THERMOMECHANICAL TESTING OF AN AERATED CONCRETE WALL

Zs. Józsa and J. Várfalvi

Department of Building Materials
Technical University, H-1521 Budapest

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Abstract

A one year old aerated concrete wall still contains a substantial amount of moisture and dries slowly. Full scale tests show that the aerated concrete material, regarded as homogeneous, has a different thermal conductivity through the wall cross section. The relationship between thermal conductivity and moisture content is determined. A 30 cm thick aerated concrete wall with mortars on both sides has a factor of thermal conductivity of 0.59 W/m^2K in spite of the high moisture content.

Testing heat-bridges (corners, slab-wall, wall-floor-footing) shows the standard temperature difference is likely to cause dew on the inner wall surface.

1. Introduction

Walls built from aerated concrets contain a substantial amount of water after construction. Drying is a slow procedure and depends on the transport properties of aerated concrete and the diffusion through the mortars.

It is known that moisture content is not steady in structures and moisture moves. The moisture collection or distribution depends on the absorption and isothermic properties, the capillary action of the material and the formed partial or saturated pressures. Because partial and saturated pressures change through the wall there is also a change in the moisture distribution.

It is possible to determine the thermomechanic properties of wall structures in a laboratory but without modeling the real effects of climate and moisture movements the results will not be the same as those measured in a real structure.

The slow drying of aerated concrete in real circumstances has a marginal influence on the thermomechanic behaviour thus the measurements are continuously taken on an experimental building.

2. Thermomechanic testing of an experimental building

2.1 *The experiment*

Thermo-elements were placed into the four vertical walls of the experimental building. These thermo-elements divide the wall cross-section into four equal parts. With the assistance of thermo-elements on the internal and exter-

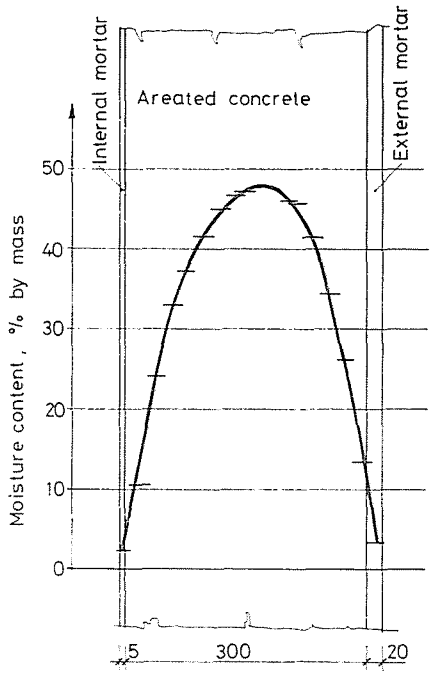

Fig. 1. Moisture content through the wall. Eastern wall, middle. 23/11/1987

nal wall surfaces and with heat current sensors the temperature distribution and the "heat current density" are measured in the wall cross-section.

The internal temperature of the experimental building is automatically controlled and kept at a constant level (ti). The external temperature is given by the climate. A computerised data logging system takes the readings at any time intervals. Measurements are taken continuously but the only ones accepted are those where the day/time temperature change was between 1—2 °C over a 4—5 day period.

Samples were taken from the wall at different time intervals to determine the moisture distribution of the wall. Figure 1 shows the moisture distribution in a 1 year old gas concrete wall. Maximum moisture content occurred at about twice the level of absorption saturation and only the 2—3 cm edge of the aerated concrete wall is regarded as dry.

2.2 *General description of wall* (1987 November)

Wall sections without "heat bridges" are selected and one dimensional heat transfer through the wall is assumed. Readings with the data logging system are taken every half hour during the period when the external temperature is close to the constant. The internal average air temperature is $t_i = 24.91$ °C, the external average air temperature is $t_e = 6.76$ °C. Table 1 shows more details.

Table 1

Property	Unit	Northern wall	Eastern wall	Southern wall
Temperature:				
t_{Es} (external surface)	°C	8.09	8.42	7.97
t_1: 7.5 cm from ext	°C	11.64	11.59	11.33
t_2: middle	°C	14.19	14.45	13.82
t_3: 7.5 cm from int.	°C	17.22	17.26	17.50
t_{Is} (internal surface)	°C	22.7	21.54	21.98
Heat transferred	W/m^2	9.19	8.46	9.14

The temperature distributions in the different wall sections indicate different moisture content in the structure. The temperature distribution in a homogeneous wall is linear under stable external and internal conditions. In our case there are marginal changes in the temperature distribution through the wall, as if there was a material change inside the wall, which indicates the change in thermal conductivity.

Table 2 shows the thermal conductivity of the aerated concrete through the wall. Table 3 shows the moisture content of the same wall sections. Data was obtained from drilled samples.

Table 2

Changing of thermal conductivity through the thickness

Thermal conductivity (W/mK)	Northern wall	Eastern wall	Southern wall	Average
I. zone	0.194	0.200	0.204	0.199
II. zone	0.251	0.222	0.275	0.249
III. zone	0.244	0.226	0.186	0.219
IV. zone	0.126	0.148	0.153	0.143

Table 3

Changing of average moisture content through the wall thickness

Moisture content % mass	Northern wall	Eastern wall	Southern wall	Average
I. zone	20.7	21.4	22.9	21.7
II. zone	44.0	44.9	30.2	42.7
III. zone	45.6	45.2	40.4	43.7
IV. zone	26.2	19.2	17.2	20.9

All of the measured moisture contents (ω) and the respective thermal conductivities (λ) are considered when the thermal conductivity is expressed as a function of moisture content,

$$\lambda = 0.00266\omega + 0.117 \tag{1}$$

The average calculated thermal conductivity of wall zones is 0.203 W/mK and the thermal conductivity of the one year old gas concrete wall structure (with mortars) is

$$\bar{k} = 0.59 \text{ W/m}^2\text{K},$$

which satisfies the appropriate Hungarian Standard ($k < 0.7$) in spite of the high moisture content.

2.3 *Thermomechanic testing of "Heat Bridges"*

Similar to the wall structures the heat bridges were tested under stable temperature differences using heat sensors. The temperature of the inner surface of the one year old gas concrete wall under the standard temperature difference (external —15 °C, internal +20 °C, $\Delta t = 35$°C) is calculated with the measured thermal conductivities of the wall zones.

It is stated that in the wall with high moisture content

— the corner — as a geometric heat bridge — could cool below dew point (Figure 2).

— On the slab — around the edges — vapour condensation is likely to occur unless an efficient heat insulator is used on the ring beam (Figure 3).

— The joint — of wall, footing and floor — is the most critical because here there is the highest chance of the lowest temperature (Figure 4a). A post

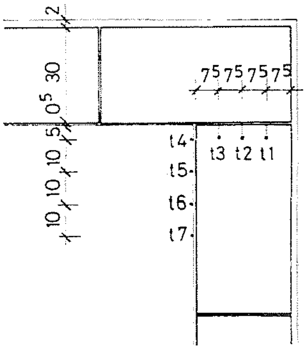

Fig. 2. Heat sensors in the corner (horizontal cross-section). External surface temperature —15 °C, internal temperature +20 °C, $t_4 = 13.3$ °C, $t_5 = 14.0$ °C, $t_6 = 14.2$ °C, $t_7 = 14.6$ °C

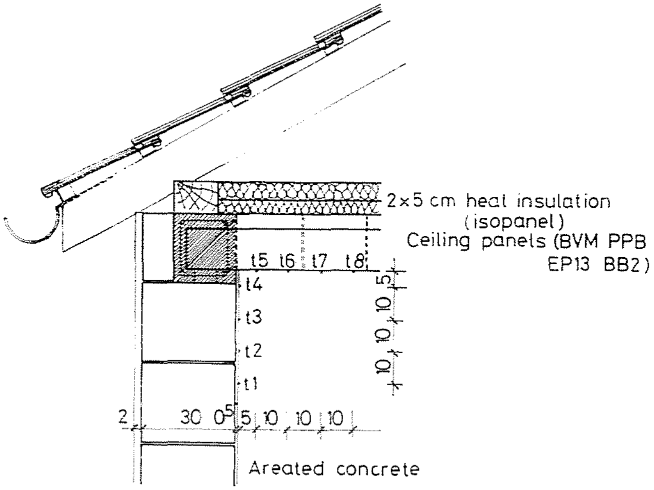

Fig. 3. Heat sensors in the wall-slab joint. External temperature −15 °C, internal temperature +20 °C, $t_1 = 15.8$ °C, $t_2 = 16.5$ °C, $t_3 = 16.5$ °C, $t_4 = 13.6$ °C, $t_5 = 12.6$ °C, $t_6 = 14.6$ °C, $t_7 = 15.3$ °C, $t_8 = 15.8$ °C

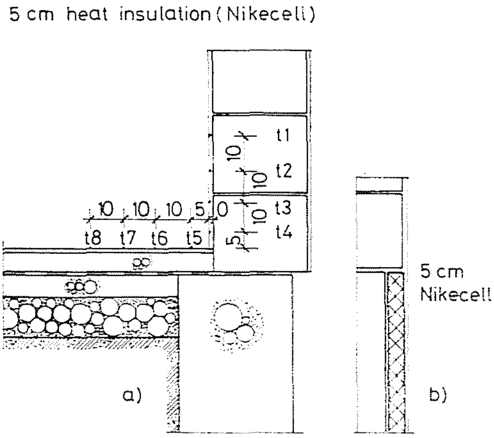

Fig. 4. Heat sensors in the wall-floor-footing joint. External temperature −15 °C, internal temperature +20 °C, a) $t_1 = 11.2$ °C, $t_2 = 10.2$ °C, $t_3 = 9.1$ °C, $t_4 = 7.4$ °C, $t_5 = 4.4$ °C, $t_6 = 5.0$ °C, $t_7 = 7.2$ °C, $t_8 = 9.1$ °C, b) $t_1 = 12.4$ °C, $t_2 = 11.9$ °C, $t_3 = 10.1$ °C, $t_4 = 9.9$ °C, $t_5 = 8.1$ °C, $t_6 = 8.4$ °C, $t_7 = 10.1$ °C, $t_8 = 11.2$ °C

insulation of the footing (Figure 4b) marginally developed the temperature distribution of the heat bridge.

As drying proceeds in the gas concrete wall the temperature increases on the internal surface of the heat bridge.

Dr. Zsuzsanna Józsa } H-1521, Budapest
Dr. János Várfalvi }