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Reconstruction of the building and conversion to hotel in the center of Zagreb, Croatia

Reconstruction d'un immeuble dans le centre de Zagreb – Croatie – en vue d'une reconversion en hotel

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ABSTRACT: Theme of this paper is a construction of the excavation pit and protection of the surrounding buildings as the part of the project of reconstruction of an existing building in the city centre of Zagreb. In order to minimize displacements of the surrounding buildings and Praška Street and to ensure the stability of the construction pit sidewalls during excavation, the basement is designed and constructed using top-down technology. This way there was no need of using geotechnical anchors that would mean building outside the plot. The retaining structure consists of 300 mm diameter drilled piles, reinforced with HEB180 steel beams. The basement ceiling slab was temporarily used as horizontal propping the piles, while there was an additional steel structure made of HEB profiles used for propping on the east side of the construction pit.

RÉSUMÉ: Cet article concerne la reprise en sous-oeuvre dans le cadre d'un projet de reconstruction d'un bâtiment situé au centre de la ville de Zagreb,. Afin de minimiser les impacts sur les bâtiments environnants au niveau de la rue Praška et d'assurer la stabilité des parois latérales des fouilles pendant les terrassements liés à la reprise en sous œuvre, le sous-sol a été réalisé de haut en bas. De cette façon, il n'a pas été nécessaire d'exécuter des ancrages géotechniques qui auraient nécessité de réaliser des travaux à l'extérieur du site propre du bâtiment. La protection des parois latérales a été assurée par des pieux forés de 300 mm de diamètre, renforcés de poutres en acier HEB180. La dalle supérieure du sous-sol a été temporairement utilisée comme étaiement horizontal entre les pieux, tandis qu'une une structure supplémentaire en profilés HEB a été réalisée pour étayer le côté est de l'excavation.

KEYWORDS: minipiles; head beams; steel structure; propping; top-down.

1 INTRODUCTION

The existing building is part of an old city block (Figure 1.), which means it is built on the edge of the site and is in direct contact with the surrounding buildings on the north, south and west site edge. Soil at the site consists of fill, clay low to high plasticity clay with small parts of sand and well graded gravel. Excavation of the construction pit is made in fill and clay. Because of the small construction site between surrounding buildings and the fact that the building will have a basement, the best technology for construction was Top-down method (Puller 2003).

Figure 1. Site location

1.1 *Retaining structure*

Retaining structure of the pit excavation consists of:

- Bored minipiles around the perimeter, 300 mm in diameter, reinforced with HEB180, S235 steel beams. The length of the piles was 8 and 10 m.
- Head beams with cross section (40 cm x 60 cm) where the piles, basement ceiling slab and sidewalls from upper floors were joined.
- Drilled minipiles inside the construction pit, 400 mm diameter that incorporate 273 mm steel pipes of which were used as a vertical support for basement ceiling slab during the excavation below and were placed inside final columns and walls. Steel pipes were a temporarily construction while drilled piles below the basement slab are a permanent construction. At the east side of the construction pit steel structure made of HEB260, S235 was used for propping.
- The foundation slab was made in sections so that piles would be properly propped at every stage of basement slab construction.

The basement ceiling slab and the foundation slab are essentially used as struts typically used in top-down technology. The slabs have high longitudinal stiffness and they eliminated subsequent horizontal displacements of sidewalls retaining structure. The ceiling basement slab was supported by reinforced drilled piles Φ400 mm. Piles at this stage of construction transfer the load of the basement ceiling slab to the ground. Temporary steel columns were cut/removed after the foundation slab and the basement structure have been constructed. Subsequent loads are transferred to the soil via the foundation slab and reinforced concrete piles below the slab, which for the final condition have the function of reducing the settlement of the building. This conception of foundation is known in the literature as pile raft foundation (Tomlinson 1994).

2 GEOSTATIC ANALYSIS

Geostatic analysis were made in Plaxis ver. 8.6. having in mind all rules for modelling constitutive models. Material model for all soils is Hardening-soil model. Soil model consists of three layers.

First layer is fill and it is 3 meters deep from the ground surface with soil parameters; cohesion of 5 kPa, friction angle of 30 degrees and Young´s modulus of 7000 kPa.

Second layer is clay 8,75 m thick with soil parameters; cohesion of 15 kPa, friction angle of 25 degrees and Young´s modulus of 8000 kPa.

The last layer is gravel with soil parameters; cohesion of 1 kPa, friction angle of 35 degrees and Young´s modulus of 30000 kPa.

Soil parameters were determined according to drillholes, standard penetration tests, pocket penetrometer, shear vane and laboratory results. SPT values for CL/CH were 6-19, for GW were 8-19 and for CH were 21-22. Pocket penetrometer and shear vane gave as values for undrained shear strength and SPT and laboratory results gave us references for the rest of soil parameters (Bolanča 2017).

Table 1. Soil parameters

Layer		FILL	CL/CH	GW	CH
γ	(kN/m^3)	20	20	20	20
cu	(kPa)	-	100	-	150
c´	(kPa)	5	15	1	15
φ´	(°)	30	25	35	30
E_{50}^{ref}	(kPa)	7 000	8 000	30 000	20 000
Layer		FILL	CL/CH	GW	CH
E_{oed}^{ref}	(kPa)	7 000	8 000	30 000	20 000
E_{ur}^{ref}	(kPa)	21 000	34 000	90 000	60 000
kx	(m/s)	1,00E-05	1,00E-09	1,00E-03	1,00E-09
ky	(m/s)	1,00E-05	1,00E-09	1,00E-03	1,00E-09
ν		0,2	0,2	0,2	0,2

where:
γ – soil unit weight
cu – undrained strength of soil
c´ – cohesion
φ´ – friction angle
E_{50}^{ref} – secant modulus corresponding to 50% of qf
E_{oed}^{ref} – tangent oedometric modulus
E_{ur}^{ref} – unloading-reloading stiffness
kx – permeability in hor. direction
ky – permeability in vert. direction
ν – Poisson´s ratio

Piles are modeled as the plate elements and ceiling slab of basement is modeled as the fixed end anchor. Excavation is 6,9 m deep. After the K_0 procedure analysis of retaining structures is made in stages; (1) activation of surrounding building with the load of 200 kPa placed at foundation that is 1 m wide, (2) activation of piles Φ300 mm, (3) activation of basement ceiling slab, (4) excavation 4,2 m deep, (5) activation of foundation slab and excavation 6,9 m deep. The excavation is below the foundation slab because the slab has deepening for basin connected to fireproof system. The last step in analysis are reduction of soil parameters and surrounding building load according to EC7, DA3 and φ-c reduction (Bolanča 2017).

The following results are presented. Total horizontal displacement is 24 mm (Figure 2.), maximum horizontal phase displacements is 16 mm.

Maximum bending moment (Figure 3.a) is 72 kN/m´ and maximum shear force (Figure 3.b) is 149 kNm/m´. With these forces and bending moments we proceed to dimensioning of supporting elements.

There was also separate calculation for drilled minipiles, 400 mm diameter. Maximum load was 500 kN per pile and maximum resistance was 998 kN.

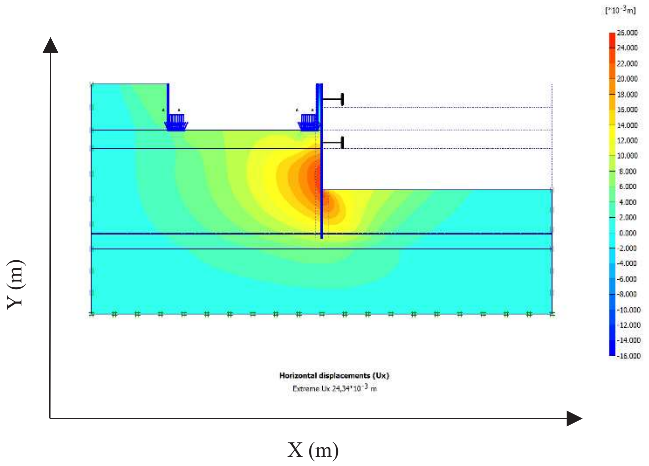
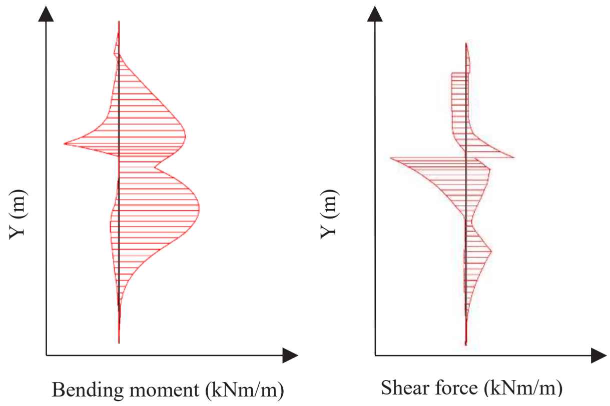


Figure 2. Horizontal displacements



a) Maximum bending moment b) Maximum shear force

Figure 3. Maximum bending moment and maximum shear force

3 STEP BY STEP CONSTRUCTION

The first step is construction of all the piles Φ300 mm (Figure 4.) at the perimeter of construction pit and the piles Φ400 mm (Figure 4.) that incorporate 273 mm steel pipes, L=6 m and 8 m which finish 2 m into the pile. They support the ceiling slab during top-down technology and steel pipes are temporary structure opposite to piles which are permanent structure.


Figure 4. Piles Φ300 mm and Φ400 mm

After that came the demolition of overground part of existing building. Then we put props below the existing ceiling slab. The props serve as supporting structure for the drill for piles that will be put at the existing ceiling slab.

Assembly of steel structure used for propping (Figure 5.) on the east side of construction pit which is at the Praška street. It will be assembled at the higher level than existing ceiling slab. It consists of steel beams HEB 260, S235 and steel brace HEB 200, S235. Removal of existing ceiling slab which has no basement below.

Construction of new ceiling slab (Figure 6.) which is used as a strut for perimeter piles and which rests on steel pipes mentioned before. Removal of steel structure used for propping at the east side of construction pit.

Top-down excavation and extraction of soil through the elevator shaft. Excavation is 4,2 m deep.

Concrete below the existing walls that will be incorporated into structure. Construction of foundation slab which is 4,2 m deep that is also used as a strut at this level. Excavation for parts of foundation slab (Figure 7.) that are deeper than 4,2 m and construction of the rest of foundation slab. Construction of walls and columns of underground structure level. Cutting off steel pipes incorporated in piles Φ 400 mm. Section C-C represents all the above-mentioned elements of the construction. (Figure 8.)

Figure 5. Steel structure used for propping

Figure 6. Construction of ceiling slab

Figure 7. Excavation for foundation slab

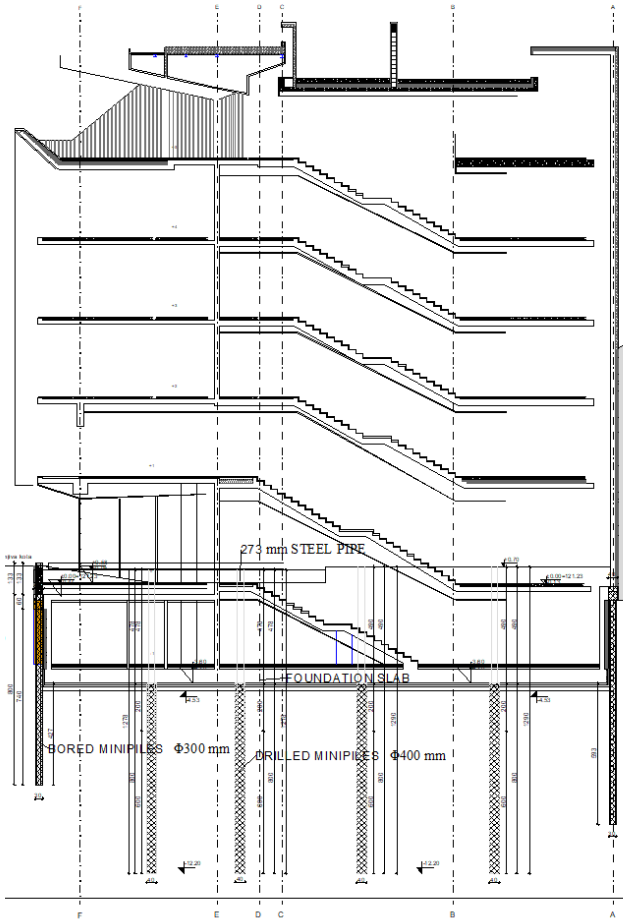


Figure 8. Section C-C

4 CONCLUSION

Benefits of this type of top-down technology are that this is safe solution which reduces effect of horizontal displacements, of retaining structure, at the surrounding buildings compared to retaining structures with geotechnical anchors. Faster construction because we don´t have prestressing of anchors and waiting for their full work capacity. Faster way of construction slabs in smaller parts than all at ones. Every part of construction is within the construction site and we don´t need approval of neighborhood tenants for geotechnical anchors. With construction of ceiling and foundation slab used as a struts the construction is limited only within construction site.

5 REFERENCES

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