DISCUSSIONS

EXPERIMENTAL ARRANGEMENTS FOR INVESTIGATION OF SOIL STRESSES DEVELOPED AROUND A DISPLACEMENT PILE[i) THE USE OF MINIATURE SOIL STRESS MEASURING CELLS IN LABORATORY APPLICATIONS INVOLVING STRESS REVERSALS[ii)]

Discussion by MARK TALESNICK[iii)]

The authors have presented a detailed description of how they have dealt with some of the problems involved in the measurement of soil pressures. They have also presented an interesting application of their calibration of pressure sensors in the analysis of a model/instrumented pile being jacked into a granular medium. The thrust of the work presented in the two papers was how to deal with the calibration of soil pressure transducers, whether they are imbedded in a soil mass or part of a structural boundary. The authors have taken for granted that the response of a soil pressure transducer is nonlinear and strongly hysteretic, and that the only way to deal with these difficulties is a complex calibration scheme.

Both of these phenomena make the interpretation of controlled experiments difficult and, at times, nearly impossible. It is important to consider that at times the actual soil response is truly hysteretic and not an artifact of the measurement system. It is well documented in the literature that such calibrations apply to a specific soil placed under specific conditions. As a result, any deviation from these conditions in the actual experimental setup will then require recalibration, or, result in an unknown level of error. Even under the most controlled conditions the placement of soil will almost invariably be non-uniform.

It is therefore surprising that the authors did not look for solutions to the problem by which the non-linearity and hysteresis could be avoided altogether, rather than be dealt with through complex calibration.

Zhu et al. (2009) went to great lengths to explain the influence of the cell effect and its importance in the calibration of a soil pressure unit. They spent an entire paper explaining the details, importance and results of pressure calibrations performed in a sand. However, based on what is shown in their second paper (Jardine et al., 2009) they completely neglected this aspect in the calibration of their Surface Stress Transducers. It seems that the sensors were not calibrated against the soil used in their experimental setup.

Talesnick (2005) presented a system, called the null soil pressure gage, which was developed to measure the normal pressure applied to a structural boundary by a soil (particulate media). The system is an active sensing solution which solves the theoretical and practical problems of interaction of the sensing surface with the soil medium. The system is based on the null method, by which the sensing membrane is constantly forced to remain undeflected. The pressure required to maintain this condition was shown to be the soil pressure applied to the membrane. Under such conditions the sensor does not require calibration. Furthermore, it was shown that the response of the Null Soil Pressure Gage was independent of the stress history (no hysteresis), soil density (stiffness) and particle size (over a wide range of sizes) for a particular sensor diameter. Testing of the system demonstrated these claims. The system has been used very successfully in both small laboratory scale projects (Talesnick et al., 2008, 2010; Talesnick and BarYaacov, 2010) and full scale models. The system allows the true nature of the pressures developed due to soil structure interaction to be examined (Talesnick et al., 2008). Hysteretic response, in many cases, will have nothing to do with the erroneous response of the measuring device. It is, therefore, paramount that the hysteretic response of the measuring system not just be calibrated away, but eliminated.

Recently the Null Soil Pressure system has been extended for in-soil measurements. The device is comprised of two components; (a) the membrane housing with a sensitive measuring face 80 mm in diameter and 1.8 mm thick. A full bridge configuration is glued to the inner side of the sensing diaphragm; 4500 foil strain gages (MicroMeasurements) have proven the best choice. (b) the membrane seal is a flat stainless steel disc which provides an air tight seal to the volume within the membrane housing. The overall thickness of the current version of the sensor is 9.8 mm. The device was designed for use within coarse sands and gravels and the dimensions can be reduced significantly.

The operation of the sensor is based on the same components and algorithm as those used in the structural boundary version of the Null Soil Pressure Gage described by Talesnick (2005).

The application of the null system to the in-soil condition is not trivial. As described by Zhu et al. (2009), placement of a stiff inclusion in a deforming media will induce cell effects. Despite this concern, a set of calibrations tests was performed on granular soils with particle sizes ranging from 0.15 mm to 15 mm (*see* Table 1), each at two levels of density, loose and dense. The calibration tests were performed in a large soil pressure vat, 550 mm in diameter, 300 mm in height. The sides of the vat were

i) By Richard J. Jardine, Bitang Zhu, Pierre Foray and Clive P. Dalton, Vol. 49, No. 5, October 2009, pp. 661–673.
ii) By Bitang Zhu, Richard J. Jardine and Pierre Foray, Vol. 49, No. 5, October 2009, pp. 675–688.
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Table 1. Particle size and densities of materials tested

Material	D_{50} (mm)	Relative density (%)	
Dune Sand	0.15	0	90
Coarse Sand	1.5	0	65
SumSum	4.5	0	—
Adas	15	0	—

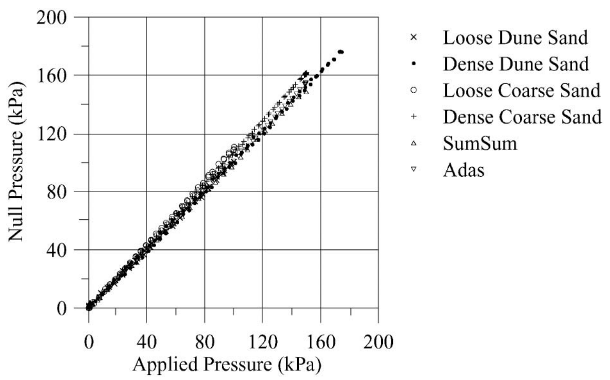

Fig. 1. Results of calibrations performed using different granular soils

covered with a friction reduction tarp (Tognon et al., 1999).

The results of the calibration tests are summarized in Fig. 1 which presents plots of applied vertical pressure (x-axis) versus the required Null Pressure (y-axis). Each plot shown is a full load-unload cycle for a specific particle size at a specific density. The fact that all the plots fall one on top of the other illustrates the lack of dependence on particle size, density and stress history. It is very clear from the plots that there is no hysteresis on unloading, all of the plots are linear and all of the plots are at a ratio of required null pressure to applied vertical pressure of close to unity. In fact, the ratio varies from 0.99 to 1.08. This outcome is surprisingly welcome, since it implies that despite the cell effect, the maximum expected error would be no more than 8% and this is without applying any sort of calibration.

A complete description of the newer in-soil Null Soil Pressure Gage, experimental system and results is currently in preparation and will be published in the near future.

References

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3) Talesnick, M. and BarYa'akov, N. (2010): Soil pressure measurement and calibration of large soil testing vessels, *Submitted for publication*.
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5) Tognon, A. R., Rowe, R. K. and Brachman, R. W. I. (1999): Evaluation of sidewall friction for a buried pipe testing facility, *Geotextiles and Geomembranes*, **17**, 193–212.