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INFLUENCE OF THE LOAD LEVEL, CHANGE IN THE FREATIC LEVEL AND HEIGHT OF THE COHESIVE STRATUM ON THE CONSOLIDATION SETTLEMENTS IN A SYMMETRICAL BUILDING.

INFLUENCIA DEL NIVEL DE CARGA, EL CAMBIO DEL NIVEL FREÁTICO Y LA ALTURA DEL ESTRATO COHESIVO EN LOS ASENTAMIENTOS DE CONSOLIDACIÓN EN UN EDIFICIO SIMÉTRICO.

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RESUMEN

La investigación evalúa las liquidaciones de consolidación generadas por un edificio de cuatro cuadrantes, donde se estudia cada uno de los tipos de pie cambiando algunos de estos parámetros, para saber cuál de estos tres aspectos es el que más influye en la liquidación de consolidación en edificios de tres niveles, La metodología incluye cambio la cantidad de niveles que afectan a la carga y dimensiones de la zapata, análisis de variables e influencia del cambio de nivel freático en otra de las zapatas y finalmente se evalúa el asentamiento con el cambio de altura del estrato blando, que será el estrato consolidado. Se concluye que el análisis de la variabilidad de los asentamientos causada por el cambio de factores niveles de carga, dimensiones de las zapatas, variabilidad del nivel freático y cambio en la altura del estrato cohesivo, donde se presentará la consolidación.

PALABRAS CLAVE : Asentamiento consolidado, cambio de parámetros, edificios con zapatas aisladas.

ABSTRACT

The research evaluates the consolidation liquidations generated by a four quadrant building, where each one of the foot types is studied changing some of these parameters, to know which of these three aspects is the one that more influences in the consolidation liquidation in buildings of three levels, The methodology includes change the amount of levels that affect the load and dimensions of the footing, analysis of variables and influence of the change of phreatic level in another of the footing and finally the settlement is evaluated with the change of height of the soft stratum, that will be the consolidated stratum. It is concluded that the analysis of the variability of the settlements caused by the change of factors load levels, dimensions of the footings, variability of the phreatic level and change in the height of the cohesive stratum, where the consolidation will be presented.

KEYWORDS : consolidated settlement, change of parameters, buildings with isolated footings.

I. INTRODUCTION

The accelerated expansion of cities and urban areas results in an increase in sustainable buildings, transport and environmental services, which correctly respond to all the needs of a society [12]. Each of these types of structures, especially heavy structures such as high-rise buildings, airports and maritime works, require a base capable of supporting the loads they generate, to which it will be subjected [1]. Thus, satisfying these geotechnical requirements will depend on the foundation system chosen, which will be determined by factors such as the condition of the soil, the economy and the sustainable impact of the construction [9].

These types of heavy structures have become more common in urban areas, especially high-rise buildings. Due to this, the demand for geotechnical engineers has been considerable [7] so that on several occasions, these buildings are built on soft clay soils, where a soil deformation analysis is essential to determine and control the consolidation settlements or, failing that, make a change or improvement to the terrain [3].

Soil compaction and consolidation processes have been a topic of interest in engineering and its practices for a long time, since they involve a great variety of applications. One of the most important and object of study in this work is soil deformation due to the submission of loads [4]. Thus, the consolidation of clay soils is affected by their capacity to be understood, since this type of soil has a very low resistance to cutting, but a high level of understanding, an aspect that is really dangerous for construction [11]. Terzaghi, explained that the behavior of the soil is linear, therefore, it compresses constantly over time, based on the amount of time the soil needs to dissipate the excess water pressure, which would later generate the settlements [6][8].

During the last decades, a large number of theories and experiments have been carried out that have tried to explain the behavior of soft soils by means of numerical models [15]. Thanks to Terzaghi's publication, there has been a better understanding of the consolidation of these soils [10], so the basis of his theory is based on the determination of the settlements in structures that are supported on saturated clay soils, estimating the time required to obtain the final settlement [2]. The final settlement includes the primary and secondary settlements, which are those caused in the construction process and at the end of the consolidation period respectively [13] [14].

Despite the fact that traditional consolidation theories do not provide the most accurate data when calculating these soil deformations, they are still very helpful for engineering practice, due to the way of knowing an approximation of these parameters easily, which allows the geotechnical engineer the magnitude of the project he is working on and later, to establish a more detailed procedure, by means of finite element calculations or software that incorporates a greater number of tools [5].

In this work, the load analysis of a four-quadrant structure, completely symmetrical and with axes separated at the same distance in both directions of space, was carried out to determine the magnitude of the settlements by changing the number of floors and the height of the strata. This was done by means of a specific programming for this structural model, where only the parameters were changed in order to delimit the way in which the soil is deformed.

II. METHODOLOGY

2.1 Determination of structure parameters

The quantitative research [8], models are analyzed and determined [11]. The determination of the structure is of 4 quadrants, that is to say, it has a total of 9 columns, where each one is separated to a distance of 5 meters in both directions of the space, each one of these columns has a height of between floor of 3 meters, the beams are in bidirectional sense with height and base of 0.5 meters, the plate of between floor is of 0.15 meters. Thus, considering a concrete density of 2.4kN/m3. Once the main parameters are calculated, a function of the weight is established based on the number of floors to be designed, where the pressures exerted are calculated and then, through the carrying capacity of the floor, the base of the footing is established.

2.2 Studies carried out.

For the concentric shoe, the changes in settlement are calculated as the number of floors to be studied changes, which affects the base of the shoe and finally the primary displacement or settlement.

In the corner footing, the change in footing settlement is made in relation to the location of the water table.

And in the dividing footing, the behavior of settlement variation according to the height of the cohesive stratum is studied.

III. RESULTS AND DISCUSSION.

The results of the stress calculation, taking into account the live and service loads of the structure for 3 and for each of the footings the value was as follows.

Table 1. Loads per footing

	BEAMS	LOSES	COLUMS	TOTAL WEIGHT (KN)	DEADLY LOAD (KN)	LIVE LOAD (KN)	SERVICE LOAD (KN)
CORNER FOOTING	18	27	3.456	48.456	475.35	375	850.35
DIVIDING FOOTING	27	54	3.456	84.456	828.51	750	1578.51
CENTRE FOOTING	27	108	3.456	138.456	1358.25	750	2108.25

Then, the widths of the footings were determined with the equation 1

$$B = \sqrt{\frac{Q}{Q_{adm}}} \qquad (1)$$

With a $Q_{admissible}$ value of 120kN you get:

Table 2. Dimensions of the footings.

FOOTING SIZE			
CORNER	B	2.66	3
DIVIDING	B	3.62	3.7
CENTRE	B	4.19	4.2

The consolidation test is carried out and the following data are obtained:

Table 3. Index of voids (e) according to the consolidation test

Pressure (kN/m^2)	H (cms)	e
0	27	1.040458015
50	26.6	1.010229008
100	26.4	0.995114504
200	26.1	0.972442748
400	25.8	0.949770992
800	25.6	0.934656489
0	26.2	0.98

For each of the studies, two layers of study soil are taken, the first is a sand, with a depth of 2 meters, besides finding a clay later, where the width can vary according to the study, in the same way, an initial phreatic level is established at 1.5 meters deep from the ground level and an initial foundation depth of 1 meter.

3.1 Centre Footing

Thus, for the first analysis, that of the concentric shoe, the settlements are calculated according to the change of floors and therefore the width of the footings.

Table 4. Initial soil conditions

Footing depth	1m
GS First layer	2.62kN/m^3
e First layer	0.62
H First layer	2m
Gs Second layer	2.75 kN/m^3
e Second layer	0.98
H Second layer	6m
Depth Phaetic Level	1.5m

Finally, the results of the analysis are:

Table 5. Settlement values according to the number of flats

# FLATS	B FLOOTING	PRESSURE KN/M2	SETTLEMENT(M)
3	4.2	131.961	0.0935
6	6	133.204	0.14152
9	7.3	140.11	0.2684
12	8.4	154.28	0.28591

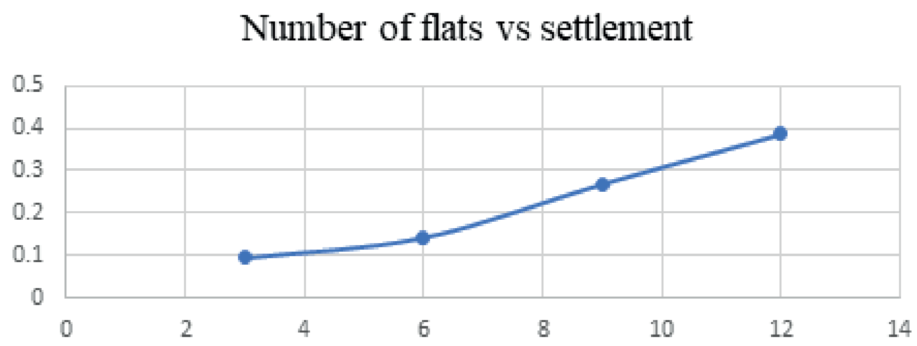


Figure 1. Number of floors vs. settlement

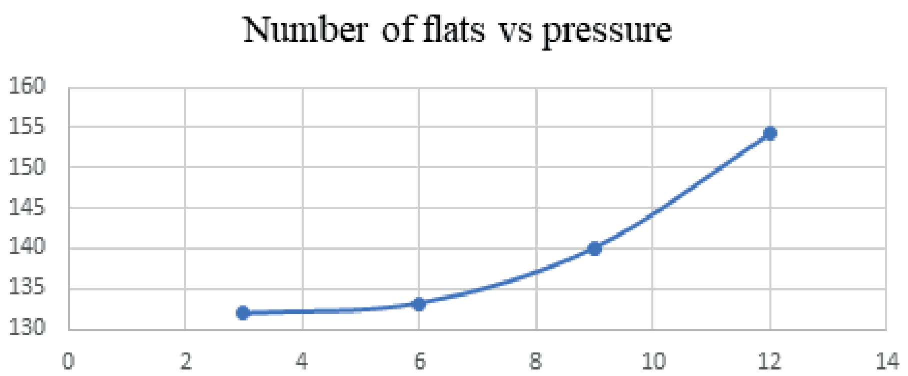


Figure 2. Number of floors vs. pressure

3.2. Corner footing.

The corner footing is worked under the following soil conditions

Table 4. Initial soil conditions

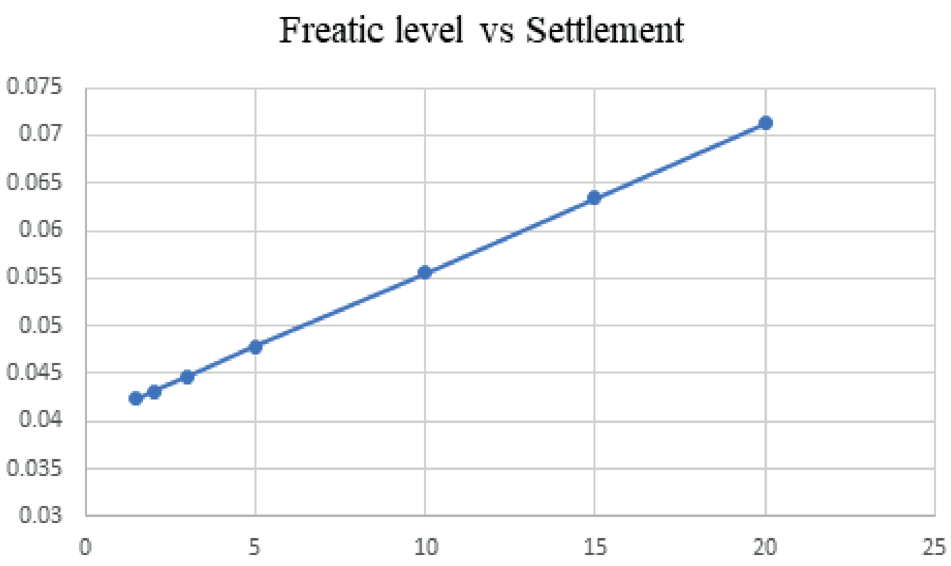
Footing depth	1m
GS First layer	2.62kN/m³
e First layer	0.62
H First layer	2m
Gs Second layer	2.75 kN/m³
e Second layer	0.98
H Second layer	6m
Depth Phaetic Level	X m

With a variability of the depth of the water table, so that the following values are obtained:

Table 5. Settlement by varying the freatic level

FREATIC LEVEL	PRESSURE	SETTLEMENT
1.5	167.5676	0.0424
2	112.9	0.0431
3	176.64	0.0447
5	188.74	0.0478
10	218.98	0.0556
15	234.25	0.0634
20	234.25	0.07129

Figure 3. Freatic level vs Settlement.



3.3. Dividing flooting

The conditions of the soil layers for the median shoe were as follows:

Table 6. Initial soil conditions

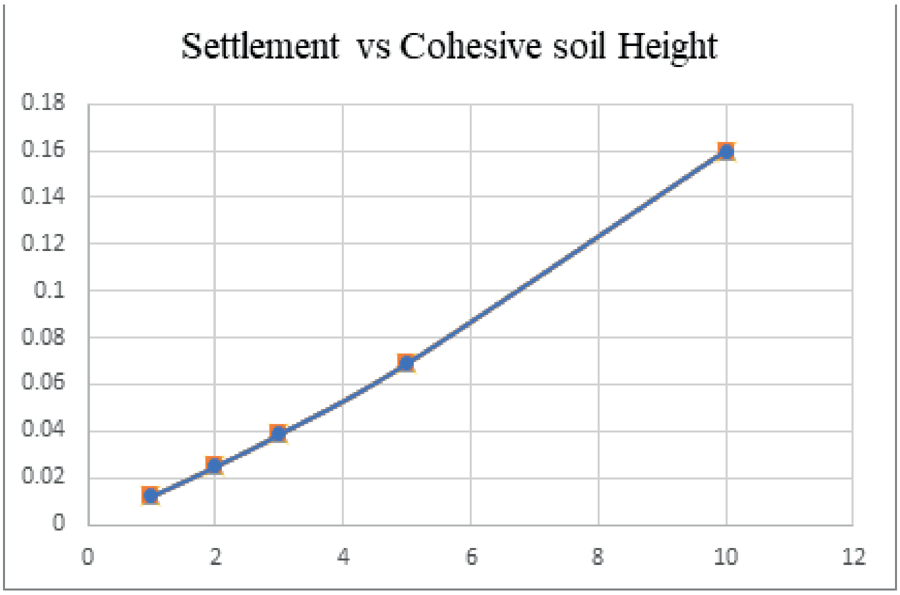
Footing depth	1m
GS First layer	2.62kN/m^3
e First layer	0.62
H First layer	2m
Gs Second layer	2.75 kN/m^3
e Second layer	0.98
H Second layer	X m
Depth Phaetic Level	1.5m

Then, due to the change in the height of the stratum, the behavior of the consolidation settlement can be observed.

Table 7. settlement according to the change in height of the cohesive stratum

H COHESIVE STRATUM	SETTLEMENT
1	0.012
2	0.0248
3	0.0386
5	0.0689
10	0.16

Figure 4. Settlement vs. Cohesive soil height.



CONCLUSIONS

The calculation of the consolidation settlements, allows us to establish if the conditions are met so that our construction is not affected at the structural level, causing failures in the same, however, this type of problems, ie settlements, vary greatly with respect to the type of foundation, soil parameters, such as what type of soil is, the variability of the water table, among other aspects.

Therefore, in this study we carried out a mathematical analysis of the variability of settlements caused by the change of some factors, among these were, the change of the load levels as well as the dimensions of the footings, the variability of the phreatic level and finally, the change in the height of the cohesive stratum, where the consolidation will be presented.

In the first study, it was observed that the increase in settlement increases by 34% when the floor level is increased from 3 to 6, and a footing width of 4. 2m to 6m, and a similar increase is observed when 3 more floors are increased, that is, three times the amount of initial floors. Later, when a level of 12 floors or more is reached, the settlement no longer has considerable variability, this is due to the fact that most of the air or water that exists between the pores has been drained, where the soil could fail due to cutting and would cause subsidence.

In the second study, the relationship between the variability of the water table, that is, the depth at which the groundwater is found, in relation to the settlement produced by the structure, is established. On this occasion, it becomes constant for the same amount of floors and the same width of footings. The results obtained have a linear form where the interstitial pressure of the water has a negative effect on the structure, because the deeper the water table the more pressure is generated and the average stresses are greater, thus generating a greater settlement.

For the last analysis, we observe the change in settlement with respect to the change in the height of the cohesive stratum, that is, the clay, where settlement is actually greater with respect to a greater height of the stratum. This indicates that the pressure exerted is transmitted along the stratum until it reaches a point of equilibrium of consolidation; however, this is very counterproductive in terms of long-term effects.

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