

DETERMINATION OF THE MOISTURE CHARACTERISTICS OF BUILDING MATERIALS BY MEANS OF A SECTIONAL COLUMN

E. L. Tertichnik

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A method is presented for finding moisture characteristics in terms of the moisture potential using a sectional column. The method of conducting the experiments and a discussion of results obtained by this method are given.

In carrying out moisture transfer calculations on multi-layer building elements based on the moisture potential, we use curves giving the dependence of the moisture content of the material on the potential and the coefficients of specific moisture capacity and moisture conduction over the practical range of moisture potential values.

The sectional column takes the form of a vertical prism consisting of layers of test material and a standard material (Fig. 1). These serve as moisture-content "meters." The layers of test material are prepared in the form of plates measuring 40 x 40 x 10 mm. The thickness of 10 mm allows the moisture potential gradient in the layers to be assumed constant without serious error.

Filter paper is used as the standard material and for convenience of working may be bound into packets weighing 0.5 g. Each layer of filter paper in the column consists of two packets or half layers. It is assumed that each half layer measures the potential of the surface with which it is in direct contact. Determination of the potential from the moisture content of the sheet of filter paper directly in contact with the surface of the test plate gives large errors if the moisture is determined gravimetrically, owing to the small weight of a single sheet.

The prism is moisture-proofed at the sides by means of metal screens lined with sheet rubber. To avoid evaporation at the junction between screens and prism a thin rubber strip is laid under the screen. The screens are secured by a screw clamp. It is recommended to start by fitting two opposite parallel screens, after first packing with rubber strip. Thus it is possible visually, and otherwise, to inspect the degree of contact between the test and standard materials. A tight joint between two screens prevents any separation of the layers on further assembly.

The assembled column is supported in a beaker of water, fed through a wick. The gap between beaker and prism is sealed, so that water can evaporate only through the upper face.

Under the influence of the difference in moisture potential between the ends of the column, moisture moves upwards, saturating the layers of test and standard materials and partially evaporating from the upper face. After a time sufficient for all the layers to attain a state of moisture equilibrium, the quantity of water entering the lower face becomes equal to the quantity of moisture evaporating. The onset of this condition is determined from the curve of change in weight of the apparatus with time. The column is then dismantled, and the weight of water in the layers of the test material and the half layers of filter paper is determined. The moisture in the standard material is converted to degrees moisture by the generally accepted method.

Each layer of test material gives one value of the moisture content or coefficient of moisture conduction as a function of the moisture potential.

To obtain $U = f(\Theta)$ for a particular layer k , it is sufficient to know the mean moisture content of this layer U_k kg/kg and the mean value of the moisture potential Θ_k^{av} . The Θ_k^{av} corresponding to this U_k (Fig. 2) in the apparatus is

$$\Theta_k^{av} = (\Theta_k^u + \Theta_k^l)/2.$$

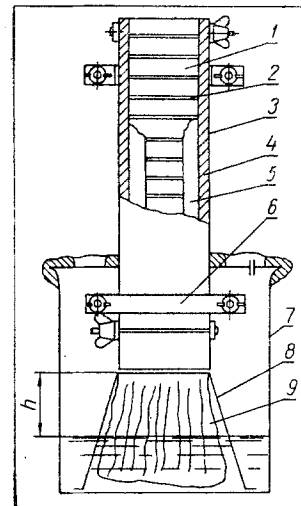


Fig. 1. Diagram of apparatus: 1) layer of test material; 2) layer of filter paper; 3) metal screen moisture-proofing; 4) sheet rubber moisture-proofing; 5) rubber strip; 6) thin tube for equalizing barometric pressure inside and outside apparatus; 7) beaker of water; 8) stand; 9) hygroscopic cotton wool wick feeding water to bottom of column

The coefficient of specific moisture capacity $\eta = \partial U / \partial \Theta$ is determined by differentiation of the moisture content with respect to the moisture potential.

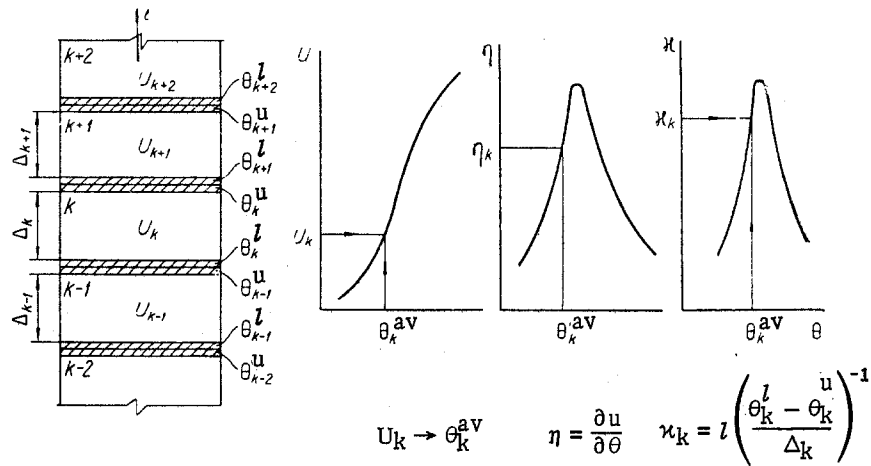


Fig. 2. Determination of moisture characteristics by the sectional column method

The coefficient of moisture conduction κ_k for layer k of the test material is given by:

$$\kappa_k = i \left[(\theta_k^l - \theta_k^u) / \Delta_k \right]^{-1}.$$

The value of κ_k obtained relates to the mean value of the potential Θ_k^{av} .

Tests show that in the construction of the apparatus good contact was achieved between the standard and test materials, especially for moisture contents greater than 150 °M. At lower values, of the order of 40 °M, the filter paper becomes stiff and more care is necessary to ensure a tight contact. With the help of this apparatus moisture characteristics were determined in the range from 20 to 1100-1200 °M. Under the conditions existing in the apparatus a potential of 1100-1200 °M corresponds to complete moisture saturation of the filter paper.

The experiments did not last longer than two months.

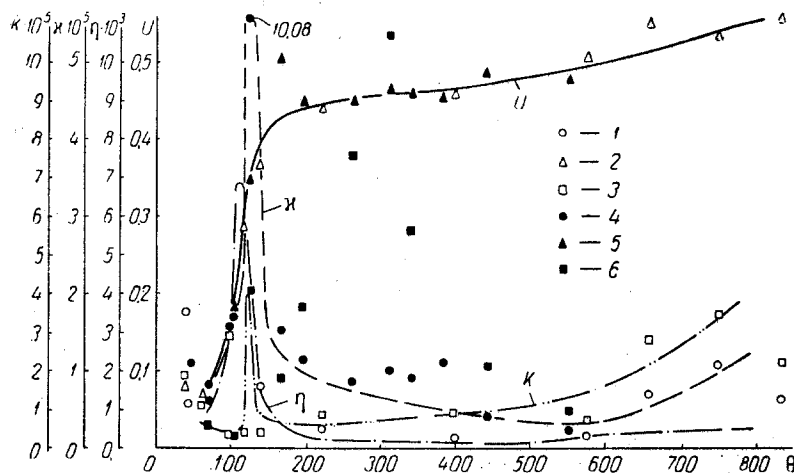


Fig. 3. Moisture characteristics of vibrated cellular concrete ($\gamma_0 = 8110$ newton/m³), obtained by the sectional column method on moistened (1 - κ , 2 - U, 3 - K) and non-moistened (4 - κ , 5 - U, 6 - K) specimens

On this apparatus to obtain characteristics at low values of the potential it is necessary to vary the distance h (Fig. 1) between the water and the end of the column or partially to moisture-proof it.

The scatter of experimental points obtained by this method is less than in similar experiments by other authors, since it is possible to use a single sample of test material and repeat the experiments over other ranges of moisture and temperature. The confidence that can be placed in the characteristics obtained is thus significantly increased.

Several material were investigated on the apparatus described. Figure 3 presents the results of tests on vibrated cellular concrete.

Two sets of apparatus were used in the investigation, in each of which were placed 12 plates of the test material. In one apparatus the plates were moistened up to a point approaching saturation before assembling the column. The relations $U = f(\Theta)$, $\eta = f(\Theta)$ and $\kappa = f(\Theta)$ were determined in the way previously described. In order to determine the coefficient of moisture conduction $K(\text{m}^2/\text{hr})$ the moisture content of the plates was first calculated from the curve $U = f(\Theta)$, and then the K values were computed.

All the characteristics are presented as functions of the moisture potential.

The data show that the spread of points for all characteristics is insignificant at moisture contents up to 200°M , after which it sharply increases, particularly for the coefficient K .

Characteristic of the variation of η , κ and K is the occurrence of a sharp maximum in the region $100\text{-}127^\circ\text{M}$. The relation $\eta = f(\Theta)$ has a maximum at a lower value of the potential than $\kappa = f(\Theta)$ and $K = f(\Theta)$.

It is of interest to note that the values of the coefficient obtained in the apparatus without preliminary moistening are significantly higher than those obtained in the apparatus with preliminary moistening in the range from 250 to 400°M .

The present method permits the determination of the moisture characteristics of building materials over a wide range of values of the moisture potential in a single experiment. Also in its favor is the possibility of carrying out several investigations on one and the same sample.

NOTATION

Θ_k^u and Θ_k^l — moisture potential at upper and lower surface of a layer, determined from the moisture potential of the adjacent half layers of filter paper; i — moisture flow through apparatus under steady state conditions; Δ_k — thickness of a layer of test material.

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Kuibyshev Structural Engineering Institute, Moscow