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Characterization of the Coefficient of Earth Pressure at Rest (k_0) at the Level of What Will Be the General Valley Drain Tunnel

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Abstract. The relation of the coefficient of earth pressure at rest (k_0) is determined by means of piezo-cells installed in the line of what will be the General Valley Dren Tunnel (located in the North-East of the Valley of Mexico) and the depth of the latter. With the piezocell, the total horizontal stress and the pore pressure are obtained directly and indirectly the total vertical stress can be obtained, in order to determine the relation of the horizontal stress and the vertical stress, that is, the value of the earth pressure coefficient at rest (k_0).

Keywords. Piezometer, piezometry.

1. Introduction

The Río de la Compañía - Dren General del Valle" (TRC-TDGV) Tunnel is planned to be built in two stages, for which it is divided into three sections, in the first stage section 1 and 2 will be built, from the confluence of the Chimalhuacán II Tunnel and even "Casa Colorada Profunda" is composed of the first section (L-06 to L-09), and the second will start from "Casa Colorada Profunda" until the vicinity of the shaft 6 of East Emisor Tunnel "TEO" (L-09 to L-15), both sections they will have a finished diameter of 7.0 m [1].

The second stage that corresponds to section 3 to the south of the two previous ones, starts from the "La Caldera" Pumping Plant and ends at the confluence with the Chimalhuacán II Tunnel, this stage the finished diameter of the tunnel will be 5.0 m. (L-00 to L-06), see Figure 1.

As can be seen in Figure 1, section 3 located in the southern part of the stretch, is located in the vicinity of the Santa Catarina Mountain range, which belongs to the Hill or Volcanic Cone of the Caldera, to the west of the line and to the East the Pine Hill is located; The Chimalhuacán Hill is located in the north-east zone and ends in the south zone of the Ex-Texcoco Lake.

In relation to the above and with the purpose of knowing the pressures of water to the depths where the structures are projected (Shafts, Tunnel, etc.), the following instruments were installed:

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- Vibrating Wire Piezometer in Shafts
- Open piezometers in inter-shafts sections
- Observation wells in each of the piezometric stations

Figure 1. Plant location TRC-TDGV. Google earth. 2018.

2. Earth pressure cells (piezocell)

In order to know the state of stresses of the soil, in the depths to which the pressure cells are installed, which were placed in the crown, axis and depth of the deep tunnel in a general way and in different directions, that is, parallel and perpendicular to the axis of the tunnel.

The pressure cell, also called the *pressure sword*, is designed to be press-fitted into the ground, where you can measure the total stress and pore pressure within the terrain where it is placed, it can be used as a tool Investigation on the site in order to obtain the state of stresses, both vertical and horizontal, depending on the direction of the installation. Additionally, it can also be used to monitor possible changes in passive and active pressures around containment structures, as well as in tunnels and other earth structures. They are usually installed in cohesive fine grain soils, including very soft or even rigid clay materials.

These equipment consist basically of two stainless steel plates welded both around its periphery. The port and filter for measuring the pore pressure is located on one of the flat sides of the plate, behind the sensor section of the cell.

The pressure cell and the port for the pore pressure, are connected by stainless steel tubes, to two transducers integrated in it, usually the vibrating string, if the dynamic measurement has been executed. It has a thermistor for measuring the temperature is also incorporated into the cell.

As these instruments were installed, the follow-up of both pore pressure and earth pressure readings was started, once the state of stresses according to the index and mechanical properties of the materials shown in the geotechnical models was known. the soundings that were used as reference for the installation of the piezocells, the interpretations of the readings obtained to obtain the Ko in the area of influence of the instrument are made, the data obtained in general form are in Table 1.

Table 1. Summary table for obtaining the K_0 for the design of the 5 m diameter finished section of the South tunnel, AYESA 2017.

						PIEZOMETER			CELL PRESSURE		
PZE No.	DATE	KM	CPTu (Ref)	Depth Borehole (m)	Depth Instalation (m)	Pore Pression (t/m²)	hidrostatic Pression (t/m²)	Abatment (t/m²)	σ'h t/m²	σ'v t/m²	k_0
1	15/03/2017	2+495.90	11	25.50	26.50	8.30	25.90	17.60	11.68	20.38	0.57
2	15/03/2017	2+920.90	13	26.00	27.00	14.23	26.40	12.17	8.08	15.45	0.52
3	15/03/2017	3+427.00	15	26.00	27.00	18.38	23.80	5.42	4.39	9.05	0.49
4	15/03/2017	4+087.00	17	20.30	21.30	16.61	17.10	0.49	4.88	8.82	0.55
5	15/03/2017	4+723.70	20	23.40	24.40	17.91	23.80	5.89	5.30	7.27	0.73
6	15/03/2017										
7	15/03/2017										
8	15/03/2017	6+521.60	27	22.50	23.50	20.46	20.50	0.04	1.76	4.83	0.36
9	15/03/2017	7+033.00	29	22.00	23.00	20.25	22.50	2.25	4.18	8.99	0.46
10	15/03/2017										
11	15/03/2017	8+189.00	33	16.00	17.00	11.74	16.50	4.76	4.85	7.95	0.61
12	15/03/2017	8+650.00	35	21.00	22.00	19.73	21.50	1.77	5.03	7.02	0.72
13	15/03/2017	9+420.10	38	20.00	21.00	20.83	21.00	0.17	7.52	10.00	0.75
14	15/03/2017	9+921.00	40	17.00	18.00	14.19	15.50	1.31	5.74	8.28	0.69
15	15/03/2017	10+440.00	43	20.00	21.00	20.37	21.00	0.63	2.53	5.17	0.49
16	15/03/2017	11+003.00	45	19.00	20.00	18.90	20.00	1.10	4.86	8.33	0.58
17	15/03/2017	11+594.50	47	21.00	22.00	22.67	22.00	-0.67	2.50	5.34	0.47

According to the results shown in the Table 1, a zoning of the resting earth pressure coefficient Ko of the tunnel design can be made, which is summarized in Table 2.

Table 2. Summary of the coefficient of earth pressure at rest (K_0) along the TDGV, AYESA 2017.

PZE INITIAL	PZE FINAL	KM INITIAL	KM FINAL	SHAFT	K_0
1	9	2+495.90	7+033.00	00-04	**0.50**
11	17	8+189.00	11+594.50	04-06	**0.70**
20	26	13+094.00	16+498.30	06-08	**0.50**
28	36	17+862.00	21+613.20	08-11	**0.45**
38	40	22+619.10	23+620.00	11-12	**0.60**
42	43	24+656.90	25+427.00	12-13	**0.50**
45	45	26+450.00	26+450.00	13-15	**0.40**

3. Conclusions

As shown in the Table 2 the predominant K_0 design is 0.5 to 45.7% of about stroke, then has the K_0 of 0.45 to 22.9%, followed by $K_0 = 0.7$ with 20%, $K_0 = 0.6$ with 9% and finally the $K_0 = 0.4$ in only one instrument.

The worst K_0 was between 0.7 L04 to L06 shafts in this area are the materials with the most unfavorable properties throughout the stroke, which matches coefficient value earth pressure at rest.

The K_0 of 0.45 is presented within the section from L08 to L11 shafts, prior to the arrival of the latter, in that area of the tunnel the slightly more unfavorable condition of 0.5 was considered in the design.

The value of 0.6 is only in a range of approximately 1 km, between probes 88 to 93, that is, 500 m before reaching L11 shaft and 500 m to the north of the same shaft, approximately. This coincides with increasing stresses in the tunnel because it is supported by relevant materials (the first hard layer) and above must lacustrine clays, which long-term due to regional collapse can lead to such increases stress into the liner. K_0 of 0.4, is located only in a position to the north of the trace, in piezocell 45 that is located in the sounding L04 of the 26 + 450 km chain before the arrival to L12 shaft.

References

[1] COMISION NACIONAL DEL AGUA (CONAGUA), 2017.