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General Discussion on Consolidation Theory and Testing

REFERENCE: Leroueil, S. and Kabbaj, M., "**General Discussion on Consolidation Theory and Testing,**" *Consolidation of Soils: Testing and Evaluation, ASTM STP 892*, R. N. Yong and F. C. Townsend, Eds., American Society for Testing and Materials, Philadelphia, 1986, pp. 719–723.

In the past 15 years, continuous oedometer testing techniques have been proposed to determine the compressibility characteristics of clays. These new tests are usually faster than the conventional oedometer test and, moreover, give continuous stress–strain curves. It is thus logical to wonder in 1985 whether or not we should abandon the conventional test in favor of continuous tests.

Essentially for the above reasons the authors would answer yes. Owing to strain rate effects on the behavior of natural clays, however, the results obtained from a "new" test will generally be different from those obtained from the conventional test (Fig. 1). Since our past experience is based entirely on the conventional test, it is necessary to calibrate the "new" test before using it in practice.

Various studies show that the effect of strain rate in natural clays is a very general phenomenon. As indicated in Table 1, strain rate effects were evidenced on a variety of clays with plasticity indices (I_p) between 8 and 105, liquidity indices (I_L) between 0.5 and 2.7, and conventional preconsolidation pressures ($\sigma'_{p\text{conv}}$) between 47 and 940 kPa. The strain rate effect is particularly evident in the normally consolidated range and at the preconsolidation pressure.

Considering Champlain clays, Leroueil et al [1] observed that the preconsolidation pressure–strain rate (σ'_p–$\dot{\epsilon}_v$) relationships had similar shapes. The σ'_p–$\dot{\epsilon}_v$ curves were thus normalized with respect to a reference strain rate taken arbitrarily equal to $4 \times 10^{-6}\ \text{s}^{-1}$ (Fig. 2). As a first approximation, the resulting general relationship can be written:

$$\frac{\sigma'_p}{\sigma'_p(\dot{\epsilon}_v = 4 \times 10^{-6}\ \text{s}^{-1})} = f(\dot{\epsilon}_v)$$

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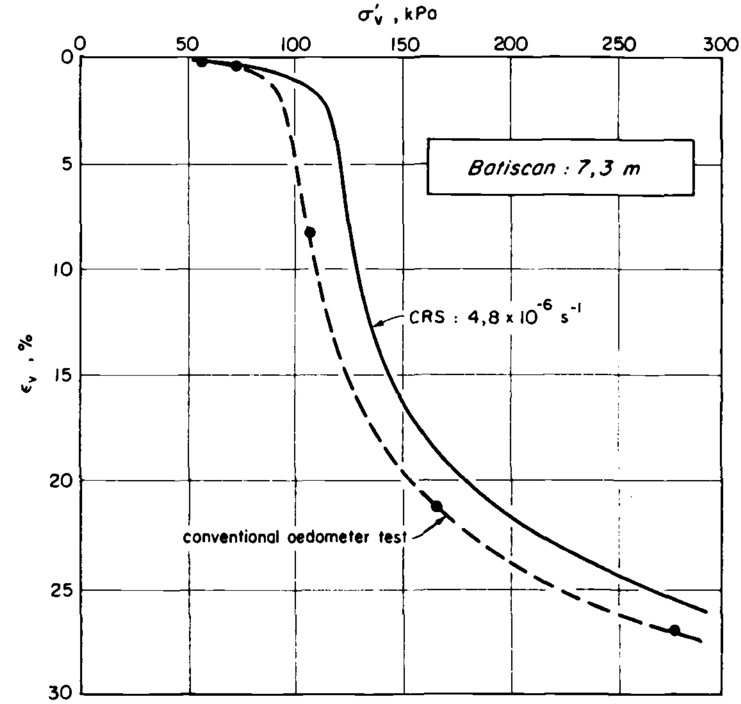

FIG. 1—*Typical compressibility curves obtained from conventional and CRS tests.*

TABLE 1—*Characteristics of clays presenting strain rate effects.*

Clays	I_p	I_L	$\sigma'_{p\,conv}$ (kPa)	S_t	Reference
Champlain clays:					
Ottawa clay	8	4	480	>50	*6*
14 clays	19 to 43	0.9 to 2.7	47 to 270	15 to 108	*1*
Louiseville	33	1.7	88	20	*4*
Other Canadian clays:					
Saint Jean–Vianney	16	1.4	940	≃100	*7*
Winnipeg	35 to 55	≃0.5	?	3	*8*
Broadback	11	2.1	175	≃200	authors' files
Other clays:					
Bäckebol (Sweden)	65	1.04	≃70	25	*9*
Belfast (N. Ireland)	20 to 40	≃0.75	?	8	*8*
Vallda (Sweden)	≃105	≃0.76	?	?	*3*

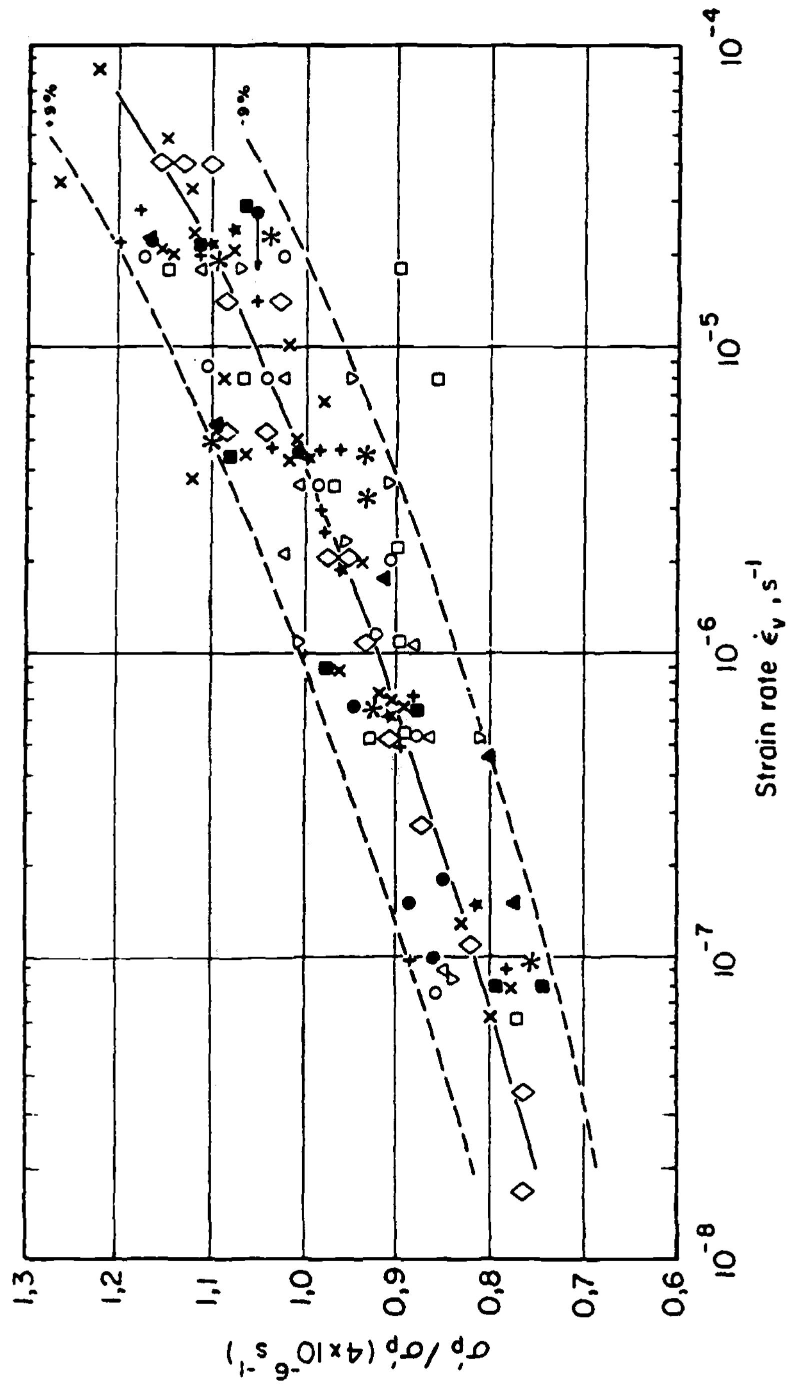

FIG. 2—*Normalized preconsolidation pressure–strain rate relationship* [1].

For conventional tests, it appears that the preconsolidation pressure of Champlain clays corresponds typically to a strain rate of 10^{-7} s^{-1}. Similar observations were made by Larsson [*2*] and Larsson and Sällfors (Fig. 8, [*3*]) on Swedish clays and by Silvestri et al (Table 2, [*4*]) on a Champlain clay.

From these remarks, it follows that the preconsolidation pressure obtained at a given strain rate can be related to the conventional preconsolidation pressure by the relation

$$\sigma'_{p\,\mathrm{conv}} = \frac{\sigma'_p(\dot{\epsilon}_v)}{\alpha_2}$$

Figure 3 shows the α_2–$\dot{\epsilon}_v$ relationship obtained for Champlain clays. For example, for a strain rate of 2×10^{-6} s^{-1}, as used in Sweden, the α_2 factor would be equal to 1.18.

Moreover, Leroueil et al [*5*] found that the effective stress–strain–strain rate relationship is unique. Therefore, not only the preconsolidation pressure, but the whole stress–strain curve, must be corrected by a strain rate factor α_2.

In conclusion, we believe that we are now ready to use continuous tests in Southern Quebec. Owing to its simplicity and to the important fact that the α_2 coefficient is the same during the entire test, we tend to favor the CRS test.

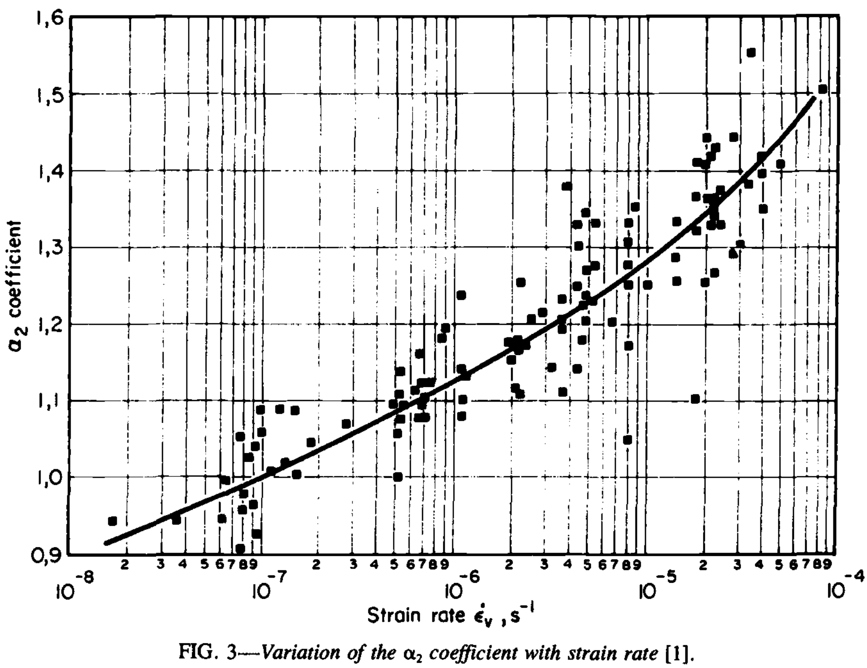

FIG. 3—*Variation of the* α_2 *coefficient with strain rate* [1].

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