Estudio de la capacidad portante de los pilotes de la Marina Gaviota en Varadero

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ABSTRACT
In the area where the Marina Gull is built they exist a very variable and complex stratification, besides the bad quality amble in the surface of the land. In this case he/she intends the use of deep foundations (you steer), to transmit the loads from the structure to deeper areas of the land that has an adapted capacity amble. Given the great structural responsibility of the piles, the very variable and complex stratification from the geologic point of view, is necessary the study and determination of the capacity of load of the Marina's Gull piles, proposing the longitude of the same ones and the number of blows during it sinks it.
Through the prosecution of the floor parameters charts summaries are presented to estimate the values of the mechanical physical properties of the floor strata and the rock. Was carried out an analysis of the results of it sinks it of the piles for different formulas as well as an analysis of load rehearsals carried out previously in the place. Finally they are defined 7 rehearsals, 56 creeks in points of interest and through the application of models to the load test and their calibration with the load rehearsals carried out in the place the real behavior of the piles settles down in the different scenarios of possible location, to define the longitude of the piles in each work object.

RÉSUMÉN
En la zona donde se construye la Marina Gaviota existen una estratificación muy variable y compleja, además de la mala calidad portante en la superficie del terreno. En este caso se propone la utilización de cimentaciones profundas (pilotes), para transmitir las cargas de la estructura a zonas más profundas del terreno que tenga una capacidad portante adecuada. Dada la gran responsabilidad estructural de los pilotes, la estratificación muy variable y compleja desde el punto de vista geológico, es necesario el estudio y determinación de la capacidad de carga de los pilotes de la Marina Gaviota, proponiendo la longitud de los mismos y el número de golpes durante la hinca.
A través del procesamiento de los parámetros de suelo se presentan tablas resúmenes para estimar los valores de las propiedades físicas mecánicas de los estratos de suelo y la roca. Se realizara un análisis de los resultados de la hinca de los pilotes por distintas fórmulas así como un análisis de ensayos de carga realizados con anterioridad en el lugar.
Finalmente se definen 7 ensayos, 56 calas en puntos de interés y a través de la modelación de la prueba de carga y su calibración con los ensayos de carga realizados en el lugar se establece el comportamiento real de los pilotes en los diferentes escenarios de ubicación posible, para definir la longitud de los pilotes en cada objeto de obra.

1 INTRODUCTION

In the area where the Marina Gull is built are a very variable and complex stratification, besides the bad quality amble in the surface of the land. In this case he/she intends the use of deep foundations, to transmit the loads from the structure to deeper areas of the land that has an adapted capacity amble. Given the great structural responsibility that falls on the piles and this very variable and complex stratification from the geologic point of view, is necessary the study and determination of the capacity of load of the Marina's Gull piles, proposing the longitude of the piles to use and the number of blows during it sinks it.

For the realization of this work they are kept in mind the reports engineer geologic point of the reports of GeoCuba, as of the ENIA, making emphasis in the description of the floors according to the creeks taken in the land of the marine Gull of Shipyard. Through the prosecution of the floor parameters charts summaries are presented to estimate the values of the mechanical physical properties of the floor strata and the rock. He/she will also be carried out an analysis of the results of it sinks it of the piles for different formulas as well as an analysis of load rehearsals carried out in advance in areas near the construction.

After having completed these tasks he/she is carried out an analysis of the capacity of load of the Marina's Gull piles in Shipyard, explaining the preliminary results of the tasks of it sinks of the piles and the creeks carried out in the place. The results of the model of the load test are summarized carried out to the piles, with the realization of an analysis and calibration of the results, arriving to conclusions and final recommendations of the work.

The general objective of the investigation is:
1. Determine the capacity of load of the piles during the test of it sinks
2. Corroborate the stratigraphy of the place due to their complexity, manifested in it sinks it of piles in the area near to the one studied

3. Determine the capacity of load of the pile through the load rehearsal
4. Establish the longitude of the piles in the different areas of the construction.

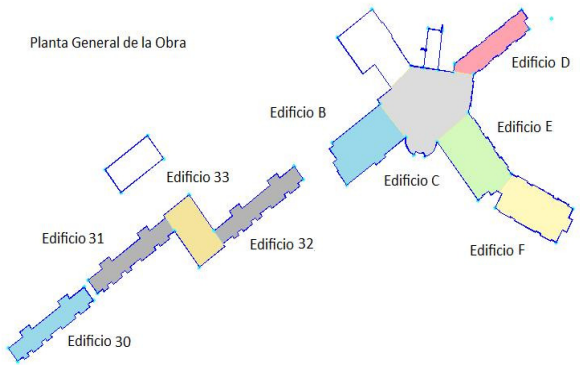


Figure 1. Plants General of the Work.

2 PRELIMANARY WORKS

Keeping in mind the general plant of the work and the carried out previous works (filler placement, creeks, it sinks of piles) he/she decides to begin the analysis of the piles of the buildings 30-33 (Area Bungalow).
With the results of the test of it sinks was carried out an analysis of the capacity of last load and of work of the piles starting from the dynamic methods, those proposed by Gerseevanov, the FWHA and the maker of the used hammer being used, I Hammer Delmag. In the chart 1 the analyses are shown carried out for 3 of the 13 sunk piles, being the pile 000 that of 15 meters that is in the stratum of calcarenita, Of the obtained results you can conclude that dispersion exists among the 3 used methods, being seemingly the most conservative the one proposed by Gerseevanov, while the method of the FWHA and the Delmag for 2 of the piles practically coincide and always with values superiors to those obtained by the method of Gerseevanov. These alone results should be taken as indicative and through the tests of loads will settle down which are adjusted of this methods but to the studied cases.

Tabla 1. Capacidad por diferentes métodos dinámicos en toneladas.

Capacity for different dynamic methods (Ton).			
Pile	000	011	006
No blocs	49	7	51
Initial longitude m	15	11	11
Longitude of sinks m	12.2	11	7.2
Capacity for different dynamic methods (Ton).			
FWHALast	236	147	238
FS 1.5	157	98	158
FS 1.92	***123***	***76***	***124***
Gerseevanov Last	188	72	192
FS 1.5	125	48	128
FS 1.92	***98***	***37***	***100***
DELMAG Last	218	99	273
FS 1.5	145	66	182
FS1.9 2	***113***	***51***	***142***

They were carried out 8 creeks in situ, all in the proximity of the sunk piles, being detected in all them the following floors.

- stuff with thickness between 2 and 3 meters
- upsets fundable with Carmelite colour with thickness between 1 and 2 meters
- silt dark gray colour, very plastic with thickness between 2 and 3 meters
- Calcarenita of yellow gray colour, of half hardness to high that is presented in some creeks like a healthy rock and in other points like a very porous material and with hollows. (Their thickness varies between the 1.5 and 2.5 meters)
- Burdens loamy of gray colour, with thickness of 4 to 5 meters, don't present in all the creeks.
- Plastic clay of gray colour, of high plasticity, blended with the gravel. Thickness of 4 to 5 meters, neither present in all the creeks.
- Hard Calcarenita, to a depth 12 meters or more, present as a healthy rock and of great resistance

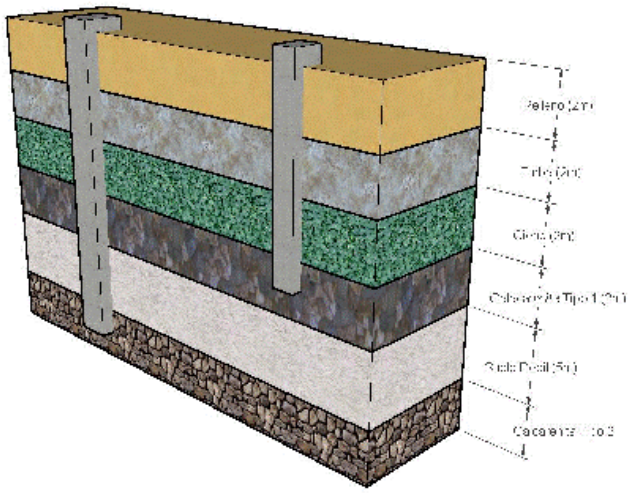


Figure 2. Soils profile.

2.2 Partial hypothesis of work

With these results of it sinks it of piles and the carried out creeks settle down the following work hypotheses:
1. you confirms the varied stratification of the place, being able to highlight the presence of about 6 filler meters and it upsets, a calcarenitas stratum that varies in thickness from 1.5 to 2.5 meters that he/she behaves as healthy or very porous rock, next about 5 floor meters burden loamy and to more depths to 12 meters the presence of a hard calcarenitas. (These results in a

general way coincide with the previous investigations carried out in the place).
2. Is proven the presence of the calcarenitas in the superior stratum with 2 well defined behaviours:
CASE 1, healthy rock, the piles cannot cross this stratum, the rejection is reached with 40 to more blocs/pie. 7 piles endorse this result and the visual inspection of the creeks in situ.
CASE 2, very porous rock and with hollows, the piles cross this stratum, and they stay "floating" in the clay strata and it burdens, being never reached more than 30 blows. (You could not continue these piles since they are of 11 meters)
3. The calcarenitas stratum that is to a depth below the 12 meters, behaves like a healthy rock and the sunken pile reached the rejection it stops more than 45 blows.

On the base of these results they intend the following scenarios of work of the foundation.

Scenario 1. Steer of 9 meters. If they reach the rejection it stops more than 35 blows, then they would be in the first stratum of healthy calcarenitas, should guarantee that it penetrates at least in him 1 D. Is considered that the capacity of work load this in the order of 90 o'clock to 110 Tons, result that it will be confirmed with the load test. The piles that don't reach the 35 blows would be in the porous calcarenita and their resistant capacity would be smaller and he/she would surely have to be sunk a new pile, after to analyze to that loads this element he/she should work.
Scenario 2. Steers of 11 meters. They cross the first calcarenitas stratum and rests in the loamy gravel, it diminishes their capacity of work load and he/she is considered this it is from 30 to 40 tons. If they achieve more than 30 blows and they don't cross the first calcarenitas stratum you would be in the same situation of the scenario 1.
Scenario 3. Steer of 15 meters. It crosses the stratum of superior calcarenitas, the floor it burdens loamy and they penetrate 1 D at least in the deepest stratum in calcarenitas. Is considered that the capacity of work load this in the order of 110 o'clock to 120 Tons, result that it will be confirmed with the load test. If they achieve more than 30 blows and they don't cross the first calcarenitas stratum you would be in the same situation of the scenario 1.

Keeping in mind the above-mentioned, he/she intends to discard the variant 2 and to work on the base of it sinks it of piles of 8 meters, assuming that it governs the scenario 1, and in case the stratum of superior calcarenitas is crossed, to analyze the load that arrives to this pile and to evaluate the possibility to sink one new.

Load test No 3. Building E and F.

3.1 Results of load test

By way of example the results of the analysis of area of the buildings are exposed AND F, in which 12 piles was sunk. In these buildings the creeks CEH 8 were perforated, CH 37, CH 39 and CH 43. The cut soils composes it the following elements:

A. stuff and it Upsets: Compound filler for material of improvement, fragments and limestone blocks. Their thickness varies between 1.5 m and 3.0 m.

B. Gray Calcarenita, of sandy texture and low hardness, with scarce hollows of 2-3 cm. Appears between 1.5 m and 3.0 m. Its thickness varies between 1.0 m and 2.9 m.

C. Gray Calcarenita, of sandy texture and very low hardness, stratification sub horizontal, with scarce hollows. Appears from 3.5 m - 5.0 m to but of 15 m of depth

Once established the characteristics of the stratigraphy of the place, that decides to rehearse the pile H037 that represents that of more complexity from the point of view soils of those sunk in the area.

Table 1. Results of it Sinks

Resultados de la Hinca Pilote H 037					
Prof. (pier)	Golpes último pier	Cala	Prof. de cala (m)	Emp. en calcarenita (m)	Espesor (m)
17	32 (R)	**CH 037**	10	2.2	1.3

Next the obtained final results are shown:

Table 2. Capacity for different dynamic methods

Capacity for different dynamic methods					
			Load capacity (Ton) Factor of Security		
	No blocs	Normative	1	1.5	2
1	**32**	**FHWA**	**219.20**	**146.14**	**109.60**
2	**32**	Gersevanov	152.23	101.49	76.12
3	**32**	Delmag	226.72	151.15	113.36
Average			199	132	99.5

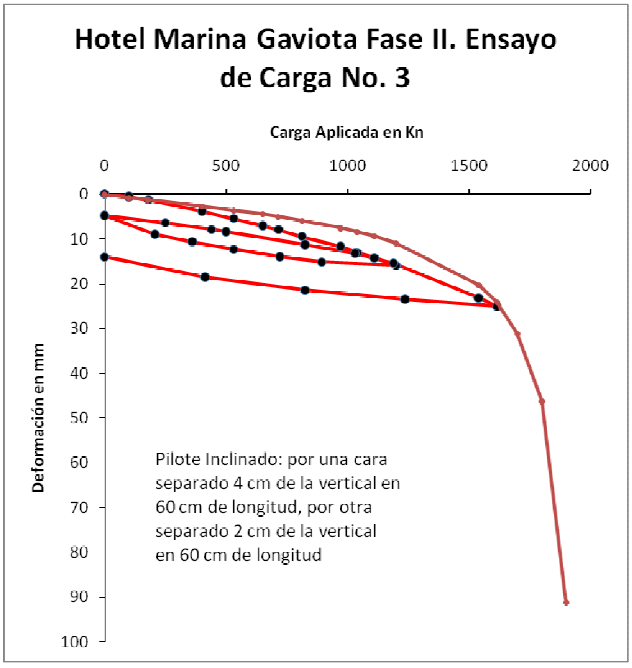
Determination the capacity of Load considering the contribution friction the Calcarenita.
Contribute to friction calcarenita 1(Hard drop. R´c = 4000 kPa) Qf = 26 kN
Contribute to friction calcarenita 2 (very low Hardness, R´c = 2000kPa) Qf = 0 kN
Contribute to friction calcarenita 2 (Very low Hardness, R´c = 2000kPa) Qp = 1887 kN
Capacity of last load Qv = 1910 kN
Capacity of last load Qv = 191 Ton

For the obtaining of this graph you consider:
It loads of Break 185 Ton

I modulate General of Deformation of the rock: 4200 Map Longitude of the pile in the rock 2.2 m

3.3 Results of the load test

Keeping in mind the obtained results intends as capacity of last load of 185 Ton and of work, for the piles that are under these conditions 100 Ton for a total longitude of 7 meters; whenever the uprightness is guaranteed in it sinks it of the pile.



Next the obtained final results are shown:

Table 4. Capacity of load of the Pile

Load capacity of pile			
	Dynamic Methos FHWA	Methods Elastic theory	Load test
Load capacity Ton	219.20	191	185
FS	2.0	1.91	1.85
Load capacity Ton	109.60	100.00	100.00

Keeping in mind the obtained results intends as capacity of last load of 185 Ton and of work, for the piles that are under these conditions 100 Ton for a total longitude of 7 meters, whenever the uprightness is guaranteed in it sinks it of the pile.

4 FINAL CONCLUSIONS

With the obtained results of the rehearsals of it sinks, the load tests and the modelling settle down the following conclusions:

1. The validity of the methodology is demonstrated used in the investigation, through the one which starting from the study of the Geologic reports Engineer (you Profile geologic, rehearsals), it is characterized in a general way the stratigraphy of the place, establishing the number of tests of he/she sinks to carry out for piles with different longitude. This allowed checking the stratigraphy of the place and the capacity of load of the piles sunk through dynamic methods. With this information he/she is defined the number of rehearsals of load minimum to carry out, and to each one of them he/she is carried out mathematical modelling to predict the behaviour of the same ones. With the results of the tests of loads been worth the mathematical pattern, being able to extrapolate the results to similar cases, without the realization of new expensive load rehearsals.
2. They are applied different you formulate dynamic and they are compared with the rehearsals of it sinks and the load rehearsals, settling down that for the conditions of the studied place, the team of it sinks and the pile type the formula that more he/she approaches to the obtained values of load capacity it is the proposal for the FWHA.
3. Starting from the application of the proposed methodology it can diminish the number of load rehearsals, giving satisfactory execution to the objectives of this work
4. Correspondence exists from the point of view ingenieril between the results of the carried out load rehearsals and the mathematical modelling, using this it finishes like instrument that allows to reduce the number of load rehearsals "in situ", being demonstrated the validity of the mathematical modelling as analysis tool and design in the problems geotechnical
5 Result final of this investigation a rational proposal of pile longitude settles down, conditions of it sinks and load capacity, in the different areas of the construction, what implies a considerable one to save of resources regarding the projected initial solution.

Next summary the results obtained as for longitude of piles, numbers of blows and capacities of last load and of work for each one of the established areas.

RECOMMENDATIONS

- Check during it sinks it of the piles that the number of established blows is guaranteed guaranteeing the penetration of the pile at least 1.5D (60 cm) in the stratum of resistant floor
- Guarantee the correct uprightness of the piles during the process of it sinks, should analyze the necessity of the previous perforation in the filler area.
- Verify the execution of the established technical parameters during it sinks it of the pile referred to the energy of the hammer to use and the use of other additions to avoid damages in the head of the pile.

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