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Hedenblad, Göran

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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Göran Hedenblad

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Moisture Permeability of some Porous Materials

Göran Hedenblad, MSc, PhD Eng.*

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1. INTRODUCTION

The moisture permeability, or as it also is called the water vapour diffusivity (δ_v) for many modern building materials depends on the moisture content of, or the relative humidity (RH), in the material; see Figure 1.

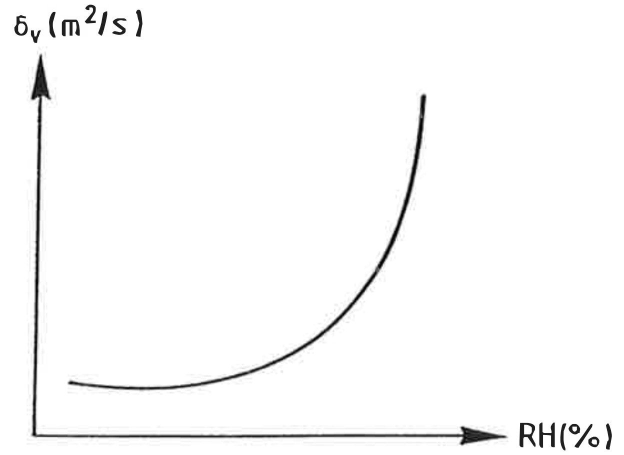

Figure 1 Moisture permeability (with the humidity by volume as potential) as a function of the relative humidity. In principle.

2. THEORY

According to Fick's first law we can write in one dimension

$$g = -\delta_v * dv/dx \qquad (1)$$

g is the density of moisture flow rate [kg/(m^2,s)]
v is the humidity by volume in the pores of the specimen [kg/m^3]
δ_v is the moisture permeability with regard to humidity by volume [m^2/s]
x is the length

* Division of Building Materials, Lund Institute of Technology, University of Lund, Box 118, S-22100 Lund, Sweden.

For many materials, the moisture permeability is not a constant, but varies with the moisture content in the material and with the temperature. δ_v may also be different if a material is under desorption or absorption.

δ_v in Eq.(1) describes the total transport of moisture in the material. The moisture flow can theoretically be divided into two parts, one which depends on pure diffusion, and one which depends on the capillary suction which acts on the moisture flow in the liquid phase.

3 THEORY FOR THE MODIFIED CUP METHOD

By using the cup method in a special way, it is possible to get δ_v as a function of the relative humidity. The modification was mentioned by Bažant and Najjar (1972) and has been developed for practical application by Nilsson (1980).

The following is almost directly from Nilsson (1980).
The moisture flow through a disc of a material is attained by placing a cup, with the disc as a lid and containing a saturated salt solution giving a humidity by volume v_1 , in a climate room with a humidity by volume v_2 ; see Figure 2.

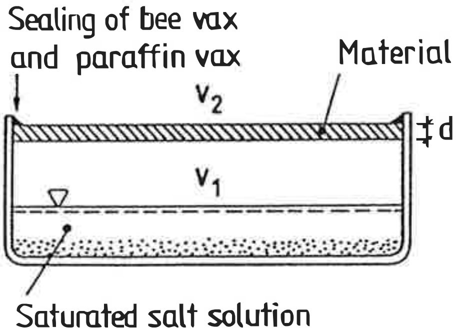

Figure 2 Principle of diffusion measurements with the cup method.

The moisture flow through the material is determined by weighing until stationary flow is obtained. The average moisture permeability in the interval between the two climates is obtained by one measurement. More information can, however be obtained by using a series of measurements.

Integrating Eq.(1) between x = 0 and x = d, where d is the thickness of the specimen, yields

$$g*d = \int_{x=0}^{x=d} - \delta_v(v) * \delta v/\delta x * dx \quad \textbf{(2)}$$

Derivation with respect to the humidity by volume v_1 is as follows after simplification

$$\delta_v(v = v_1) = d * \delta g/\delta v_1(v = v_{1i}) \quad \textbf{(3)}$$

Eq.(3) means that by a series of measurements with a constant climate at one side and gradually higher humidity by volume v_{1i} at the other, the effect of moisture on the moisture permeability can be measured at discrete humidity by volume and not only as the mean value during an interval. A complete deducation is given in Nilsson (1980). Nilsson uses vapour pressure instead of humidity by volume.

In Figure 3 the moisture flow rate is shown as a function of humidity by volume at the bottom side of the specimen. The higher v is, the higher is the moisture flow rate. The moisture permeability is achieved by determining the slope of the curve in Figure 3 for different humidities. When the temperature during the test is constant we can use RH instead of v.

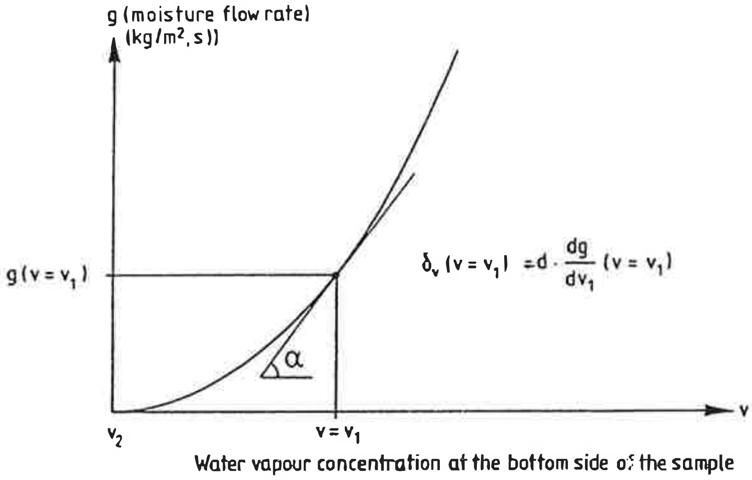

Figure 3 Determination of the moisture permeability.

4. EXPERIMENTAL ARRANGEMENT

The variation of δ_v as a function of RH between 35 to 100 % has been investigated with the cup method mentioned above. RH outside the cups is about 35 % and RH inside the cups is about 60, 75, 82, 85, 90, 95, 98 and 100 %. These RHs are brought about with saturated salt solutions (except 100 %). A cup is shown in Figure 4.

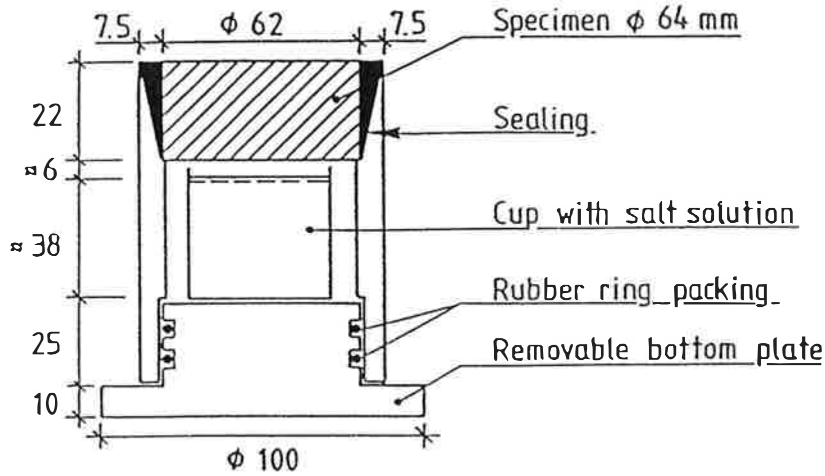

Figure 4 Moisture permeability cup.

The bottom of the cup is removable therefore the cup can be refilled with liquid . This means that the liquid surface in the cup can be nearly constant and close to the bottom side of the sample (about 7 to 10 mm.). This is important for open materials. If the distance between the sample and the liquid surface is increased, the moisture resistance of the air gap would be big compared to the moisture resistance of the sample. RH on the bottom side of the sample would then be much lower than the RH of the salt solution. During the evaluation of the results, the moisture resistance af the air gap, has been considered.

5. RESULTS

At BML we have measured the moisture permeability for about 15 different materials. Some of the preliminary results are shown in Figure 5 to Figure 8.

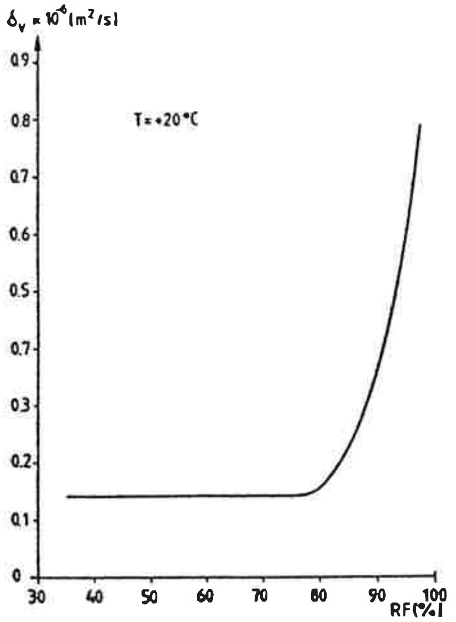

Figure 5 Hardboard

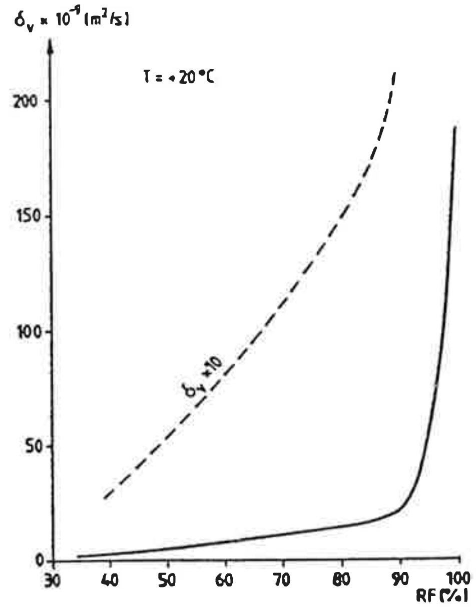

Figure 6 Linoleum

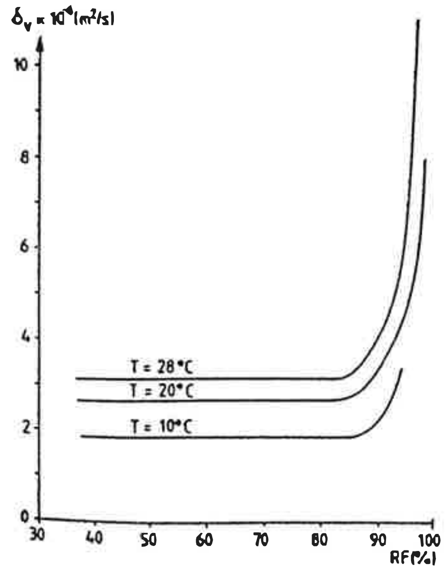

Figure 7 Lightweight concrete

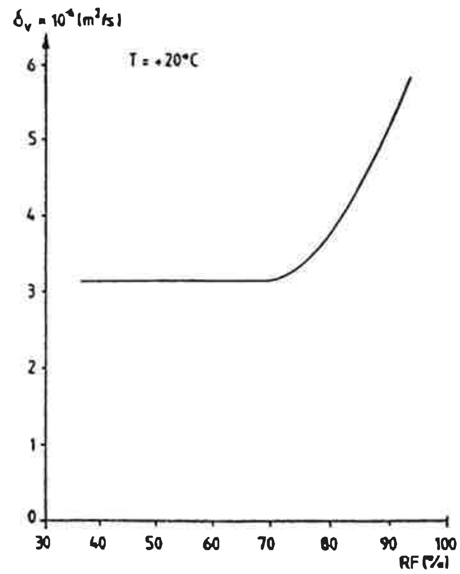

Figure 8 Plasterboard

6. REFERENCES

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