STRAIN CAUSED BY TEMPERATURE IN A MASONRY STRUCTURE

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ABSTRACT The properties of a masonry structure and its behaviour are determined by interactions of brick and mortar.

Thermal expansion of bricks and mortars depend on the strenght and the pore properties. Water content of materials have an influence on the behaviour of a masonry structure.

INTRODUCTION

In this paper different properties of bricks and mortars having an influence on the extent of dilation are dealed with.

In Finland daily temperature fluctuations can be considerable. Masonry structures are often subjected to the most stress in spring and autumn, when temperature range is on both sides of the freezing point. Relative humidity and rainy weather also affect here. If the bricks have a good pore size distribution and are well burnt they will resist decay by freezing water.

Experience in frost resistance shows that small pores present caused the greatest risk of frost demage. It is known that water freezing to ice expands by 9 %.

MATERIALS AND METHODS

The test materials constitute a normal burned red clay bricks both a cement-sand mortar (A) and a lime-cement-sand (35/65) mortar (B).

The pore properties were determined by mercury porosimetry model "Micromeritics Pore Sizer 9300 (1). Water adsorption were measured by so called desiccator methods (2). In this methods the samples were allowed to be equilibrated with vapours of certain salt solutions at 25 ^{o}C.

Dilation curves were measured by the Demec measuring pins (3). In the laboratory the test pieces were kept in a weather cabinet in which the temperature varied between +30 ^{o}C and -30 ^{o}C. The other properties were tested using the SFS-standard methods.

RESULTS

The main causes of strain in structures are shrinkage during the setting of the mortar, changes in volume due to fluctuations in moisture content, strain caused by the load on the structure and heat changes.

It is important to know the microstructure of materials (4). In the structural tests a mercury porosimeter was used to determine the pore distribution, the pore size and the pore volume of the samples (table 1). We measured pores below 0,2 µm by water adsorption method. Water adsorption of mortars A and B and brick differ from each other (fig. 1). The brick which has a little fine pores bellow 1 µm is a typical well burnt one. Bricks burned at relatively low temperature normally have highter fine pores. Dilation behaviour of the materials depends on pore properties (table 1). The water froze in the samples due to the irregular strain (fig. 2, point x).

The dilation difference of the brick and mortar A is caused by the great amount of fine pores in the lime-cement mortar (B) (fig. 2).

The cement based mortar (A) contains a little fine pores and the dilation properties are similar to those of the brick.

Table 1 Pore properties of materials.
D = pore diameter (μm)
V = filled pore volume (dm^3/kg)
A = cumulative specific area (m^2/kg)

D μm	V m^3/kg	A m^2/kg	D μm	V m^3/kg	A m^2/kg	D μm	V m^3/kg	A m^2/kg
200.5	0	0	200.5	0	0	200.5	0	0
106.1	.007	0	106.1	.001	0	138.8	.0	0
82.04	.197	1	72.19	.002	0	90.24	.01	0
69.41	.030	1	56.40	.002	0	60.16	.02	1
60.16	.046	2	32.81	.003	0	45.12	.02	1
54.69	.062	3	23.44	.003	0	30.60	.02	1
51.56	.077	5	18.41	.004	0	20.27	.02	2
46.27	.090	6	14.91	.005	1	15.29	.03	3
41.02	.104	7	11.21	.007	1	13.07	.03	3
36.09	.112	8	9.54	.012	3	11.72	.03	3
31.66	.121	9	3.58	.019	8	9.91	.03	4
27.34	.131	10	1.39	.029	30	9.30	.03	5
22.01	.138	11	1.00	.038	60	6.15	.03	5
13.27	.150	14	0.78	.050	115	4.48	.04	9
9.30	.155	16	0.68	.064	188	3.20	.04	16
2.29	.160	22	0.57	.081	297	2.09	.06	38
1.21	.171	49	0.51	.094	396	1.66	.07	66
0.68	.180	91	0.45	.108	511	1.22	.08	99
0.41	.186	140	0.33	.133	775	0.78	.09	134
0.17	.194	251	0.25	.146	948	0.35	.10	168
0.08	.200	473	0.17	.156	1138	0.18	.10	171
0.05	.205	759	0.11	.166	1414	0.09	.10	186
0.03	.206	916	0.07	.173	1742	0.006	.10	416
0.01	.207	1045	0.03	.184	2719			
0.007	.207	1341	0.015	.190	3852			
0.006	.209	1471	0.011	.192	4531			
			0.009	.194	5307			
			0.006	.198	7558			
MORTAR A			MORTAR B			BRICK		

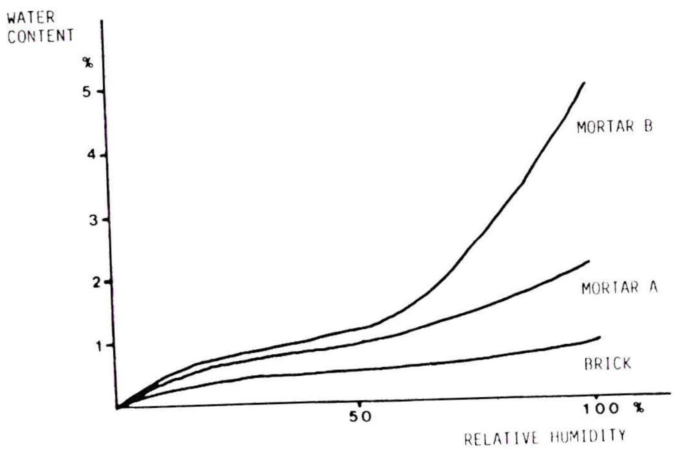

Fig 1 Water adsorption of materials.

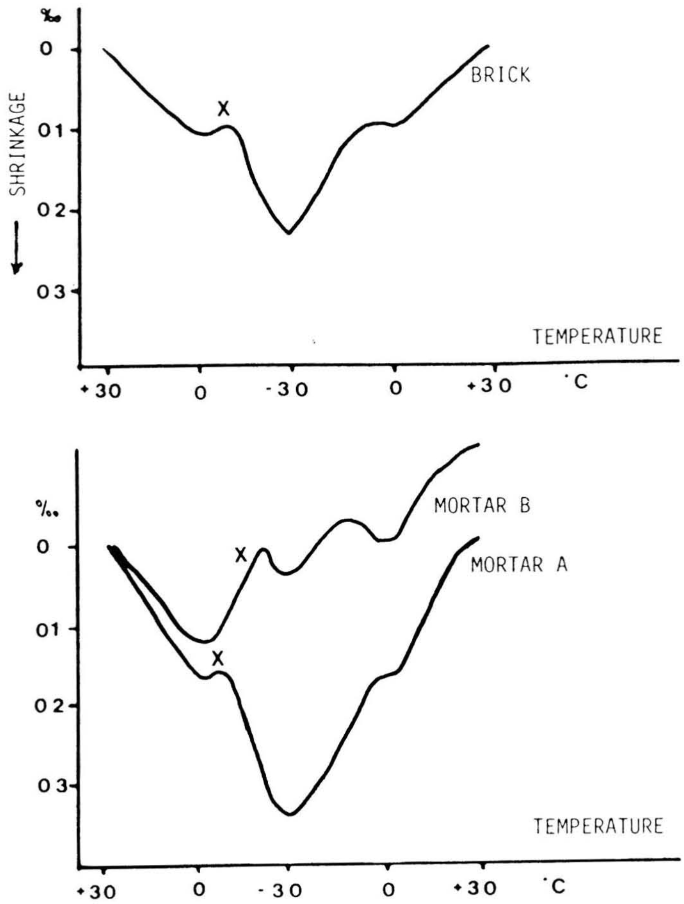

Fig 2 Dilation behaviour of materials.

The strenght of masonry made by mortar (B) dropped average 70 % after freezing-tharwing test. In the same test the strength of mortar (A) did not drop.

SUMMARY

A comparison of the dilation curves and the pore distributions of the test pieces, in which there way a large pore volume composed of capillary pores and a high water adsorption, revealed more irregular expansion than in the other samples.

In attempting to achieve a durable masonry structure, the strain in brick and masonry ought to be as similar as possible in order to avoid the fluctuations in temperature arising from tension on the structure.

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