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Failure of Retaining Structures in Town Lezha and their Consequence in Neighbouring Building

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ABSTRACT

The Lezha town has a very complicate geology, high underground water table and high seismicity. Near of eight floors building was constructed a new building with two underground stories. The retaining structures at the time of excavation to the undergo damage to cause the serious problems on the existing building. In these paper I, would like to present the analyses of phenomena and the engineering measures for rehabilitation of situation. The most dangerous phenomena in the studied area were suffusion problems. From these phenomena the existing eight stories buildings underwent the differential settlement, which arrived near the limit value of settlements. The engineering measures consist of on creation of the concrete wall obstructive for the movement underground water and reconstruction of existing concrete wall to arrive rehabilitation of the situation.

INTRODUCTION

The Lezha town is located in northwestern part of Albania (Fig.1). It's a historical, cultural center and touristic place in Albania, because of is near (10 km) of beautiful Shengjini beach.

According to geological and seismical phenomena the town of Lezha has a high seismicity and the effect of earthquake was underlined by soft soils deposit, which has a thickness 50-60m. The soils are represented by the sands and silty sands with organic matters that are very porous. The underground water table is situated 0.5-1.0m from natural surface. During the 15-17 last years in Lezha town has had very fast development related to urban aspect. So, many multi stories buildings (8-9 floors) with 1-2 underground floors are constructed on this area. During of this processes of the buildings construction sometimes were happened the differential damages, essentially by insufficiency of engineering measures because of some engineers are not competent for such phenomena, where in these soils these phenomena can be happened. Inasmuch, they haven't considered in right manner the soils-structure interaction in this area something happen. In this paper we would like to present a characteristic phenomenon, which was occurred in the soils of the studied area during deep excavation, the performance of the almost limit state in existing buildings and engineering measures for the rehabilitation of situation.

Fig. 1. Location of Lezha town

THE PHENOMENON CHARACTERISTICS

Closed to eight floors buildings with mat foundation, which are situated on 3.8m deep from natural surface, was realized the retaining structures (concrete wall) with dimension lengths 12m and depth 12.5m (each of them). The concrete walls were constructed for new buildings for two underground floors (Fig.2). During the processes of excavation (when was arrived 3m down a mat foundation of existing building) the concrete wall was revolved and it had damage to caused in the existing mat foundation dangerous settlement. The settlements are not stabilized during the time; therefore they arrived up to 8 cm near to excavation and 1cm at other side of building. During all the time of excavation it was pumped water from the hole. After 5-7 days by settlements, the inclination of existing mat foundation arrived tag θ = 0. 0035 very dangerous value because of the allowable limit is tagθ_{limit} = 0.0040.

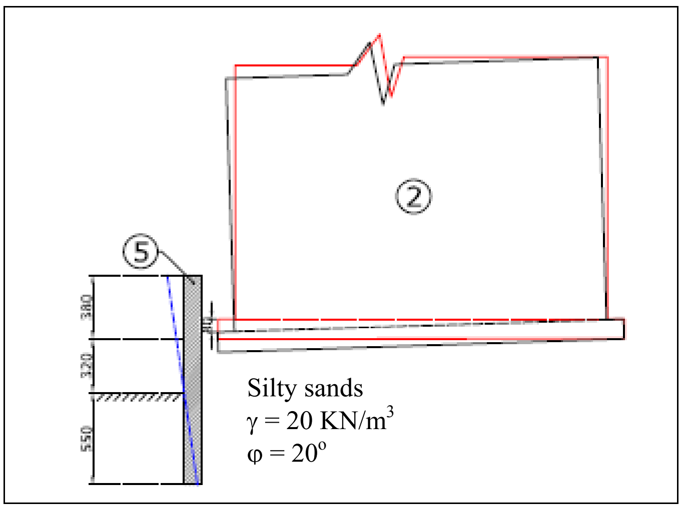


Fig. 2. a. Cross section A-A

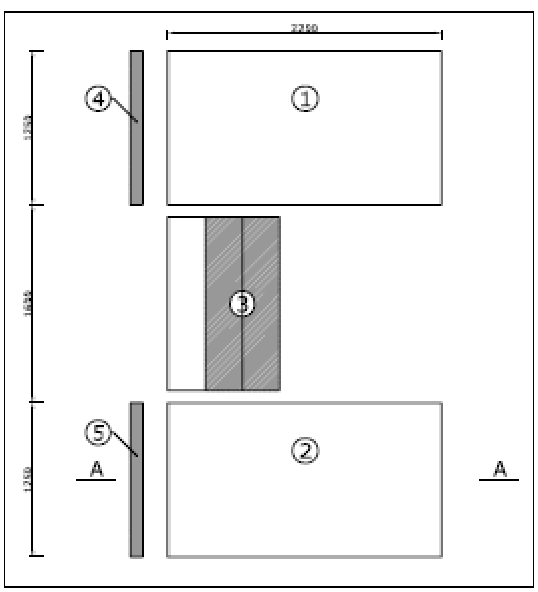


Fig. 2. b. Plan of buildings

1, 2 - eight stories buildings
3- Two stories buildings
4, 5 – concrete walls H=12.5m

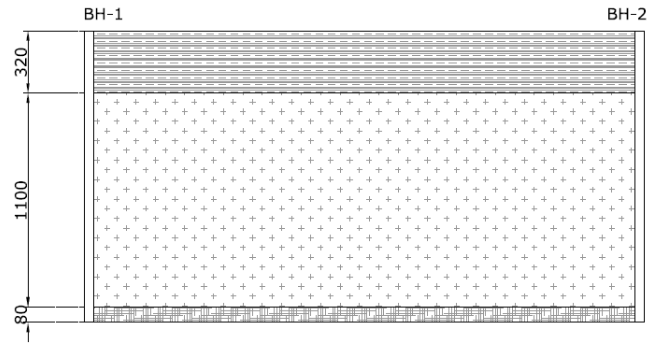


Fig. 3. Lithological profile of investigated site

ANALYSES OF THE DAMAGES CAUSES OF RETAINING STRUCTURES

Geological Situation

Initially we have realized some new bore holes to clarified the geological situation and to determinate the exactly the geotechnical properties of soils. From bore holes results the geological profiles consist from three layers (Fig. 3) and underground water table is 1-1.3m deep of natural surface.

Geotechnical Properties of Soils

From laboratories tests in undisturbed samples taken from drillings carried out in the investigated area we have the following results (Table 1);

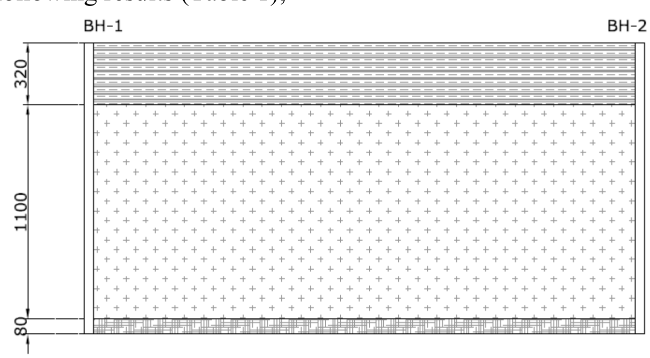


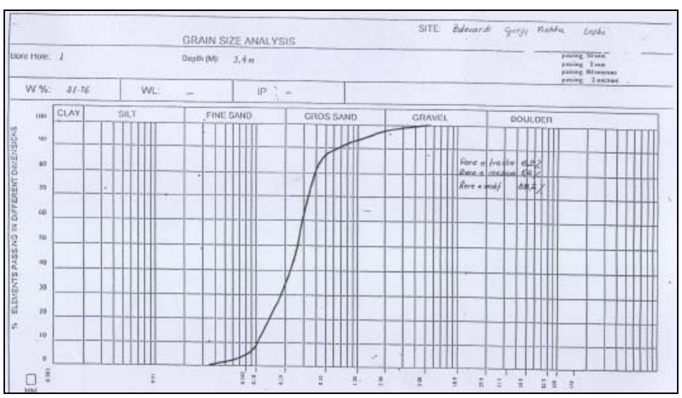
Table 1

Nr.	Properties	Unit	Layer 1	Layer 2
	Specific gravity	γo –KN/m^3	27.03	26.65
	Bulk density	γ –KN/m^3	18.42	19.74
	Moisture content	W - %	33.27	31.76
	Void ratio	e	0.9556	0.7788
	Liquid limit	WL - %	39.5	-
	Plastic limit	Wp - %	26.79	-
	Relative density	Dr - %	-	55
	Frictional angle	φ	17	20
	Cohesion	C - kPa	2-3	3-5
	Compres. index	Cc	0.16-0.1	0.09-0.053
	Swell index	Cs	0.02-0.01	0.005-0.007
	Consolidate coef.	Cv cm^2/s	0.00179	0.0046-0.0029
	Soils classific.		OL	SP and SM

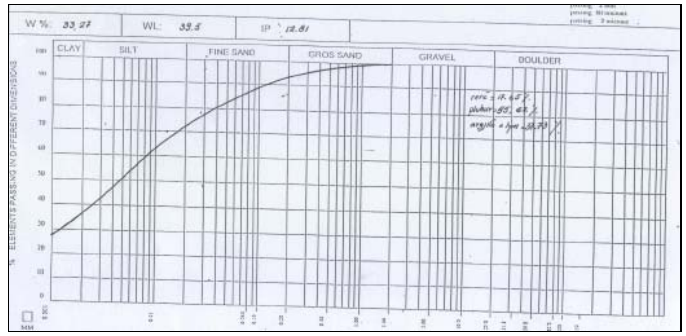
From the laboratories tests results that:
The bearing capacity of soils is for layer nr.1. *R* = 120-140 kPa and for layer nr.2. *R* = 150-170 kPa, that means these soils form a weak basement.

The soils are classified in "C" category by EC-7 and "D" category by EC-08.

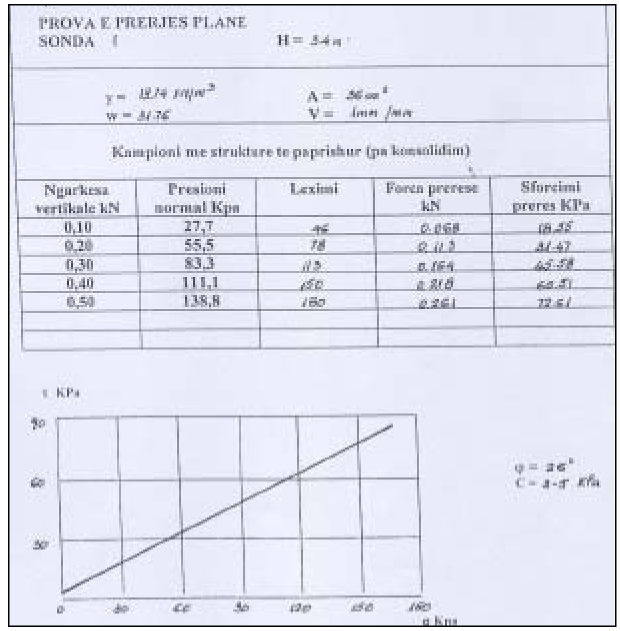
This situation isn't regarded well by engineer for good design of retaining structure.



(a.1)



(a.2)



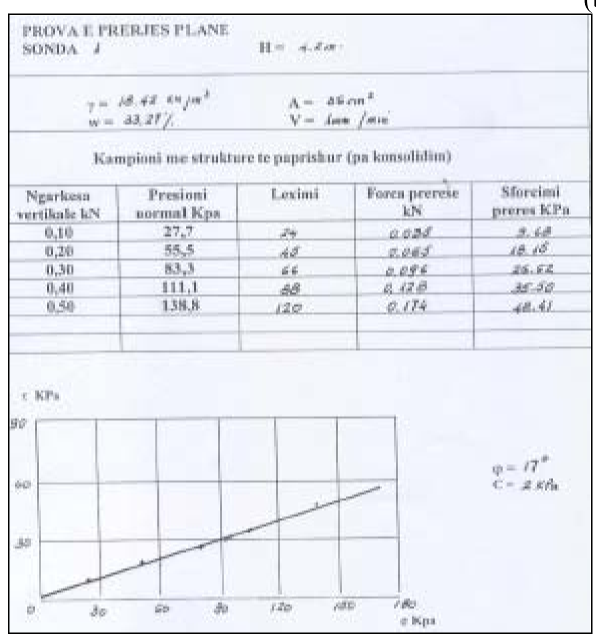
PROVA E PRERJES PLANE
SONDA 1 H = 3.4 m

γ = 19.74 kN/m³ A = 36 cm²
w = 31.76 V = 1mm /min

Kampioni me strukture te paprishur (pa konsolidim)

Ngarkesa vertikale kN	Presioni normal Kpa	Leximi	Forca prerese kN	Sforcimi preres KPa
0,10	27,7	46	0.068	18.55
0,20	55,5	78	0.113	31.47
0,30	83,3	113	0.164	45.58
0,40	111,1	150	0.218	60.51
0,50	138,8	180	0.261	72.61

(b.1)



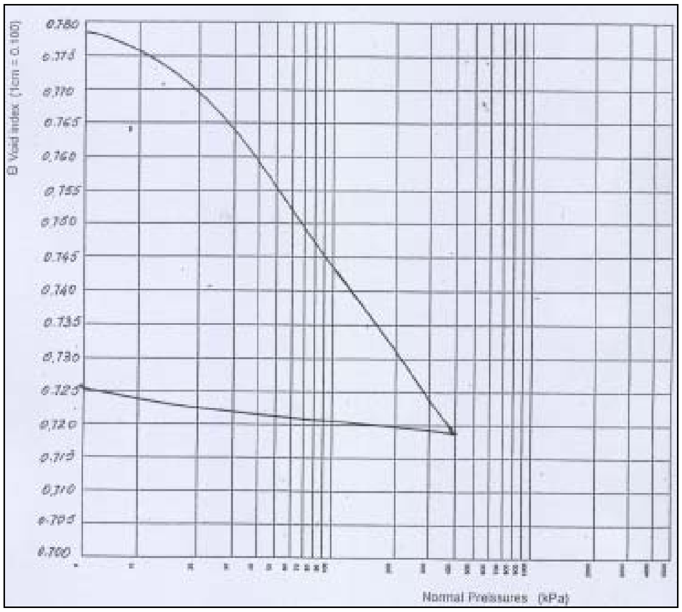
PROVA E PRERJES PLANE
SONDA 1 H = 4.8 m

γ = 18.42 kN/m³ A = 36 cm²
w = 33.27 % V = 1mm /min

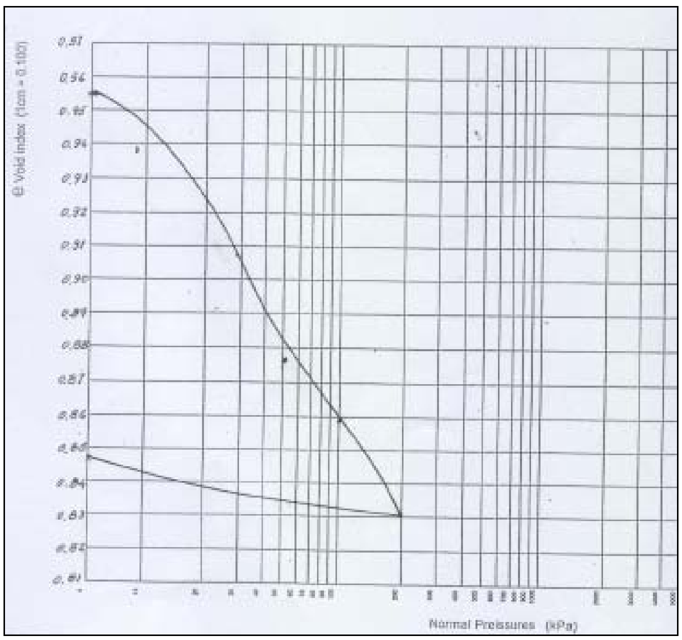
Kampioni me strukture te paprishur (pa konsolidim)

Ngarkesa vertikale kN	Presioni normal Kpa	Leximi	Forca prerese kN	Sforcimi preres KPa
0,10	27,7	24	0.035	9.68
0,20	55,5	45	0.065	18.15
0,30	83,3	66	0.096	26.62
0,40	111,1	88	0.128	35.50
0,50	138,8	120	0.174	48.41

(b.2)



(c. 1)



(c. 2.)

Fig. 4. Sieving and hydrometer tests at borehole nr.1 in depth 3.4m (a1) and 4.2m (a2) and shear box test at borehole nr.1 in depth 3.4m (b1) and 4.2m (b2) and oedometric test at borehole nr.1 in depth 3.4m (c1) and 4.2m (c2).

Verification of necessary depth fixation concrete wall.

After our calculation to consider the concrete wall as sheet pile wall (cantilever pile) and to report (refer) a new geological profile and new soils properties (Fig. 5) results that: The necessary depth fixation concrete wall was 5.5m.

In consequence the concrete wall is unstable.

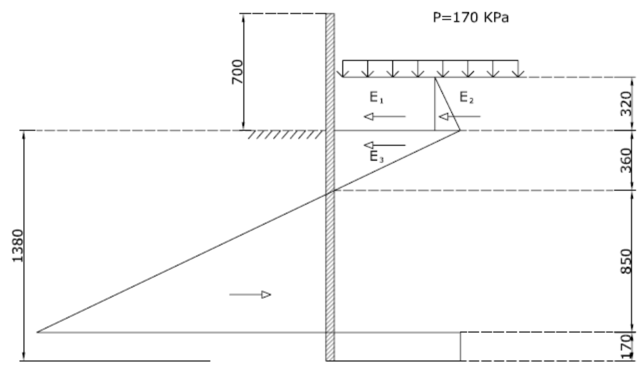


Fig. 5. Sheet pile walls and earth pressure diagrams (E1=308; E2 = 55; E3 = 205).

Verification of hydraulic natural gradient and his comparison with critical hydraulic gradient.

During the excavation of hole it was pumped continually the water from the bottom of hole. When was arrived the depth of 7.0m from natural surface, we have a hydraulic gradient:
$i = 5.7/2 = 2.85$. (Difference: L=1.5-2m distance of holes and $\Delta H = 7.0 - 1.3 = 5.7$m piezometric head).

By physical properties of second layer we have calculate the critical hydraulic gradient:
$i_{ek} = (26.72/10 - 10) \cdot (1/1{+}0.07788) = 0.91$

So, we have very critical situation because of $i > i_{ek}$ and it sure that suffusion phenomenon will be occurred.

Finally by analysis of damages of concrete wall (5) we take the following conclusion.
It has had two errors in design processes.
The causes of damage of concrete wall are incomplete acknowledgment of soils situation and their properties and occur by suffusion phenomenon.

THE ENGINEERING MEASURES TO STABILIZE THE SITUATION

First of all immediately we take engineering measures to put of 4m concrete on the bottom of excavation hole. By our calculations results that after application of 100 kPa pressure (4m X 25 KN/m^3) the concrete wall make sure temporally to be fixed in 5.5m depth under the bottom of excavation (Fig.6).

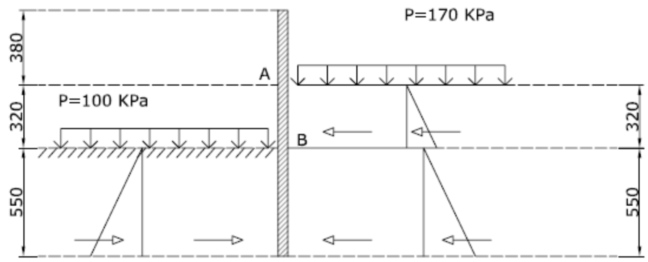


Fig.6. Verification of sheet pile walls after putting 4m concrete on the bottom of hole (ΣEr = 1132 KN/m; ΣEl = 1830 KN/m).

The existing concrete wall, after excavation was enough damages (injury). For these reasons we have constructed the new sure and resistant retaining structure. We have choose the piles with diameter d = 70.0cm, fixed under the bottom of hole 8.0m depth and with report L/d = 8, 57 (Fig. 7).

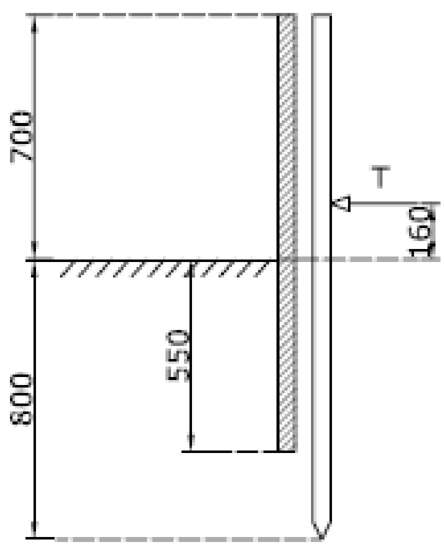


Fig. 7. The lateral loaded pile

The bearing capacity of the piles in horizontal load is H = 417KN.

The horizontal load from earth pressure is T = 418 KN/m. We have situated close pile to pile to have a factor safety Fs = 1.43. At the same time we have realized mortar cement wall against the seepage in the fine sands soils.

For the second concrete wall (4), where it is not coming the excavation we have executed (accomplished) a reconstruction. We have conceived this retaining structure as anchored sheet pile wall or with support. On the first phase we can to excavate until 3.5m depth from natural surface and we can to put the first support. Then we can continue excavation until 7.0m depth. The real fixed depth of concrete wall was 6.5m. From our calculations this depth is insufficient for the stability of retaining structure. The necessary length of concrete wall will be 13.7m (Fig. 8).

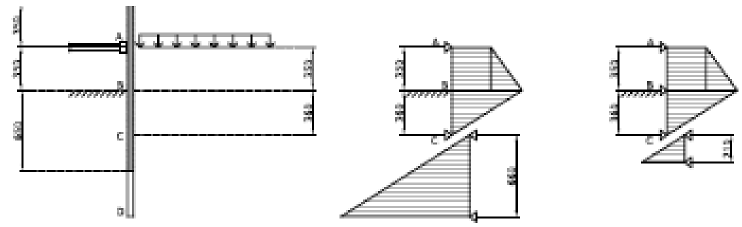


Fig. 8. The scheme of second sheet pile wall with one and two support.

So, it is necessary to put the second support (Fig. 8b) to insured a resistible retaining structure. The second support shall to put in the bottom of the hole. On second phase, when we can realized the mat foundation of new building, which transmits in the basements 130 kPa pressure we can to take off the supports and in conditions the necessary fixed depth of retaining structure will be 3.5m (Fig. 9).

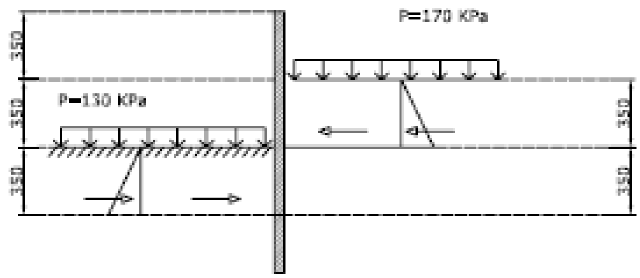


Fig. 9. The schema for calculation of second phases.

CONCLUSIONS

Construction of the underground floors on the weak soils and especially on the saturated fines sands or silty sands presents some serious problems:
The performance of the hydraulic gradient $i > i_{ek}$, shown the suffusion phenomenon has occurred, which is very dangerous for the stability of retaining structures.

The occurrence of the suffusion phenomenon is accompanies with increase of porosity of soils and in consequence they are present the supplement settlement to cause in the existing building the occur of limit state.

The engineering measures in any case will be in conformity with real conditions of soils and they depend from retaining structures attempt rapid stabilization of structure.

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