Foundation engineering - Brazilian practice

L'ingéniérie des fondations - La pratique brésilienne

J.MILITITSKY, Professor, CPGEC/UFRGS, Brazil
N.C.CONSOLI, Research Assistant, CPGEC/UFRGS, Brazil

SYNOPSIS: During the 8th Brazilian Conference on Soil Mechanics and Foundation Engineering, held in Porto Alegre, RS, in 1986, the senior author of the present paper was the general reporter on the subject Foundation Engineering. During the Conference a survey on foundation engineering practice was made. Out of 650 questionnaires, 40 where adequatedly filled out. The present work is the presentation and analysis of such survey.

1 IDENTIFICATION OF GROUPS ACCORDING TO THE MAIN ACTIVITY

According to the following classification, the distribution of activities was:

Activity	%	Nº
Consulting (design)	32,50%	13
Contractor (piling contractor)	27,50%	11
State company (client owned by the government)	20,00%	8
Research (University or technologycal institution)	12,50%	5
Private company (client privatly owned)	7,50%	3
	100,00%	40

2 TYPICAL PROJECTS

According to the number of answers, percentage of projects where the respondents where involved are as follows: routine 71,75%, special projects 17,75%, off-shore 7%, and research 4,05%. It can be identified that the large majority of projects are routine problems in foundation engineering.

3 CODES AND STANDARDS

The use of codes and standards was questioned. Presently, foundation engineering in Brazil is covered by NBR-6122 (1986). As the code was first presented as a preliminary version in the present structure in 1978 and amendments were made in 1984, the question was made in order to identify how such evolution was followed by the practice. In some fields of application different codes and standards are widely used, as presented in table I.

Brazilian cities have no code of practice covering foundation engineering, the National Code is the only document to be referred to in routine projects.

It can be seem that the new versions of the Code are not followed by the practice.

4 SITE INVESTIGATION AND SOIL TESTING

The practice, according to the distribution of groups is presented in Fig.1. It can be seen that SPT is, by large, the main source of soil data, regardless the acticity concerned. The only group where SPT covers less than 80% is the State Company (53,63%).

5 SHALLOW FOUNDATIONS

5.1 Minimum depth

A question still open to discussion in the professional practice is the minimum depth of shallow foundations. The 1978 Brazilian Code of Practice established 1,50m (5 foot) as a minimum, is all cases. The present code (1986) specifies 1,50m as a limit just for foundations at the limit of the site. Fig.2 shows a very scattered distribution.

5.2 Shallow foundation in soil, basic information for design

Fig.3 shows how the basic information for the design of shallow foundations in soil is obtained. The main source is SPT correlation (49,35%), followed by past experience (17,97%). A prescription referred as Table presented by the Brazilian Code of Practice, with a description of soil condition is used in 11,86% of cases. Both field and laboratory testing are not widely used (7,16 and 7,7% respectively).

5.3 Allowable bearing capacity of shallow foundations in rock

Fig.4 shows the state of practice on the subject. The 3 main approaches to solve the problem are rotary drilling information (37,37%), past experience (31,85%) and the Brazilian Code of Practice table (18,89%). Load tests are used in special projects but no reference was made in the survey.

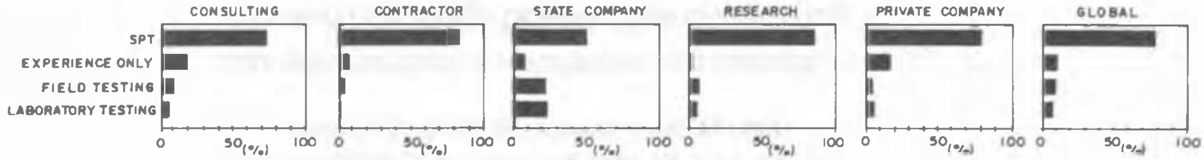


FIGURE 1 - INVESTIGATION AND SOIL TESTING.

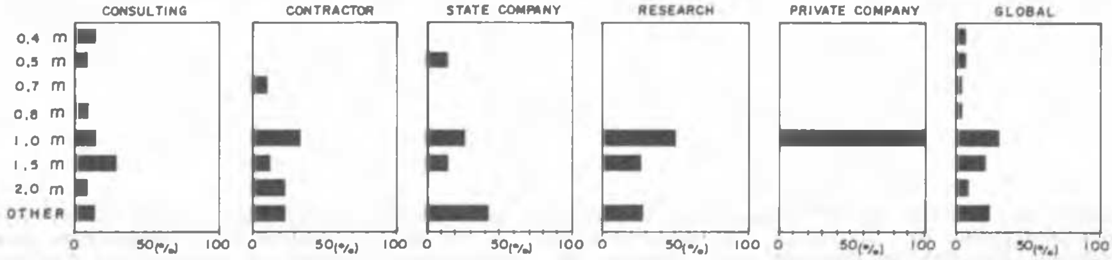


FIGURE 2- MINIMUM DEPTH FOR SHALLOW FOUNDATIONS.

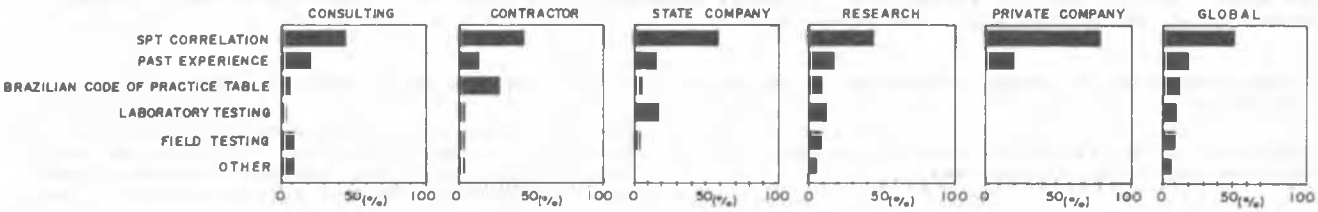


FIGURE 3- SHALLOW FOUNDATIONS ON SOIL, DATA FOR DESIGN.

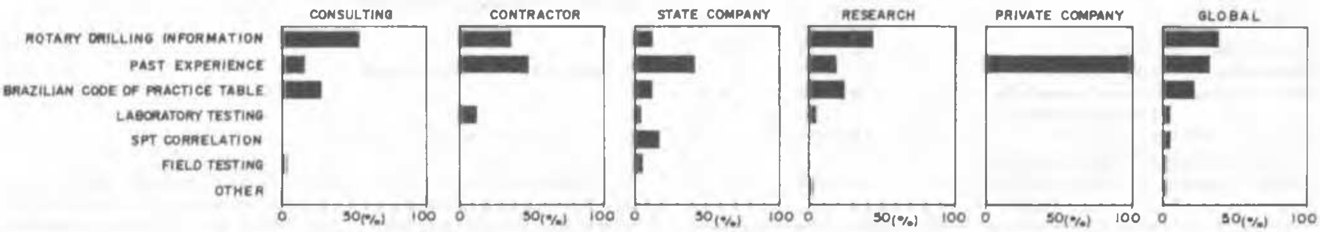


FIGURE 4-SHALLOW FOUNDATIONS IN ROCK, ALLOWABLE BEARING CAPACITY

Table 1. Use of codes and standards.

	NBR 6122/1978	NBR 6122/1984	NBR 6122/1986	No code	Other
Consulting	14,62%	20,77%	37,69%	16,54%	10,38% (ACI, API, DIN, BSI, Canadian)
Contractor	27,27%	13,64%	40,00%	13,64%	5,45% (ACI, BSI)
State Company	1,25%	25,62%	0,63%	26,25%	46,25% (API, AASHO, Petrobrás, DN)
Research	0	10,00%	58,00%	10,00%	22,00% (Canadian, BSI, DIN)
Private Company	33,33%	33,33%	0,00	33,33%	0
GLOBAL	15,00%	19,38%	30,62%	18,12%	16,88%

5.4 Colapsible soils

As some Brazilian regions present soils with sensitivity to the water, a question was made to evaluate how important the practice considers the question. Very few references (3 reports) were made. In the regions of such soils, it is common practice not to use shallow foundations.

5.5 Vegetation effect

Scarce references to the effect of roots in nearby structures are presented in the survey. Probably less than the real number of problems caused by tree roots is identified correctly, due to the lack of knowledge of the extension of the problems.

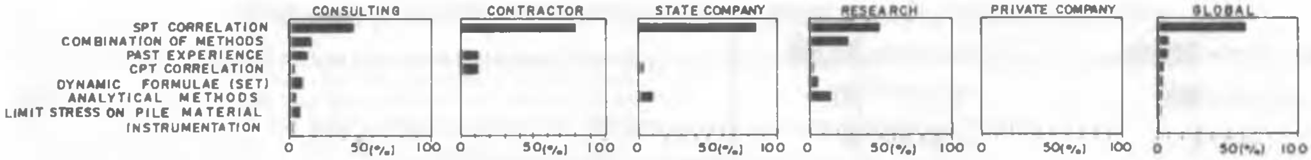


FIGURE 5 - FRANKI PILE - DESIGN FOR COMPRESSION.

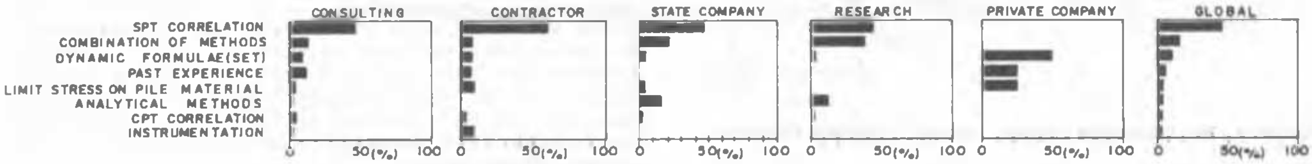


FIGURE 6 - CONCRETE/STEEL PILE - DESIGN FOR COMPRESSION.

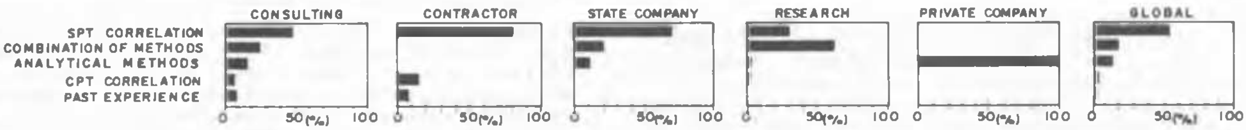


FIGURE 7 - LARGE BORED PILE - DESIGN FOR COMPRESSION

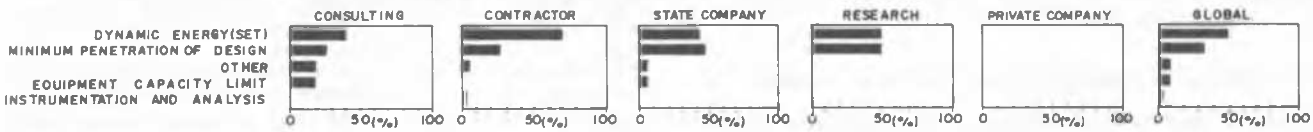


FIGURE 8 - CONTROL OF INSTALLATION, MINIMUM LENGTH - FRANKI PILE

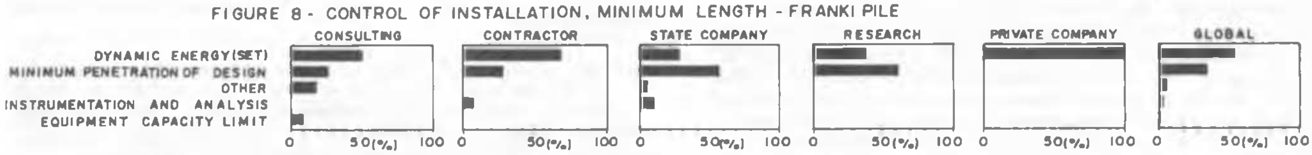


FIGURE 9 - CONTROL OF INSTALLATION, MINIMUM LENGTH - CONCRETE/STEEL PILE.

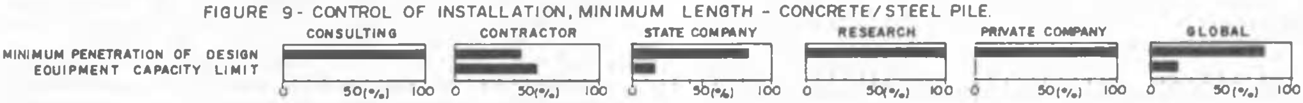


FIGURE 10 - CONTROL OF INSTALLATION, MINIMUM LENGTH - LARGE BORED PILE

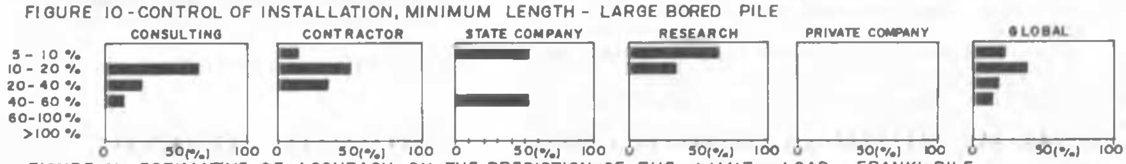


FIGURE 11 - ESTIMATIVE OF ACCURACY ON THE PREDICTION OF THE LIMIT LOAD - FRANKI PILE.

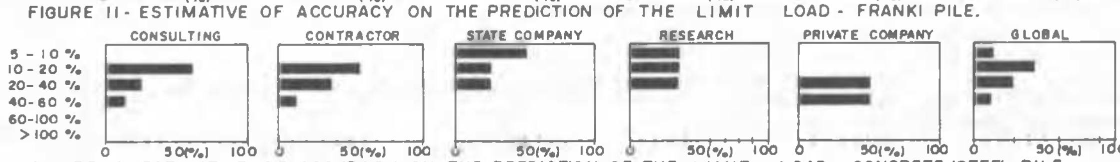


FIGURE 12 - ESTIMATIVE OF ACCURACY ON THE PREDICTION OF THE LIMIT LOAD - CONCRETE/STEEL PILE.

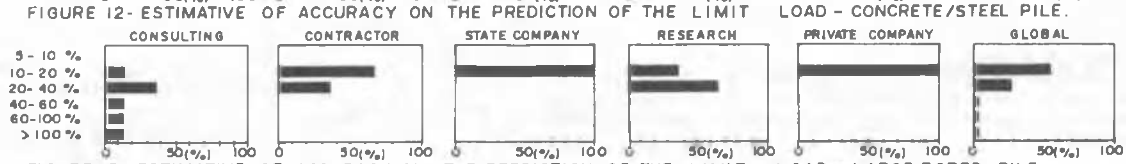


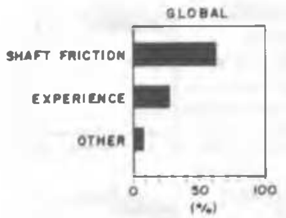
FIGURE 13 - ESTIMATIVE OF ACCURACY ON THE PREDICTION OF THE LIMIT LOAD - LARGE BORED PILE.

6 DEEP FOUNDATIONS

The foundations considered are the ones most widely used in Brazil, according to the survey result.

6.1 Design for compression

The design for compressive loads, considering just the methods for prediction (pile load test is not a prediction tool) for the types of piles covered are presented in Fig.5, 6 and 7. The Franki pile design covered by Fig.5 shows that SPT correlation is the preferred method. Fig.6 shows the design approaches for concrete and



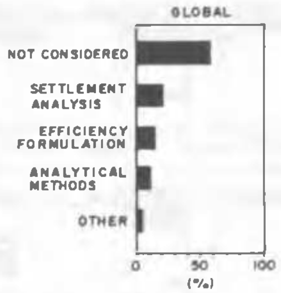


FIGURE 14 - PILE DESIGN FOR TENSION. FIGURE 15 - GROUP EFFICIENCY.

metal driven piles. Once again the SPT is the most widely used tool for prediction, followed by combination of methods and dynamic formulations. The case of large bored piles is again a demonstration of SPT dominance in the Brazilian engineering practice (Fig.7). For this case combination of methods and analytical methods are second and third, respectively.

6.2 Control of installation, minimum length

Fig.8, 9 and 10 presents the control of installation, considering the pile (Franki, concrete and steel) type and group of activity. For driven piles set and minimum penetration of design are the used methods (Fig.8 and 9). For large bored piles minimum penetration of design is the first and equipment capacity limit the second, as a general control, except for the piling contractors were equipment capacity limit came first.

6.3 Estimative of accuracy on the prediction of the limit load estimative

Fig.11, 12 and 13 shows how is the penetration accuracy for the different piles under consideration. More than 50% are under 20% accuracy for any kind of pile. It is quite surprising how confident are the professionals, specially considering the basic data for design used. According to some publications (Milititsky, 1986; Alves, 1984; Shioi, Y. and Fukui, J., 1982) SPT based methods to estimate pile capacity present more scatter than the suposed by the answers presented.

6.4 Design for tension

Fig.14 shows that pile design for tension are the same used for compression, considering just shaft friction, being "experience" the second method.

6.5 Group efficiency

The problem of group efficiency is presented in Fig.15. It can be seen that the large majority of the indications does not consider the problem. Settlement analysis is the most used technical approach, followed by efficiency formulation and analytical methods.

7 CONCLUSIONS AND FINAL REMARKS

Investigation and soil testing in brazilian practice is dominated by the use of SPT. The vast majority of foundation problems are solved with such data. The Code of Practice on Foundation Engineering must adress specific remarks on limitations, correct extrapolation and use of SPT results.

For shallow foundations, the table presented by the Brazilian Code is used as a source of information for soil and rocks. Being a very large country, more detailed soil description, considering each region of the country and real soil properties should be the direction of future development.

Following world wide practice in piling, which is both an art and a science, pile load test must be incentivated. Such tests should reach failure, or, at least, large displacements, in order to improve the knowledge of pile behaviour and the performance of the prediction tools.

The results of the present survey may constitute a basis for the development of a wider and more detailed study on Foundation Practice in Brazil, which may be used as a source of information for future ammendments of the Code of Practice on Foundation Engineering.

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Alves, I.P.M. (1985). Behaviour of bored piles in RS state. MSc Dissertation (in portuguese), UFRGS Graduate Programme in Civil Engineering.

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Shioio, Y. & Fukui, J. (1982). Application of N-Value to design Foundations in Japan. Proc. II ESOPT, vol. 1, p.159-164.