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THE DURABILITY OF PAINTS ON SAND-LIME BRICK WALLS CONSIDERING WATER SORPTION AND VAPOUR PERMEABILITY IN A TWO-LAYER SYSTEM

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Abstract. It is assumed that the proposed coatings are suitable for finishing selected surfaces. However, our research indicated that the provided specific physical-mechanical properties of the coatings may change in a new combination of "coating – substrate". It was found while analysing the results of grouped paints investigations that specific nature of vapour permeability and absorption, the effect of opposition thereof, the expansion of destruction and expression of its symptoms were characteristic of each group. Physical-mechanical properties of constructions substrate and finishing layer can supplement one another or, quite contrary, stimulate destruction. Analytical review of the influence made by two parameters (vapour resistance and rain penetration) upon durability of paints of various structural origins indicated that usually rain-penetration influence was higher. However, while evaluating humidity of complete finished layer (paint + substrate) as a process: "rain pënetration – moisture migration from the inside (drying) – vapour isolation of the coating as a barrier to drying process", in case of film-forming paints the influence of vapour resistance is high too.

Keywords: paints, physical-mechanical properties, interaction of materials, service life.

1. Introduction

Vapour permeability and water sorption processes of individual materials are sufficiently well analysed and known [1–14]. However, the parameters were obtained irrespective of paint–substrate interaction. On the other hand, the importance of adverse effect of the above processes upon adhesion of the paint and destruction was not evaluated.

A lot of various finishing materials are provided on the market; however, physical-mechanical properties are strictly peculiar. The interaction of combinations of such materials as paint, mastic, dry mixtures with the materials of finishing surfaces is rather complicated [8–9]. A task is set to investigate the reaction of complex derivative of finishing layer forming materials with surface layer of walls as well as of the above materials to external effects and their intensivity.

Since several hundreds of combinations can be formed when using paints for different surfaces, sand-lime brick was chosen for the investigation. The choice was predetermined by the advantages of sand-lime brick surface and comparatively homogeneous capillary structure [15–20], so that less scattered results might be obtained.

2. Method and results

2.1. Investigation of water vapour permeability and surface water sorption in a two-layer (painted sand-lime brick) system

Water vapour permeability coefficient was determined in 20 °C environment according to requirements of the standard [14].

Vapour permeability coefficients were determined by preparation of 6 specimens of 100 mm diameter and about 25 mm thickness: 3 specimens of the materials without paint and three specimens with surfaces already painted. The painted specimens were fixed to a cup, paint facing down (cup method) [21–22]. The same specimens were used for detecting the surface water sorption. Measurement results are given in Tables 1, 2.

According to various values of paint vapour permeability, three level groups of paints can be distinguished. The first level group paints are of low vapour permeability coefficient δ_p < 0,032 mg/(m·h·Pa), there are no silicate paints. Silicone paints vapour permeability depends solely upon concentration. The second level group paints are with permeability δ_p = (0,032 – 0,048) mg/(m·h·Pa). Paints of all groups according to paint nature belong to this (permeability) level group. The third

Table 1. Physical factors and resistance to complex effects of silicone paints on sand-lime brick walls

Subgroup and paints mark		Physical factors				Resistance to complex effects C, cycles
		Vapour permeability coefficient δ_p, mg/(m·h·Pa)	Vapour resistance, m^2·h·Pa/mg		Water sorption coefficient w, kg/(m^2·h^{0,5})	
			Brick layer Z_p	Paints Z		
	0	0,054	0,462	0	0,942	180
a	18	0,046	0,545	0,083	0,288	116
	EAS	0,028	0,897	0,435	0,029	116
	HSX	0,026	0,946	0,484	0,070	71
b	16	0,037	0,678	0,216	0,081	116
	21	0,033	0,757	0,295	0,062	119
	SV	0,027	0,942	0,480	0,051	179
	SO	0,026	0,966	0,504	0,101	179

Note. 0 – non-painted brick.

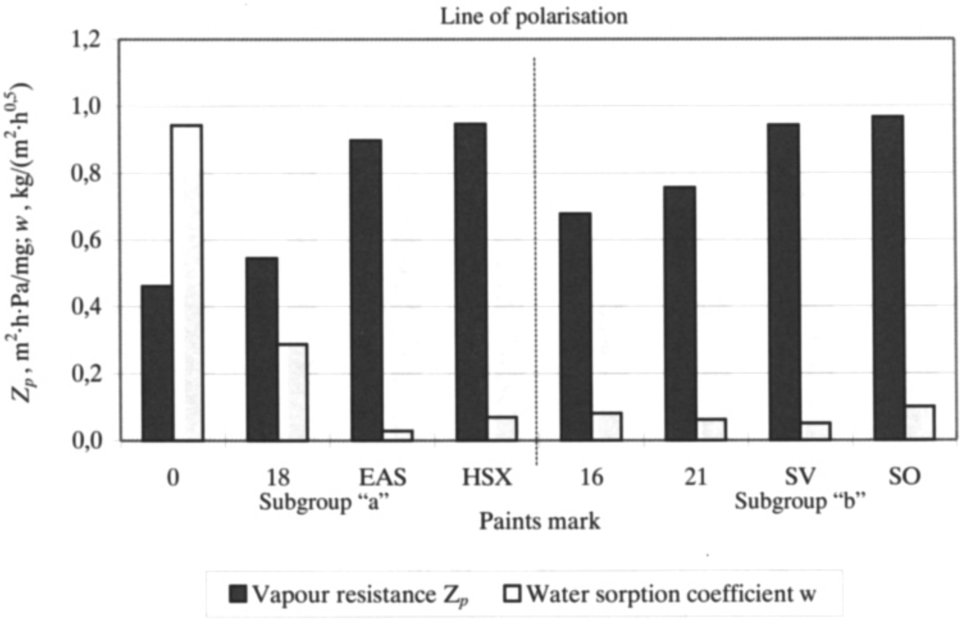

Fig 1. Comparison of variation in vapour resistance and water sorption coefficients of silicone applied to sand-lime bricks

level group coatings are of high permeability δ_p = (0,048 – 0,054) mg/(m·h·Pa). Nearly all groups of silicate coatings belong to the third vapour permeability group. There are no paints of silicone and only one of polyacrylates.

Analyses of all the compositions of the paint groups indicate that vapour permeability depends on the paint used, on polarity of film-makers and on bonding agents applied. Silicate paints are particularly sensitive to the above ingredients.

Water vapour resistance Z_p, [m^2·h·Pa/mg] is in reverse proportion to vapour permeability δ_p :

$$Z_p = \frac{d_x}{\delta_p}, \qquad (1)$$

where d_x – a thickness of samples of bricks, m.

Results of investigation and comparison of vapour resistances and water sorption coefficients of coated sand-lime bricks (d_x = 0,025 m) are given in Table 1, Fig 1; Table 2, Fig 2.

Silicone paints are classified in two subgroups: a) paints containing pigments: 18, EAS, HSX; b) paints without pigments: 16, 21, SV, SO. Silicone paints in the subgroups are located in increasing order of vapour resistance, supposing that vapour resistance effect on durability will be higher than that of water sorption coefficient.

Fig 1 illustrates that all silicone compositions (except for mark 18) show a high vapour resistance (Z_p = 0,68÷1,0 m^2·h·Pa/mg) and low water sorption ($w \leq 0,1$ kg/(m^2·h^{0,5}).

As can be seen (from Fig 2), with an increase of vapour resistance less than twice, water sorption coefficient decreases more than 30 times. Aqueous disperse paints are polaried according to water sorption coefficient in two subgroups: a) paints 1, 3, 2, 8 (w = 0,81÷0,6 kg/(m^2·h^{0,5}); b) paints 20, AVA, N, EAF, AE

Table 2. Physical factors and resistance to complex effects of aqueous polymeric disperse paints on sand-lime brick walls

Subgroup and paints mark		Physical factors				Resistance to complex effects C, cycles
		Vapour permeability coefficient δ_p, mg/(m·h·Pa)	Vapour resistance, $m^2 \cdot h \cdot Pa/mg$		Water sorption coefficient w, $kg/(m^2 \cdot h^{0,5})$	
			Brick layer Z_p	Paints Z		
	0	0,054	0,462	0	0,942	180
a	1	0,052	0,486	0,024	0,811	54
	3	0,052	0,485	0,023	0,654	110
	2	0,053	0,476	0,014	0,650	121
	8	0,041	0,618	0,156	0,602	148
b	20	0,033	0,758	0,296	0,101	179
	AVA	0,032	0,776	0,314	0,040	102
	N	0,032	0,776	0,314	0,038	179
	EAF	0,030	0,840	0,380	0,032	179
	EA	0,038	0,658	0,195	0,024	82

Note. 0 – non-painted brick

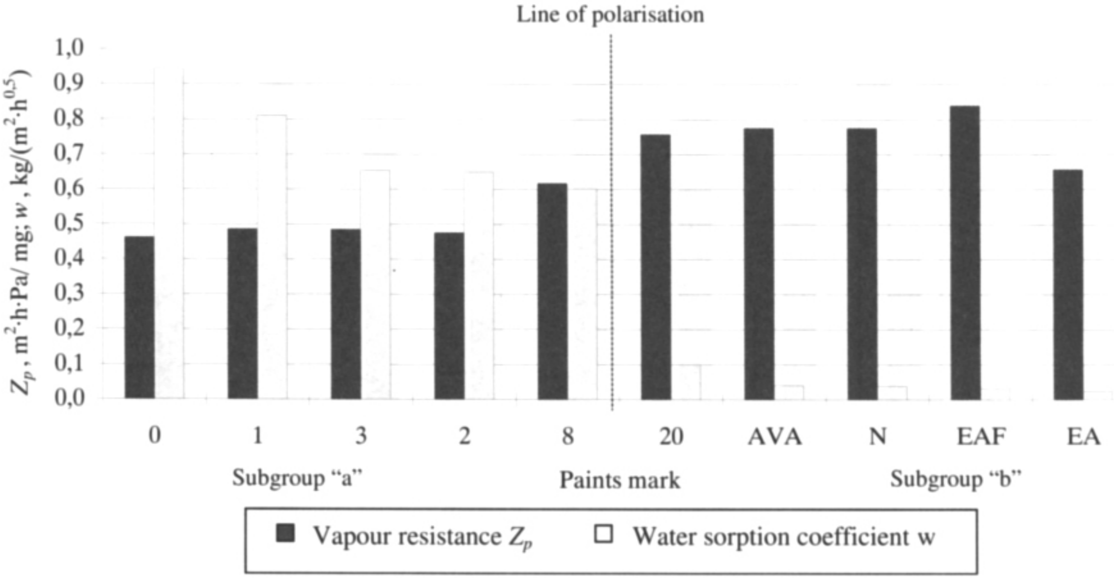

Fig 2. Comparison of variation in water sorption coefficients and in vapour resistances of aqueous polymeric disperse paints applied to sand-lime bricks

($w \leq 0,1$ $kg/(m^2 \cdot h^{0,5})$). Water sorption coefficients of neighbouring paints (8 and 20) in separate subgroups vary 6 times.

One can ask if approximate durability of paints can be predicted according to individually taken quality parameters of paints. Is the preconceived statement: low vapour resistance – low rain penetration – "good"; high vapour resistance – high rain penetration – "bad" reliable? With that end in view, special preliminary investigations into durability were carried out.

2.2. Investigations in the durability of painted sand-lime brick surfaces considering water sorption coefficient and vapour permeability

Resistance (in modelled cycles) to complex effects was compared with resistance of non-painted surface of brick. It was determined that resistance of non-painted surface of silicate brick was about 180 cycles. After 170–180 cycles, binding hydrosilicate crystal structure of sand-lime brick surface layer (0,05÷0,2) mm disintegrates. Afterwards, fine sand particles (filling), hydro-silicates disintegration products and inclusions of paint, dirt and other adhered aerosols easily fall off or are washed away.

Resistance to complex effects test was carried out in a climate chamber. Graphic views of resistance to complex effects are given in Figs 3, 4. Values of physical factors and resistance to complex effects are written in Tables 1, 2.

Durable paints are considered able to withstand more than 150 cycles, acceptable durability coatings – those withstanding (110÷150) cycles and indurable coatings, the durability of which is less than 110 cycles.

Paint HSX (subgroup a) large molecules of silicone resin have poor penetration into small pores of sand-lime brick. Silicone resin which does not penetrate brick, gives

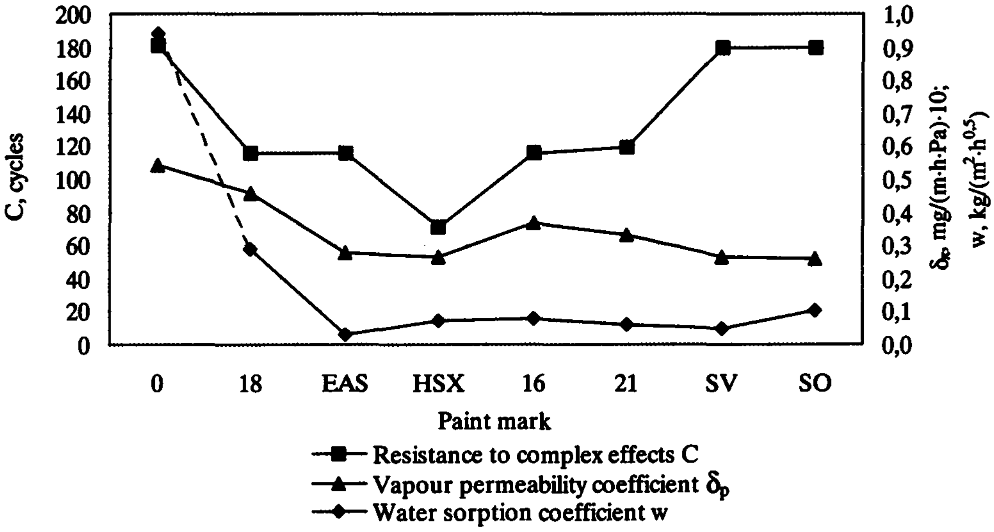

Fig 3. Resistance to complex effects of silicone paints on sand-lime brick walls considering water sorption coefficient and vapour permeability

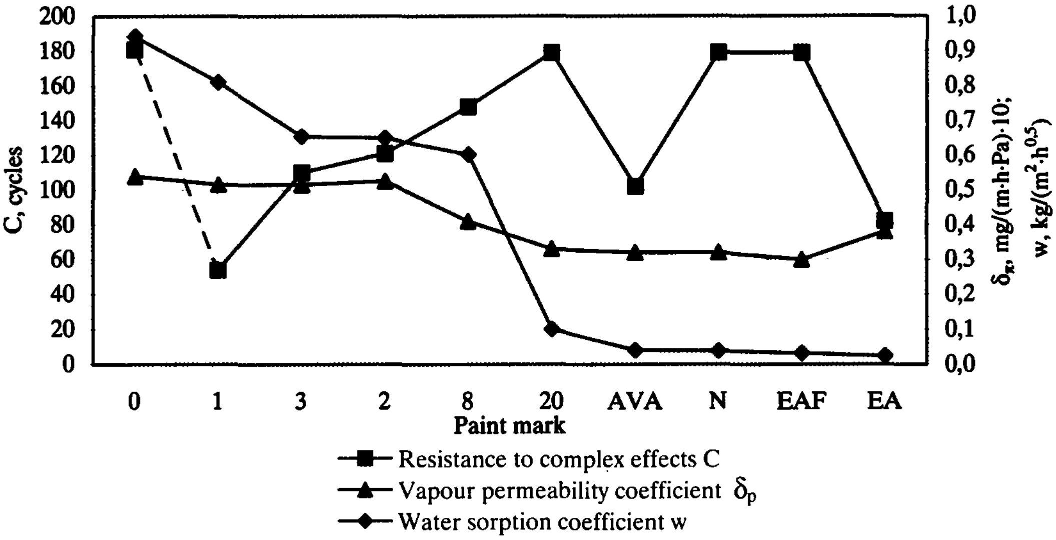

Fig 4. Resistance to climate effects of aqueous polymeric disperse paints on sand-lime brick walls considering water sorption coefficient and vapour permeability

yellow spots after 50 cycles, large blebs appear later. HSX paints cannot be used for sand-lime bricks.

Silicate paint containing no pigment "b" do not peel off or crack. With time, hydrophobic properties of such paints decrease.

However, they protect the surface of sand-lime bricks sufficiently well and for a long time.

Fig 4 shows that in case of aqueous polymeric disperse paints it is difficult to say anything positive about paint durability considering vapour resistance (or permeability). The durability of such paints as well as that of the subgroups is polarised (not so distinctly due to vapour permeability decrease) in respect of water sorption coefficient. All three durable paints fall in subgroup "b" where water sorption coefficients are very low.

3. Conclusions

1. Single-valued comparative results of paint durability and reduction of their scattering are obtained by classification of the paints according to the origin of film bonding agent and the filling: 1) paints formed out of aqueous polymeric dispersions, 2) silicate paints, 3) paints formed out of polyacrylates and silicones solutions in organic solvents or silicone dispersions.

2. Resistance of paints made out of polyacrylates and silicone solutions in organic solvents or silicone dispersions to climate effects depends upon limit values of vapour resistance determined by investigations. There are no lamination and no cracks in case of non-pigment silicone paints. Hydrophobic properties of such paints de-

crease with time, however sand-lime brick surface is protected quite well and for a sufficiently long time.

3. Durability of paints formed out of aqueous polymeric dispersions as well as the subgroups of paints is polaried (not so distinctly due to some decrease in water vapour permeability) in the direction of fast decrease of water sorption coefficient.

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