Diaphragm wall

Grouting, anchoring, civil engineering, shotcrete concrete, instrumentation

CENTRE CULTUREL ET DES EXPOSITIONS (CULTURE AND EXHIBITION CENTRE)

MONACO

A turnkey 17 000 m² excavation

The project for the Cultural and Exhibition Centre (CCE) enclosure, a 17,000 m² excavation descending to a depth of 25 metres, i.e. 19 metres below the level of the Mediterranean sea, is located in a seismic site with uneven geology.

The area available for construction in the Principality of Monaco is becoming scarce and new buildings are being constructed on land reclaimed from the sea. The CCE development falls into this category. It is located by the sea, on an earth platform, bordered by a dyke composed of concrete elements laid on a rock fill spoil bank.

Preliminary earthworks brought the level of this earth platform from an elevation of + 5,50 to + 2,50, the level of the work platform.

The substratum on the land side consists of hard Jurassic limestone, fractured and permeable. On the sea side, the land consists of compact lime marl which is not very permeable. The Larvotto fault divides these two areas in the longitudinal direction of the fault.

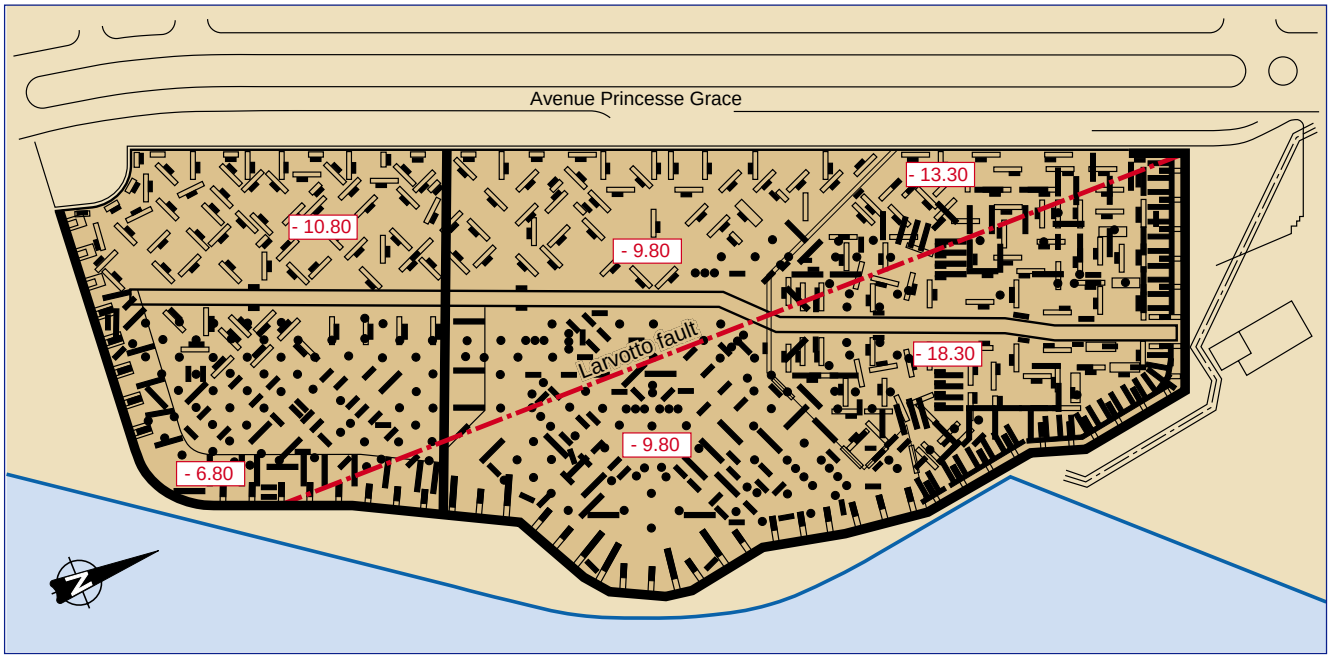
Half of the excavation hits

Overall view of the site (diaphragm wall with buttresses, T walls, slabs)

CLIENT:	STATE OF MONACO - OFFICE OF PUBLIC WORKS
PROJECT MANAGER:	GROUPING OF MONACAN ARCHITECTS, NOTARI-GENIN
STRUCTURAL ENGINEERS:	COYNE & BELLIER
SUPERVISION OFFICE:	VERITAS
OPC:	COTEBA MONACO
GENERAL CONTRACTOR:	SOLETANCHE SAM
SUB-CONTRACTORS:	EGTM (FLOORS); EGTM - ALBERTI (EARTHWORKS)
DURATION OF WORKS:	JANUARY 1993 TO JANUARY 1998 (INCLUDING 1 YEAR OF SITE STOPPAGE)
COST OF WORKS:	FF 380 M, EXCLUSIVE OF TAX
STAFF SINCE SEPTEMBER 1996:	60 TO 100 PEOPLE

MAIN QUANTITIES:

- Diaphragm walls and foundations (concrete, slurry) : 25,000 m²
- Foundation concrete : 22,000 m³
- Foundation steel : 3,000 t
- Injection slurry : 25,000 m³
- Small diameter boring (grouted bases, anchors, micro-piles, nails) : 105,000 ml
- Civil engineering concrete : 24,000 m³
- Civil engineering steel : 4,000 t
- Earthworks : 250,000 m³
- Demolition : 5,000 m³
- Draining slab : 17,000 m²
- Shotcrete concrete : 2,000 m²
- + pumping device, instrumentation (topo, piezo-electric detectors, wedges, etc.)



Plan view of the different levels of the base of the excavation

this substratum, which then plunges nearly thirty meters on the sea side, where it is covered with very fine quaternary sand and backfill which was used there to reclaim this land from the sea.

The CCE development is almost entirely buried, for architectural and aesthetic reasons, to avoid having a wall that acts as a screen along the sea front. The length of the project is 220 m for a width of 55 to 85 m. The chamber is a self-stabilising and watertight box.

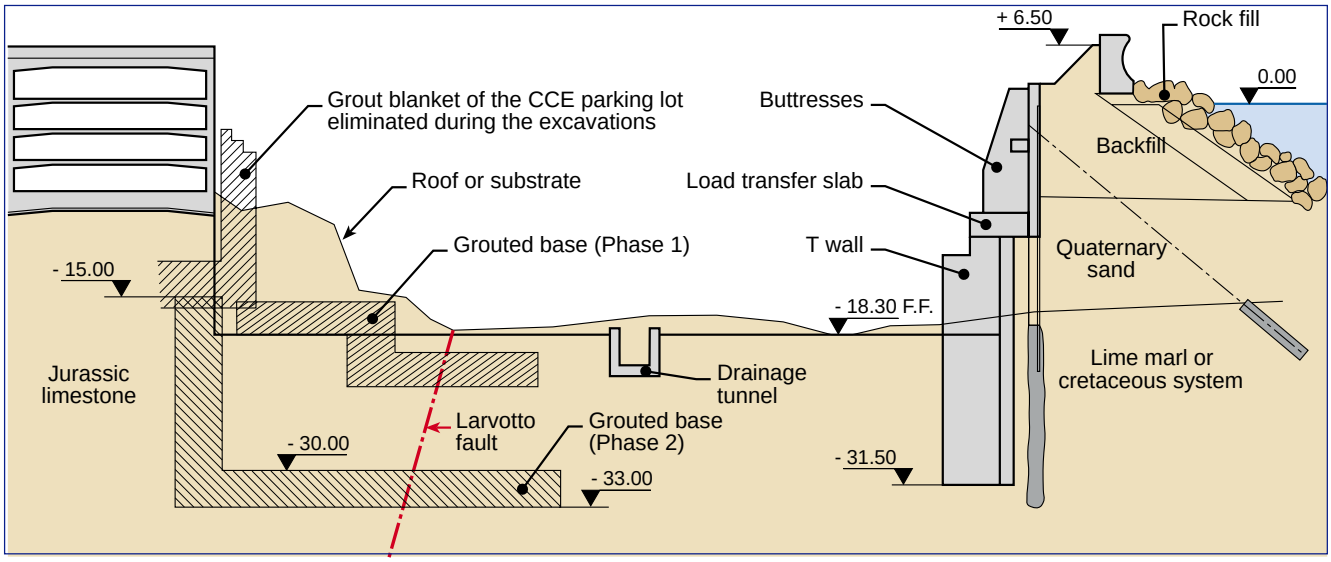
Water drainage is through a drainage slab and a drainage tunnel, as far as the collection pit (-25 NGF) where a permanent pump mechanism is installed.

To carry out the excavations, a self-stabilising ground support was required on three sides. This consisted of a diaphragm wall held in place by anchors and a wall-buttress-slab assembly during the service stage. There are two types of foundations for the structure: shallow foundations where the rock is flush and deep foundations (barrettes, piles and micro-piles).

The initial support consisted of a diaphragm wall, 1.02 m thick, which went down to the level of the lime marl, with a maximum depth of 34 m. This is maintained throughout the works by 220 prestressed anchors 5 to 7 t, anchored in the quaternary sand and the lime marl. A 15 m grouted wall extends the diaphragm wall to ensure the relative watertightness of the box. During the service phase, the self-stability of the ground support is ensured by the use of reinforced concrete buttresses, which are supported on the slab and deep foundations.

The project has changed considerably during the course of the work.

The southern part of the site was deepened by 3 m in the central part



Cross section of the northern part (the very deep section)

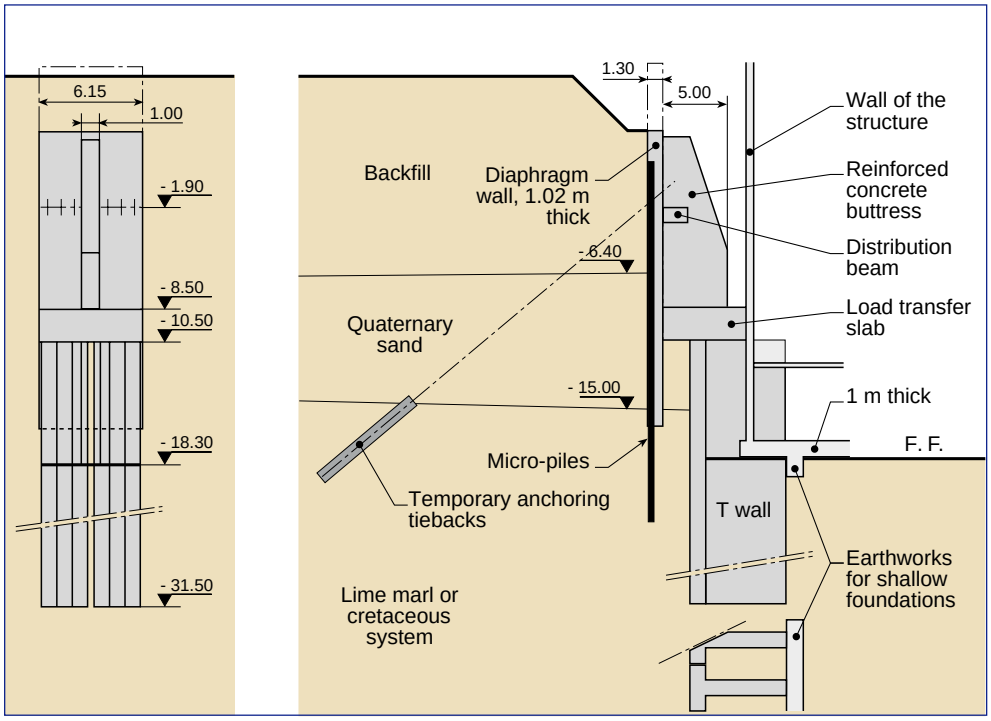
and diaphragm barrettes with micro-piles were used to transfer the thrust loads.

A second layer of 7.15 t anchors was placed under the ground water table in the central area to ensure a tension of 0.6 TG approximately is maintained in the first layer of anchors (duration in excess of 18 months).

The northern area of the site was deepened by 9.00 m.

A second ground support was built inside the first ground support, using diaphragm wall T panels, anchored in the rock. The two ground supports were connected using a 2 m thick slab on which reinforced concrete buttresses were erected.

Prior to all of these support works, new watertight bases were grouted in the Jurassic limestone wedged at altitude in relation to the new excavation bases to ensure under-pressure stability.



Section of the ground support in the northern part

The drainage mechanisms include a drainage blanket made of 4/60 materials and a layer of anti-contamination "bidim"* (see note) and 2.50 x 2.50 surface drains pointing towards the drainage tunnel,

Plan view of the southern part (drainage tunnel, excavated foundations, small struts installed)

View of the north part of the site and of the ground support (rib of the T walls, load transfer slab, buttresses)

as far as the collection pit, the lower point of the development at -25 NGF. The tunnel enables the collection of all the water, the inspection and cleaning of drains, as well as any eventual additional works that may be required over time.

* Translator's note: "bidim" is a brand name used for an under-layer placed between the watertight covering and the earth.

The second ground support: T panel wall

Taking into account the nature of the land, 40% sand and 60% rock (resistance to compression exceeds 800 bars), "Hydrofraise" rig was used for the drilling.

First of all, however, we had to demolish previously existing foundations.

This work consisted of 70 mm drilling, spaced out at 0.8 to 0.9 m followed by blasting using charges in the region of 350g/m^3 of concrete. For the demolition we used chisels and buckets for clearing.

The excavations were carried out perpendicular to the axis of the foundations to be demolished, they were then filled with lean-mixed concrete.

We encountered several types of difficulties during the drilling of the diaphragm walls:

- the hardness of the land, leading to the consumption of a large number of picks
- the presence of 109/127 micro-piles from the initial development and HA 50 steels
- the characteristics of the mud with high cake and filtrate (intake of sea water)

We used three types of bentonite, "Cforage", C2 and CM20 (mud mixed with polymer).

The 2,80 x 5,50 T cages were constructed on site in one single unit of 24 m (35 t each). A particular feature of the cages is the inclusion of HA56 steels and a high density of 210 KGs/m^3 steel

Two spreaders, one T spreader and two cranes (one 200 t and 50 t) were used to handle the cages.

The concrete used was specially designed for the purposes of this site. It consists of low grade aggregates (0/14) to ensure improved mixing and a better steel/concrete traction coefficient for the reinforcing cages.

Other works

Blasting was used for the excavations in the rock (more than 30,000 m^3) according to a mesh size of 1.50 x 1.50 approximately and loads of 250 to 350 kgs/m^3 of land.

Close to the diaphragm wall constructions and the grouted wall along a 3-m strip, we used a hydraulic rock breaker.

A tower crane was installed in the deep section to the north of the excavation to facilitate the digging work, the drainage blanket and slab works.

The site constraints were essentially of an environmental nature, that is to say the discharge into the sea of the water from the pump, noise and air pollution.