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The use of a compression modulus to describe compaction behaviour

Several authors, including Carless & Leigh (1969) have used a compression modulus of the form log (P)/(D) (where P is a function of axial pressure, and D is a function of density of the compact) to describe the compaction behaviour of particulate materials. The following results may indicate a need for caution in certain instances when using a parameter of this type.

In a discussion of the effect of moisture on the compaction of sodium chloride at a series of pressures, Huffine (1953) quoted mean values of the "pressing modulus", $d \log P_a/dV_r$ proposed by Bal'shin (1938), although the relation between the logarithm of applied pressure P_a, and the relative volume V_r was not linear over the entire range of applied pressure. The "pressing modulus" was shown to increase when the particulate material was previously exposed to conditions of elevated humidity. Huffine considered that this implied an increase in the resistance to consolidation of the compressed material. However, inspection of Huffine's data (Table 1) shows that at each applied pressure, the relative volume was greatest for the dry material.

Table 1. *Effect of moisture on the relative volume of compacts prepared from* 24–28 *mesh sodium chloride* (*Huffine*, 1953)

Applied pressure (p.s.i.)	Relative humidity of storage for 24 h			
	0%	36·4%	54·2%	74·9%
1880	1·374	1·355	1·329	1·278
9410	1·150	1·126	1·146	1·101
33940	1·020	1·001	1·005	1·014
61200	1·001	0·987	0·993	1·001
$d\log P_a/dV_r$	3·17	3·32	3·58	3·67

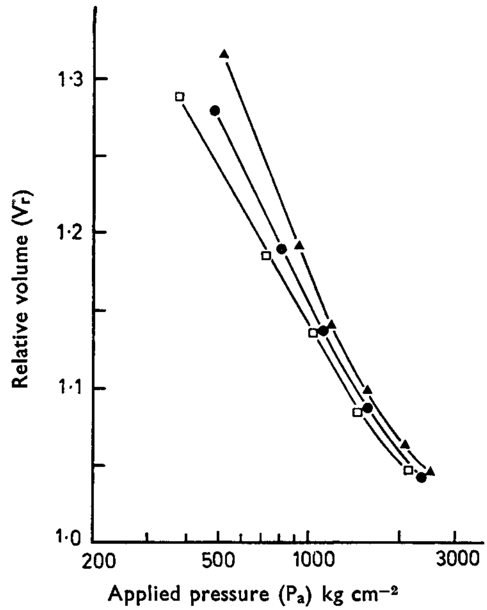

FIG. 1. The effect of moisture on the relation between the relative volume and the logarithm of applied pressure for sodium chloride (30–40 mesh) ▲; dry material compressed in a "conditioned" die, ●; 0·02% moisture, □; 0·55% moisture.

During the initial stage of compaction, consolidation occurs mainly by the relative movement of intact particles. The present results (Fig. 1) demonstrate that at low pressure, the relative volume of material containing moisture is much lower than that of a dry compact. This suggests that the formation of temporary struts, columns and vaults (Endersby, 1940) is minimized by a lubricant effect of moisture at the die wall and interparticulate boundaries (Shotton & Rees, 1966).

At higher pressures, when voidage reduction occurs mainly by deformation and fragmentation, the lubricant property of moisture will have less effect on consolidation, and the slope of a graph of relative volume versus logarithm of applied pressure is therefore decreased by moisture. Consequently, the "pressing modulus" d log P_a/dV_r is increased although at all values of applied pressure the relative volume is lower than for dry material. Accordingly, in such cases it is insufficient to quote values of the pressing modulus unless the actual relations between pressure and relative volume are also considered. Huffine's conclusions that moisture increased the resistance to consolidation, and did not exert a lubricant effect, appear to be invalid for this reason.

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