Current Status of Pressuremeter Testing Education in the USA

Etat des Activités d'Enseignement des Méthodes d'Essai Pressiométrique aux USA

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ABSTRACT: This paper presents the status of current pressuremeter activities in the United States of America (USA) including pre-bored, self-bored and full-displacement pressuremeter testing. A questionnaire was widely distributed to academics to assess the level and type of activities in research and teaching. Current research efforts were categorized in terms of improvement of installation procedures for both pre-bored and self-bored probes, data interpretation methods and modeling of the pressuremeter curve. Innovations in probe design, sensor technology and software development were also considered. As part of this survey, a series of questions gauged the degree that pressuremeter testing and design methods are being taught at both undergraduate and graduate level courses in civil and geotechnical engineering courses at US academic institutions. Teaching efforts are compared to what is done for other tests such as the Standard Penetration Test (SPT) and the Cone Penetration Test (CPT). The results from the survey provide a current status of pressuremeter testing instruction in the US and allow the development of a framework for broader use and dissemination of pressuremeter testing technology in practice and in academia.

RÉSUMÉ : Cet article présente l'état des activités pressiométriques en vigueur aux États-Unis d'Amérique (USA), y compris les essais au forage préalable, à l'autoforage et au plein-déplacement. Un questionnaire a été distribué aux universitaires pour évaluer l'intensité et le type d'activités au niveau des essais dans le but de recherche et d'enseignement. Les recherches actuelles ont été classées en termes d'amélioration des procédures d'installation des sondes à la fois au forage préalable et à l'autoforage, les méthodes d'interprétation et la modélisation de la courbe pressiométrique. Les innovations au niveau de la conception des sondes, la technologie des capteurs et le développement de logiciels ont aussi été considérés. Toujours dans le cadre de cette enquête, une série de questions a permis d'évaluer dans quelle mesure les méthodes d'essai pressiométrique sont enseignées au cours de premier cycle et cycles supérieurs dans les cours de génie civil et géotechnique dans les établissements universitaires américains. Cet enseignement est comparé à ce qui se fait pour d'autres essais tel que le test de pénétration standard (SPT) et le pénétromètre (CPT). Les résultats de l'enquête fournissent un état actuel de l'enseignement de l'essai pressiométrique aux États-Unis et permettent l'élaboration d'un cadre pour une utilisation plus large afin de diffuser les technologies de l'essai pressiométrique dans la pratique et dans les milieux universitaires.

KEYWORDS: teaching in situ testing, field methods, pressuremeter education, USA

1 INTRODUCTION

The use of in situ testing in an integral part of site characterization and several methods have gained increasing acceptance worldwide in geotechnical practice during the past few decades. In the USA, the use of the Standard Penetration Test (SPT) remains prominent but is increasingly accompanied by more modern field methods such as the Cone Penetrometer Test (CPT) and various geophysical techniques.

This paper presents results from a questionnaire distributed to members of the United States Universities Council on Geotechnical Education and Research (USUCGER). This organization has over 100 member institutions and an email list reaching over 400 individuals in the USA and abroad. The questionnaire, disseminated using SurveyMonkey®, consisted of a series of 13 multiple choice or matrix of choices with multiple answers questions focused on determining to what degree is pressuremeter technology being taught at American universities in both undergraduate and graduate geotechnical programs. Comparisons are made to other field methods including SPT, CPT, flat plate dilatometer test (DMT), field vane test (FVT) and geophysical techniques. The survey was filled out by 40 respondents and the responses to each question are summarized herein. The results are somewhat biased since it is likely that most of the respondents are those interested in the pressuremeter test and/or in field methods. Others with little or no interest in field investigations and in situ testing probably

ignored the survey thinking that their contribution to this questionnaire would not be very accurate and/or helpful.

2 SURVEY RESULTS

In this section, the results collected by the SurveyMonkey®survey are summarized in the form of graphs and statistics. Several comments were provided by the respondents and those are presented under each question.

Question 1: In which undergraduate courses do you cover field exploration (drilling and sampling) and in situ testing (SPT, CPT, etc.)?

The results showed that 94.9% of respondents cover field exploration in the foundation courses while 56.4% introduce it in the basic introductory soil mechanics and geotechnical courses. Some of these topics are covered in elective combined undergraduate/graduate courses such as geotechnical earthquake, site characterization or applied geophysics and in some cases as part of the laboratory component of the intro soils course.

Question 2: Which in situ tests are discussed in your undergraduate lectures?

The results from this question are shown in Figure 1. Nearly all programs cover the SPT and the CPT in their undergraduate courses. However, only about 50 to 60% of the programs discuss tests such as the field vane, the dilatometer and the pressuremeter. Depending on research done at particular institutions, other methods are also introduced such as the borehole shear test.

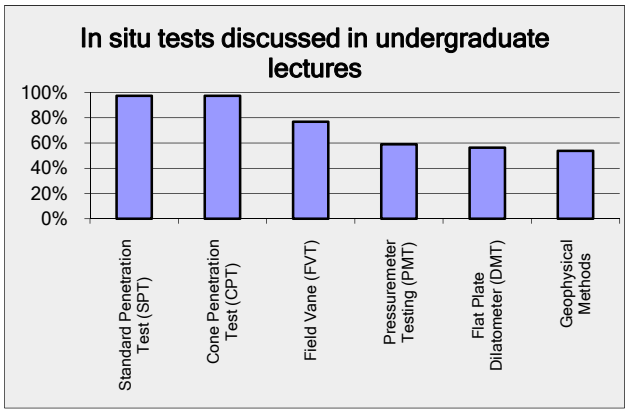

Figure 1. In Situ Tests Discussed in Undergraduate Geotechnical Courses

Question 3: How much lecture time is devoted to each in situ test in your undergraduate courses?

The results from this question are shown in Figure 2. Clearly most of these topics are simply introduced in those courses. About 50% of the programs spend less than 10 minutes on the DMT, PMT and geophysical methods. About 25% of the programs spend between 10 and 20 minutes on the SPT, CPT and FVT. Overall, the SPT is the test most widely discussed with 25 % of the programs spending between 1 and 2 hours of lecture time.

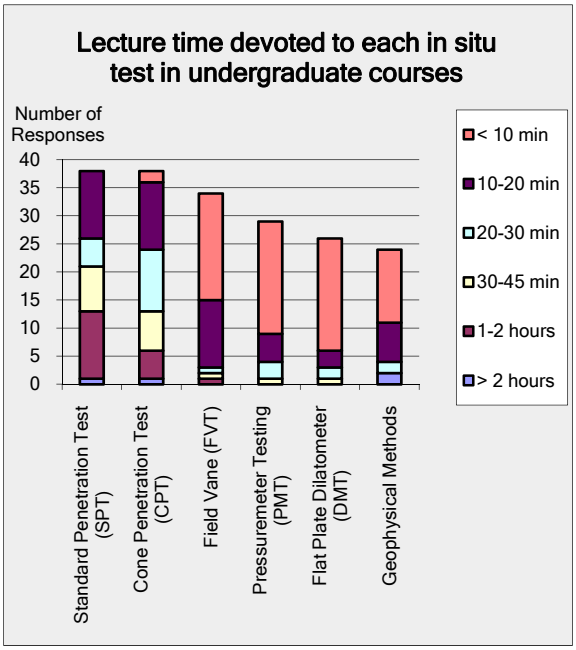

Figure 2. In Situ Tests Lecture Time in Undergraduate Courses

Question 4: In which graduate courses do you cover field exploration (drilling and sampling) and in situ testing (SPT, CPT, etc.)? Please select all that apply.

The large majority of programs discuss field exploration and in situ testing in the foundation design courses (83%) while about 35% of programs cover these topics in the Advanced Soil Mechanics and in the In Situ Geotechnical Testing (Site Investigation) courses. The material is also cover in a number of other courses including graduate Soil Properties Laboratory, Geophysical Surveys in Earthquake Engineering and Earthquake Engineering, Soil Improvement (as verification methods), Earth Dams, Geo-Environmental especially for evaluation of hydraulic conductivity. It should be noted that for many geotechnical programs, graduate courses are also open to seniors.

Question 5: Which in situ tests are discussed in your graduate lectures? Please select all that apply.

The results to this question clearly reveal that field methods are discussed primarily at the graduate level. The SPT and CPT are covered in 100% of the programs followed closely by the field vane and then geophysical methods, PMT and DMT, all in more than 80% of the programs. Other methods are also discussed such as the borehole shear, borehole nuclear methods, in situ

hydraulic conductivity and plate load testing. Figure 3 shows the percentage for each test category.

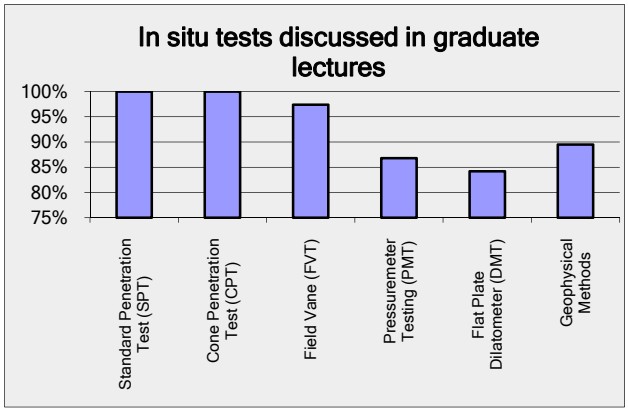

Figure 3: In Situ Tests Discussed in Graduate Lectures

Question 6: How much lecture time is devoted to each in situ test in your graduate courses?

The results from this question are shown in Figure 4. For the SPT and CPT, 25% of the programs spend less than 30 minutes while another 25% dedicate 1-2 hours and about 13% cover the material in greater details, using over 3 hours. For the DMT, PMT and geophysical methods, approximately 40% of the programs spend only 10 to 30 minutes on these topics while about 15% of them use an hour or more. It is somewhat surprising that as much as 20% of the programs spend less than 10 minutes on the FVT, DMT, PMT and geophysical methods. Other in situ test methods receive significant lecture time such as hydraulic conductivity testing and borehole shear.

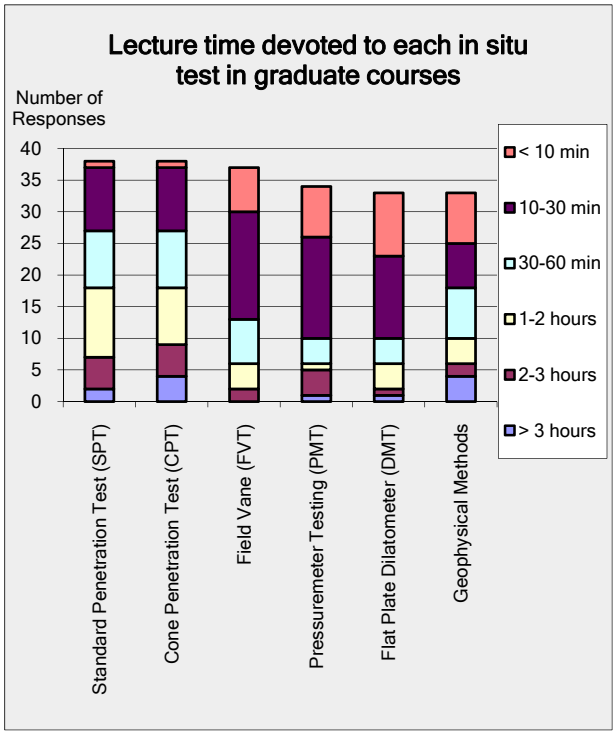

Figure 4: In Situ Tests Lecture Time in Graduate Courses

Question 7: If you indicated that you cover Pressuremeter Testing, rank each topic in terms of importance.

Figure 5 shows the results for those that indicated that they lectured on pressuremeter testing in their classes (85%). The survey shows that ASTM procedures and design methods based on pressuremeter test results are deemed useful information for about 50% of the respondents. The type of pressuremeter, the installation methods and the data interpretation are found to be important to very important in about 2/3 of the programs.

Question 8: Do you own or have access to a pressuremeter?

Of the 15 responses to this question, 10 owned a pressuremeter while 8 also have access to a pressuremeter.

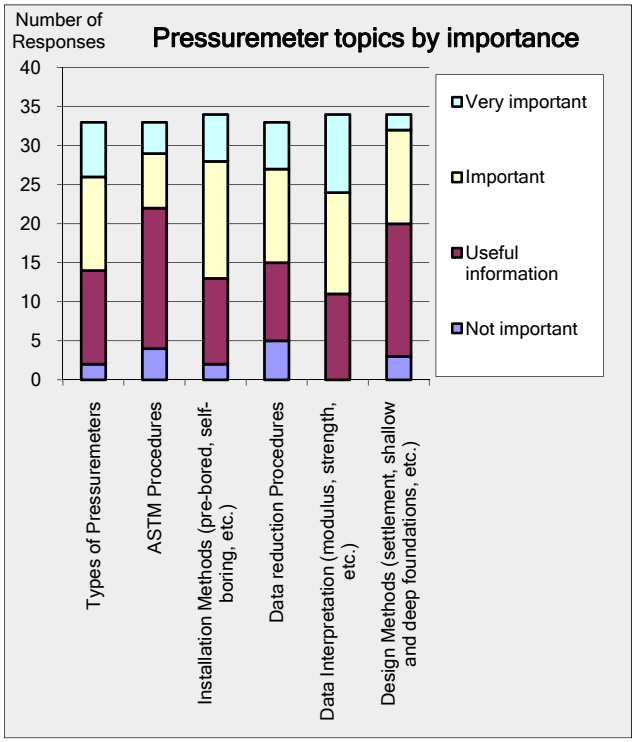

Figure 5: Pressuremeter Topics by Importance

Question 9: What type of pressuremeter do you own or have access to? Check all that apply.

For the same 15 respondents, 11 owned or have access to a pre-bored pressuremeter while 3 owned or have access to a self-bored and a full-displacement probe. Three of the respondents specifically mentioned that they owned a Texam probe.

Question 10: Are you currently involved in research using the pressuremeter.

This question, answered by 28 respondents, shows only 2 currently active in research. More than 15 are not currently active but have done some research with the pressuremeter in the past. Eleven of the respondents have no interest in pursuing this area of research.

Question 11: If you own a pressuremeter, do you have students perform testing as part of their coursework or research work?

Half of the 15 respondents do not have their students perform testing with the pressuremeter. The other half either let them perform testing regularly or occasionally. In such cases, only graduate students perform the testing.

Question 12: What resources would you find useful in your courses? Check all that apply.

Figure 6 shows what resources respondents would find helpful in delivering pressuremeter course material in their geotechnical courses and research efforts. Overall, with the exception of live video feed of actual testing, 70% of the respondents find that video of installation and testing, PowerPoint presentations, set of course notes, data examples with interpretation, design examples and cases histories are equally helpful.

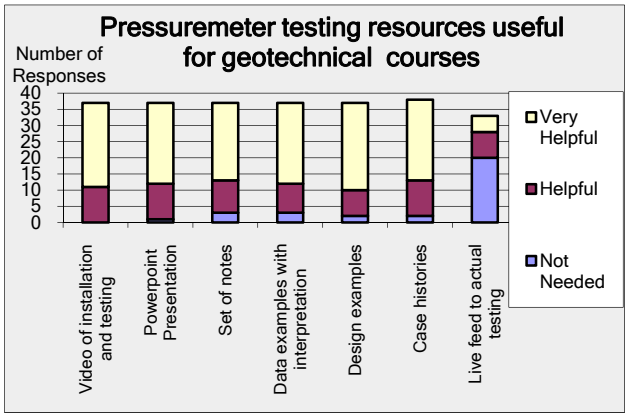

Figure 6: Helpful Pressuremeter Instructional Resources

Question 13: Why do you think Pressuremeter Testing has not gained in significant popularity in the past two decades as compared to the CPT, DMT and geophysical methods?

Several very insightful answers were given to this question. Recurring comments included complexity of equipment, need for trained operators, lack of ruggedness, equipment breakdowns, time consuming test, lack of availability and more costly than other tools such as the SPT and CPT. Others pointed out, as this survey revealed, that the pressuremeter test and its interpretation is not routinely taught in geotechnical courses and in practice. The lack of publicity, publication of case histories, current research and training of practicing engineers in its use and interpretation makes it less desirable for use on projects. However, for caisson design for several large buildings in the USA and abroad, it has shown the pressuremeter to be an invaluable tool. It was also pointed out that very little research has been done since the 70's. The pressuremeter is not as main stream in the USA as the CPT and SPT and thus there is little incentive to use it as it is rarely part of local practices. The soil conditions in the USA are, for the most part, often not conducive to good quality PMT and therefore its use can not always be justified unless specifically requested to meet certain design needs. Drilling practices in the USA are also not always well-suited for high quality borehole preparation for testing. The interpretation of the test results is also deemed difficult but for experienced users its use in evaluating settlement and capacity of deep foundations is praised. Compared to the SPT, CPT and DMT, the PMT provides discrete information at a much higher cost which makes it less competitive. Finally, in areas requiring seismic design, the CPT and SPT are favored over other in situ tests such as the PMT and DMT.

3 CONCLUSION

The primary objectives of field characterization can be summarized as follows:

- allow testing of soils/rocks which are difficult or impossible to sample for laboratory testing,
- obtain better spatial evaluation of soil/rock properties,
- test soil/rock deposits in their natural environment and,
- involve a larger volume of soil/rock than possible with conventional laboratory testing.

In general, current field technologies when compared to laboratory testing are no longer regarded as slow, expensive and uncertain processes of determining engineering properties of soils and rocks. The field of geotechnical and geoenvironmental site characterization has continually progressed in terms of equipment, sensors, deployment, methodologies and approaches for data processing and interpretation in the past few decades. Nevertheless, as shown in this survey the perception is that certain tools such as the pressuremeter are time consuming and too complex. However, if future and current geotechnical engineers are not taught the basic use and interpretation of the various test methods, opportunities to improve in efficiency and safety of our design are likely to continue its slow progress. Proper training and understanding of more sophisticated test methods will lead to greater use of field methods such as the DMT, PMT and geophysical techniques. Unlike other in situ tests, the pressuremeter requires careful preparation of a field "specimen" for testing. If this process is successful, the resulting information from the test is of great value in design.

The results from this survey clearly show that a conversation on geotechnical education especially with respect to site investigation and in situ testing is urgently needed to address the needs of the geotechnical profession. As indicated in the Introduction, these survey results are biased since only those with an interest in field investigation and methods likely provided their input, making this conversation even more necessary.

4 ACKNOWLEDGEMENTS

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