DESIGN OF THE DRY PRECINCT WITH SLURRY WALLS FOR THE UNDERGROUND STRUCTURE OF A MALL AND OFFICE CENTER

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Abstract – The paper is concerned with the employment of the design result of a slurry walls precinct, in "Cetatea Noua" downtown area of Oradea city in Romania. In the same time, the paper looks to show that this dry precinct designed with slurry walls is a work which can be included in the category of hydrotechnical works.

Key words: numerical modeling, slurry walls design.

1. INTRODUCTION

The dry precinct, situated in the Oradea, Citadel Square at the intersection of Kogalniceanu, Grivitei, Cantemir and Sucevei streets, is developed in order to accomplish the underground structure of a Mall and Office Center consisting from a two levels parking place of about 6500 square meters. The upper structure consist from 4 buildings of 3 (retail building), 5, 9 and 12 stories respectively (fig.1).

Fig 1 Location of the dry precinct designed with slurry walls

2. DESIGN SECTION

The excavation wall in Section 1 is supported by a concrete diaphragm wall. The wall is supported by temporary grout anchors. The soil stratification is in accordance with borehole BH Synt. (fig.2, [1]). The active earth pressure is applied in the calculation. For the determination of earth resistance a reduction factor of internal friction for the wall friction of ½ phi. The safety of the foot support is verified for the proof of wall embedment with a values equal to or greater than 1.56. The safety factors of the foot support for the calculation of the section forces and anchor forces is 1.2. In the calculation, the wall foot is considered. The analysis of the boundary condition equations is carried out for load case 2.
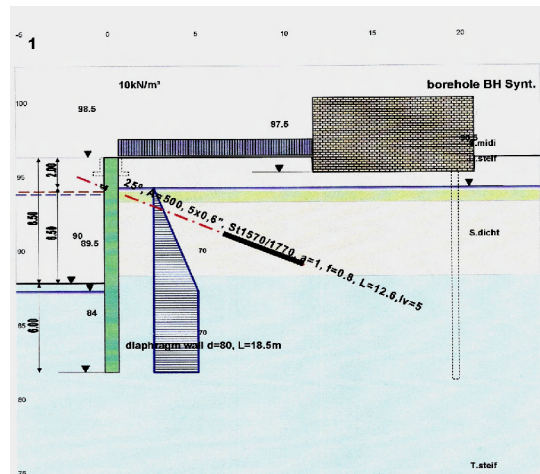

Fig 2 The dimensions of excavations

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3. CALCULATIONS

The calculation consists of six phases. In the first phase the walls are constructed and the surface loads are activated. In the second phase the first 2.30m of the pit is excavated without connection of anchors to the wall. At this depth the excavation remains dry. In the third phase the first anchor is installed and pre-stressed. The fourth phase involves further excavation to a depth.
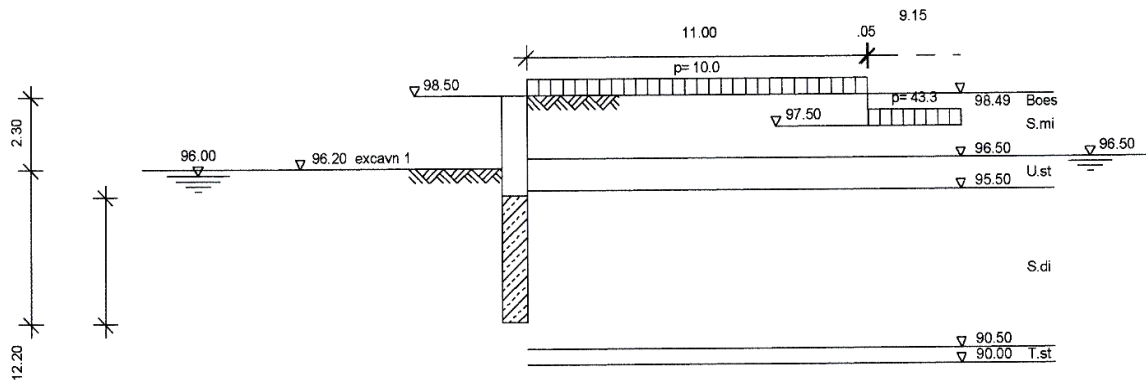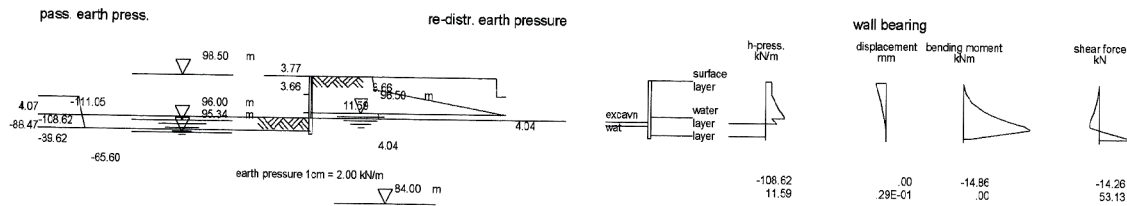
Figure 3 The second phase

Figure 4 The displacement, bending moment and shear force corresponding to the second stage
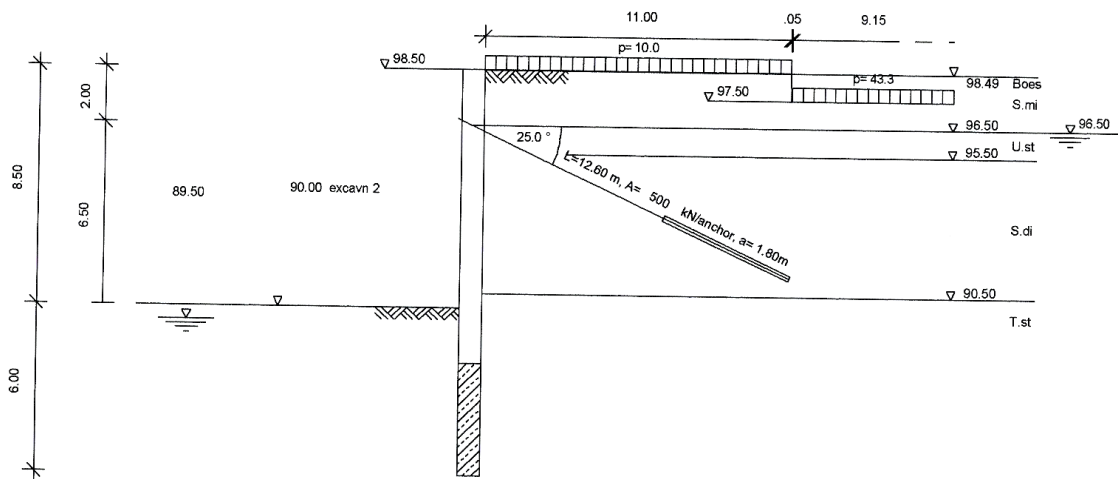
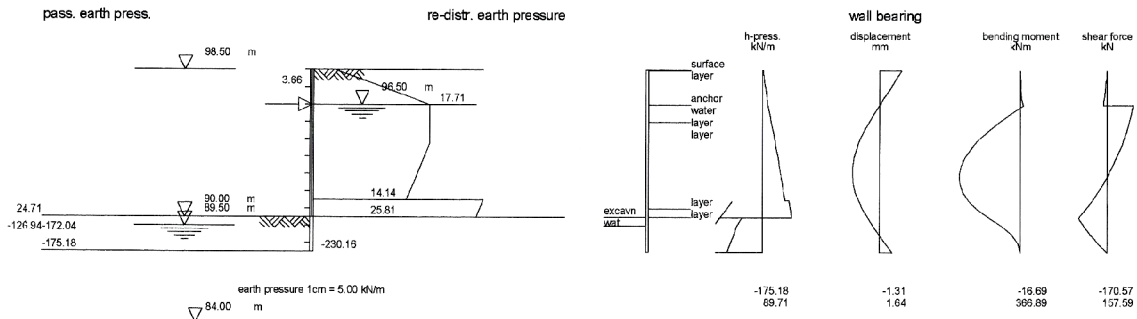**Figure 5** The fourth phase

Figure 6 The displacement, bending moment and shear force corresponding to the fourth phase

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4. ANALYSIS OF THE SUPPORT FORCE IN THE SOIL 1

In accordance with DIN1054 4.3.2(2)-7 the reaction force in the soil is determined from the difference of earth- and water pressure, external load, eventual earth resistance forces at the back of the wall and the supporting forces. The total earth pressure is determined from the wall analysis with redistributed earth pressure, the earth resistance and the permissible foot support force
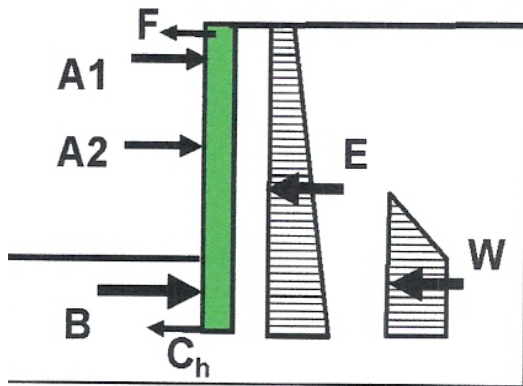

Figure 7 The loads combinations

safeties:
- embedment T= 6.00 [m]
- passive earth press. Safety $\gamma(Ep) = 1.30$ [-]
- permanent load, safety $\gamma(G) = 1.20$ [-]
- safety for determination of section forces for foot support $\gamma (S) = 1.20$ [-]

loads:
- redistributed, cut earth press. E = 138.3 [kN/m]
- water pressure W = 630.0 [kN/m]
- passive earth press. E_{ph} = 1518.5 [kN/m]
- permissible foot support force E'_{ph} = 1143.8 [kN/m]

H = E + W + F + Ch + E_{ph} / ηs – E'_{ph} = 679 [kN/m]
Resistance:
Anchor forces were not increased in the WALLS-calculation final stage is relevant support force $A_{1,h}$ = 213.1 [kN/m].

Sum of the supporting forces $\Sigma A_{i,h}$ = 213.1 [kN/m]
Reaction force of soil B = H - $\Sigma A_{i,h}$ = 465.9 [kN/m]

Ultimate limit state condition:

loads $\Sigma Ed,i = H \cdot \gamma_G = 679 \cdot 1.2 = 814.8$ [kN/m]
resistance(1) $\Sigma Rd,i = \Sigma A_{i,h} \cdot \gamma_G + E_{ph}/\gamma_{Ep} = 213.1 \cdot 1.2 + 1518.5 / 1.3 = 1423.8$ [kN/m]

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loads $\Sigma Ed,i = 814.8 < 1423.8 =$ resistance $\Sigma Rd,i$, boundary condition is fulfilled

(1) The resistance of the support is selected greater or equal the actions

5. ANALYSIS OF THE VERTICAL FORCE SECTION 1

The vertical capacity is verified at the level of excavation by end bearing and skin friction. The vertical component of the passive earth pressure is added to the vertical foot force.
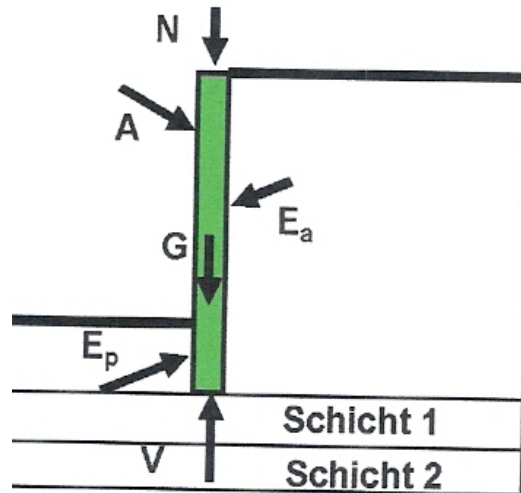

Figure 8 The structural system

G is determined at the level of the excavation with consideration of the water pressure on the wall toe.

load:
- wall length = 1.00 [m]
χ = E_0<50%: 1-$E_0 \cdot 0,012$, E0≥50%: 0,4-(E_0-50)·0,008 = 1.00 [-]
$V = N + A_v + \chi \cdot E_{av} + G - E_{pv} = 167.2$ [kN/m]
E_{pv} = 87.9 [kN/m]
section at excavation level: $E_{l,k} = V + E_{pv} = 255.1$ [kN/m]

Soil parameters	Below toe of wall		Below BO excavation			
	Layer 1	Layer 2	Layer 1	Thickness [m]	$q_{s,k}$ [kN/m²]	$R_{s,k}$ [kN]
Layer designation	T. steif		1T.steif	6.00	30	360
Layer thick. [m]	99.0		2			
φ' [o]	18.0		3			
cohesion c' KN/m³]	50.0		4			
specif. weight of soil γ [KN/m]	20.0		5			
wet specif. weight γ' [KN/m³]	10.0		sum	6.00	$R_{s,k}$ [kN]	360
qb,k [KN/m²]	175.0					

type of wall foot:
- fixation depth = 6.00 [m]
- wall thickn. = 0.80 [m]
- pile base area A_b = 0.80 [m²/m]
- skin friction surface A_s= 2.00 [m²/m²]
- level of ground water belo 0.50 [m]

Ultimate limit state condition: LF 2:

$q_{b,k}$ = 175 [kN/m²]
$R_{b,k} = A_b \cdot q_{b,k}$ = 140 [kN/m]
$R_{s,k} = A_s \cdot q_{s,k}$ = 360 [kN/m]
$R_{l,d} = (R_{b,k}+R_{s,k})/gamP$ = (140+360)/1.4 = 357 [kN/m]
$E_d = E_k \cdot gamG$ = 255.1 · 1.2 = 306 [kN/m]
loads $\Sigma E_{d,i}$ = 306.2 < 357.1 = resistance $\Sigma R_{d,i}$,
boundary condition is fulfilled

Geotechnical assumptions

The geotechnical calculations are carried out according to the new set of standards. Live loads > 10 kN/m² are enlarged with the relation of the safety factor or the live load to permanent load. This calculation according to the new standards uses a version of WALLS which has not yet been adapted. For this, the safety of the embedment is determined with the global safety factor as the product of the safety factors for permanent load and passive earth pressure. The same is applied for the analysis acc. to KRANZ. The safety factor for the determination of section forces is 1.0 acc. to DIN1054, as the safety for horizontally loaded piles. For sheet pile walls and concrete walls, the loads are redistributed to the depth below excavation level.

Anchor length - verification of external stability
Anchor position A1
Maximum length of A1 reached in excavation phase 2
Wall heigth total (m) 14.50
Wall thickness (m) .80
Level of anchor (m) 2.00
Inclin. of anchor (deg) 25.00

Anchor force (kN) 500.00
Inclin. teta (deg) 26.48

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Anchor length l = 12.60 (m)

Factor of saved eta 2.53
Efficiencies anchors 1
Number of fail. planes 1
From pt. x(m)/z(m) to pt. x(m)/z(m)
.00/14.50 12.96/ 8.04
All values per m width
End verification of external stability.
Anchor verification

6. CONCLUSIONS

Results obtained after modeling the slurry wall have contributed to the possibility of reinforcement so the structure to behave accordingly when in service in order to later build an underground parking with two levels. In addition, readings from the five inclinometers located on its contour showed that theoretical modeling deformations are close in size to them.

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