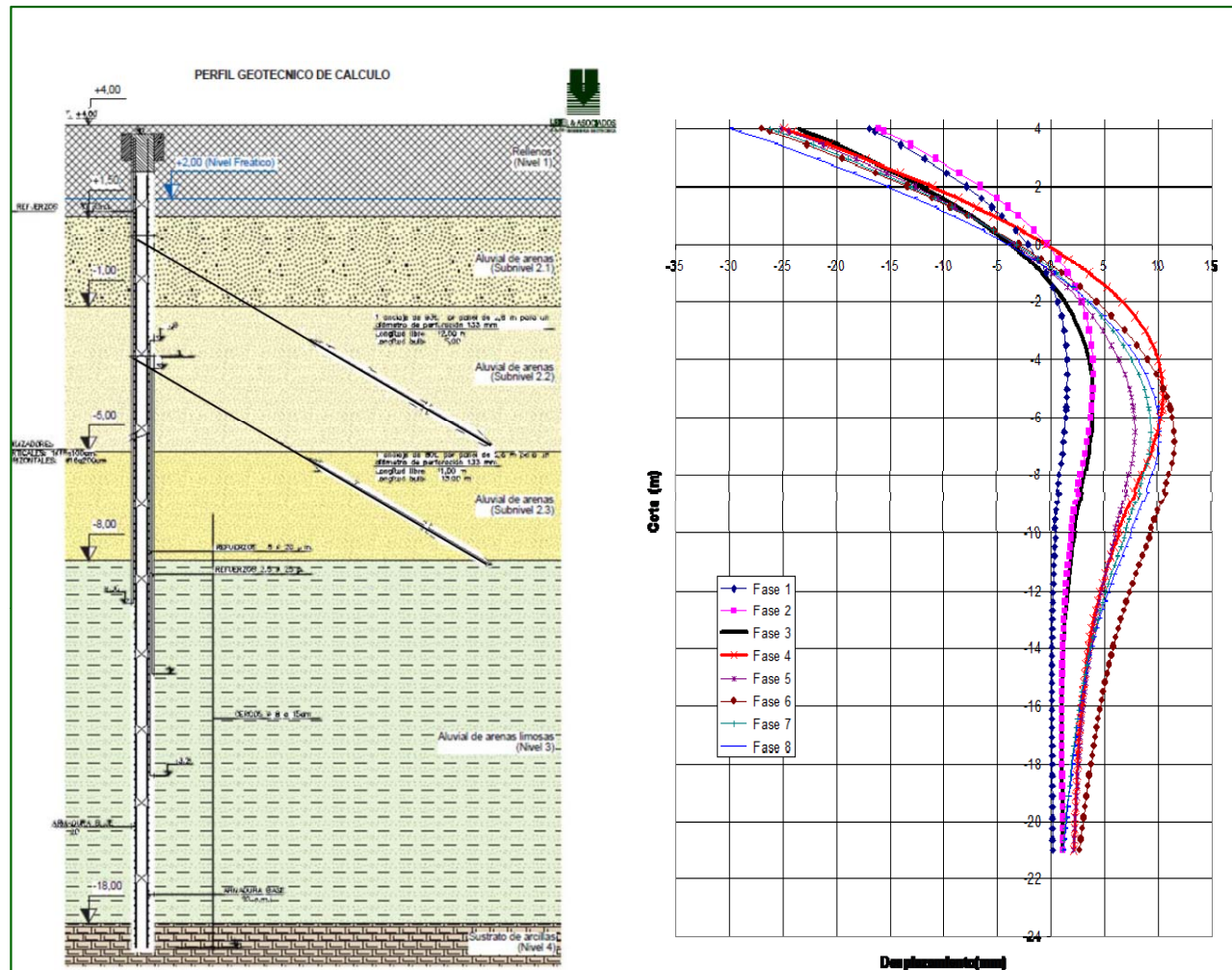
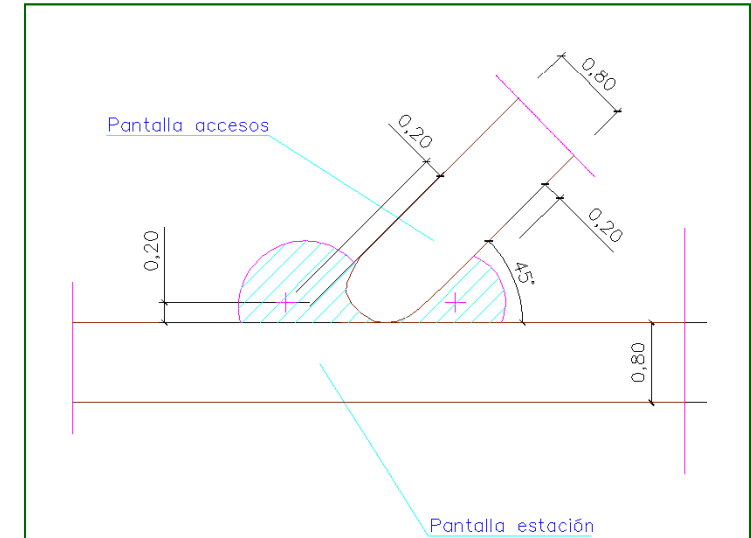


- *An ambitious project for the extension of the existing station to accommodate the new high speed trains.*
- *Excavations of up to 12 meters in alluvial sands with the ground water level 2 meters deep.*
- *High seismicity area*
- *Impact on existing walls and foundations*



- Draining bases
- Segmental diaphragm walls
- Temporary and permanent anchoring
- Jet grouting treatment in wall joints
- New deep and shallow foundations

Detail of jet grouted joint



HSR across the city of Murcia. 1 / 2

Client: ADIF

- 8 km of underground track in an urban environment
- Design of the new underground “El Carmen” Station
- Difficult soil conditions:
 - Alluvial soils from Segura River valley
 - Shallow groundwater levels
 - High seismicity area



Buildings adjacent to the tracks



Old “El Carmen” Station



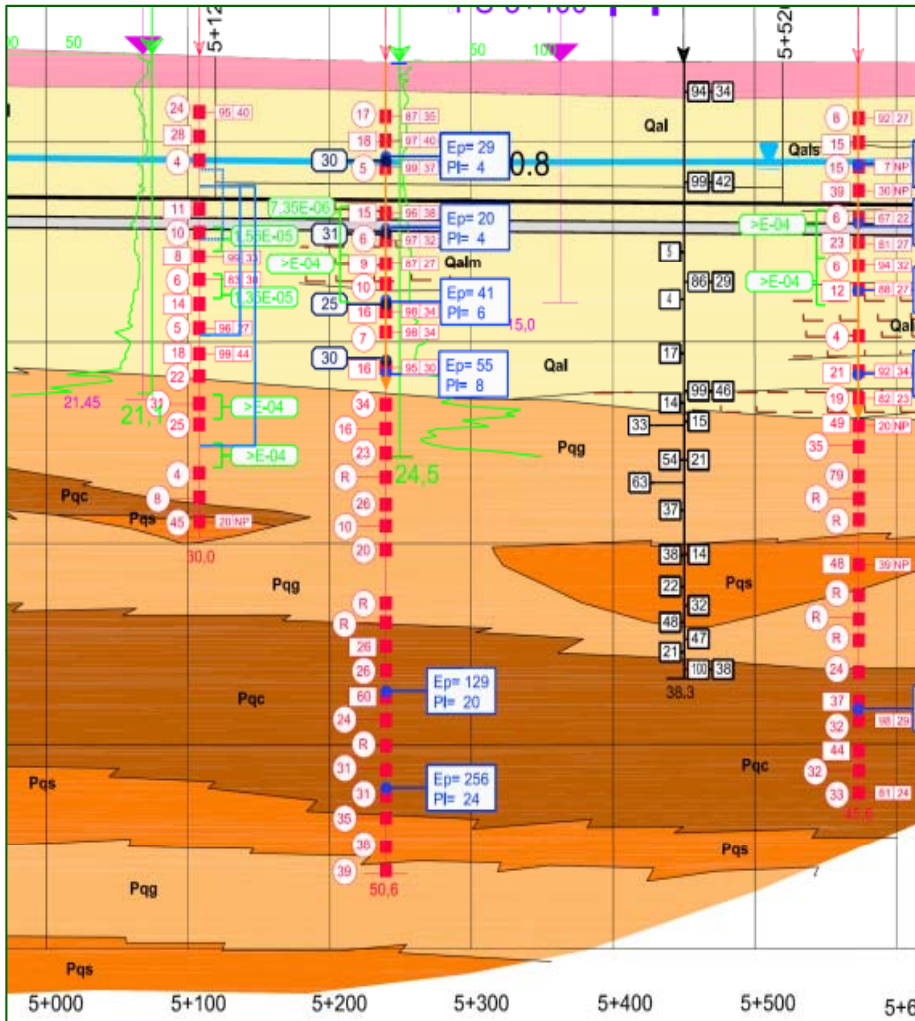
Railroad crossings

HSR across the city of Murcia. 2 / 2

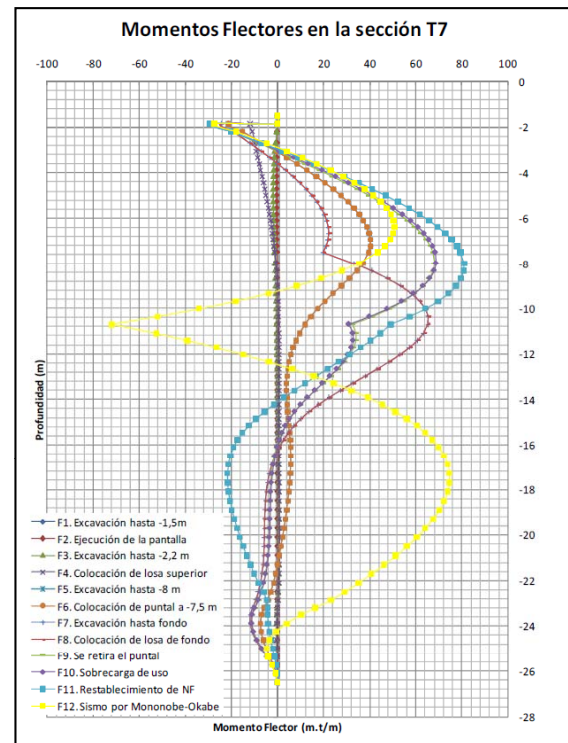
Client: ADIF

U&A tasks:

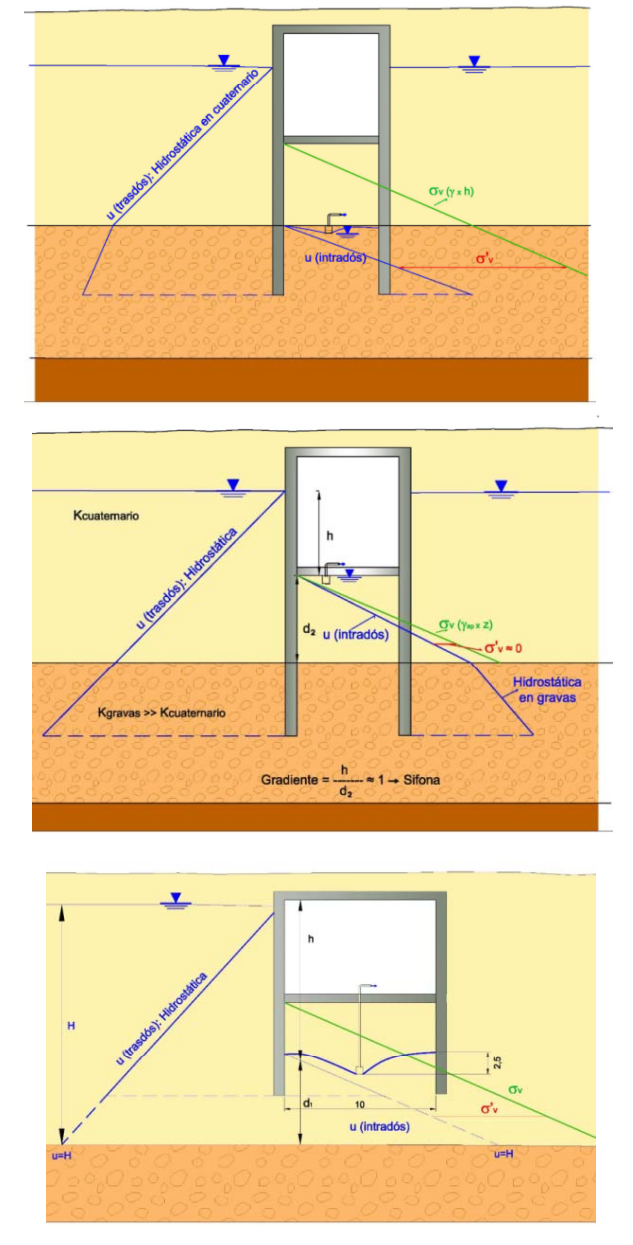
- Site investigation and detailed geotechnical profile. Soil characterization
- Design of tiedback slurry walls, foundations and water lowering systems. Control of uplift long term pressures



Diap. Wall bending moments

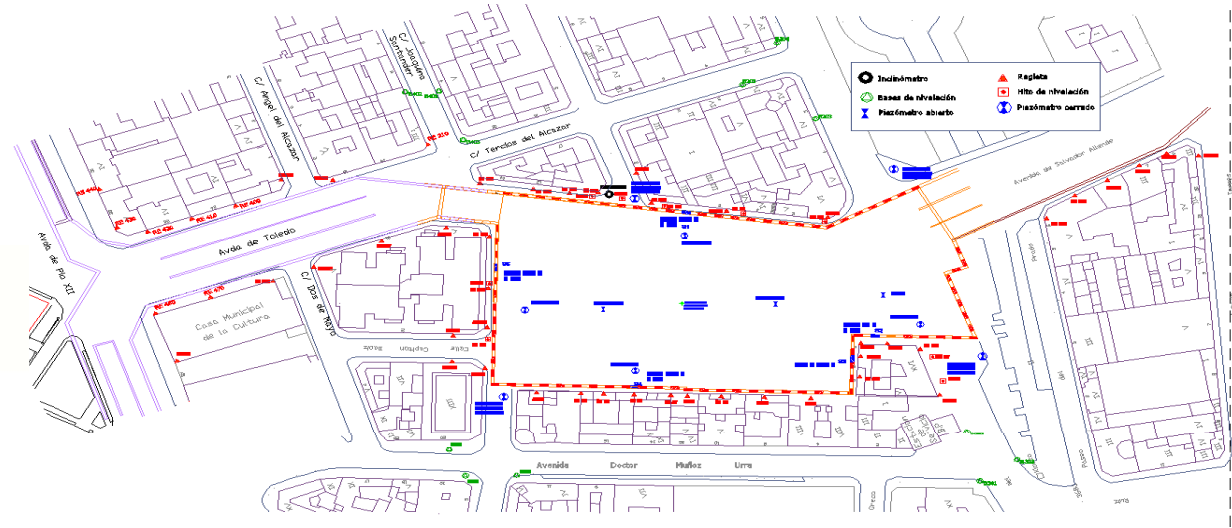


Water lowering scenarios

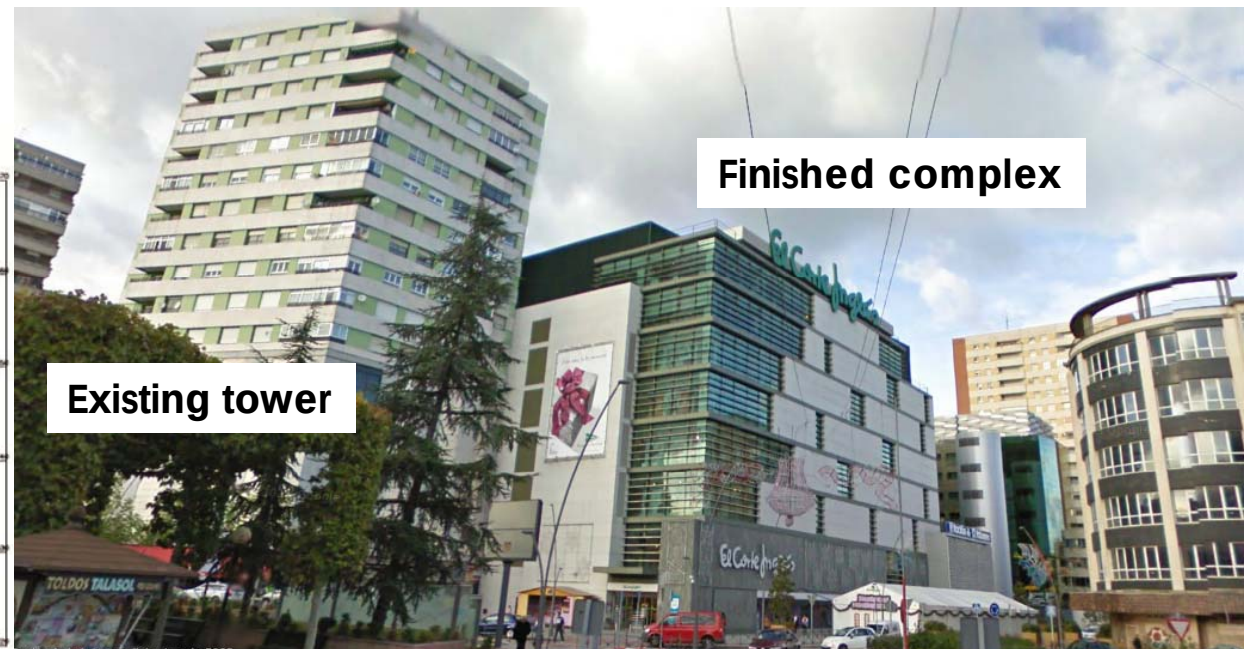
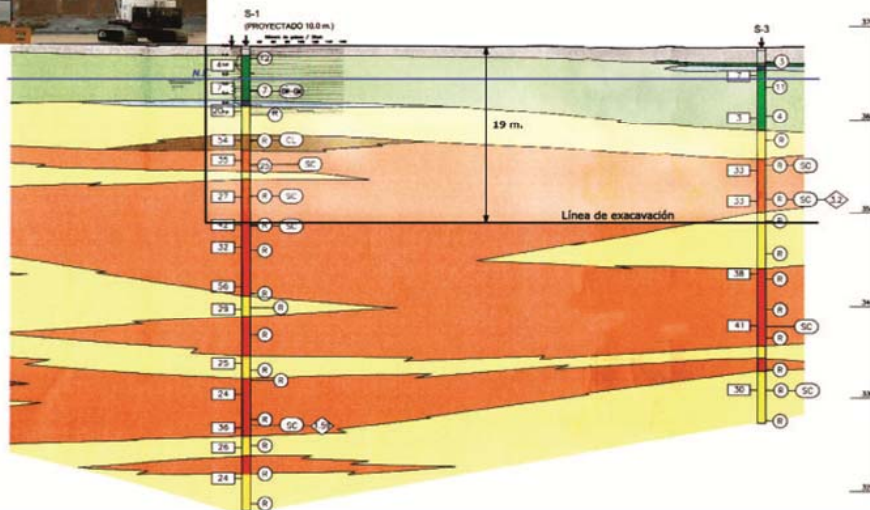


Underground bus station, shopping mall, business center and access tunnels, Talavera de la Reina. 1 / 3

- Building complex with 4 underground floors and access tunnels
- Contiguous buildings up to 17 floors high. Shallow foundations.
- Alluvial gravels and silty sand substrate
- Water level 2 meters deep



Schematic view of existing adjacent building with respect to the soil profile and the excavation performed



Finished complex

Existing tower

Bus station, shopping mall, business center and access tunnels, Talavera de la Reina.

2 / 3

CONSTRUCTIVE PROCESS CONDITIONED BY ADJACENT BUILDINGS

Diaphragm wall construction adjacent to an existing building



Steel columns embedded into previously drilled shafts for top-down construction



Second basement slab for top-down construction



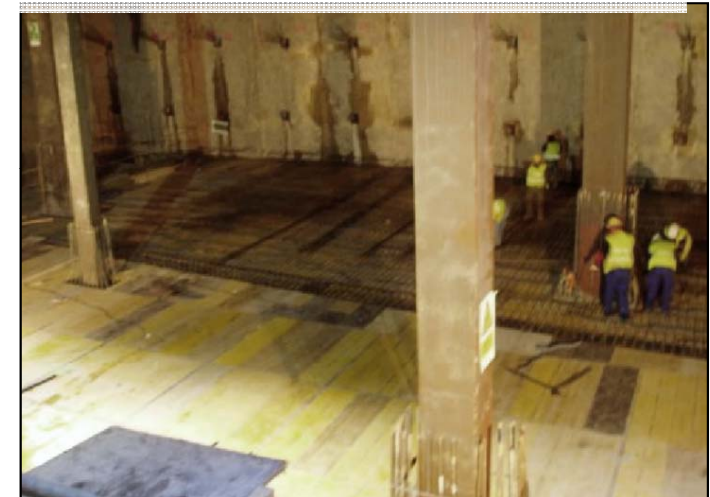
Excavation with partial slab support



1800 kN ground anchors between floor slabs



Seepage through anchors between floor slabs



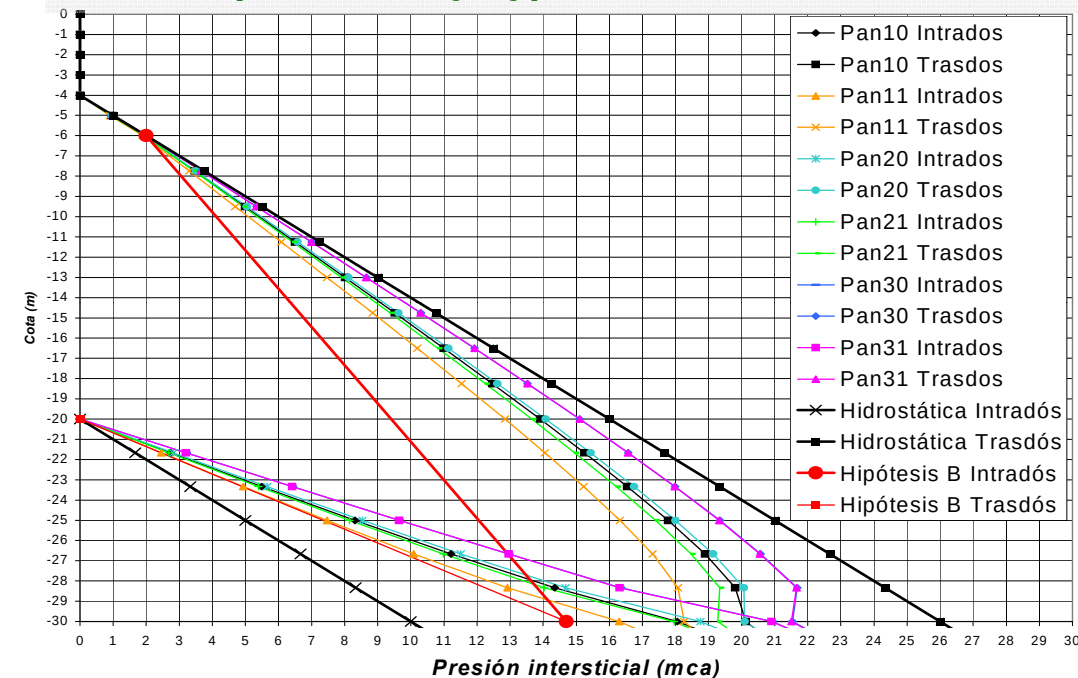
Bus station, shopping mall, business center and access tunnels, Talavera de la Reina.

3 / 3

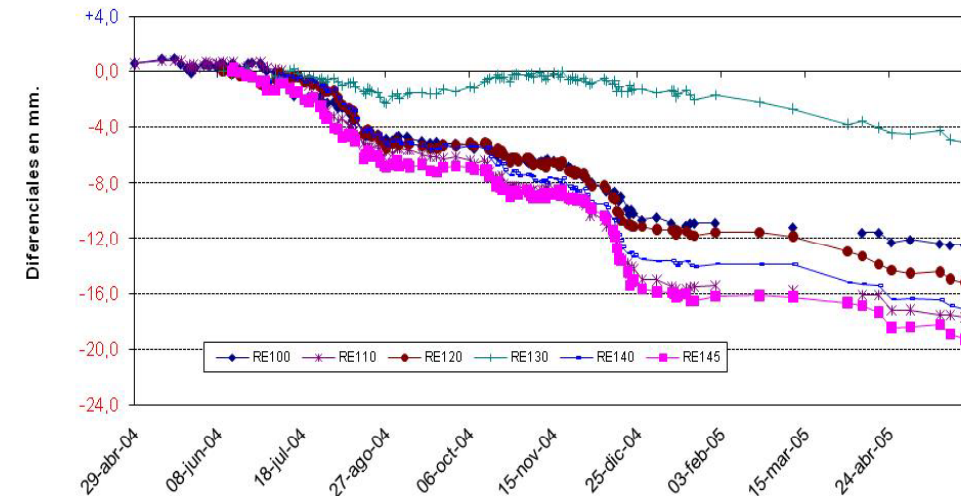
Other relevant aspects:

- Hydrogeological study that allowed the construction of a drained base in silty sands
- Optimization of the retaining walls following this study and monitoring results

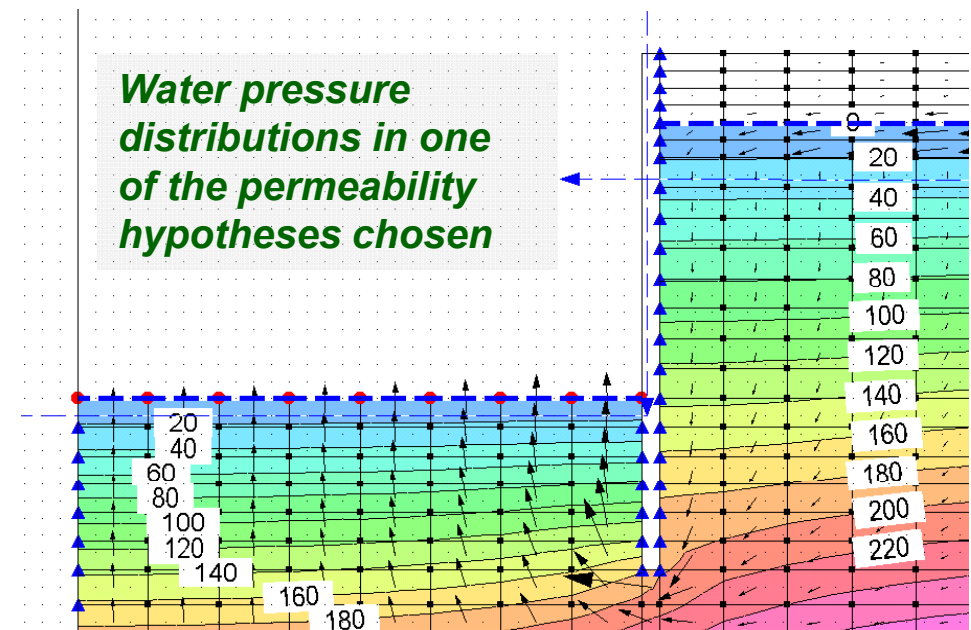
Water pressures on both sides of the wall with different permeability hypotheses



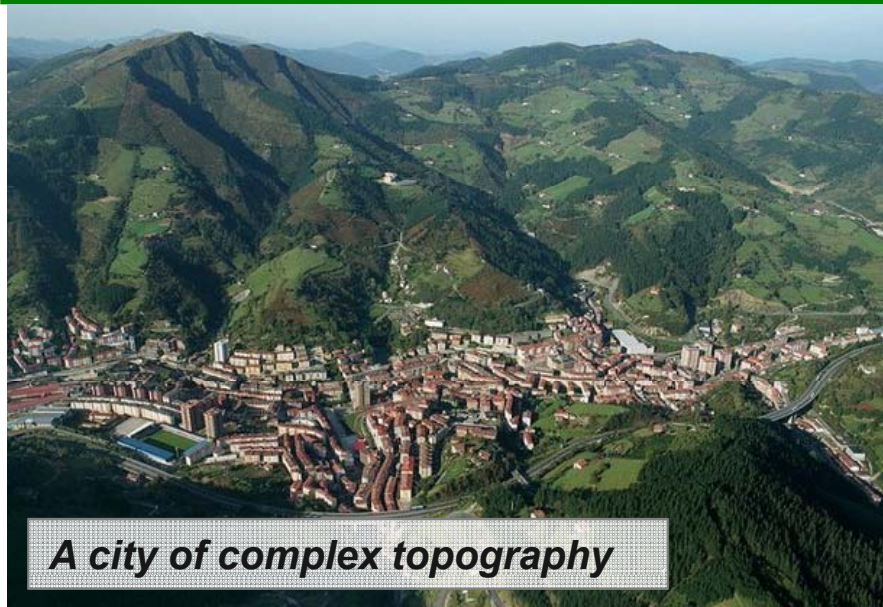
Settlement monitoring in adjacent tower



Water pressure distributions in one of the permeability hypotheses chosen



Large urban excavation in Eibar, North of Spain 1 / 2



A city of complex topography

U&A designed and monitored a large urban excavation with adjacent buildings.



Excavation for 3 to 7 underground floors.

Excavation in rock using segmental anchored panels

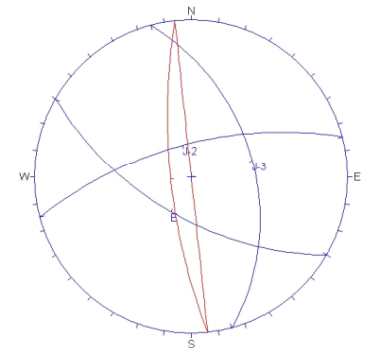
Large urban excavation in Eibar, North of Spain 2 / 2

- Up to 6 rows of ground anchors



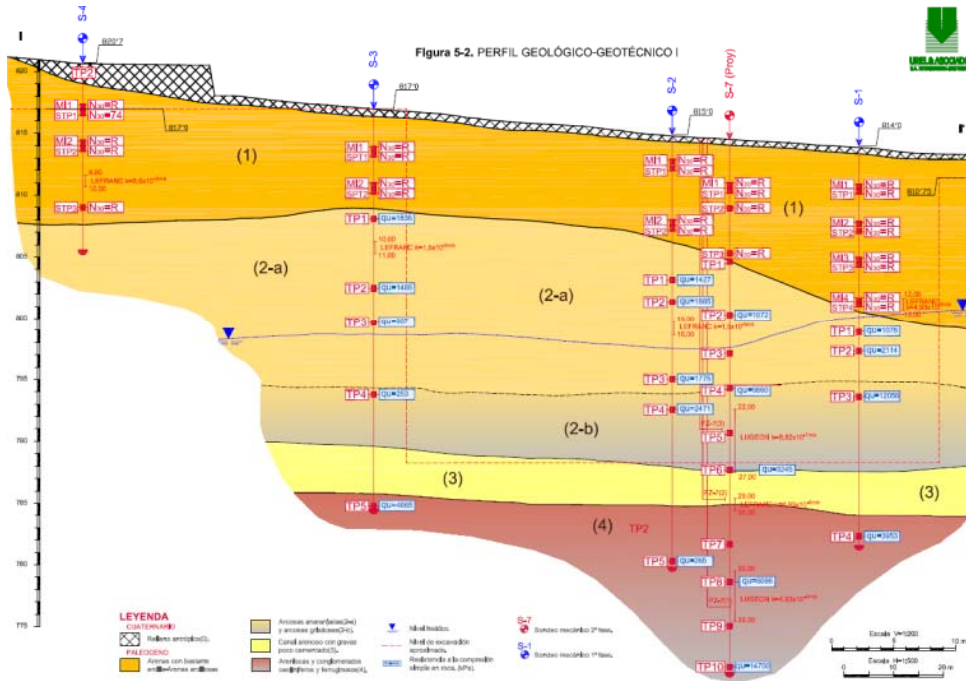
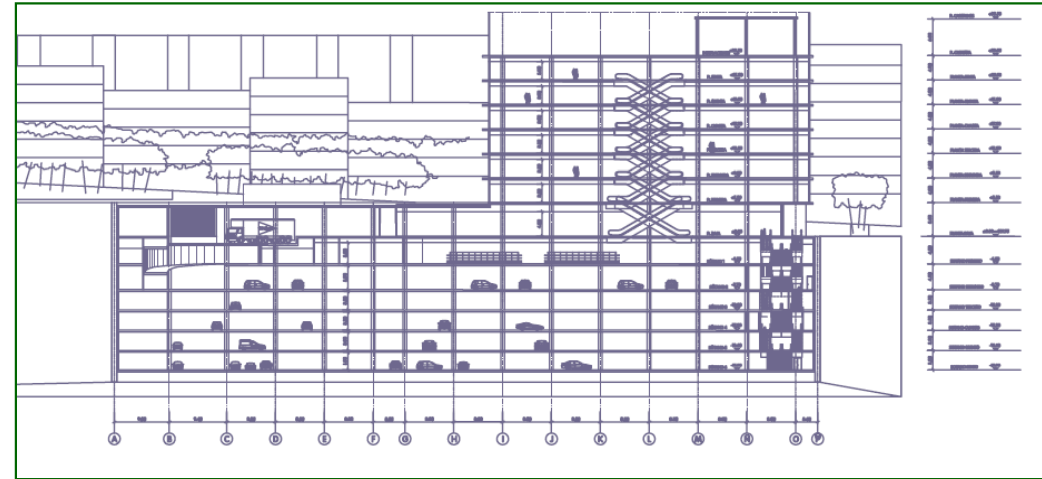
In each of the wall surfaces the orientation of the rock structure is different.

The rock is a flysch formation with a highly marked bedding conditioning possible instabilities



Shopping mall and public service building in Salamanca 1 / 2

- 6 basement floors and 7 floors above ground
- Excavation in sands and sandstone



Shopping mall and public service building in Salamanca 2 / 2

Trenchcutter for diaphragm wall



3 levels of tiebacks



Mid-height water level

Shallow foundations and drainage blanket to control water seepage



Excavation in 15 m of sandstone using expansive concrete



S-5 30.50-30.80 TX

Shopping mall in Cartagena (Murcia)

1 / 2

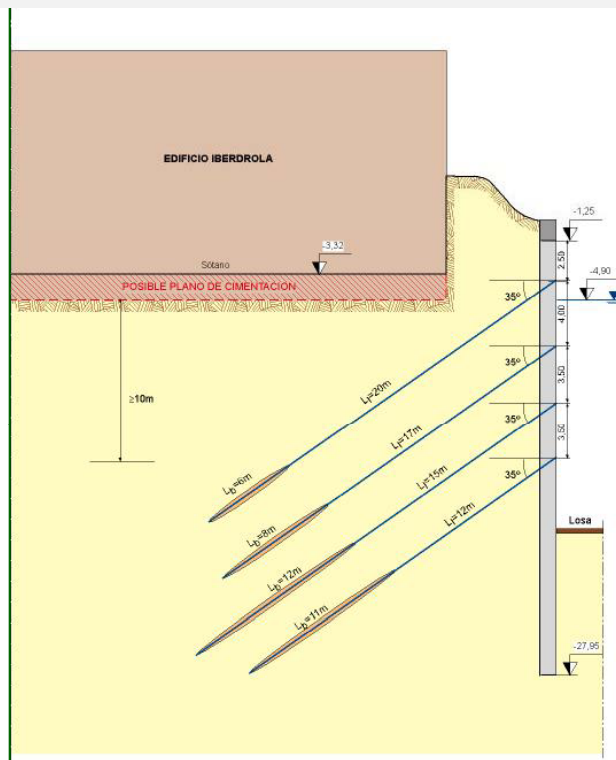
12.000 m² in plan. 4 basement floors

Quaternary soils above overconsolidated tertiary clays

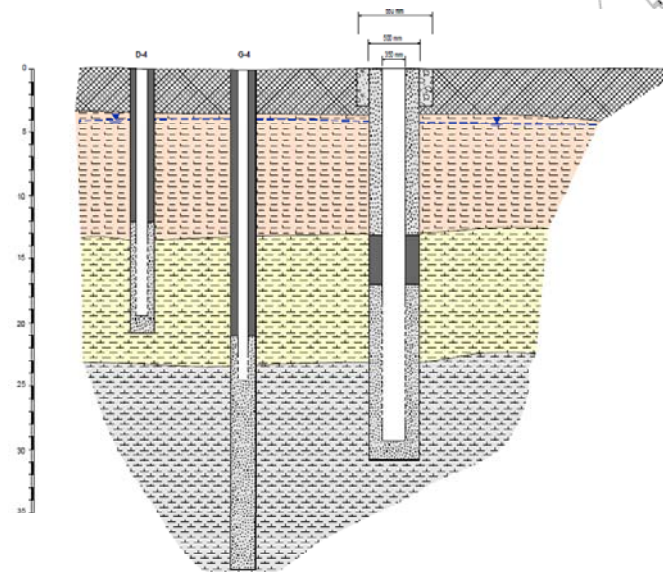
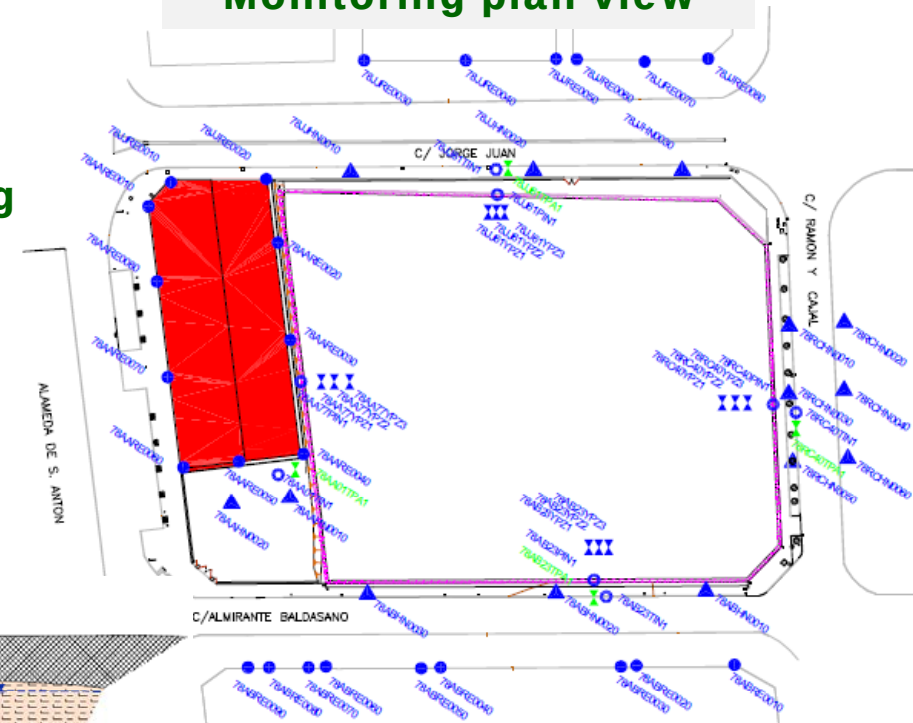
Water table at the ground surface

Design of tied-back diaphragm wall, water lowering and foundations

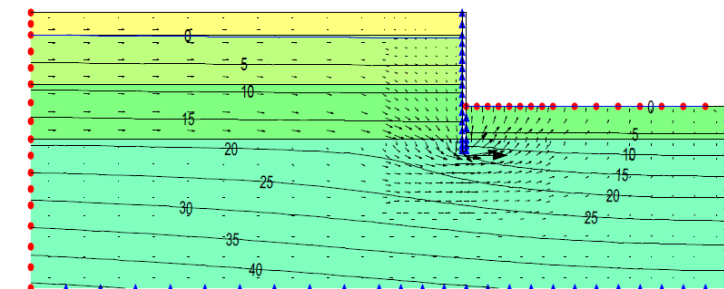
Cross section along adjacent historic building



Monitoring plan view



Construction of drainage wells and nearby piezometers



Modelling the flow nets

Diaphragm wall construction



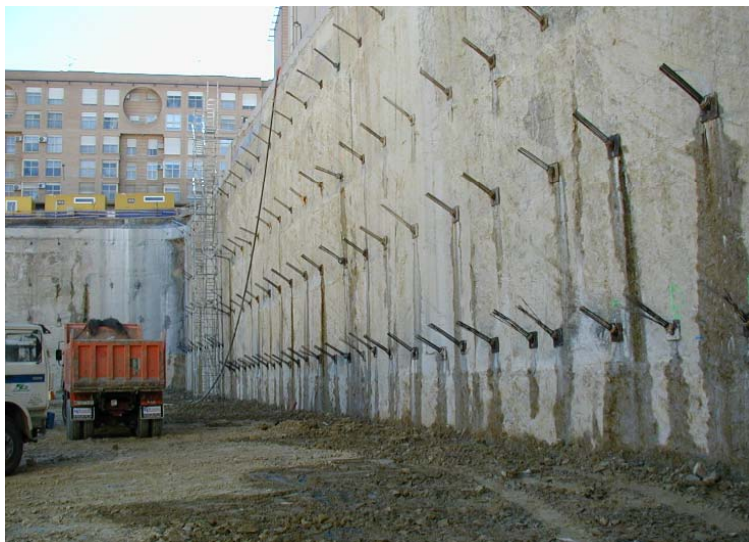
Anchor tests



Wall monitoring (pressure cell)



Wall with 4 rows of anchors



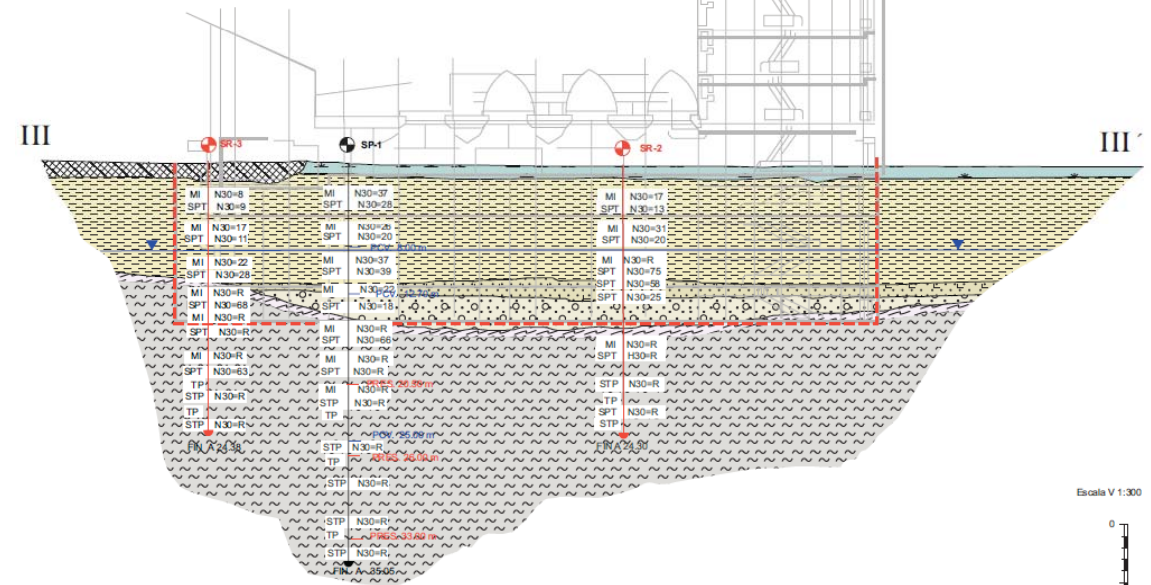
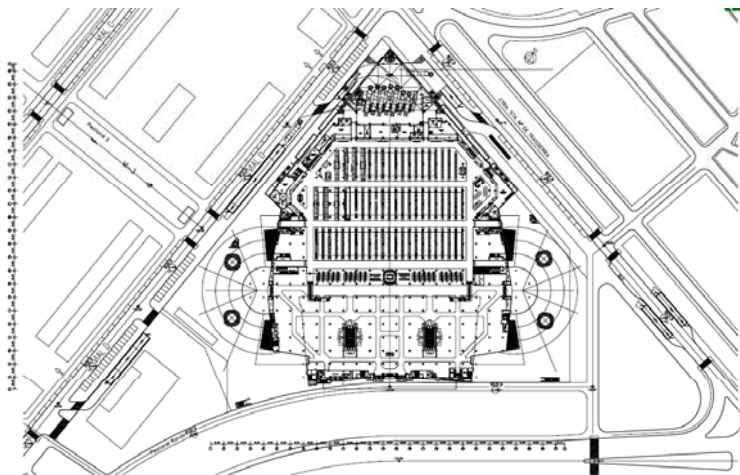
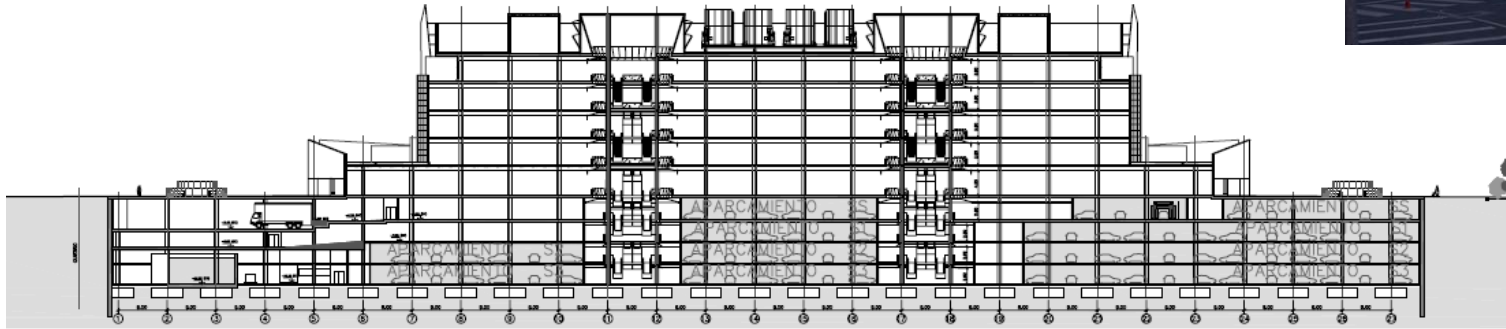
Footings and drainage blanket base excavation



Finished shopping mall, close to a historic building



Geotechnical study for a building with 5 floors above ground and 4 underground floors. The excavation reached 15 meters.



The base of the excavation was located on tertiary expansive overconsolidated clays. Footings working at high loads were designed and constructed.

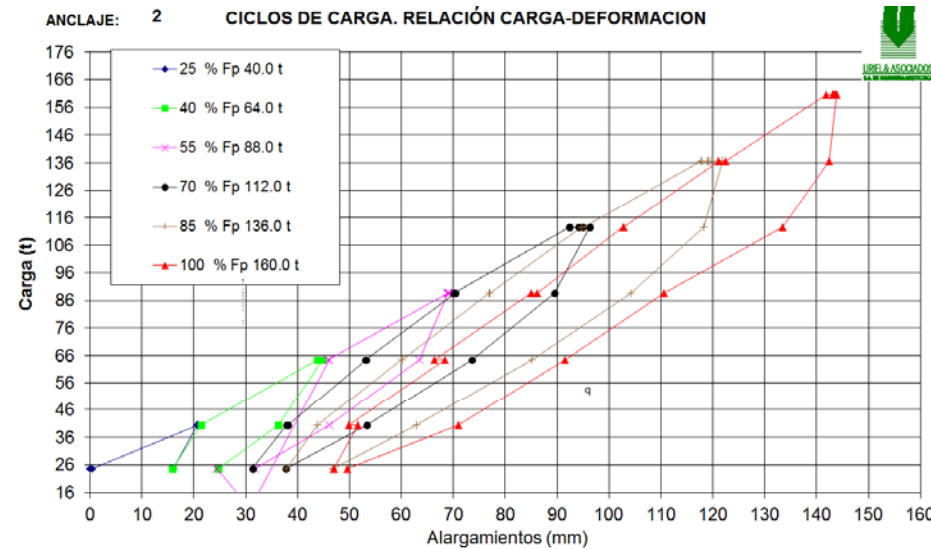
The retaining system of the excavation for the 4 basement floors was designed via a continuous reinforced concrete diaphragm wall, anchored periodically. Some tests were previously carried out on some proof anchors to optimize their design

Recommendations to avoid the effects of expansive soils close to ground surface were given.

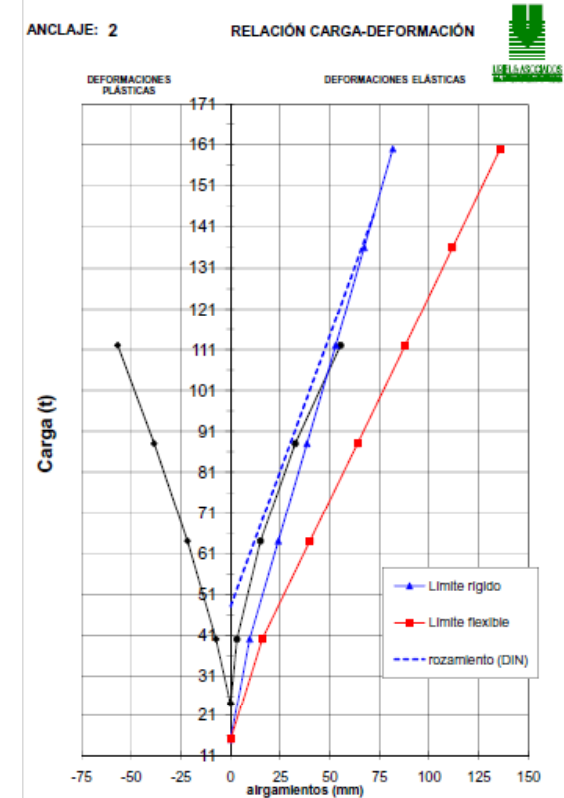
On site assistance during anchor construction and testing



Anchor suitability tests. Load vs. displacements



Theoretical free length limits



Geotechnical study and construction assistance for a shopping mall in Jaén

1 / 3

Geotechnical study for a building with 6 floors above ground and 4 basement floors.

Depth of the excavation was 15 meters.

Construction assistance was provided.

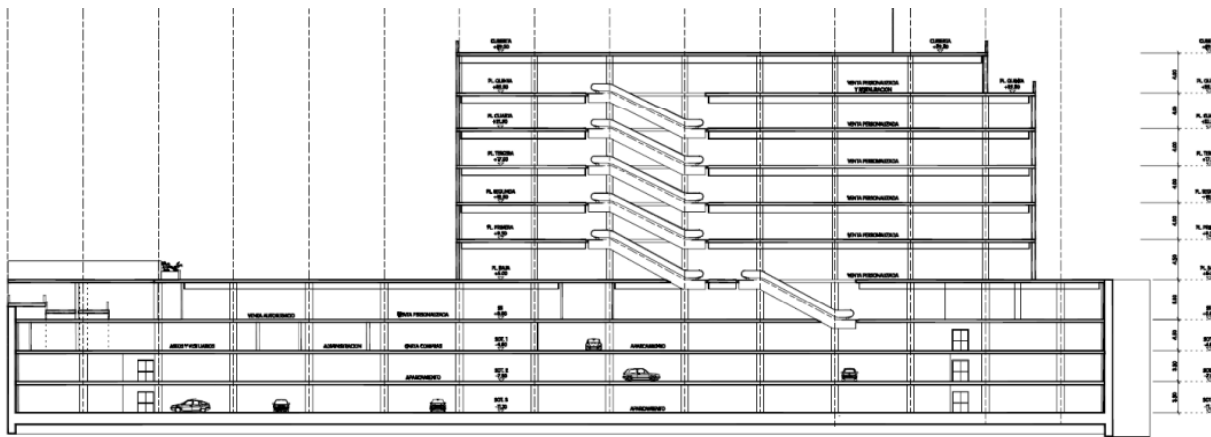
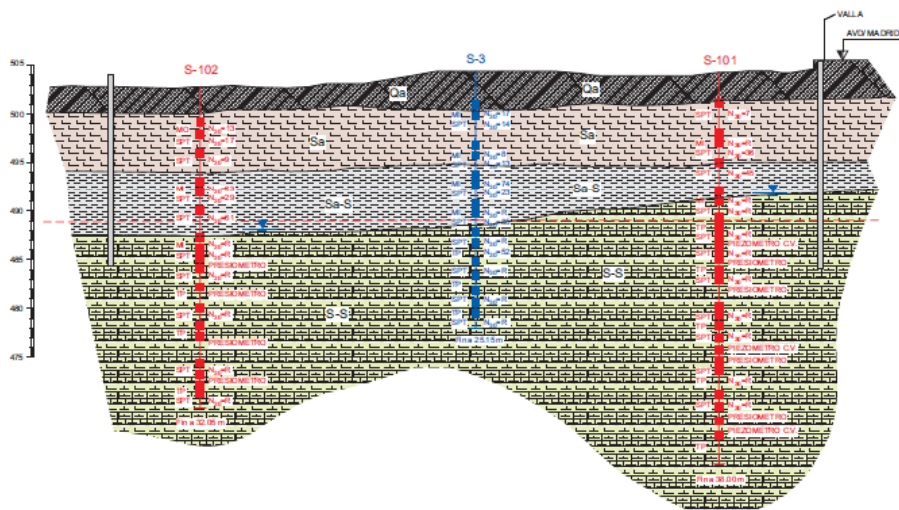
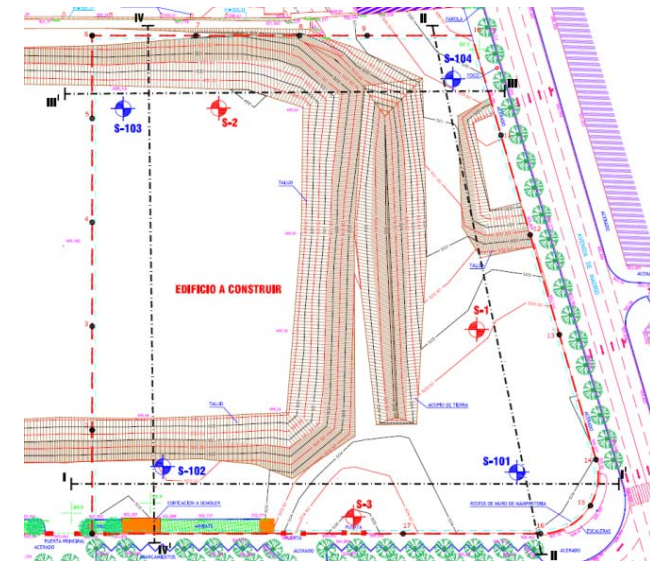
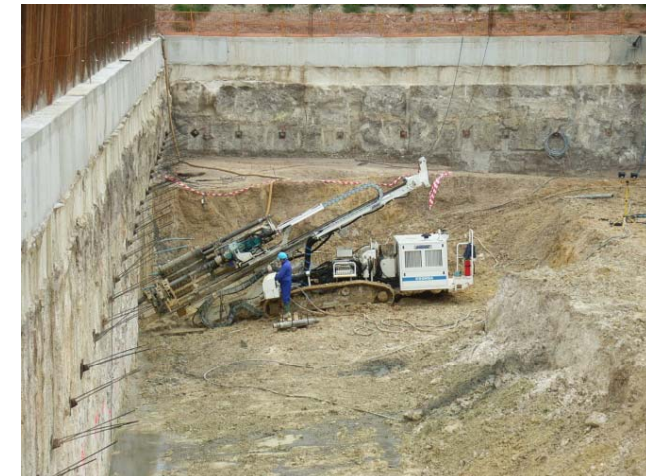


FIGURA 8 : PERFIL GEOLOGICO GEOTECNICO I-I'



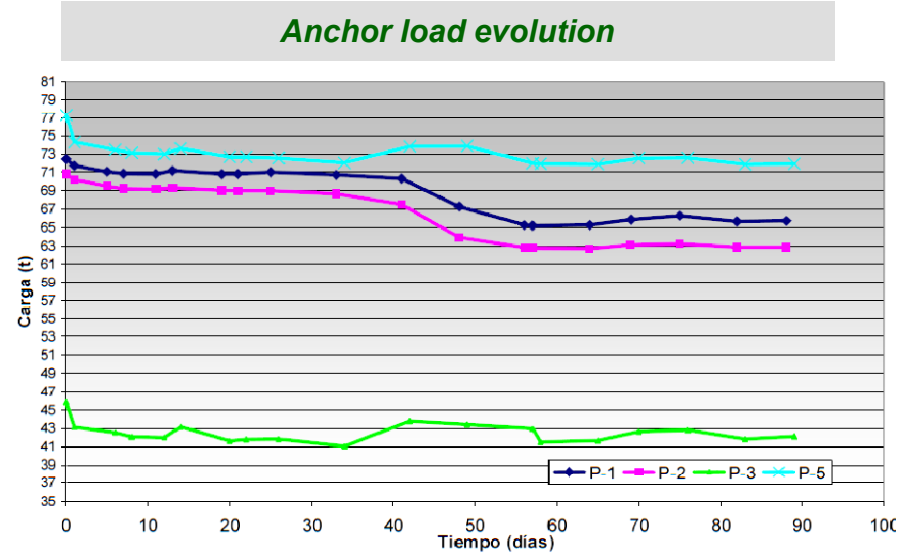
LEYENDA

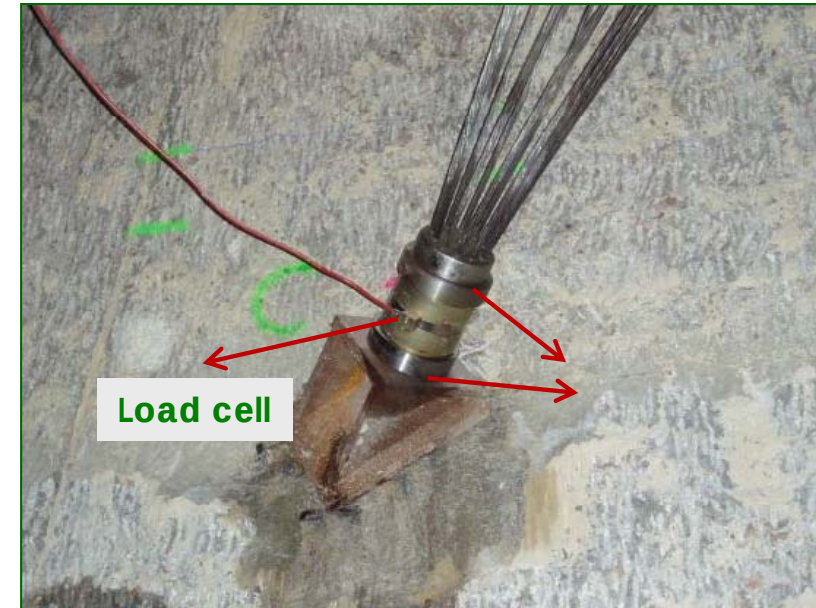


Geotechnical study and construction assistance for a shopping mall in Jaén

2 / 3

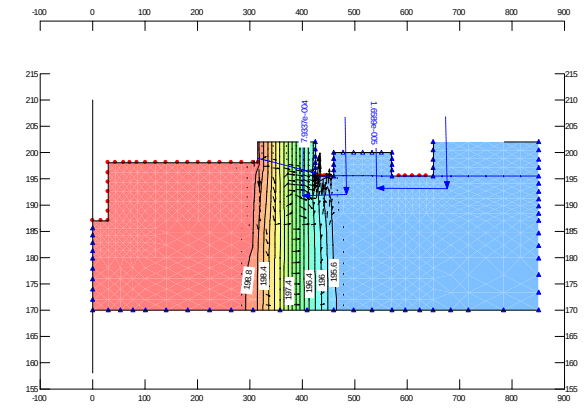
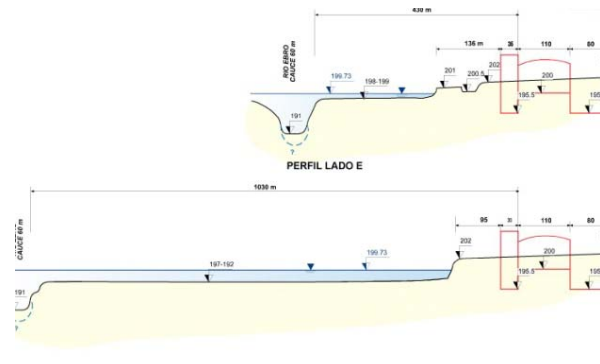
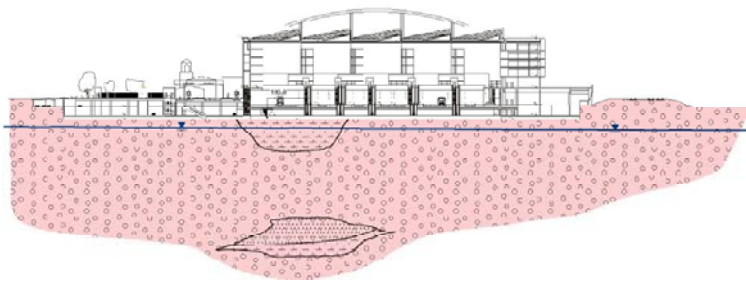
- Excavation of basement floors inside a tied-back diaphragm wall perimeter
- Deep foundations by means of drilled shafts were designed
- Very high piezometric levels were detected in the upper soil layers. The excavation was taken to a tertiary clayey substrate of low permeability. A drained bajlanket was designed and constructed.
- The tertiary clays of the site are of very high plasticity and well known to lead to significant creep in the ground anchors. A very special design and construction method for this elements were required





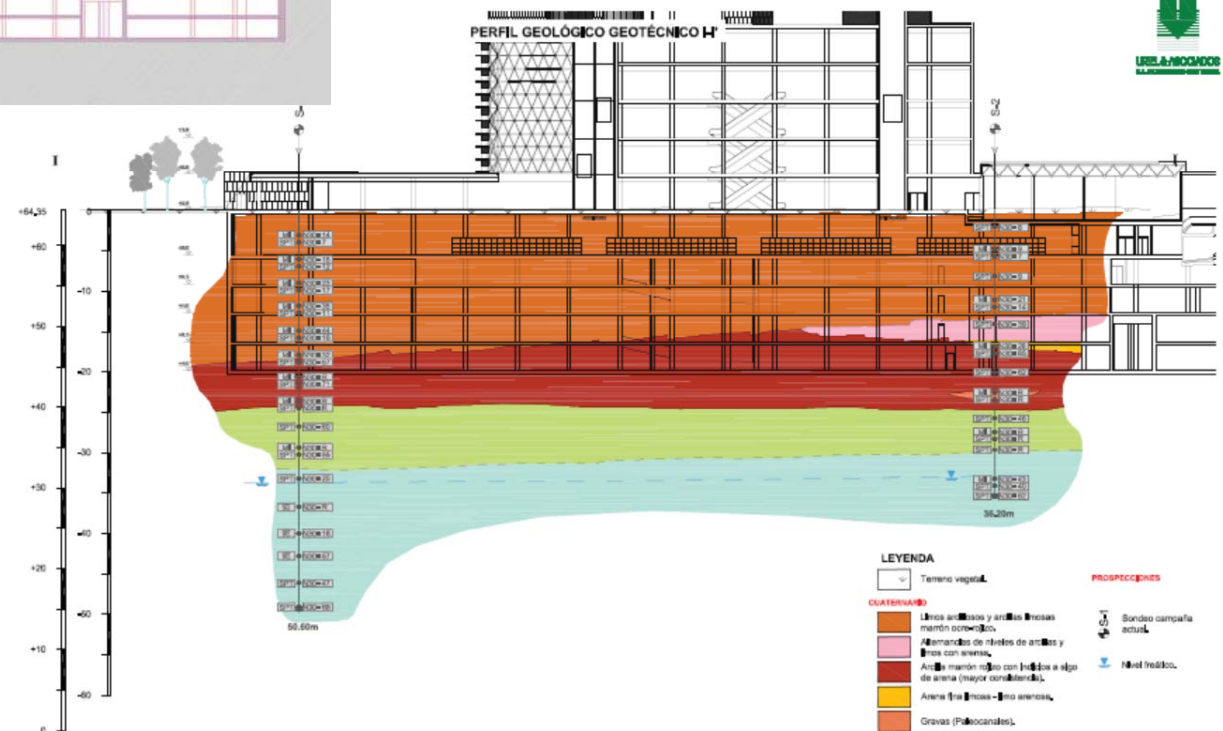
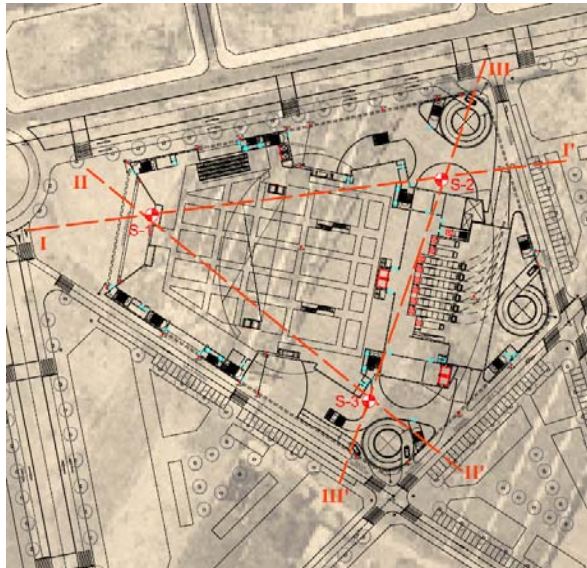
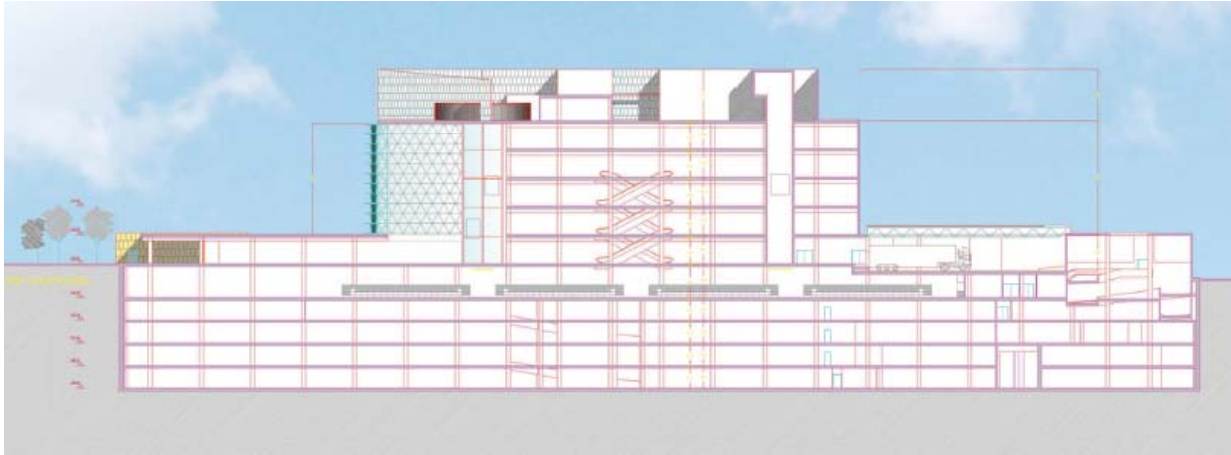
Geological, geotechnical and seismic study for the new HSR “Delicias” Station,. Zaragossa

- 14.000 m² rectangular station, laid out subparallel to River Ebro at approximately 0,5 km.
- The project contemplated the need to perform excavations at both sides of the existing station to accommodate parking basements. Both had to be linked with the station via a connecting corridor (“transfer”).
- The groundwater level was located close to the elevation of the excavation, and was subjected to considerable fluctuations caused by the river.
- The project had the particularity that it was founded on an alluvial terrace directly affected by the river water level oscillations. A detailed ground water flow analysis was carried out to design the foundations and the measures to counteract water flow and uplift.



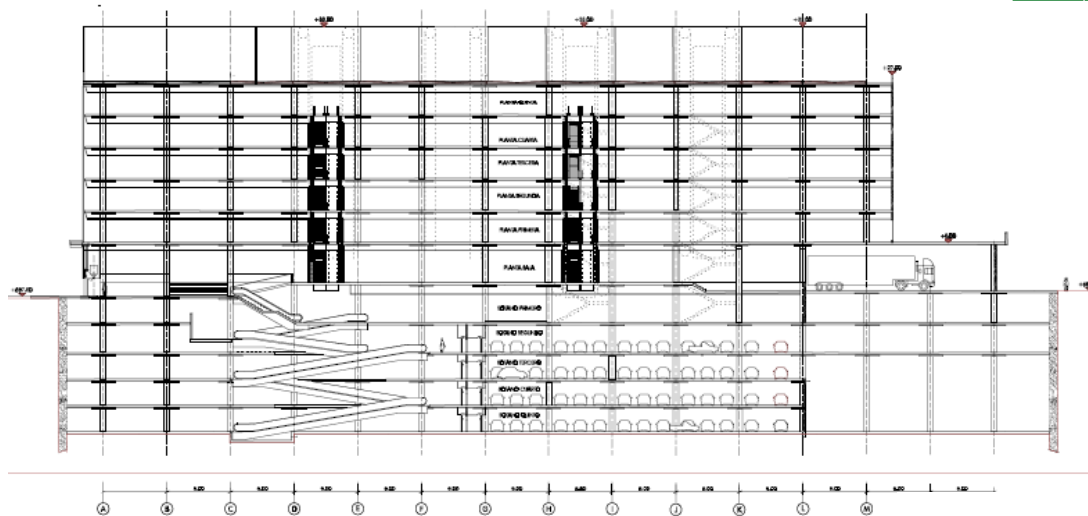
OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **EL EJIDO: 5 BASEMENTS (≈ 20 m). 30.000 m². SLURRY WALL + TIEBACKS. RAFT FOUNDATION.**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. CONSULTANCY ON DIAPHRAGM WALL & TIEBACKS DESIGN AND CALCULATION, FOUNDATION DESIGN AND GROUND WATER CONTROL**

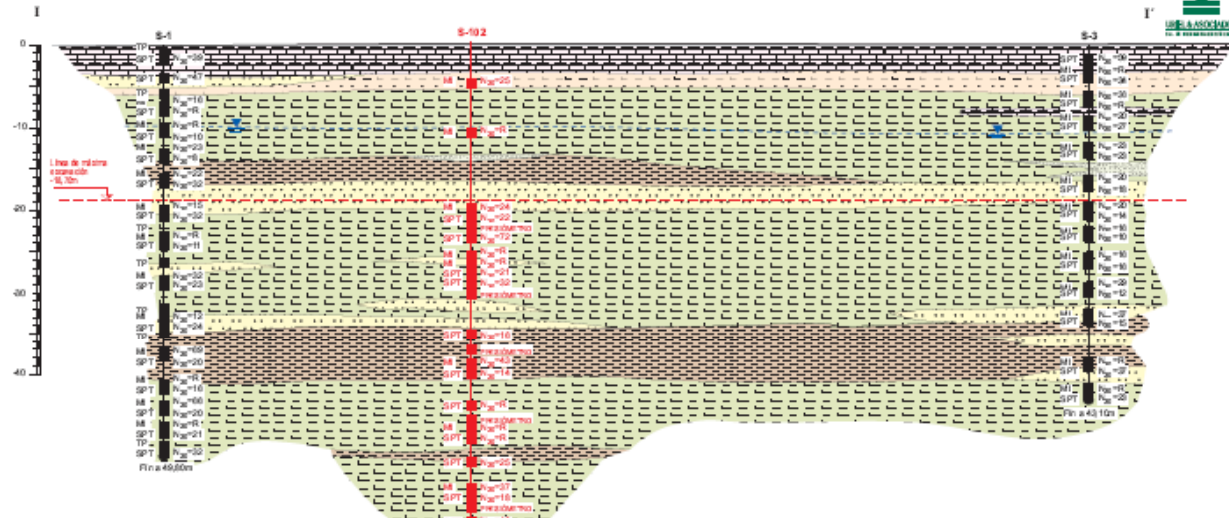


OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **ALBACETE: 5 BASEMENTS (20 m). 10.000 m². SLURRY WALL + TIEBACKS. DRILLED SHAFTS AS FOUNDATIONS.**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. CONSULTANCY ON DIAPHRAGM WALL & TIEBACKS DESIGN. FOUNDATION DESIGN AND GROUND WATER CONTROL. INTERPRETATION OF PULL-OUT AND SUITABILITY TESTS ON MULTI-BULB GROUND ANCHORS**

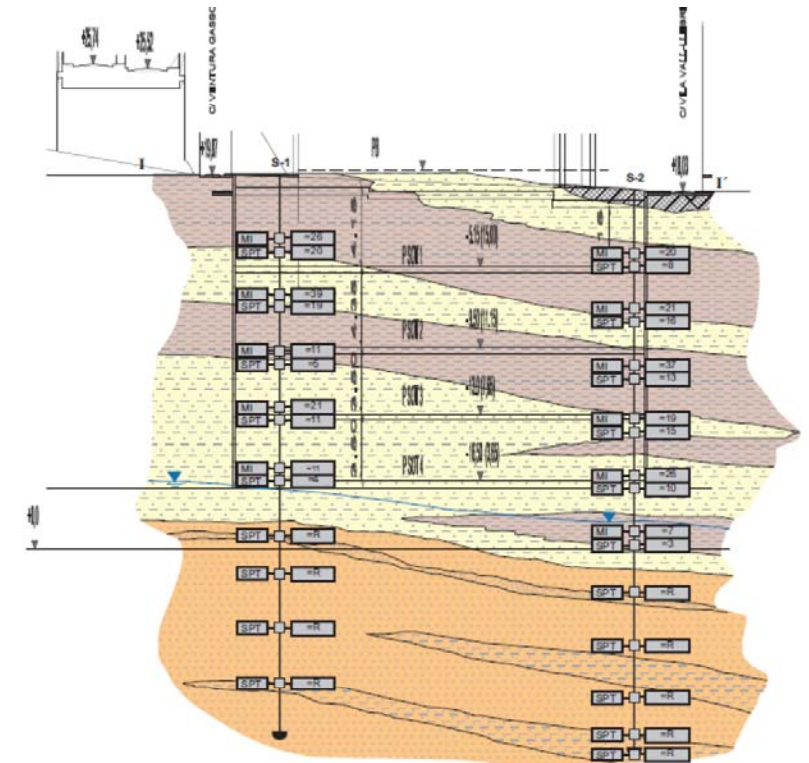
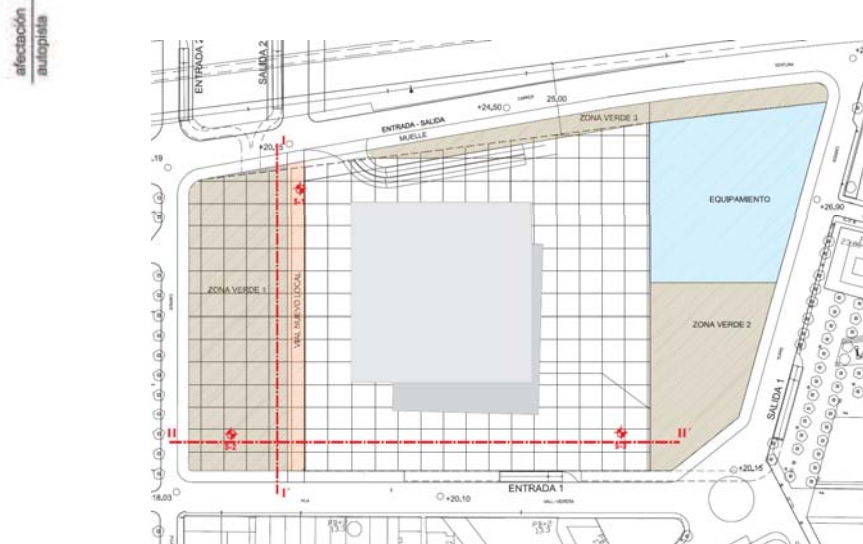
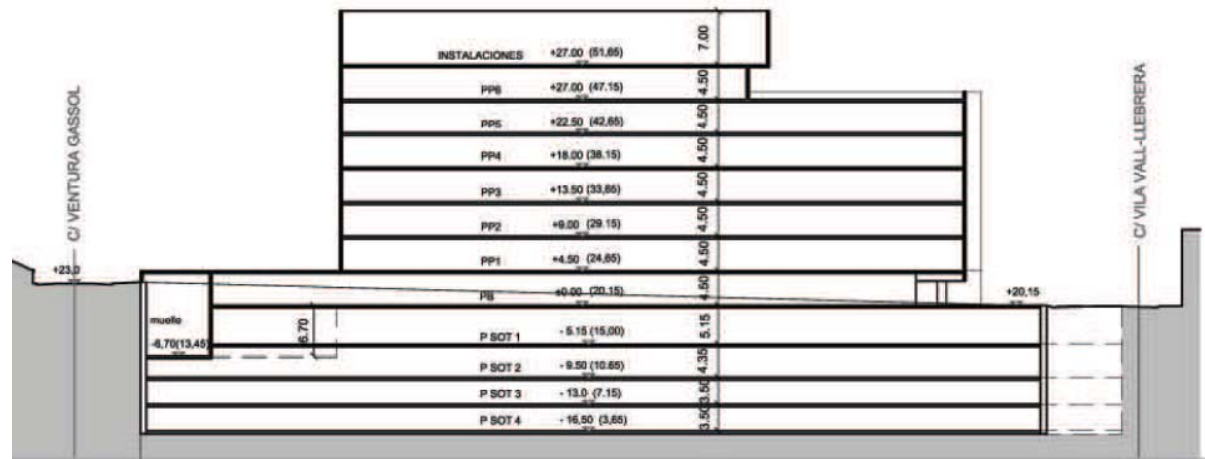


PERFIL GEOLOGICO-GEOTECNICO I-I'



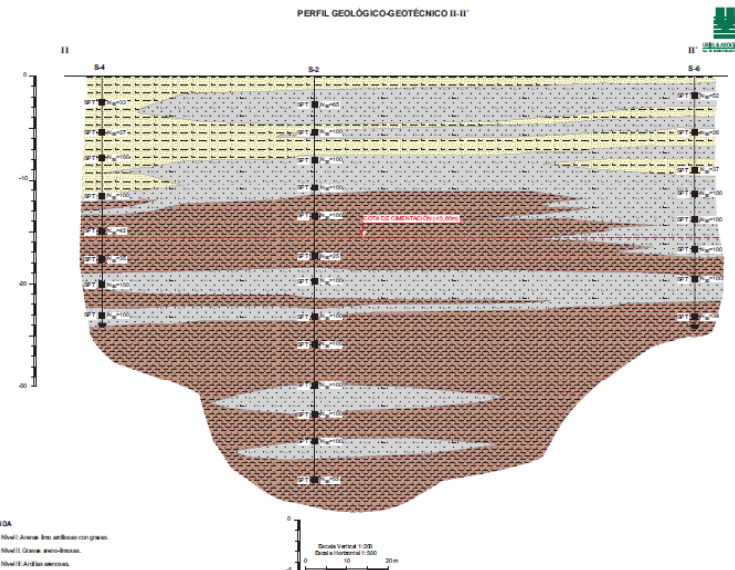
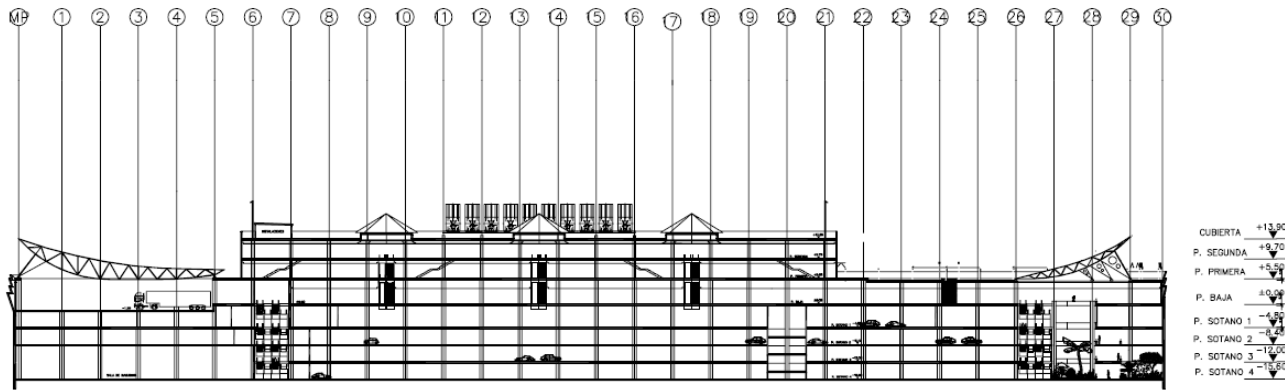
OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **BADALONA: 4-5 BASEMENTS (≈ 18 m). 16.000 m². SLURRY WALL + TIEBACKS.**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. RECOMMENDATIONS ON DIAPHRAGM WALL, TIEBACKS AND FOUNDATIONS.**



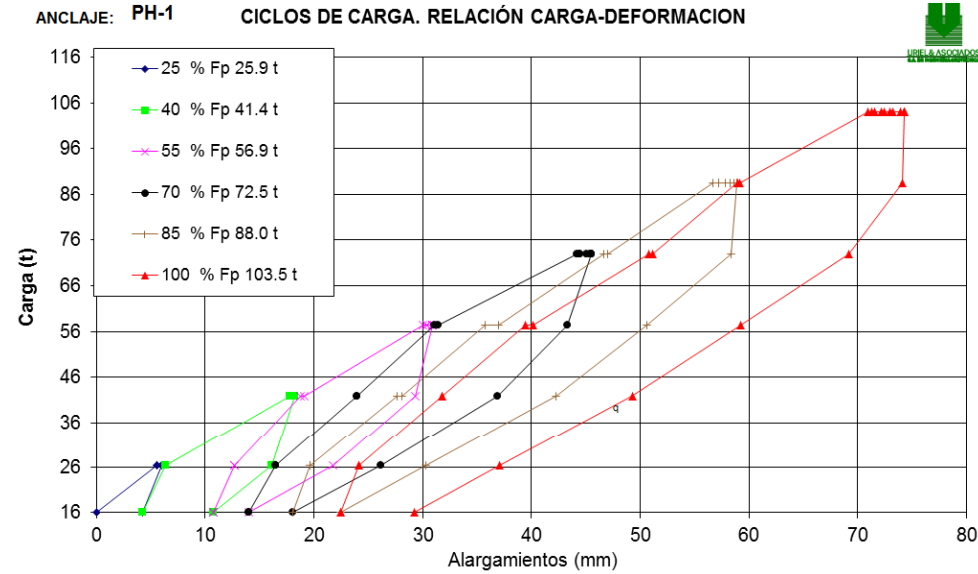
OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **ELCHE: 4 BASEMENTS (17 m). 15.000 m². SLURRY WALL + TIEBACKS. FOOTINGS ON DENSE SOIL**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. CONSULTANCY ON DIAPHRAGM WALL & TIEBACKS DESIGN AND CALCULATION, FOUNDATION DESIGN.**



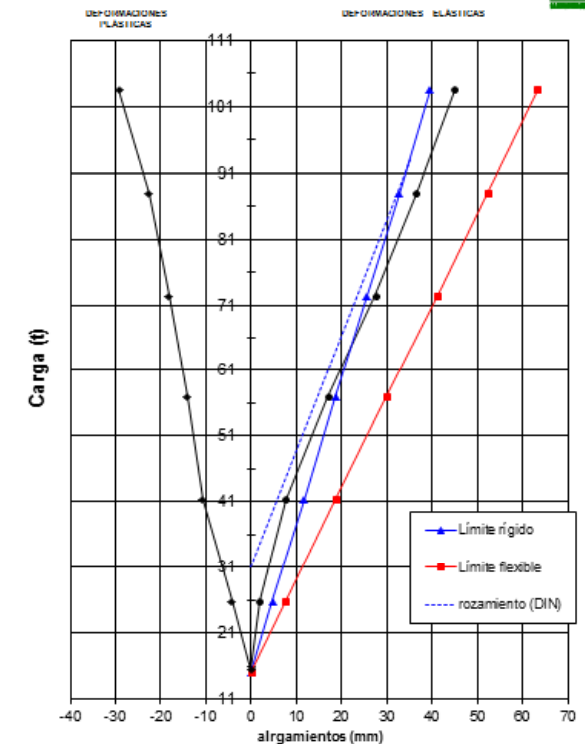
OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- GUADALAJARA. URIEL & ASOCIADOS TASKS: ANALYSIS OF TIEBACKS FAILURE. DESIGN AND INTERPRETATION OF PULL-OUT AND SUITABILITY TESTS. NEW DESIGN OF TIEBACKS.



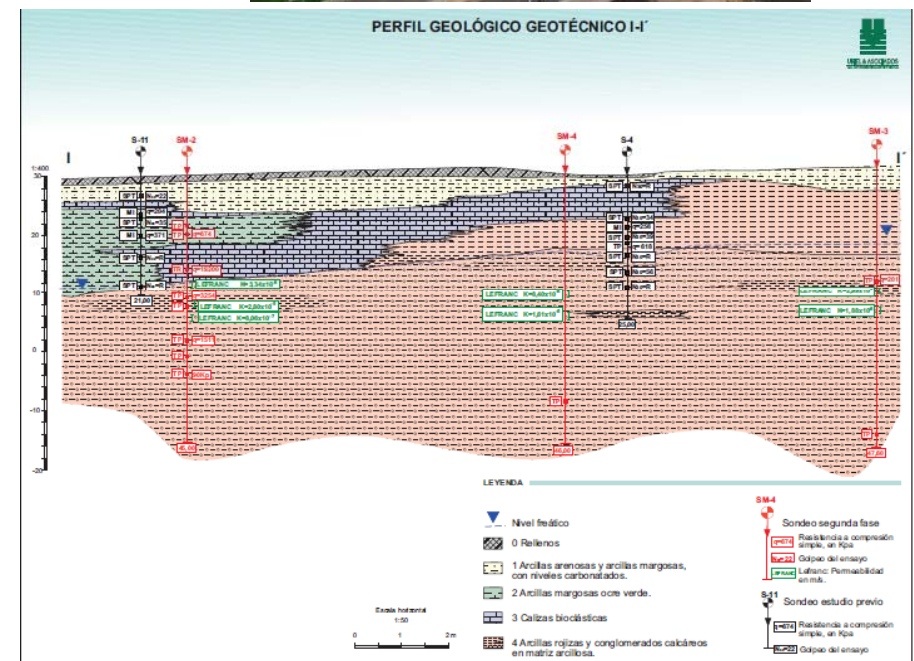
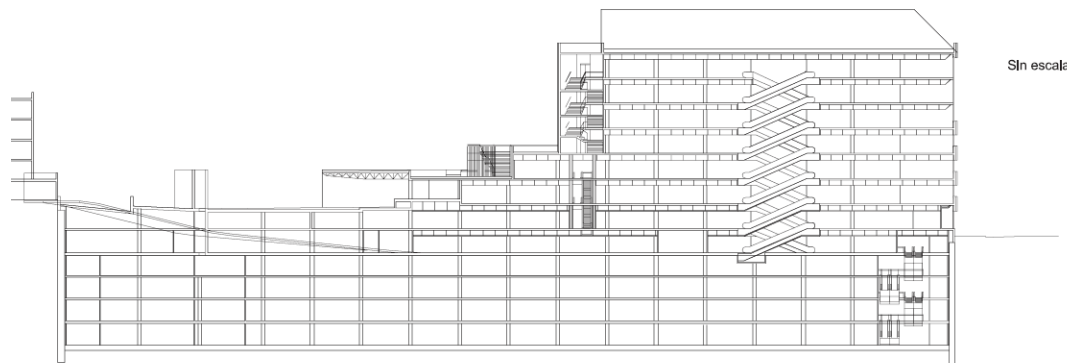
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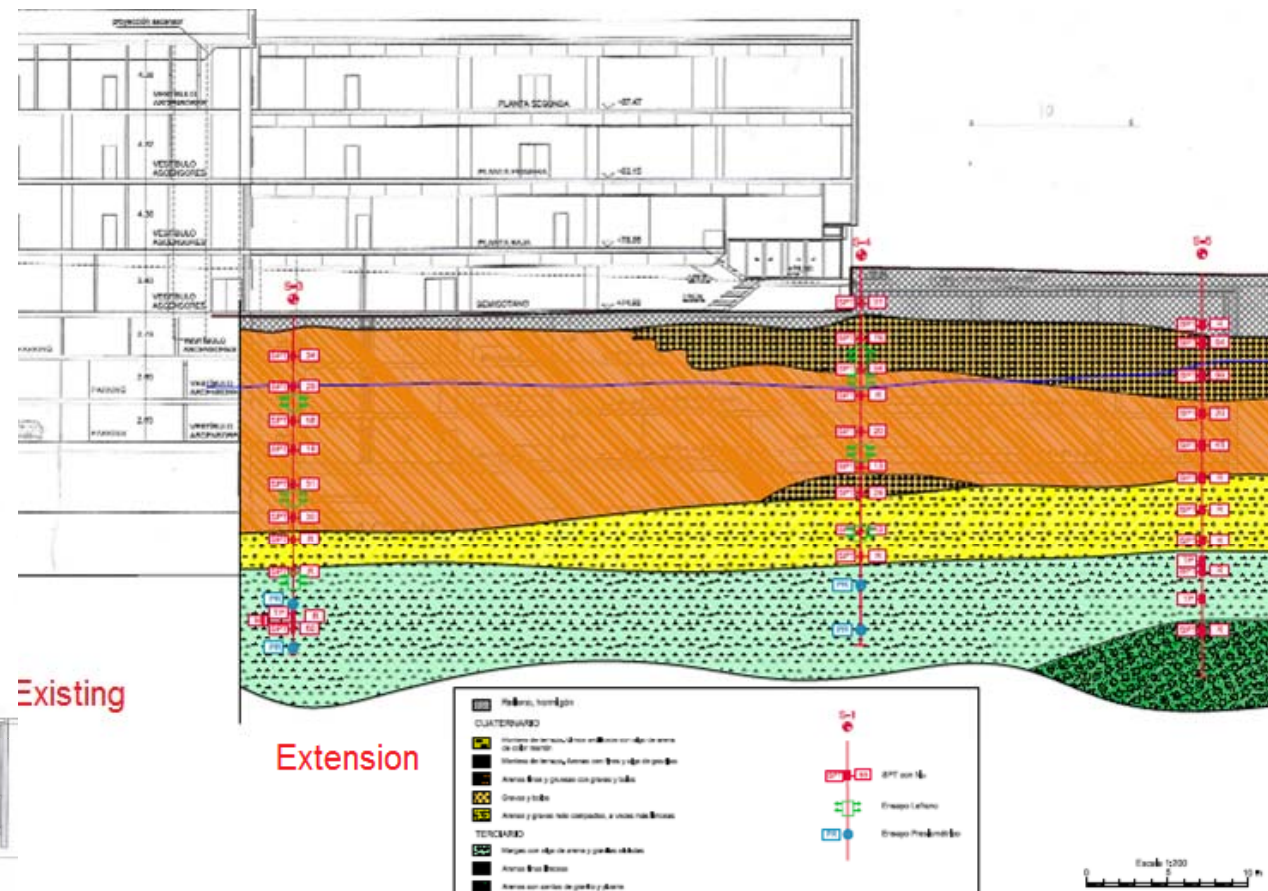
OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **TARRAGONA: 5- 6 BASEMENTS (> 20 m). 16.000 m². SLURRY WALL + TIEBACKS. RAFT FOUNDATION**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. CONSULTANCY ON DIAPHRAGM WALL & TIEBACKS DESIGN. FOUNDATION DESIGN AND GROUND WATER CONTROL. INTERPRETATION OF PULL-OUT AND SUITABILITY TESTS ON MULTI-BULB GROUND ANCHORS**



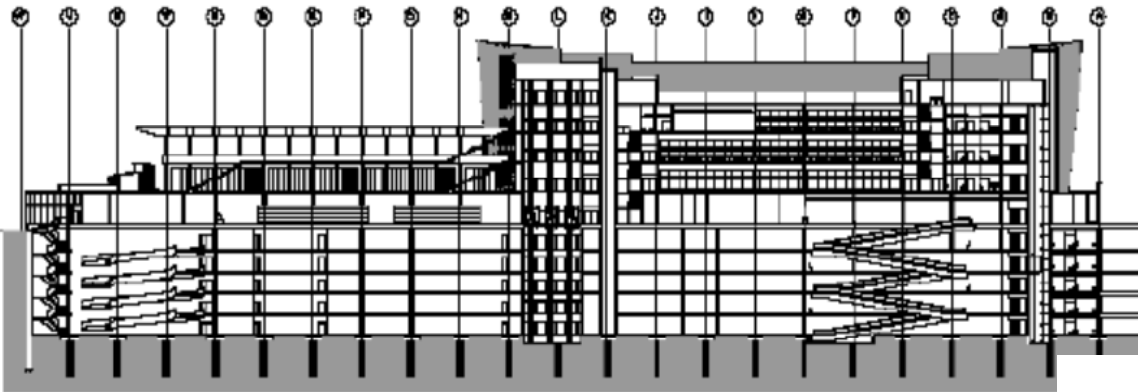
URIEL & ASOCIADOS
S.A. DE INGENIERIA GEOTECNICA

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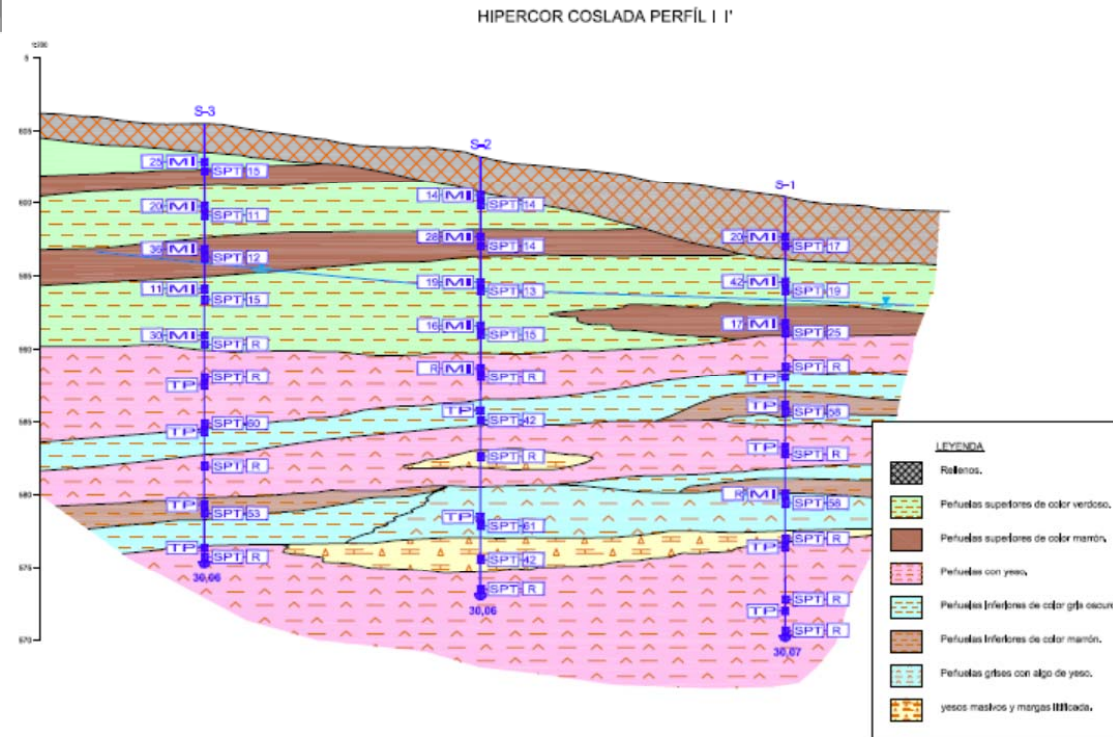


OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **COSLADA: 5 BASEMENTS (≈ 18 M). 30.000 m². SLURRY WALL + TIEBACKS. FOOTINGS.**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. RECOMMENDATIONS ON DIAPHRAGM WALL & TIEBACKS DESIGN, FOUNDATION DESIGN AND GROUND WATER CONTROL.**



• *Still under construction*



OTHER SHOPPING MALLS AND LARGE BUILDINGS IN URBAN AREAS INVOLVING DEEP EXCAVATIONS, PILE WALLS, DIAPHRAGM WALLS, TIEBACKS AND GROUNDWATER CONTROL

- **MATARÓ: 6 BASEMENTS (> 18 m). 10.000 m². SLURRY WALL + TIEBACKS. FOUNDATIONS BY MEANS OF DRIVEN PILES**
- **URIEL & ASOCIADOS TASKS: GEOTECHNICAL INVESTIGATION AND REPORT. RECOMMENDATIONS ON DIAPHRAGM WALL & TIEBACKS DESIGN, FOUNDATION DESIGN AND GROUND WATER CONTROL.**

