the acceptance of finite strain and the inclusion of self-weight.

The extension of any model to an environment different from that in which it has been tested should be undertaken with great care. In this case, a simple model has provided good correlation with accurate laboratory measurements, but an extension to field conditions is likely to require greater flexibility with regard to the soil parameters. This

could be achieved with either approach.

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In situ measurement of horizontal stress in overconsolidated clay using push-in spade-shaped pressure cells

P. TEDD and J. A. CHARLES (1981). *Géotechnique* 31, No. 4, 554–558

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The Authors present in situ measurements of horizontal stress at a site in Essex made using push-in pressure cells and the Camkometer. We have been engaged in a laboratory study of the soil properties at this site. In particular, careful measurements of the capillary pressure p_k' have been made which can be used to determine the horizontal stress using the method suggested by Skempton (1961).

The samples were 105 mm in diameter and 600 mm long and were obtained by thin-walled push sampling. They were stored in the steel tubes with waxed ends. Each sample was trimmed to 102 mm in diameter and 204 mm in height. Pore pressure was measured using a high air entry porous disc and a transducer. Contact between sample and porous disc should be avoided during setting up and this was achieved by standing the sample on two semi-circles of fuse wire (0.864 mm in diameter). The small amount of air trapped by this procedure would be dissolved under the high cell pressures that were used. During the setting up period the pore pressure in the measuring system

was monitored and no significant drop in pressure was observed. Filter paper drains were not used as it has been found that these substantially affect initial sample suction.

After mounting and jacketing the sample the cell was rapidly filled with water and a cell pressure of 800 kN/m² applied. On application of the cell pressure the fuse wire was forced into the sample base and the sample came into contact with the porous disc and the pore pressure measuring system. The sample was then left for about two days so that any pore pressure gradients within the sample could equalize. A small increment of cell pressure was then applied in order to check the value of the pore pressure parameter B . The difference between the measured pore pressure and the applied cell pressure was taken as the initial suction p_k' of the sample.

The results of four tests from the Essex site are given in Table 1. The values of K_0 have been derived from the expression

$$K_0 = \frac{p_k'/\sigma_v' - A_s}{1 - A_s}$$

where A_s has been taken as $\frac{1}{3}$ and $\frac{1}{2}$. A value of

Table 1. Measured values of capillary pressure p_k' and associated values of K_0 and σ_H

Depth: m	Soil type*	Overburden pressure σ_v : kN/m ²	Pore pressure u : kN/m ²	p_k' : kN/m ²	B	$A = \frac{1}{3}$		$A = \frac{1}{2}$	
						K_0	σ_H : kN/m ²	K_0	σ_H : kN/m ²
3	CB	60	0	65	0.972	1.12	67	1.16	69
8.4	LC	168	52	155	0.975	1.51	227	1.68	247
15.1	LC	302	117	231	0.991	1.35	370	1.47	391
19.7	LC	394	162	347	0.971	1.75	567	1.99	624

* CB Claygate beds, LC London clay.

Fig. 1

$A_s = \frac{1}{3}$ corresponds to an isotropic elastic material; London clay typically gives initial values of A_s of approximately $\frac{1}{2}$.

In Fig. 1 the laboratory determined values of total horizontal stress σ_H are compared with the measurements presented by the Authors using push-in pressure cells and the Camkometer. The laboratory determinations lie within the scatter of the Camkometer self-boring pressuremeter results and hence a little below the measurements made with the push-in pressure cells.

The results of the laboratory investigation give support to the validity of the field measurements of horizontal stress that have been made at the Essex site. The laboratory measurements of p'_k may be on the high side because of suctions set up by local shearing between the walls of the sample tube and

the soil during the sampling operation. A correction for this would bring the laboratory values of σ_H closer to the Camkometer self-boring load cell results.

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- Skempton, A. W. (1961). Horizontal stresses in an overconsolidated Eocene clay. *Proc. 5th Int. Conf. Soil Mech., Paris* 1, 351–357.

Authors' reply

Professor Burland and Mr Maswoswe have presented useful information from their laboratory study of capillary pressure in undisturbed samples from the Essex site. Their data complement the in situ measurements of horizontal stress from push-in pressure cells and the Camkometer. The laboratory determinations of total horizontal stress are greater than the Camkometer self-boring load cell results. They lie within the scatter of the self-boring pressuremeter results and are a little below the measurements made with the push-in pressure cells. The push-in cells could be expected to over-read slightly due to the method of installation.

In attempting evaluation of these different methods of measuring horizontal stress, the principal difficulty is the lack of knowledge of the actual horizontal pressure in the undisturbed clay. This absence of knowledge is not peculiar to the Essex site but is always the case. However, the vertical stress at shallow depths in uniform soil conditions below a level ground surface is known with reasonable certainty and is equal to the overburden pressure. There has recently been an opportunity to install push-in spade-shaped pressure cells from a tunnel bored in the London clay. Cells have been installed to measure vertical stress and it is hoped that a comparison with known overburden pressure will lead to a better understanding of the amount push-in cells over-read in London clay.