

48th C.G.S. Conference, Vancouver, B.C. #131
Sept. 1995, Vol. 1.

Pressuremeter Testing for Phase I at the Syncrude CANLEX Test Site

J.M.O. Hughes¹, D.Roy², R.G. Campanella², P.M. Byrne², and P.K. Robertson³

¹*Hughes In-Situ Engineering, Inc.*

²*University of British Columbia*

³*University of Alberta*

ABSTRACT

A preliminary review of the pressuremeter tests performed at the Syncrude site as a part of the Phase I of CANLEX project is presented. The results indicate that the material in the zone from 34 to 37m depth is a very uniform material exhibiting a dilative behaviour when sheared.

RÉSUMÉ

Une revue préliminaire des essais pressiométriques effectués sur le site de Syncrude faisant partie de la phase I du project CANLEX est présentée. Les résultats indiquent que le matériau dans la zone cible de 34 à 37m de profondeur est très uniforme montrant une tendance dilatante sous l'action de cisaillement.

INTRODUCTION

The zone of interest in the CANLEX Phase I investigation program is a layer of free draining material between 30 and 40m depth. In view of the low water table and high in-situ stresses inferred from the results of the screening program (Robertson, 1994), a self-boring pressuremeter capable of sustaining a high cavity pressure was deemed necessary. In November, 1993, eight pressuremeter tests in pre-bored holes were carried out by Hughes In-situ Engineering, Vancouver, to ascertain the in-situ state of stress indicated that the self boring tool should be able to develop a cavity pressure of 2500kPa in order to measure deformation properties over a wide range of cavity strains (up to 10%). The self-boring pressuremeter cavity expansion tests were also carried out by Hughes In-Situ Engineering employing a probe with a cavity pressure capacity of 3500kPa. Four cavity expansion tests were performed in this program.

FIELD PROGRAMS AND RESULTS

A series of cavity expansion tests were performed in November, 1993, in Cell 24 of the Mildred Lake Settling Basin (MLSB) at the Syncrude site to estimate the pressure necessary to deform the cavity to about 10% cavity strain (the ratio of the change in the bore-hole radius to the un-deformed bore-hole radius). The estimate was necessary for selecting an appropriate self-boring pressuremeter for characterizing the target zone materials in the detailed site characterization program in Phase I of the CANLEX Project. This series of tests were performed in a pre-bored hole drilled for fixed piston sampling (FPS-3/PMT: 54062.67 North, 53468.36 East). The probe was 76.2mm in diameter, 1.83m long. The hole was drilled employing a 74.5mm diameter tricone bit (Hughes In-Situ, 1994). Five tests were performed in this program in 6 hours. The data indicated that a probe capable of sustaining a cavity pressure of 2500kPa would be necessary in the self-boring pressuremeter testing program at this location. Analyses of data following Carter et al. (1986) to lead to values of peak friction angle in the range 34° to 40°. A value of 0.25 was assumed for the Poisson's ratio in these analyses and the constant volume friction angle, ϕ_{cv} , was taken as 34°.

The self boring pressuremeter used in the detailed site characterization program was also supplied by Hughes In-Situ Engineering. This probe was capable of developing a pressure of 3500kPa. The self-boring pressuremeter tests were performed in March, 1994, at one location in Cell 24 of the MLSB (SBPMT-1: 54069.28 North, 53469.15 East). Attempts of performing cavity expansion tests at another location (SBPMT-2: 54065.57 North, 53458.49 East) had to be aborted as the jetting system was damaged by gravels falling from the surface into the hole. The probe is installed in the horizon of interest with minimal disturbance by jetting a drilling slurry through a jetting rod placed at the centre of the instrument. The drilling fluid was pumped at about 300kPa pressure at a flow rate of approximately 30 to 40 litres per minute. The self boring probe used in these tests was of 76.2mm diameter. The expansion of the cavity was controlled manually using pressurized (bottled) nitrogen. The data acquisition is fully automated via a microcomputer. Although the tests reported in this paper were all completed within four hours, the pre-drilling through the dense layer overlying the target zone was very time consuming. However, it should be noted that these tests had to be carried out under inclement weather with temperature dropping to -30° Celsius. Gravels falling into the hole from the working pad also affected productivity.

Fig. 1 presents the data from tests at 35.0, 35.8 and 36.6m depths. These tests are remarkably similar to each other. Also, these tests do not exhibit the characteristics of bore hole disturbance. These results are completely consistent with the observations from the penetration testing program at this site (Campanella, et al., 1995). However, unlike piezocone penetration, self-boring pressuremeter test allow estimation of material properties from the existing principles of mechanics without the necessity of any empirical correlation.

The data from the self-boring pressuremeter cavity expansion tests were modelled employing a very simple elastic perfectly plastic constitutive relationship (Carter et al., 1986). Plane strain configuration was assumed in these analyses. This simple method uses a single value of the average shear modulus over the entire domain. The average value of the effective shear modulus is approximately equal to 70% of the unload-reload modulus. The value of Poisson's ratio used in this exercise was 0.25. Mohr-Coulomb failure criterion is employed with Rowe's dilatancy relationship. A value of 34° was taken for ϕ_{cv} .

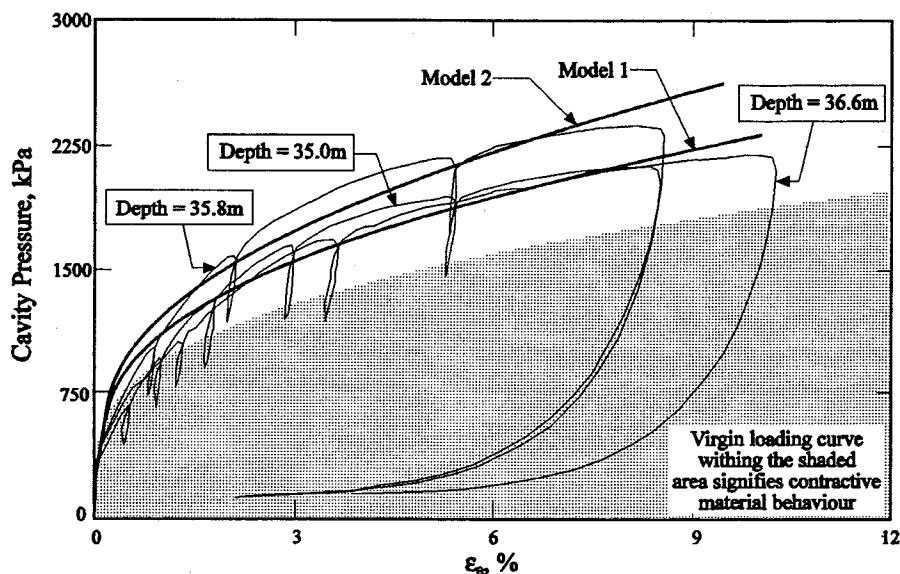


Fig. 1. Modelling of In-Situ Cavity Expansion Data from Self Boring Pressuremeter Test

Models 1 and 2 (Fig. 1) simulate the data from 35.8 and 36.6m depths quite reasonably. The value of K_0 in Models 1 and 2 is about 0.5 and the peak friction angles are 41° and 37° , respectively. These results indicate that the layers between 35 and 36.6m depth are expected to behave in a dilative manner when sheared. The state parameter based correlations (Plewes, et al., 1988) when used with the nearby piezocone penetration data (SCPTU 9404), also leads to a similar conclusion. More realistic models have been successfully used (e.g., Byrne et al., 1995) in back-analysis of self boring pressuremeter data to predict the drained and undrained behaviour of a soil element.

SUMMARY

This report has presented the results of the pressuremeter tests carried out as a part of the general site characterization program of the Phase I of the CANLEX Project. A total of five in-situ cavity expansion tests were carried out to obtain a preliminary estimate of the state of in-situ stresses. In these tests a pre-boring technique was used. Subsequently, four cavity expansion tests were performed using a self boring pressuremeter. The analysis of these results show dilative material behaviour in simple shear. The results also indicate a large degree of consistency in the material encountered in the target zone.

ACKNOWLEDGEMENTS

This work was partly supported by CANLEX (Canadian Liquefaction Experiment), which is a project funded through Collaborative Research and Development Grant from the National Science and Engineering Research Council of Canada (NSERC), and B.C. Hydro, Quebec Hydro, Syncrude Canada Ltd., Suncor Inc. and Kennecott Corporation. The collaboration includes geotechnical consultants, AGRA Earth and Environmental Limited, Klohn-Crippen Consultants Ltd., Golder Associates Ltd., Thurber Engineering Ltd. and EBA Engineering Consultants Ltd., as well as faculty and students from the Universities of Alberta, British Columbia, Laval, Carleton and Sherbrooke.

REFERENCES

- Byrne, P.M., Roy, D., Campanella, R.G., and Hughes, J. (1995), "Predicting Liquefaction Response of Granular Soils from Self Boring Pressuremeter," Submitted for publication, SD27: Dynamic Properties of Gravels, ASCE, San Diego.
- Carter, J.P., Booker, J.R., Yeung, S.K. (1986), "Cavity Expansion in Cohesive Frictional Soils", *Géotechnique*, Vol. 36, No. 3, pp. 349-358.
- Hughes In-Situ Engineering, Inc. (1994), "Preliminary Review of Self-Boring Pressuremeter Tests Performed at the Syncrude CANLEX Site," Report. Submitted to Dr. P.K. Robertson, University of Alberta.
- Hughes In-Situ Engineering, Inc. (1994), "Pressuremeter Testing at Syncrude for the CANLEX Project Data Summary and Preliminary Analysis," Report. Submitted to Dr. P.K. Robertson, University of Alberta.
- Plewes, H.D., and Davies, M.P. (1988), "CPT Based Screening Procedure for Evaluating Liquefaction Susceptibility," Proceedings, Annual Symposium of Canadian Geotechnical Society, pp. 4-1 to 4-9.
- Robertson, P.K. (1994). "CANLEX Report: Screening Program, Phase I", University of Alberta, Department of Civil Engineering.