Natural Moisture-content, Porosity and Compaction of Clayey Deposits

It seems desirable that attention should be directed to the very discordant figures for porosity (or void-ratio) of clayey sediments that are yielded by the two different methods of determination that may be adopted, namely, by direct measurement or by calculation from the natural moisture-content. I cannot but think that the discrepancies must have been commented on during the past two decades as knowledge of natural moisture-contents steadily grew; but my inquiries have failed to produce any reference to a published discussion of their implications.

In the following paragraphs the symbols m and n are those used in geotechnical (soil-mechanics) laboratories, m for the natural moisture-content expressed as grams of water per 100 gm. of solid dried to constant weight at 105–110° C., and n for the porosity calculated from m and expressed in the usual manner as the percentage of the total volume occupied by voids. The symbol P is retained for the porosity determined directly by the standard methods. The void-ratio e is the volume of voids to the volume of solid.

The evaluation of m presents no difficulties; but precautions are necessary to ensure that the samples when tested are as nearly as possible in their natural 'undisturbed' condition (in the engineering sense). Weathered or obviously fissured samples are rejected. Sediments lying below the ground-water table are known to be, with few exceptions, saturated down to a considerable depth, although the precise limit is in doubt. All the samples here referred to came from this zone of saturation.

A small but representative selection of values of m, n and P for some British clayey sediments is given in the accompanying table.

	m	n	P
Pleistocene bedded clay	50	57 per cent	31 per cent
Tertiary clays	28	43	29
Upper Cretaceous Gault	29	44	24
Jurassic, Lias	22	37	24
Triassic, Keuper	12	24	12
Coal measures, shale	13	26	10

By way of contrast to the discordant values shown in the last two columns, the results for n and P in the case of a fine-grained calcareous material such as the Upper Chalk reveal no discrepancy. The mean of a number of values obtained by different investigators with samples from various parts of the country is closely 44 per cent for both n and P. It will be observed that this figure falls into its appropriate place in the age-sequence, between the Tertiary clays and the Gault, in the column for n, but not in that for P.

Since the determinations of m and P for sediments from other European countries and from America, so far as I have been able to trace them, are of the same order of magnitude, horizon by horizon, as those listed in the table, and since the procedure followed is similar, there seems no escape from the conclusion that the standard method of directly determining porosity is not suitable for materials containing an appreciable quantity of clay. It is not feasible to allow sufficient time in the laboratory for the restoration of the structure which previously existed in or around the clay-mineral lattices but which was destroyed when the samples were dried.

It should be noted that the volume-shrinkage caused by drying of the test-specimens seems to be inadequate, at least in most cases, to account for the difference. Even if it did so, the objection to the use of the low P values still remains.

That such low values should have been recorded for P will probably not surprise those familiar with the physical changes in clayey materials (for example, loss of plasticity, lowering of liquid limit, increase of grain-size, etc.) produced after even short periods of air-drying.

The porosities vary, of course, according to which particular clay-mineral species is dominant. In due course, we may hope to compile a table for each dominant species. The few figures that are available for montmorillonoid clays indicate that they will fall into a separate series with values of n much higher (as their swelling capacity would suggest) than those in the above table. Passing reference may also here be made to the abnormally low porosity of boulder clay, first discovered by H. C. Sorby and ascribed by him to exceptionally high compression, possibly by ice-load. The determinations of m have confirmed his observations. An average figure for m is 15, whence n is 28 per cent, Sorby's value for P being 24 per cent. The discrepancy here is smaller than in the case of the other clays mentioned, possibly because of the very different mineralogical composition, the quantity of silt and rock-flour in the matrix being usually considerable.

From the values of P set out in the table, and from other similar direct determinations by the standard methods (for example, on air-dried cuttings from deep well drilling) the void-ratio e appears to be only a third to a half its true value as calculated from m. If additional records confirm this, many inferences that have been drawn from the erroneous figures for e will need to be revised, and calculations relating to depth of burial, gravitational pressures, compaction, bulk-density and volumes of sediments may require substantial adjustment.

Many other interesting problems are presented by the records of m that have already accumulated. Since these are all too few, however, it is to be hoped that full advantage will be taken of the exceptional opportunities for collecting and testing clayey sediments at present afforded by numerous engineering undertakings and programmes of exploratory and other borings distributed widely throughout Great Britain.

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Prominence Activity and the Sunspot Cycle

The relationship that exists between the distribution and frequencies of prominences at the limb of the sun and the sunspot cycle has been discussed by several workers[1]. The most outstanding feature is the existence of two distinct zones of prominence activity in each hemisphere. The low-latitude zones extending from the equator to about 50° are always present, although prominence activity in these zones is least at the epoch of sunspot minimum. The high-latitude zones have a different life-history. Prominence activity in these zones drops very suddenly and becomes quite inconspicuous shortly after sunspot