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VAPOUR PERMEABILITY AND WATER ABSORPTION OF DIFFERENT EXTERIOR PAINT SYSTEMS

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Increasing focus on the durability aspects of buildings and materials as well as increasing air pollution requires better understanding of the performance of exterior coated materials facing the outdoor climate.

Several factors affect the deterioration of a material, but environmental exposure is one of the primary reasons for material deterioration. The is a lack of data on moisture related properties for use in calculation models predicting the transient heat and moisture transfer in multi layer constructions.

Of special interest are water vapour permeability and sorption properties of paint systems and products. There is also a need for measurements of water vapour permeability as a function of relative humidity.

The purpose of the experiments reported in this paper was to establish material data for various construction materials (sand-lime bricks, cement-lime plaster, cement plaster) painted with three different paint systems (paints of aqueous polymeric dispersions, silicate paints, paints based of polyacrylate also silicone solutions in organic solvents, or silicone dispersions).

Water vapour permeability values were calculated for both painted and unpainted specimens.

It is established that the paint under consideration should be grouped according to their composition and characteristics of their macrostructure and base or primer layer to be covered by paint according to their susceptibility to moisture absorption and deformation.

The complex and partial methods have been worked out for application at investigation of destruction processes. Partial methods have been applied in the cases of investigation of the physical and mechanical characteristics, which are necessary to be evaluated before direct weather durability test in the climatic chamber along the program of simulated effects.

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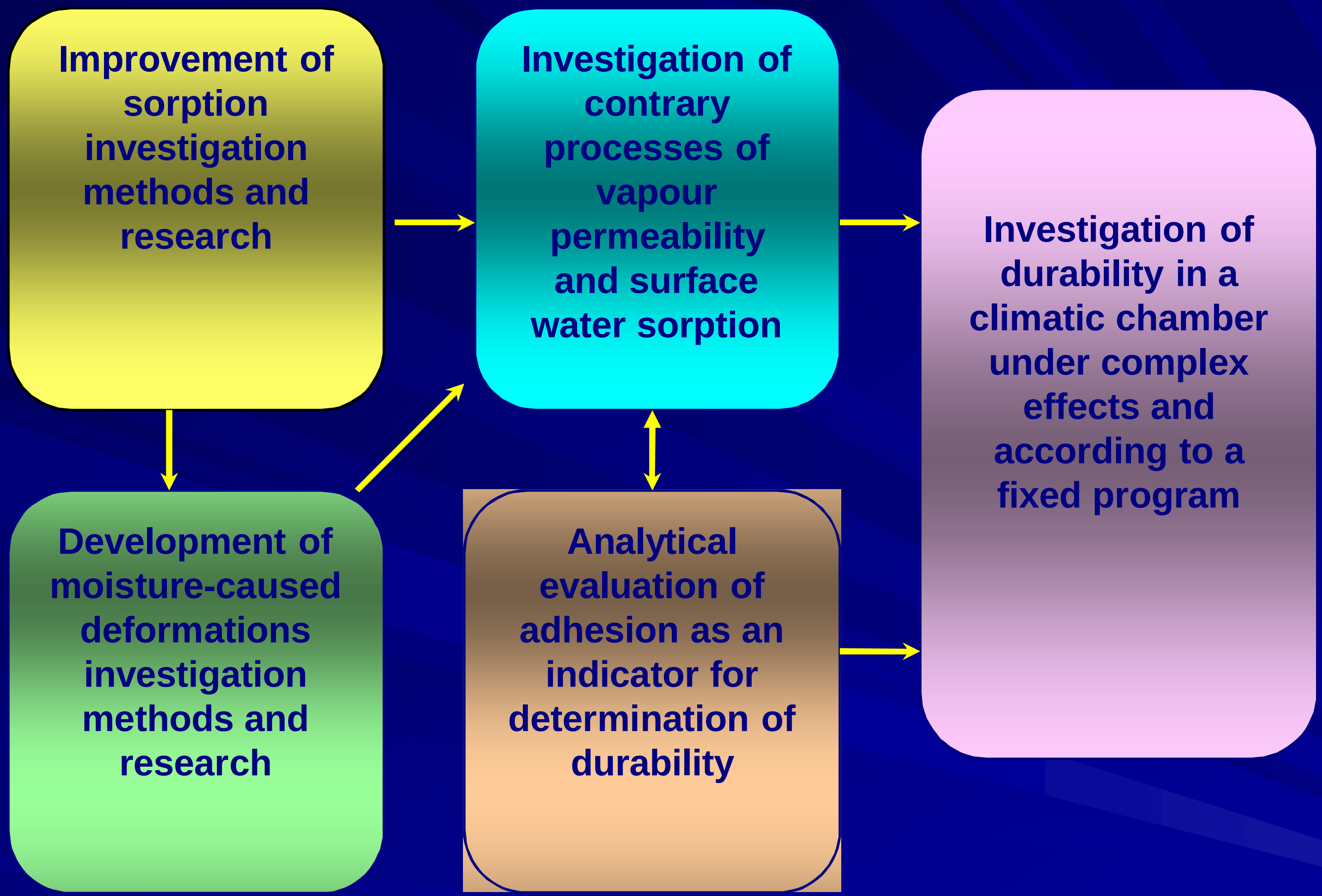


Principal scheme of complex research methods

The methods of generalised complex investigations were designed on the basis of the results of investigations carried out according to the stage-by-stage methods.

It was found that the specific physical and mechanical properties determined for the paints alone may change in the new combination of *"paint - substrate".* The comparative results of durability were obtained by the classification of coatings in three groups according to their structural nature:

1) *paints formed out of aqueous polymeric dispersions;*
2) *silicate paints;*
3) *paints formed out of polyacrylates and silicone solutions in organic solvents, or silicone dispersions.*

Several hundreds of combinations of coating and substrate are possible when a number of surfaces are coated with various paints in this study, plaster was chosen for investigation.

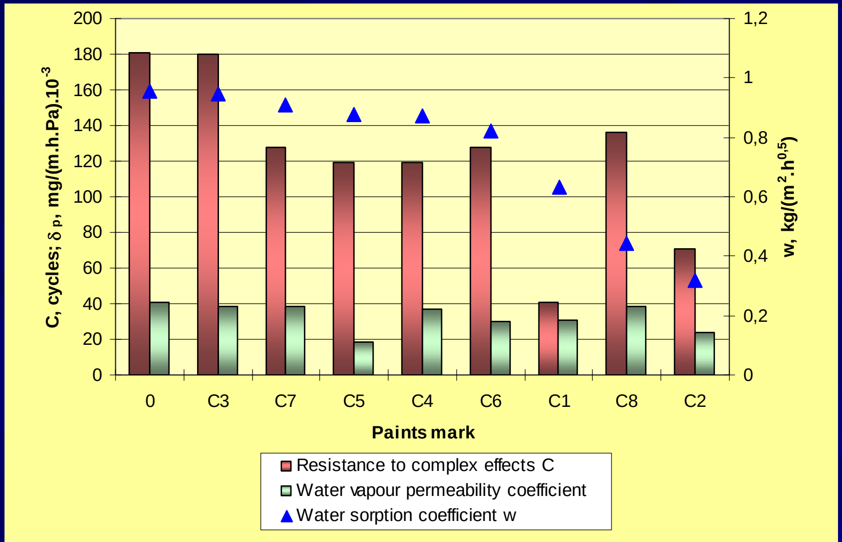
The plaster was coated using paints of different origin (total 26 compositions). Analyses of compositions of the paints indicate that vapour permeability depends on the paint used, polarity of film-makers, and bonding agents used.

Water vapour permeability coefficient was determined in 20 ^{o}C environment according to requirements of the EN ISO 12572:2001.

Measurements were performed using 3 specimens of 100 mm diameter and 25 mm thickness of the uncoated plasters and 3 specimens with surfaces painted for each of the 26 coatings in the study. The painted specimens were fixed on a cup, paint facing down.

The specimens used for determination of vapour permeability were also used for determination of the surface water sorption coefficient by DIN 52 617.

RESULTS

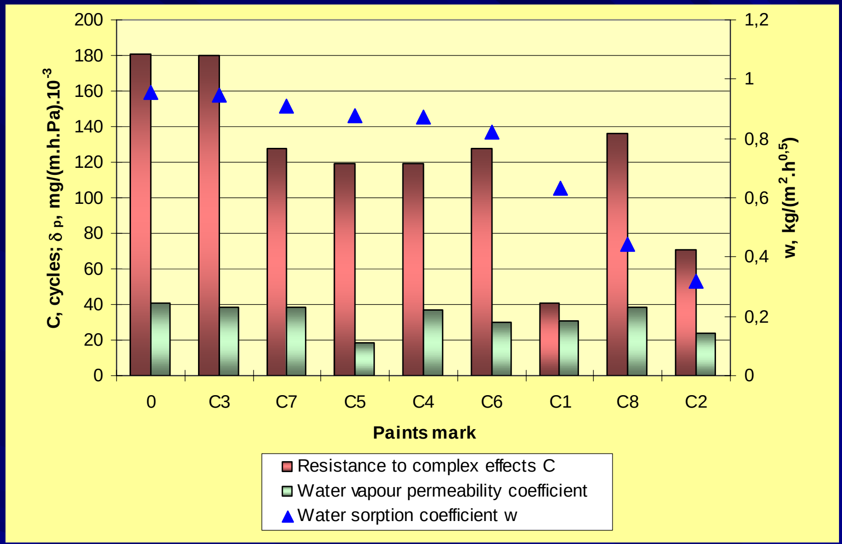


The comparison of physical values of cement plaster and durability of silicate paints.
Notes: paints mark 0 - non-painted plaster.

Negative influence of water sorption and positive influence of vapour permeability upon silicate paints durability prevail. This influence especially distinct for durability of paint (*C8*): water sorption coefficient distinctly decreased and vapour permeability distinctly increased.

High water sorption coefficient [$w = 0.63$ kg/(m^2·h$^{0.5}$) and $w = 0.32$ kg/(m^2·h$^{0.5}$)] has negative influence for indurable paints (*C1* and *C2*).

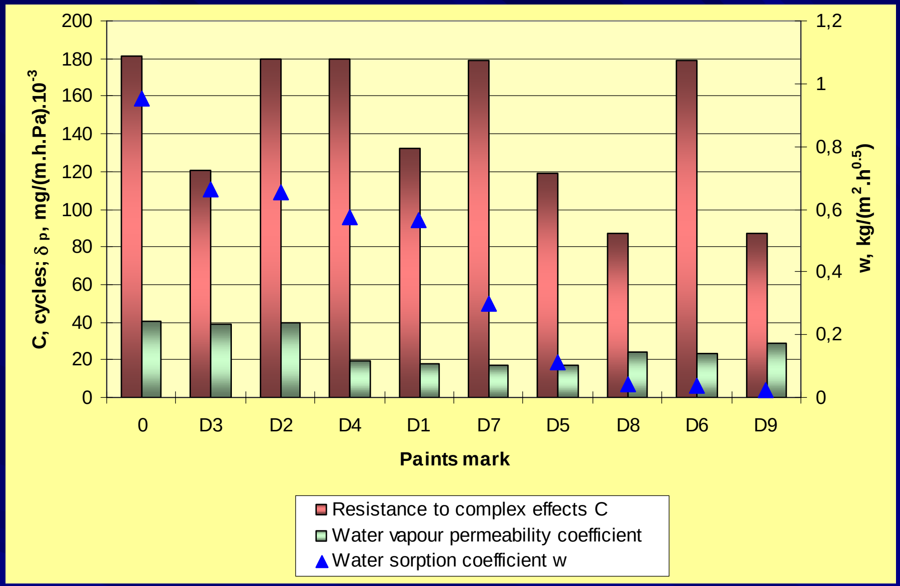
These paints are formed of derivatives of salts of silicic acid and fillings inside the film. Adhesion with substrate is assured by forces of electrostatic interaction between surface groups.



The comparison of physical values of cement plaster and durability of silicate paints.
Notes: paints mark 0 - non-painted plaster.

Parameters of surface water sorption and vapour resistance have approximately identical influence upon durability of paints. Vapour resistance should be $Zp \leq 1.3$ m^2·h·Pa/mg and water sorption coefficient – $w < 0.88$ kg/(m^2·h$^{0.5}$). Reducing water sorption coefficient to $w = 0.4$ kg/(m^2·h$^{0.5}$) and vapour resistance to $Zp = 0.7$ m^2·h·Pa/mg might increase durability (15–20)%.

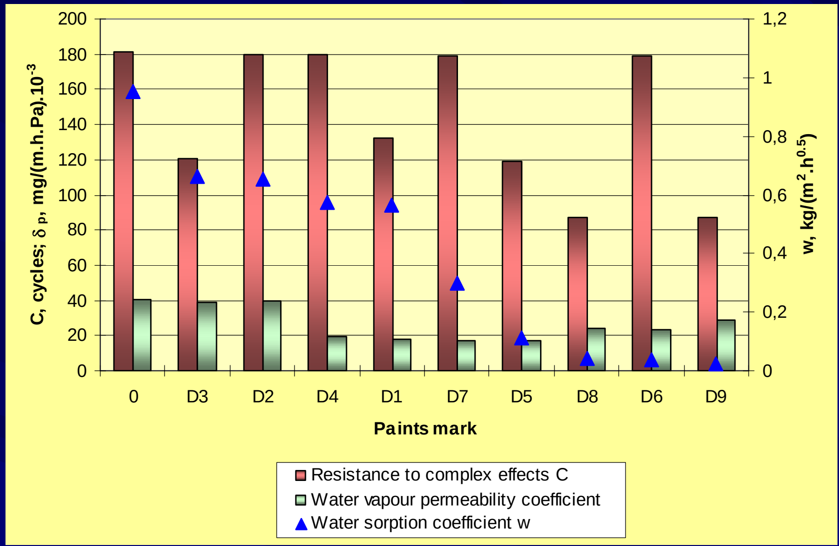
Durability of properly hardened paints should be attributed to the category of acceptable durability (C = 120 – 180 cycles).



The comparison of physical values of cement plaster and durability of aqueous polymeric disperse paints.
Notes: paints mark 0 - non-painted plaster.

The aqueous polymeric dispersion paints are distributed according to the water sorption coefficient in two subgroups: a) *D1, D2, D3, D4* [$w > 0.55$ kg/(m^2·h$^{0.5}$)]; b) *D5, D6, D7, D8, D9* [$w \leq 0.30$ kg/(m^2·h$^{0.5}$)].

As can be seen at the increase of vapour resistance of less than a factor of two decreases the water sorption coefficient more than a factor of 30. The water sorption coefficients of paints *D1* and *D5* in separate subgroups vary by a factor of 5.

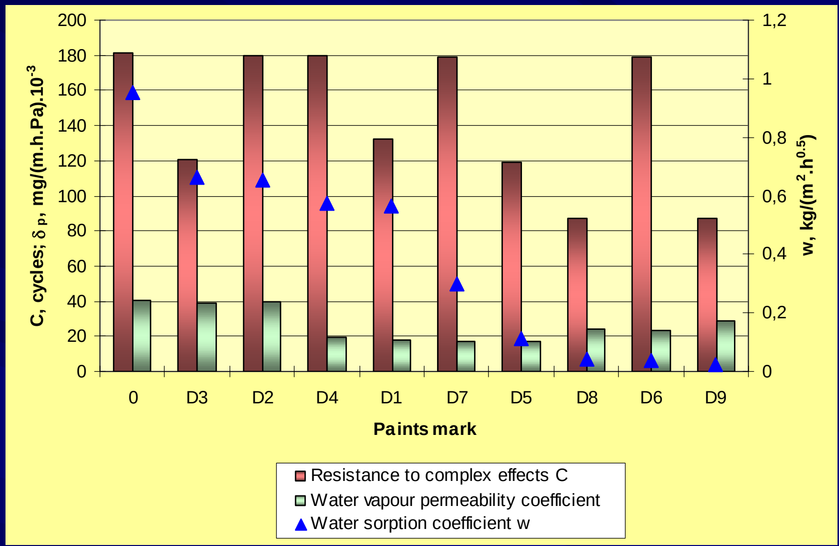


The comparison of physical values of cement plaster and durability of aqueous polymeric disperse paints.

Surface water absorption in the case of the paints of subgroup “a” is high – these are relatively “rain permeable” paints: w = (0.56 - 0.66) kg/(m^2·h$^{0.5}$). Their vapour resistance Zp = (0.63 - 0.64) m^2·h·Pa/mg [δp = (0.039 - 0.040) mg/(m·h·Pa)].

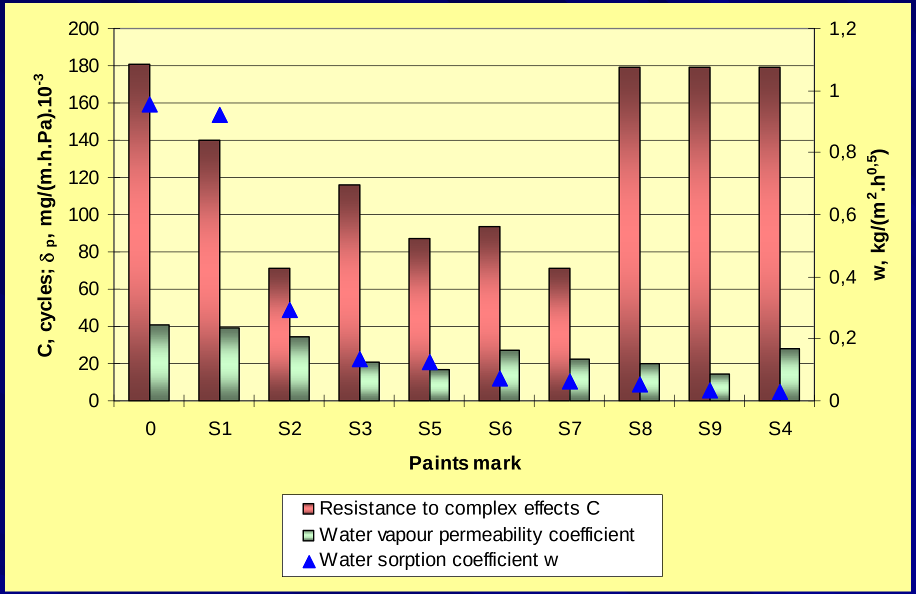
Surface water absorption in the case of paints of subgroup “b” is low – these are rather “tight” paints w = (0.024 - 0.10) kg/(m^2·h$^{0.5}$). Their vapour resistance Zp = (0.87 - 1.49) m^2·h·Pa/mg [δp = (0.029 - 0.017) mg/(m·h·Pa)] is on the average 35% higher than those of subgroup “a”.

In the all cases the vapour resistance increase was influenced by using the acrylic bonding agent in appropriate proportions. The increase of vapour resistance is permissible and does not reduce durability of a properly selected composition of the paint. In the case of subgroup “a” permissible water sorption coefficient $w < 0.66$ kg/(m^2·h$^{0.5}$) and the highest value of vapour resistance $Zp < 1.38$ m^2·h·Pa/mg [$\delta p > 0.018$ mg/(m·h·Pa)] are suitable with respect to durability. In the case of subgroup “b” all physical parameters are high enough. The reason for classifying two paints *D8* and *D9* as non-durable considers the bonding agent: specifically, the amount of bonding agent was insufficient.



The comparison of physical values of cement plaster and durability of aqueous polymeric disperse paints.

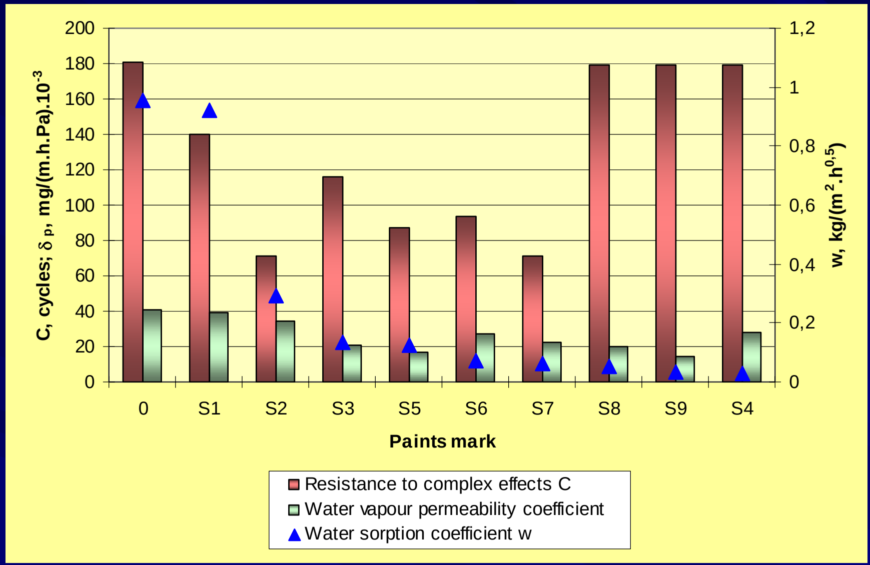
Durability of paints in the case of insufficiently stabilized compositions of the aqueous polymeric dispersions is defined as $C < 80$ cycles irrespective of the values of the water sorption and vapour permeability coefficients. Destruction of the paint specimens in the study is manifest through fast wrinkling of the film, mould formation, loss in the adhesion and washing off after 50-80 cycles.



The comparison of physical values of cement plaster and durability of polyacrylates and silicone solutions in organic solvents or silicone dispersions paints.

Paints formed out of polyacrylates and silicones solutions in organic solvents, or silicone dispersions. Hardened films of polyacrylates' or silicones constitute uniformity of the paints. They have no emulsifiers. Adhesion of paint - substrate is ensured by intermolecular interaction between bonding agent of paint and substrate. Because of the organic polymers of silicons are highly resistant, their films are stronger, more elastic and more resistant to temperature.

In respect of a cement plaster, the paints of the group concentrate on the scale of low and average water sorption moisture. Macrostructure of the surface is uniform, not textured.



The comparison of physical values of cement plaster and durability of polyacrylates and silicone solutions in organic solvents or

silicone dispersions paints

The durability of the paints containing pigment of the above group is extremely sensitive to vapour resistance. With increase of $Zp > 0{,}64$ $m^2 \cdot h \cdot Pa/mg$, negative influence of vapour resistance grows fast. Appearance of blebs indicate reduced adhesion.

The nature of destruction is close to lamination: occurrence of tiny blebs - their merging and bursting; lamination or “scale” type cracking of a paint. Chemically instable paints are spotty. In some cases the spots are already observed following 90-140 testing cycles. Appearance of spots preceding mechanical desintegration of pants is not analysed in the article, even though the spots have aesthetic depreciation sense. Aesthetic destruction is also typical of some compositions with acceptable mechanical durability.

150 accelerated cycles in the climatic chamber correspond to 12 years at an average natural ageing.

CONCLUSIONS

- *Durability of the paints formed out of aqueous polymeric dispersions as well as the subgroups of paints is distributed in the direction of fast decrease of water sorption coefficient.*
- *Water absorption of non-durable paints is high; vapour resistance has no significant influence. Surface water absorption of usable paints decreases faster than vapour permeability. Silicate paints resistance to climate effects is more dependent on surface water absorption and less dependent upon vapour permeability.*
- *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. Hydrophobic properties of silicone paints decrease with time, however sand-lime brick surface is protected quite well for a sufficiently long time.*

THANK YOU FOR YOUR ATTENTION !