SOME FIELD CORRELATIONS ON DYNAMIC PENETRATION RESISTANCES IN EXPLORATORY BORINGS, BY GEOTECNICA, BRASIL

ALGUNAS CORRELACIONES DE LA RESISTENCIA A LA PENETRACIÓN DINAMICA EN SONDEOS DE EXPLORACION HECHAS POR LA GEOTECNICA BRASIL

Prof. Victor F. B. de Mello (1) - Eng. Evelyna E. Souto Silveira (2) - Eng. Arthur Rodrigues Quaresma (3).

Summary: The principal body of data accumulated by GEOTECNICA over the past fifteen years, in over 10.000 borings - connected with the very rapid growth of the foremost Brasilian cities, is tied to the Mohr-Geotécnica sampler, employed under very carefully systematized and controlled conditions. The equipments and methods employed are summarized for due comparison. Further, statistical correlations are established to determine the influence of various factors capable of affecting GEOTECNICA's penetration index, and a method of quality control employed is described and discussed. Finally, some correlations are stablished with reference to the Standard Penetration Test (as locally performed, since all details of the equipment and procedure were not initially specified) and to the point resistance measured by the static penetrometer.

Sumário: El cuerpo principal de los datos acumulados por la GEOTECNICA durante los últimos quince años, en aproximadamente 10.000 sondeos ligados al crecimiento extremamente rápido de las principales ciudades del Brasil, es concernente al sacamuestras MOHR-GEOTECNICA, empleado bajo condiciones muy cuidadosamente sistematizadas y controladas. El equipamento y los métodos empleados fueron resumidos para la debida comparación. Además, correlaciones estadísticas fueron establecidas para determinar la influencia de los diversos factores capazes de afectar el índice de penetración de la GEOTECNICA, y fué descrito y discutido un método de control de calidad empleado. Finalmente algunas correlaciones fueron establecidas con referencia al "Standard Penetration - Test" (como es ejecutado localmente, ya qué todos los detalles del equipamento y del processo no fueron inicialmente especificados) y a la resistencia en punta medida por el penetrómetro estádico.

Director of Works (1) - Head of Research and Statistics Branch (2) - Head of the subsoil Reconnaissance Sector (3

GEOTECNICA S/A - Engenheiros Consultores.

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Introduction

It is well recognized in the field of foundation-engineering that the determination of spoon penetration resistances in exploratory borings is of paramount importance to the solution of the vast majority of foundation problems. Since the spoon samples retrieved from the so-called dry-sample borings are quite satisfactory for the complete identification of the soil-type involved, under whatever system of classification may be selected, it was merely necessary to associate a simultaneous measurement indicative of the consistency or density of the respective soil, in order to provide all the data required for rational evaluation of the subsoil's probable behaviour.

It was indeed fortunate for Brasil that when the outstanding growth of its principal cities evolved into the building of skyscrapers, some systematic practices had been recently introduced, in foundation exploration, by Dr. O. Grillo and his initial collaborators in S. Paulo: thus it may be claimed that thousands of buildings erected in the past 15 years have foundation designs in some way attached to a single systematic procedure of routine subsoil investigation When the Standard Penetration Test was introduced by Geotécnica about a decade ago, it was naturally adapted to the existing procedures, in whatever details appeared to be left open in the text (1)*. Thus, both of these dynamic penetration resistance indices have been mentally correlated to certain design decisions (e.g. allowable bearing pressures, lenths of precast piles, etc..) that appear to have worked satisfactorily, and we are presently attempting to translate this experience into whatever empirical equations and rules may be found adaptable.

Meanwhile, the subject of dynamic penetration resistances has very commendably been brought into a focus of attention, for the purpose of elucidating questions that arise on their fundamental interpretations, and with the intention of recommending an international standard test. Within any concerted effort toward establishing such a highly desirable penetration test of universal acceptance, the influence of each factor on the results will have to be investigated not merely by carefully controlled laboratory tests (2,3,4) but also by the analysis of field evidence (5,6,7): furthermore, due care should be taken towards preserving any worthwhile interpretative experience attached to existing methods that may be abandoned for the sake of future uniformity.

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* These numbers relate to the references listed at the end of the text.

Herein are described some of the principal items of our penetration resistance measurement, as well as some of the statistical studies that have been and are being conducted to evaluate their influence under routine working conditons.

The Mohr-Geotécnica penetration resistance, and the Standard Penetration Test (S.P.T.) as conducted by Geotécnica:

The common reconnaissance boring, of most wide-spread use until recently, employed 2" casing and collected drive samples in the so-called Mohr-Geotécnica spoon sampler, of outside and inside diameters of 1 5/8" and 1" (Drw. 2). The driving energy is the same (65 kg falling through 0.75m) as is applied to the Standard Penetration Test (S.P.T.): the implements and method of applying these blows may be deduced from details presented in Drw. 1.

Since the dissemination of the S.P.T. spoon (Drw.1) and of 2" shelby sampling of clay strata (special reconnaissance borings) the 2" casing has been practically entirely substituted by 2 1/2" casing which permits the use of all these samplers interchangeably. The perforation within this casing of 65mm internal diameter is performed by a spiral auger of 56mm diam. (Drw. 2) above the water level, and by wash-drilling (Drw. 2) below it, using a bit with a cutting-edge 60mm wide.

The spoon sampler is attached to a set of 1" galvanized pipes (inside and outside diameters of 24.5 and 33mm, weight 3 kg/m) connected in lengths of 2m by standard water-pipe sleeves. These are important details to bear in mind because not only are rotary drill rods (AX,BX,EX) being used at places (3) but also square steel bars are known to be used extensively in the Iberian peninsula, and everywhere the name Standard Penetration Test is being applied merely because the sampler is the same and the driving energy is believed to be the same. We must also call special attention to details of our driving weight (Drw. 1): the guiding rod is attached to the weight and runs down the 1" pipe, the pipe is fitted with a protecting head to receive the blow, and the under side of the weight is fitted with a hard wood cushion.

The only real differences between our common Mohr-Geotécnica penetration index (R.P.I.) and our version of the S.P.T. result from the differences in size of the samplers and from the fact that the former index was referred to the number of blows for the first 30cm of penetration whereas the latter is based on the number of blows for 30cm of penetration after an initial penetration of 15cm. It must be noted, however, that before starting the penetration count the weight is allowed to rest on the composition rods attached to the spoon: thus there is an initial static penetration through loose material collected at the bottom.

Since the very beginning it was realized that it was better to insist upon strict routines that did not require the fallible, and frequently calculated, judgment of the field crews. Therefore, strict instructions were maintained requiring a sample from every meter of perforation, and requiring the counting of the number of blows for every 15cm of penetration from 0 to 45cm. This same procedure was maintained for both samplers. Thereupon, in the office, when classifying the soil, the penetration index was computed by adding the number of blows over the first 30cm penetration of the small sampler (R.P.I.) or over the final 30cm penetration of the big sampler (S.P.T.).

Such are, in short, the equipment and procedures implied in the Mohr-Geotécnica penetration index (R.P.I.) and the Standard Penetration Test (S.P.T.) as used in Brasil.

Continuity of penetration characteristics over total driven length.

The recommendation to disregard the blows for the first 15cm of penetration in the Standard Penetration Test appears reasonable if one takes into account the probability that over a certain depth below the bottom of the hole the condition of the soil has been affected by stress variations and swelling or failure (8). Since this had not been done with the Mohr-Geotécnica sampler, it was feared that these results might be vitiated, although the vast accumulated evidence appeared to indicate to the contrary.

A systematic investigation was therefore undertaken, an example of which is reproduced in Drw. 3. To begin with, the penetration resistance data from hundreds of samples in each type of soil, at different consistencies or relative densities, were pooled for the determination of graphs and equations similar to that shown in the upper graph of Drw. 3, corresponding to a coarse and medium sand. The number of blows for the three consecutive stretches of 15cm were transformed into fractions of the total, to make the beginning and end points coincide for all samples. Thereupon a statistical analysis was used to determine the nature of the curve of best fit through these two fixed end-points and the two intermediate variable points. An equation of parabolic form was found suitable. In the next step the equation of the best fit $n = a + bp + cp^2$ for the three last points ($p = 15, 30$, and 45cm) was computed, and it was checked to see how closely to the (0,0) point it passed: it was found that this latter point invariably fell within the 95% confidence limits of the above equation, proving to satisfaction that there is no real discontinuity in the penetration behaviour over the first 15cm and last 30cm. This same conclusion was also reached by investigating the relationship between the Mohr-Geotécnica penetration index over the first 30cm (R.P.I.) and a possible substitute for it using the last 30cm (R.P.F.): at the bottom of Drw. 3 the overall average relationship R.P.F. = f(R.P.I.) is furnished based on random data including all types of soils, and the statistical proof is summarized to the effect that despite the variation of soil types and the simple linear relationship established, this relationship is valid to better than the 5% significance level.

Quality Control

In view of the above discovery, it appeared extremely useful, under the working conditions prevalent in Brasil, to maintain the requirement of a separate count of the number of blows for each successive 15cm of penetration, and to use this data for the purpose of a quality control, similar to that which is current in industry, by comparison of the R.P.I. and R.P.F. values within the confidence limits estatiscally established. The graph shown in Drw. 4 has been used very satisfactorily for this purpose; it has been possible to detect, on the spot, unsuspected conditions of sudden change of soil layer, damage or deterioration of equipment (spoon or driving weight) or temporary systematic deviation of any boring crew from the standard procedures recommended.

We therefore feel justified in recommending some such quality control, quite independent from field operations. The counts over three to four parts of the total driven length may be employed, without necessary restriction to 15cm lengths.

One important factor that is presently being investigated as a result of these studies is the length of sample that enters the sampler. In most of the soils encountered in our routine work (briefly described in the following table) it appears that only about 15-30cm of soil enters the sampler, the remainder of the penetration probably being achieved by displacement of the soil as if a solid bar were driven. It would obviously be most desirable that the number of blows registered as the penetration index correspond, as exactly as possible, to that part of the penetration over which the soil is retrieved in the sampler. This factor may call for adjustments of the internal dimensions of these spoon samplers.

Influence of soil type upon R.P.F. - R.P.I. relations.

The difference between the R.P.I. and R.P.F. values should basically furnish indications on the influence of release of stress above the water table, and of the total effects of release of stress plus slaking and swelling below the water table. Such effects may well be different for different soils. The relations between R.P.F. and R.P.I. were therefore investigated separately for several of the soil types listed in the above table. These results are summarized in Drw. 5. In a general way it may be seen that the more sandy soils (e.g. soil types 9 and 5) indicate a slightly greater effect of stress release, i.e. the difference between the R.P.F. and R.P.I. values is slightly greater; the silty clay soils nos. 1 and 3 indicate just the opposite tendency. At any rate, however, the differences between various soils are very small and it is observed that a smaller no. of data (e.g. soil type 6) can easily invalidate these tendencies

Below the water level, where the cumulative effect of stress release and of contact with free water is felt, soil differences transpire in a more pronounced manner, and now the relative position of clayey and sandy soils is reversed: the added effect of swelling is therefore important.

Influence of contact with free water (submergence)

In view of the above indications of a moderately pronounced influence of water, it was sought to investigate this effect separately in a few soils under two different conditions: by comparison of the equations from drawing 5 for the condition above and below the water table; and by comparing data of soils above the water table under the two distinct methods of perforation, in the dry (auger) and by use of water (wash-drilling).

The five small graphs presented in drawing 6 show that in every case for a given RPF value the RPI value above the water level (lines (B)) is greater than below (lines (a) which confirms the softening effect. The statistical analysis of co-variance summarized in table I of the same drawing proves that these differeces are significant (to 5% significance level).

It has been noticed that above the water table different results may be obtained if the perforation is done in the dry or by wash-drilling (9,10). An analysis of co-variance based on 138 pairs of results shows, however, that there is no significant difference. It is concluded that the difference above mentioned may, therefore, be due principally to the impossibility of cleaning a deep hole properly by the spiral auger, as a result of which there is an accumulation of friction.

Effect of depth on tendencies toward disturbance (above water table

Assuming that the disturbance effects are reflected by the difference between RPF and RPI-values, the study of such effects in the clay-type soil n° 1, above the water table, was carried one step further, by separating the data within five-meter increments of depth. The result of this statistical analysis is summarized in Drw.7, the upper graph representing the straight line relations as determined, and the lower one representing linear equations which were forced to pass through the origin.

With the exception of case (d) (depth 15m) for which the number of data was very scant, it may be observed that there is a steady change of behaviour with depth - a tendency that was demonstrated to be significant by statistical analysis. It is interesting to observe in the upper graph that the straight lines cross at almost the same point (RPF ≈8, RPI ≈6) indicating that the behaviour is different in soft-to-medium material and stiff-to-hard material. In the soft material the softening effect is greater at the greater depths, whereas in the stiffer clay the reverse is found to be true.

Correlation between the Mohr-Geotécnica index (RPI) and the Standard Penetration Test. (SPT)

In a recent foundation study involving a coarse and medium sand deposit of appreciable thickness, hundreds of borings were called for, using separately the two spoon samplers. This furnished an excellent opportunity to establish a correlation SPT vs. RPI in this soil, in order to confirm previous correlations (9). This correlation was first established rather satisfactorily, although based on a relatively small number of data, by comparing penetration indices of the two samplers within the adjacent borings, at distances of about 0.5m. In order to increase the number of data, an attempt was made to extend this correlation to cases of borings at distances of about 30m. The deposit was apparently homogeneous and it was thought sufficient to use pairs of values at the same elevations and depths. However, a shot-gun plot resulted (Drw. 8 b), indicating rather high scatter in individual values. This problem, nevertheless, was easily by-passed by taking average values (at each elevation and depth) for several borings of each type: these average values led to the correlations shown on graphs c, d and e of the same drawing confirming in a very satisfactory manner the earlier correlation. This statistical analysis was based on 912 values derived from 42 borings.

This same subsoil investigation is lending itself to another investigation with reference to the effect of depth on the penetration resistances in cohesionless soils. On an average, the borings have not revealed the steady increase of SPT or RPI values with depth as should be obtained judging from carefully conducted laboratory investigations (2,3).

Correlation between SPT and static cone penetrometer

The foundation studies for the new federal capital, Brasilia, involve principally an unsaturated "porous" red silty clay, which has been extensively investigated not merely by dynamic penetration resistances but also by the static penetrometer, for the sake of pile foundation designs.

Drawing 9 presents the preliminary results of attempted correlations between the SPT values and static point resistance values. In the upper graph a single relationship was established irrespective of depth: the confidence limits on this equation proved to be very wide, indicating that another factor was interfering. The lower graph indeed proves that the depth affects the desired correlation in quite a consistent manner: for a given SPT value, the point resistance increases with depth, so that it may be concluded that the point resistance values increase more rapidly with depth than the SPT. Since it cannot be concluded whether the SPT value itself does not also vary with depth in a soil of constant consistency, this study is presently being extended by establishing correlations between the SPT values and the unconfined compression strength of undisturbed specimens from various depths. Drawing 10 shows the results of the first correlation of this type obtained on a similar "porous" unsaturated silty clay from S.Paulo, soil type nº2.

Conclusions

Statistical analyses based on a sufficient number of data from routine subsoil investigations can furnish interesting correlations, sometimes even indicating unsuspected influences; the examples shown above demonstrate that to begin with an ample number of data should be used so as to permit sorting out the several factors capable of influencing results. While much needs to be done to investigate correlations of dynamic penetration resistances with fundamental geotechnical properties such as strength and density, the undisputable conclusion remains that this method of subsoil investigation yields consistent results, that can be adapted to techniques of quality control, which permit empirical correlations to be established with certain design decisions, proven by experience. Geotécnica is presently engaged in seeking such correlations on two important items-allowable bearing pressures on footings, and estimate of precast pile lengths.

Conclusiones

Analises estadísticas basadas en un número suficiente de datos de investigaciones rotineras del subsuelo pueden proveer correlaciones interesantes que indican a veces hasta influencias inesperadas; los ejemplos arriba presentados demuestran que inicialmente un amplio número de datos deberia ser usado para permitir que se eliminen los varios factores capazes de influenciar los resultados. Aunque mucho deba ser hecho para investigar las correlaciones de la resistencia de la penetración dinámica con las propiedades geotécnicas fundamentales como la resistencia y la densidad, permanece indisputable la conclusión de que este método de investigación del subsuelo lleva a resultados consistentes que pueden ser adaptados a técnicas de control de calidad, que permite que sean establecidas correlaciones impéricas con ciertas decisiones de proyecto, provadas por la experiencia. La Geotécnica está en el presente momento empenada en establecer tales correlaciones con referencia a dos importantes itens - presiones unitarias admisibles en zapatas, y apreciaciones de larguras de pilotes pre-fabricados.

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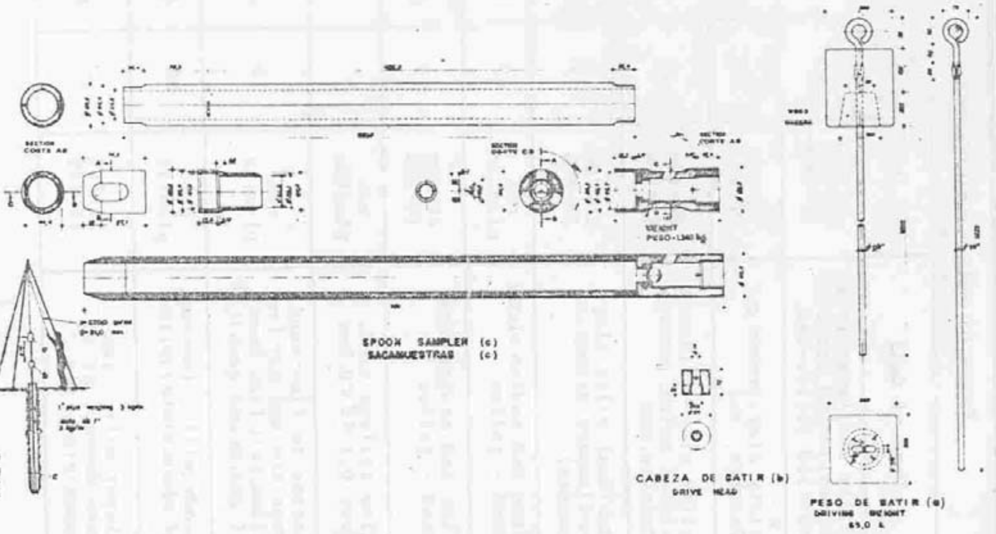
TABLE OF SOIL CHARACTERISTICS

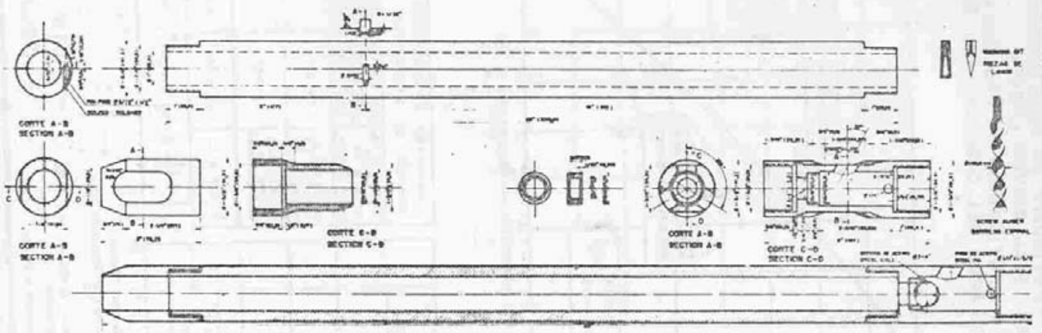
N	Type of Soil	LL% /LP%	APPROXIMATE GRAINSIZE		
			% Clay	% Silt	% Sand
1	silty clay-plastic preconsolidated, inactive mottled yellow-red.	50-90% 20-40%	50	20	30
2	silty clay-porous and friable, red	60-70% 30-40%	40	30	30
3	silty clay-mature residual soils, porous, friable, red	30-40% 10-20%	40	40	20
4	residual silty clay, red (mature decomp. of gneiss)	50-70% 25-30%	30	30	40
5	fine and medium clayey sand - yellow	not plastic	25	15	60
6	fine and medium clayey sand - yellow	30-50% 15-25%	20	15	65
7	fine uniform sand, grey $0{,}1 < \varnothing < 0{,}2$ mm	not plastic	–	5	95
8	coarse to fine sand, some silt and clay (residual soil from decomp. of gneiss and granite)	not plastic	10	30	60
9	sandy silt - (decomp. of micaschists) yellow	not plastic	20	50	30
10	clayey silt - (mature decomp. of micaschists), red	25-35% 19-26%	30	55	15

TERZAGHI-PECK SAMPLER AND DRIVING METHOD
SACAMUESTRAS TERZAGHI-PECK Y MÉTODO DE HINCA



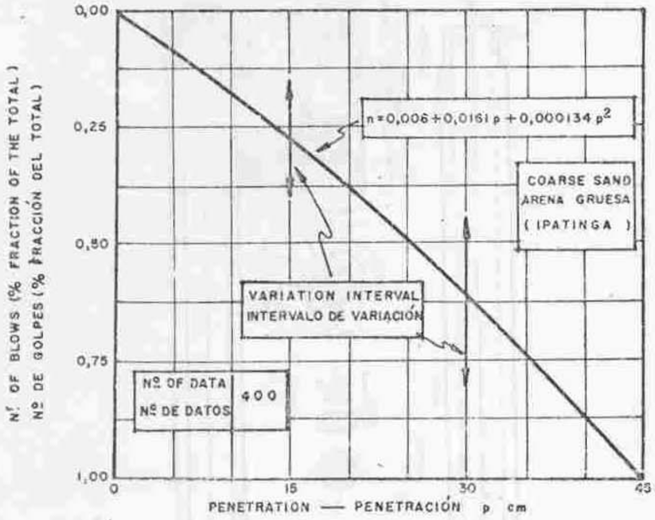
DRW
DIBUJO 1

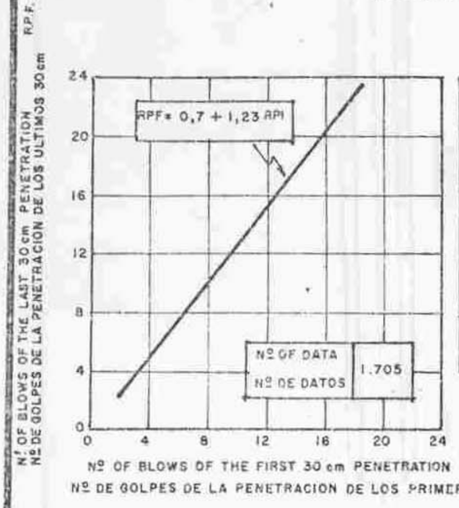
MOHR – GEOTÉCNICA SAMPLER AND PERFORATING EQUIPMENT
SACAMUESTRAS MOHR – GEOTÉCNICA Y PIEZAS DE PERFURACIÓN



DRW. 2
DIBUJO

DEMONSTRATION OF CONTINUITY OF PENETRATION CHARACTERISTICS OVER TOTAL DRIVEN LENGTH
DEMONSTRACIÓN DE LA CONTINUIDAD DE LAS CARACTERÍSTICAS DE PENETRACIÓN A LO LARGO DEL CUMPLIMIENTO TOTAL CLAVADO





ANALYSES OF STATISTICAL VARIANCE
ANALISE DE VARIANCIA ESTATÍSTICA

SOURCE OF VARIATION FUENTE DE VARIACIONES	SUM OF THE SQUARES SUMA DE LOS CUADRADOS	DEGREES OF FREEDOM GRADOS DE LIBERTAD	VARIANCE VARIANCIA
DUE TO REGRESSION DEBIDO A LA REGRESSIÓN	79 667	1	s_r^2 = 79 667
ON THE REGRESSION SOBRE LA REGRESSIÓN	36 763	2	s^2 = 18 381
T O T A L	116 430	1704	s_t^2 = 68,33

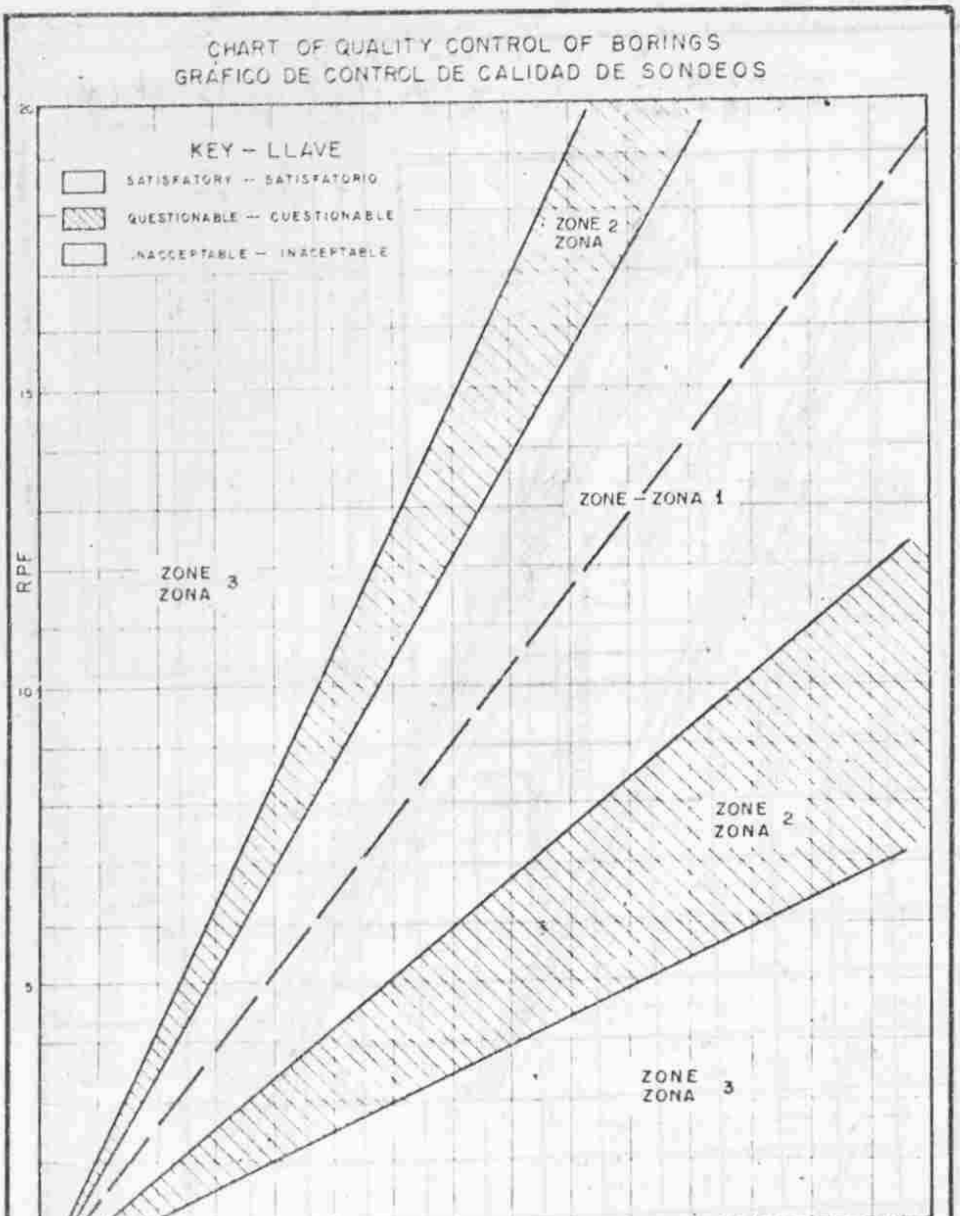
$\frac{s_r^2}{s^2}$ = 4,334 > 2,99* ∴ RPF = f (RPI)

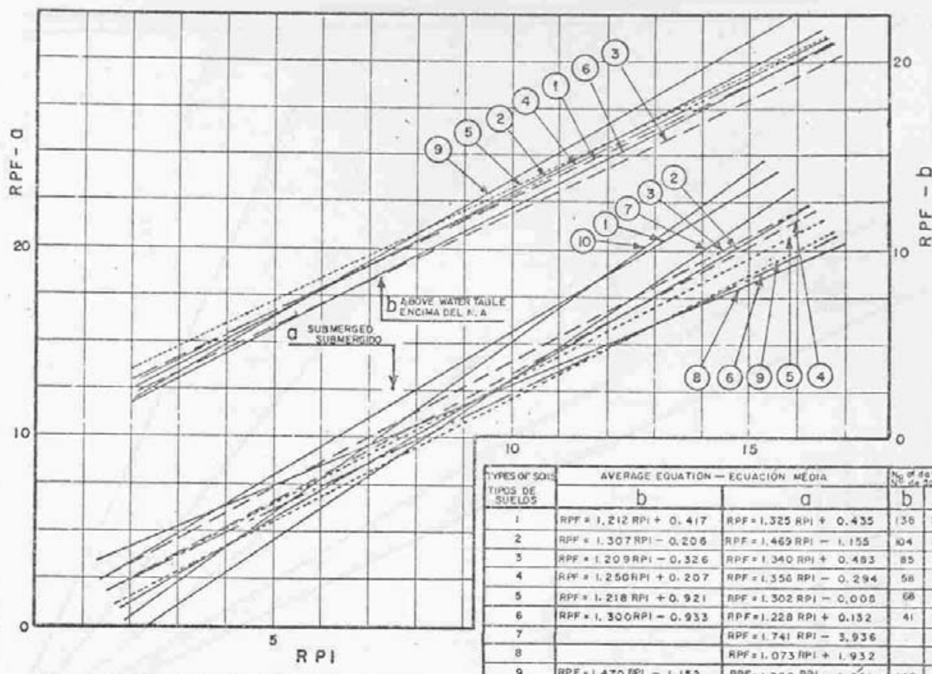
* 2,99 = F_p WITH 5 % SIGNIFICANCE LEVEL — CON 5 % DE NIVEL DE SIGNIFICANCIA

(TABLE V – VARIANCE RATIO – FISHER & YATES)

DRW. 3
DIBUJO

CHART OF QUALITY CONTROL OF BORINGS
GRÁFICO DE CONTROL DE CALIDAD DE SONDEOS





TYPES OF SOILS TIPOS DE SUELOS	AVERAGE EQUATION — ECUACIÓN MEDIA		No of data Nº de datos	
	b	a	b	a
1	RPF = 1,212 RPI + 0. 417	RPF = 1,325 RPI + 0. 435	136	251
2	RPF = 1. 307 RPI − 0. 206	RPF = 1,469 RPI − 1. 155	104	116
3	RPF = 1. 209 RPI − 0, 326	RPF = 1.340 RPI + 0. 483	85	120
4	RPF = 1. 250 RPI + 0. 207	RPF = 1,356 RPI − 0. 294	58	25
5	RPF = 1. 218 RPI + 0. 921	RPF = 1. 302 RPI − 0,008	68	70
6	RPF = 1. 300 RPI − 0. 933	RPF = 1.228 RPI + 0.132	41	82
7		RPF = 1.741 RPI − 3,936		85
8		RPF = 1. 073 RPI + 1. 932		80
9	RPF = 1,470 RPI − 1,152	RPF = 1.299 RPI − 1,041	149	86
10		RPF = 1,852 RPI − 3.936		30

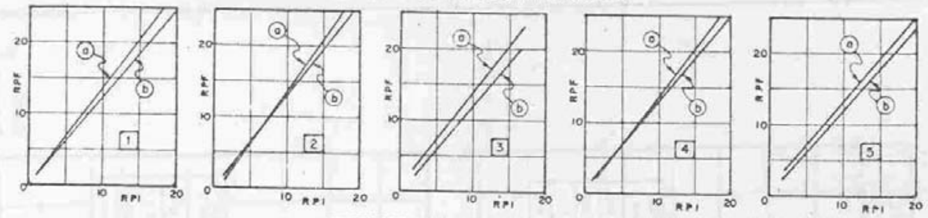
DRW. 5
DIBUJO

COMPARISON OF DISTURBANCE EFFECTS IN DIFFERENT SOILS
COMPARACIÓN DE EFECTOS DE ALTERACIÓN EN SUELOS DIFERENTES

DRW.
DIBUJO 6

INFLUENCE OF THE WATER ON CORRELATION
INFLUENCIA DEL AGUA EN LA CORRELACIÓN

RPF = f (RPI)



☐ TYPES OF SOILS FROM TABLE I
TIPOS DE SUELOS DE LA TABLA I

a = SUBMERGED SOIL — SUELO SUBMERSO
b – SOIL ABOVE WATER TABLE — SUELO ENCIMA DEL N.A.

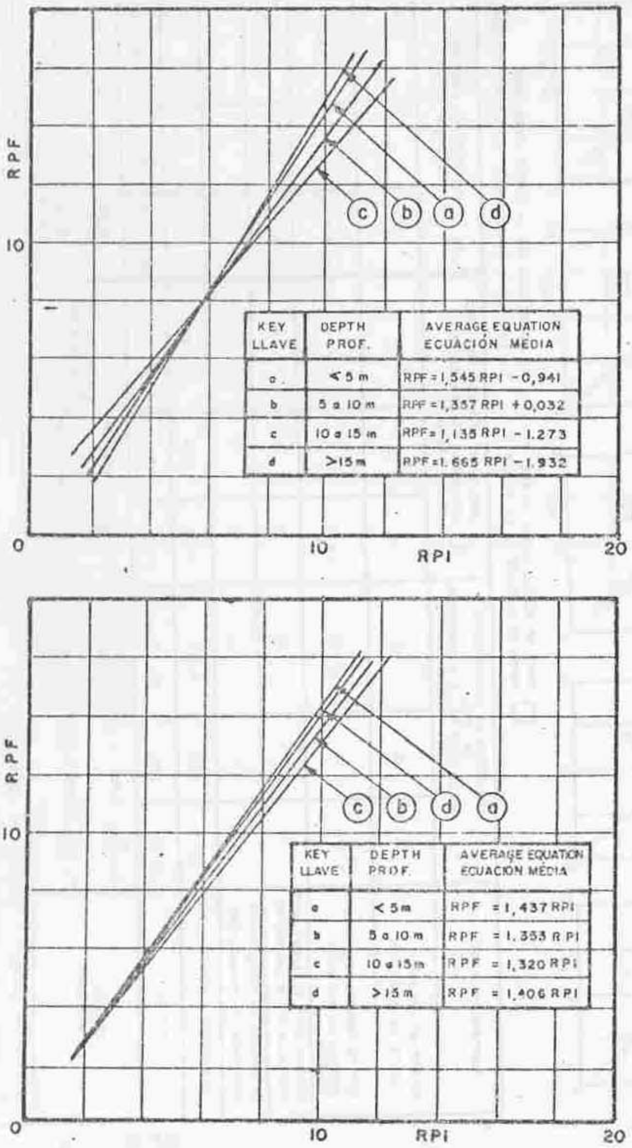
COMPARED CASES	I INFLUENCE OF SUBMERGENCE OF SOIL INFLUENCIA DE LA SUBMERSIÓN DEL SUELO			II INFLUENCE OF WASH DRILLING INFLUENCIA DE LAVADO DEL TALADRO			III REFFERENCE DRAWING REFERENCIA DIBUJO		
SOURCE OF VARIATION FUENTE DE VARIACIÓN	A	B	C	A	B	C	A	B	C
DUE TO GENERAL REGRESSION DEBIDO A LA REGRESIÓN GENERAL	11, 510	1	11, 510	2916	1	2916	153.301,12	1	153,301
DISTANCE BETW STRAIGHT LINES DISTANCIA ENTRE LAS RECTAS	72	1	72	4	1	4	117.814,71 **	364 **	323,66 **
DIFFERENCE OF PARALLELISM DIFERENCIA DE PARALELISMO	15	1	15	7	1	7			
REMAINDER - RESTO	1,583	385	4,117	499	134	3,724			
TOTAL	13,182	388	33, 97	3426	137		271.115,83	365	742,78
RESULTS RESULTADOS	$F_I = \frac{72}{4,117} = 17,488 > 3,84^{*}$ UNSATISFACTORY NO SATISFACTORIO $F'_I = \frac{15}{4,117} = 2,793 < 3,84^{*}$ SATISFACTORY SATISFACTORIO			$F_{II} = \frac{4}{3,724} = 1,074 < 3,84^{*}$ $F'_{II} = \frac{7}{3,724} = 1,880 < 3,84^{*}$ SATISFACTORY SATISFACTORIO			$F_{III} = \frac{153,301}{323,61} = 4,736 > 3,84^{*}$ SATISFACTORY - SATISFACTORIU SIMPLE VARIANCE ANALYSIS ANALISIS DE VARIANCIA SIMPLES		

A = SUM OF SQUARES – SUMA DE LOS CUADRADOS
B = DEGREES OF FREEDOM – GRADOS DE LIBERTAD
C = VARIANCE — VARIANCIA

* $3,84 = F_p$ (WITH 5 % OF SIGNIFICANCE LEVEL — CON 5 % DE NIVEL DE SIGNIFICANCIA) - FISHER & YATES TABLE

** ON THE REGRESSION — SOBRE LA REGRESIÓN

INFLUENCE OF DEPTH ON CORRELATION – RPF=f(RPI)
INFLUENCIA DE LA PROFUNDIDAD EN LA CORRELACIÓN

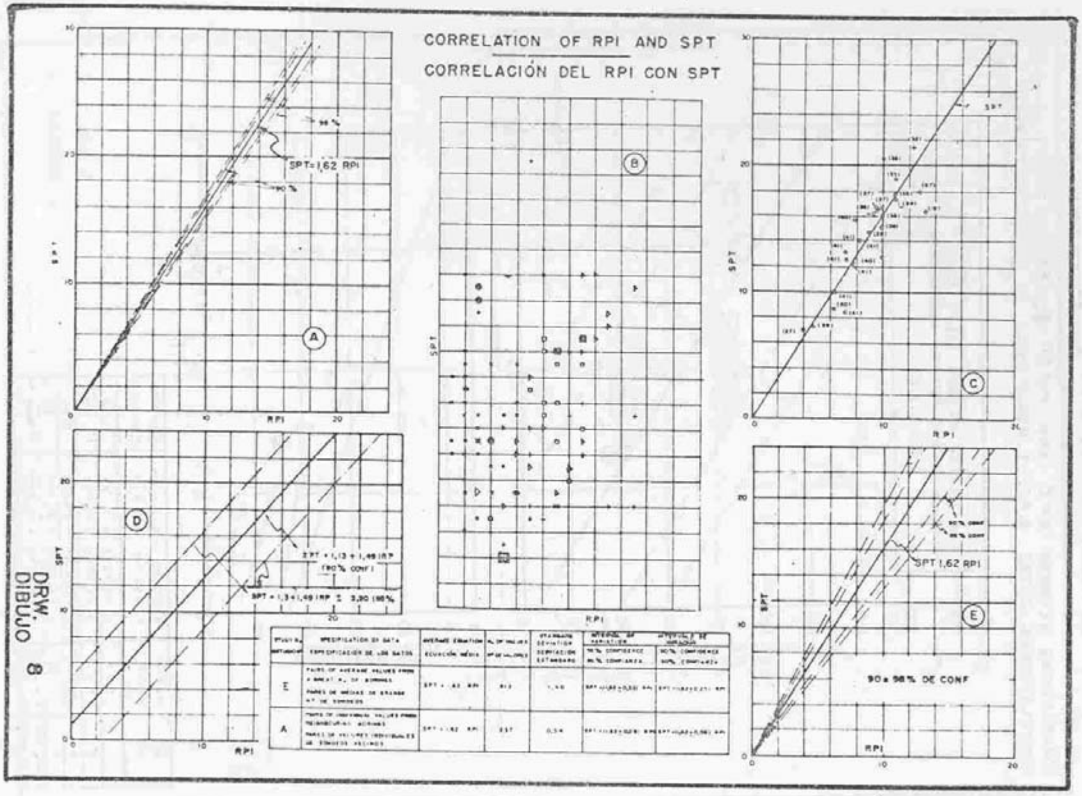


KEY LLAVE	DEPTH PROF.	AVERAGE EQUATION ECUACIÓN MEDIA
a	< 5 m	RPF = 1,545 RPI − 0,941
b	5 a 10 m	RPF = 1,357 RPI + 0,032
c	10 a 15 m	RPF = 1,135 RPI − 1.273
d	>15 m	RPF = 1.665 RPI − 1.932

SOIL TYPE No 1
TIPO DE SUELO Nº 1

KEY LLAVE	DEPTH PROF.	AVERAGE EQUATION ECUACIÓN MEDIA
a	< 5 m	RPF = 1,437 RPI
b	5 a 10 m	RPF = 1,353 RPI
c	10 a 15 m	RPF = 1,320 RPI
d	> 15 m	RPF = 1,406 RPI

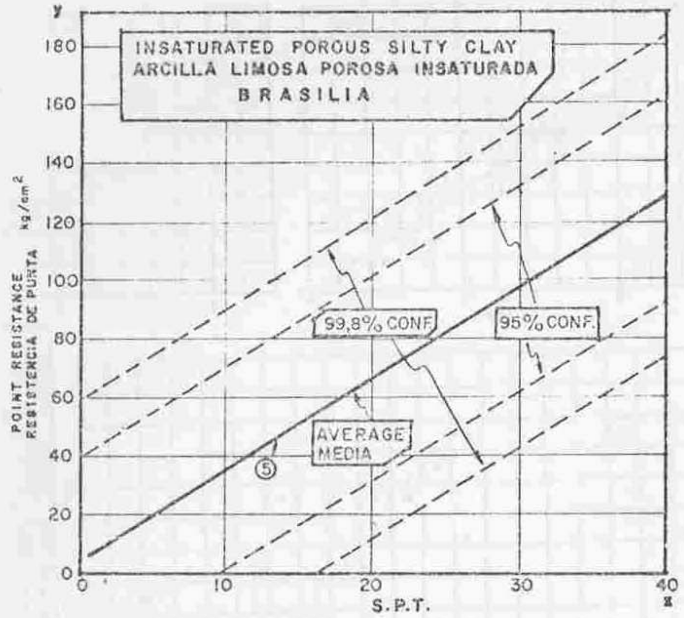
DRW.
DIBUJO 7

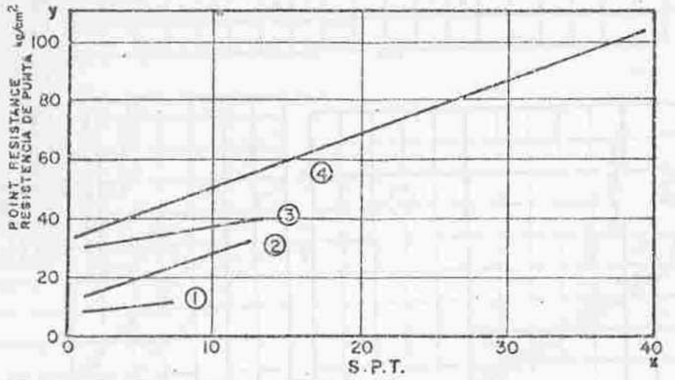


STUDY No. ESTUDIO No.	SPECIFICATION OF DATA ESPECIFICACIÓN DE LOS DATOS	AVERAGE EQUATION ECUACIÓN MEDIA	No. OF VALUES Nº DE VALORES	STANDARD DEVIATION DESVIACIÓN ESTANDARD	INTERVAL OF VARIATION 90% CONFIDENCE 90% CONFIANZA	INTERVALO DE VARIACIÓN 90% CONFIDENCE 90% CONFIANZA
E	PAIRS OF AVERAGE VALUES FROM A GREAT No. OF BORINGS PARES DE MEDIAS DE GRANDE Nº DE SONDEOS	SPT = 1,62 RPI	813	1,40	SPT=(1,62±0,33) RPI	SPT=(1,62±0,27) RPI
A	PAIRS OF INDIVIDUAL VALUES FROM NEIGHBOURING BORINGS PARES DE VALORES INDIVIDUALES DE SONDEOS VECINOS	SPT = 1,62 RPI	257	0,54	SPT=(1,62±0,29) RPI	SPT=(1,62±0,36) RPI

DRW. 8
DIBUJO 8

CORRELATIONS BETWEEN S.P.T. AND POINT RESISTANCE (DEEP SOUNDING)
CORRELACIONES ENTRE S.P.T. Y RESISTENCIA DE PUNTA (PENETROMETRO ESTATICO)



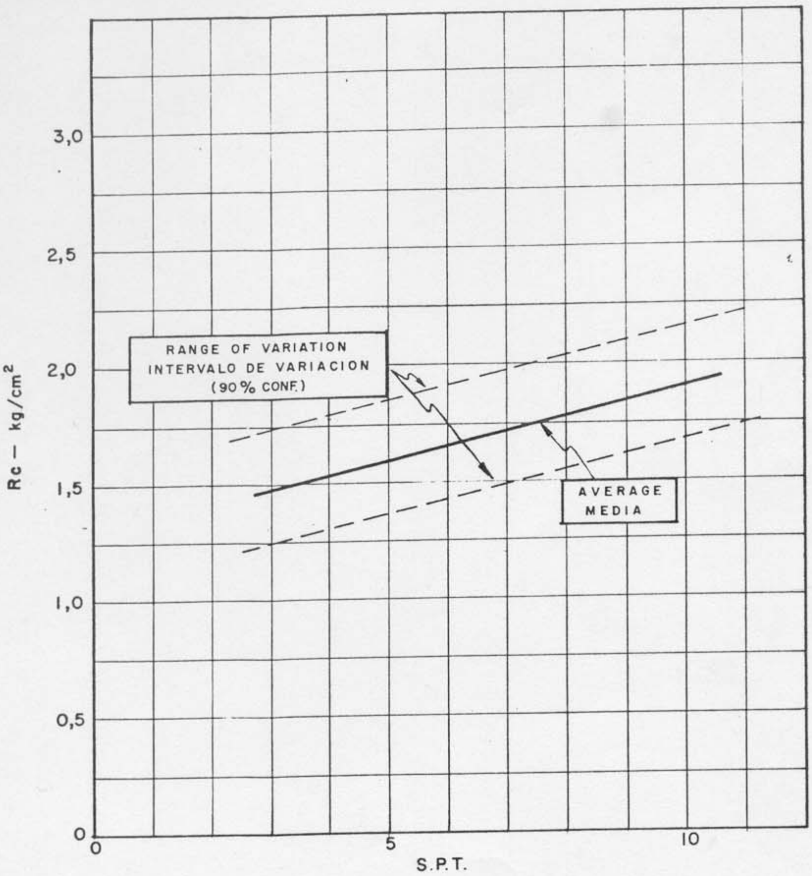


Nº Nº	DEPTH PROF. (m)	AVERAGE EQUATION ECUACIÓN MEDIA	Nº OF DATA Nº DE DATOS
1	0 – 5	$y = 0,467x + 7,167$	100
2	5 – 10	$y = 1,681x + 11,129$	100
3	10 – 15	$y = 0,808x + 29,691$	54
4	15	$y = 1,780x + 33,110$	70
5	TOTAL	$y = 3,107x + 4,262$	366

DRW. 9
DIBUJO 9

PRELIMINARY CORRELATION OF UNCONFINED COMPRESSION STRENGTH AND STANDARD PENETRATION TEST

CORRELACIÓNES PRELIMINARES DE LA RESISTENCIA A COMPRESSIÓN SIMPLES Y STANDARD PENETRATION TEST



Nº OF TESTS Nº DE ENSAYOS	AVERAGE EQUATION ± RANGE OF VARIATION ECUACIÓN MEDIA ± INTERVALO DE VARIACIÓN (90 % CONF.)	STANDARD DEVIATION DESVIACION ESTANDARD
72	Rc=0,061SPT+1,3±0,242	0,147

Rc = Unconfined compression strenght
Resistencia a compressión simples

SPT = Standard penetration test

Data from Group 2
Datos del Grupo 2

DRW 10
DIBUJO 10