Foundations for the rehabilitation of an ancient building

Fondations pour la réhabilitation d'un ancien bâtiment

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SYSNOPSIS The problems are described in connection with a rehabilitation project of a 15th Century building in Burgos (Spain) involving the excavation of three basement levels below groundwater level and having to conserve several parts of the ancient building. An analysis is made of the different problems encountered. The solution finally adopted, at present being carried out, includes a perimeter retaining wall constructed just below two façade walls, by means of the soil freezing technique and the temporary underpinning of the interior walls by means of a reinforcing structure consisting of micropiles.

1 - INTRODUCTION

The "Casa del Cordón" Building is a fortified palace built in the city of Burgos (Spain) during the last years of the fifteenth Century. Its architectural construction corresponds to the transition between the Gothic and Renaissance styles.

Nowadays the building belongs to the "Caja de Ahorros Municipal of Burgos" which decided to rehabilitate it to instal the company's head offices. The projet includes the excavation of a cellar 11.5 m high, with three levels, to lodge a Conference Hall, safe box facilities for clients and underground parking.

The Fine Arts Authorities have given permission for the rehabilitation works of the Building but have imposed the condition that several parts of the palace must be conserved, such as two façades,the central cloister and a lateral arcade.

Fig. 1 shows the plant of the Building and the parts that must be conserved during the works. The total surface area is about 4,000 m2,70% corresponding to the palace and 30% to old houses, the grounds of which are incorporated into the palace building.

Fig. 2 shows a view of the Building correspond ing to the façade onto Calvo Sotelo Square.

The walls of the palace are constructed of cut limestone blocks laying on a spread foundation 1.5 m wide, made of stone and lime mortar.The foundation depth is about 2.0 m from ground level.

2 - GROUND CONDITIONS

The geological soil profile of the ground is as follows:

I) backfill, about 2.0 m deep;

II) gravel and sand down to 4.0 to 6.5 m depth;

III) silty-sandy clay lying 2.0 to 3.0 m thick in some zones;

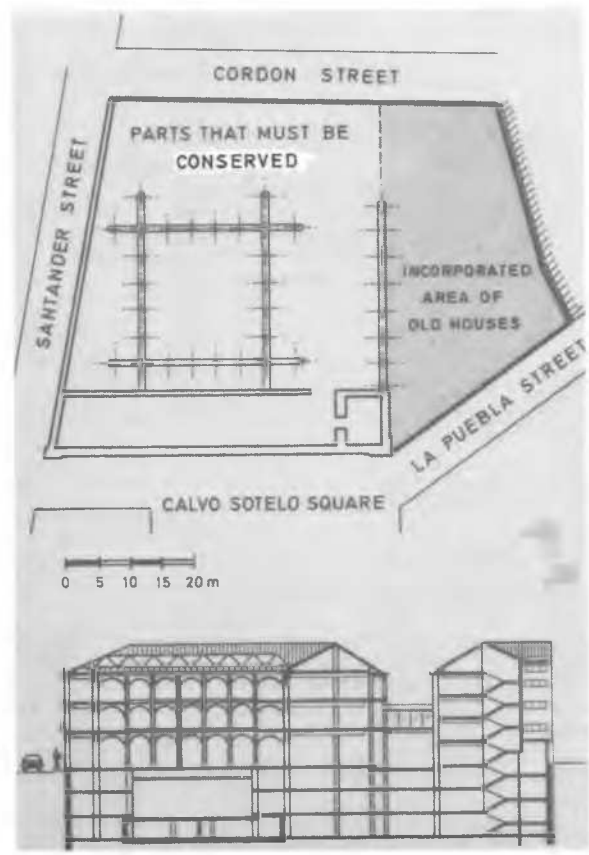

Fig. 1 - Plant of the "Casa del Cordón" and cross-section of the new Building.

iv) marl with gypsum lying from about 6.0 to 10.0 m depth downwards.

Fig. 2 - View of the "Casa del Cordón" Building

Fig. 3 shows the mean soil profile. The water table lies at about 2.5 m depth with a small gradient towards the Arlanzon River that flows parallel to the façade onto Calvo Sotelo Square and about 150 m away.

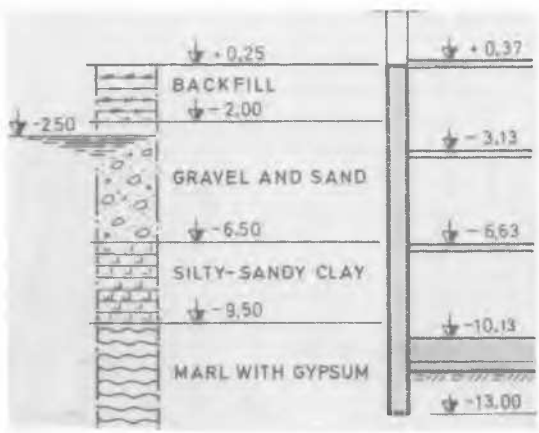

Fig. 3 - Mean geological soil profile and building underground levels.

3 - DESIGN PROBLEMS ENCOUNTERED

Due to the ground conditions, mainly the presence of ground water and the permeability of the gravel and sand layer, and also due to the above mentioned project characteristics, several problems arose.

These problems may be resumed as follows:

i) need of a water-proof screen surrounding the area to be excavated.

ii) need of a supporting structure to bear the ground and water thrusts.

iii) need to brace some parts of the ancient building, during the cellar excavation works, until the permanent supports were constructed.

iv) need to restrict as much as possible the movements of those structural parts of the palace that must be conserved in order to avoid damage during the works.

4 - SOLUTIONS ADOPTED

In order to solve the problems that have just been resumed, Rodio Company collaborated with the Project Manager Dr. of Architecture F. Moreno-Barberá.

The possibilities of several foundation techniques were analized to answer the requirements and to solve the problems. Subsequently, the solution adopted was as follows:

i) Temporary underpinning of all the structural elements that must be conserved inside the Building.

ii) Perimetric reinforced concrete wall, embedded in the marls, in order to create a resistant and water-proof enclosure, permitting the ground to be excavated inside this.

Initially, for this last purpose, a diaphragm wall, constructed by the slurry trench tecnique, was designed, sited along the perimeter line except along the façades to be conserved where the diaphragm wall was sited just inside. The solution could be carried out along all the perimeter line except in three separate zones located in the façades, where the machynery was not able to work. In those three zones the soil freezing technique was envisaged as a way to complete the perimeter wall. Finally, the need for space inside the cellar made it necessary to locate the perimeter wall just below the existing façades. So for all this zone of the building the soil freezing technique was adopted in order to construct a continous pier foundation, also serving as perimetric retaining wall.

5 - TEMPORARY UNDERPINNING CHARACTERISTICS

The purpose of the underpinning was to transfer the loads of the structural elements that must be conserved from the existing foundations to the ground below the cellar excavation bottom.

For this, the system designed was as follows:

i) The existing foundations had to be strengthened by two reinforced concrete beams (0.5 x 1.3 m) which had to be pressed over the spread foundations by means of stressed steel bolts, as indicated in Fig. 4 (2 steel bars 40 mm Ø every 2.0 m, stressed to 500 kN).

ii) The foundations had to be underpinned

with "Ropress" micropiles that have a steel pipe reinforcement, fitted with non-return grout valves in the lower part of the pipe, in order that the bonding to the ground could be created by grouting cement mixture at high pressure.

The micropiles were also to be fitted with an inner steel rod in order to preload the micropiles before they were bonded to the foundation beams. After that the rods were to be relieved and the pipe filled with cement mixture. Two types of micropiles, 250 and 450 kN allowable load, were designed, which had to be preloaded to 200 and 350 kN respectively.

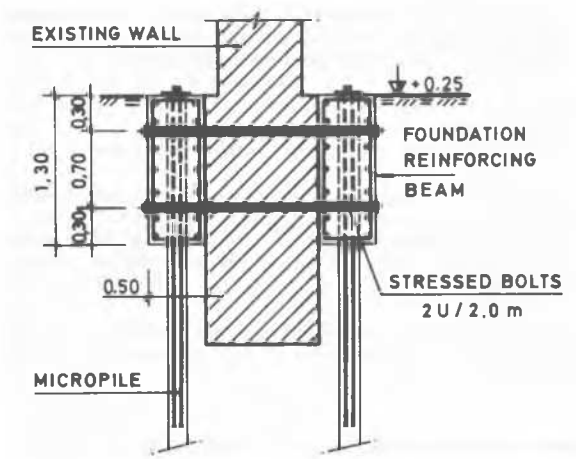

Fig. 4 - Foundation reinforcement and temporary underpinning.

6 - CONTINUOUS PIER FOUNDATION WITH SOIL FREEZING TECHNIQUE

As we mentioned above, to construct the perimeter retaining wall below the façades of the Building, it was decided to make adjacent piers by using the soil freezing technique.

First of all, it was considered advisable to strengthen the spread foundation of the walls by placing two reinforced concrete beams (0.40 x 1.50 m) in a similar way as described above for the temporary underpinning.

After that, the construction process was to be the following (see Figs. 5 and 6):

i) In a first phase, 16 thick hollow cylinders of frozen soil were to be constructed, with the following characteristics:
- inner Ø: 4.0 m to 4.5 m
- thickness: approx. 1.0 m
- distance between axes: 6.5 m. to 7.0 m approx.

ii) Exacation was to be carried out inside the cylinders in alternate order and rectangular piers were to be concreted, 2.0 or 3.0 m long.

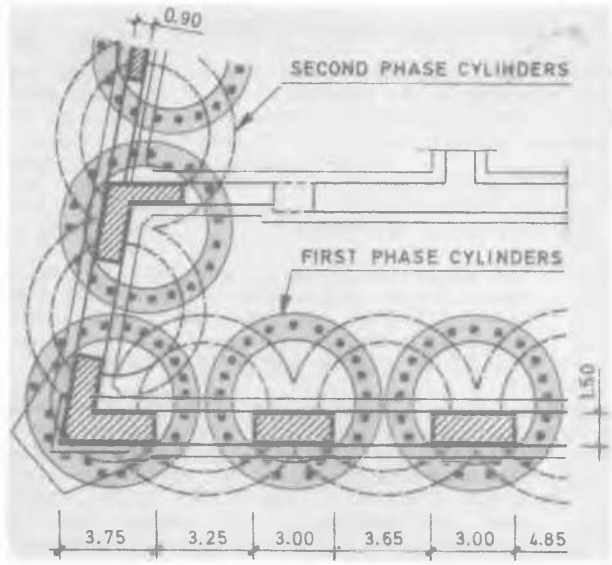

Fig. 5 - Plant of frozen soil cylinders and pier foundation panels.

iii) The cylinders were to be filled with properly compacted soil.

iv) In a second phase, 15 intermediate cylinders of frozen soil were to be constructed (5.0 m inner Ø).

v) Excavation was to be carried out inside the second phase cylinders and rectangular piers 4.0 or 4.5 m long were to be concreted, joined to those of the first phase.

vi) The second phase cylinders were to be filled with properly compacted soil.

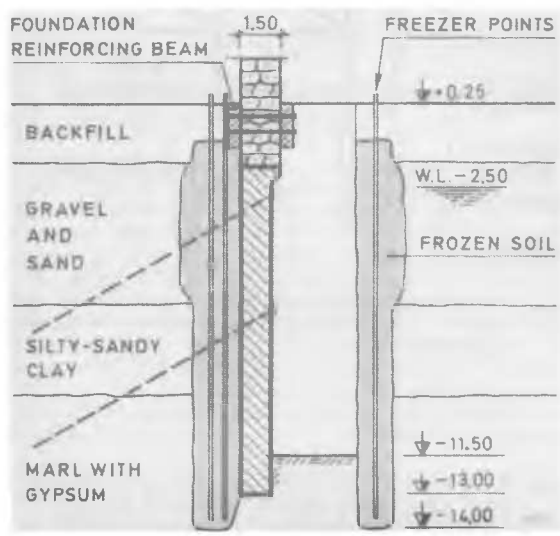

Fig. 6 - Section of a frozen soil cylinder and a pier foundation panel. Anchors are placed during general excavation.

7 - GENERAL EXCAVATION PROCEDURE

After the perimeter wall and the inside underpinning works were completed, as described above, the general excavation was to be executed according to the following procedure:

I) First of all the ancient structures had to be braced in order to obtain overall rigidity for them.

II) The excavation had to progress in three phases down to levels -2.8 m, -6.5 m and -11.5 m placing two rows of temporary anchors grouted into the ground at -2.8 m and -6.5 m levels.

III) As the excavation progresses the micropiles are to be conveniently braced each 2.0 m in order to create temporary supports (Fig. 7)

IV) When the bottom of the excavation is reached (-11.5 m level) the permanent structure is to be constructed and the micropiles then removed.

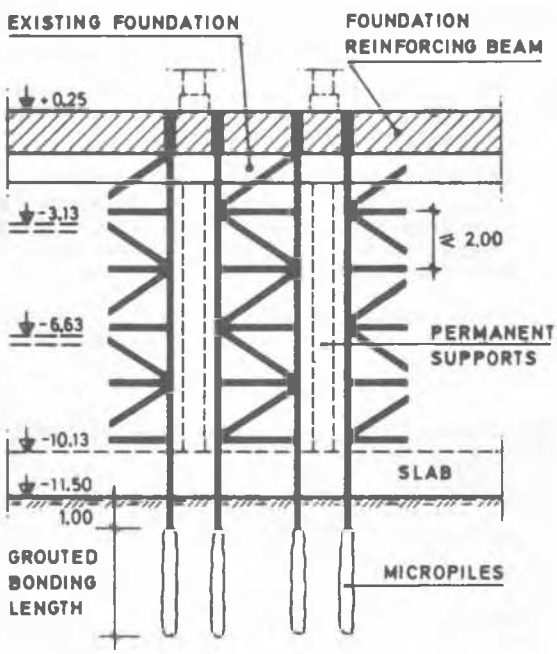

Fig. 7 - Temporary supporting structure made with micropiles during general excavation.

8 - CONSTRUCTION

The works for the rehabilitation of the "Casa del Cordon" Building began in June 1.983. They were contracted to Agroman Company associated with Rodio Company to perform the soil freezing works.

To date (June 1.984) the works of underpinning and the perimeter retaining wall have been completed and the general excavation has just started. During the perimeter retaining wall construction the water table level rised about 50 cm.

For the construction of the pier foundation panels below the façades, using the frozen soil technique, two freezing plants were used, of 160,000 Kcal/h refrigerating power each.

Along the perimeter of each cylinder of frozen soil, about 24 freezer points were installed, approx. every 0.80 m, to freeze soil in about 1.0 m thickness. As cooling fluid, a terpene mix was used instead of brine.

Each cylinder of frozen soil took about 15 days to create. The soil temperatures and the frozen soil evolution was monitored by thermo-electric couples installed in the ground and automatically controlled by microcomputer.

Excavation inside the cylinders could be started when the temperature at the theoretical excavation boundary reached -5ºC.

The works for inner excavation, reinforcement, framework and concreting took about 25 to 30 days per cylinder. Fig. 8 shows the construction of a pier foundation panel inside a frozen cylinder.

During the works no relevant movements of the façades were observed nor any damage to same.

Fig. 8 - Construction of a pier foundation panel inside a frozen soil cylinder.

9 - CONCLUSION

The case history reported here indicates that the frozen soil technique may be used for building underpinning works, at least in similar cases where the configuration of the fabrics and foundations, (conveniently reinforced when necessary) prevents heaving risk.