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Technique of the Assessment of Crack Resistance of the Protective Decorative Coatings

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Abstract

Information about a technique of an assessment of resistance of protective decorative coatings is provided. An estimation method for crack resistance of coatings based on the ratio between the length of the crack, and the Vickers indentation fracture toughness.

Keywords: varnish coatings, crack resistance, coefficient of intensity of tension

1 Introduction

Results of the experimental researches testify that in use of protective decorative coatings of external walls of buildings there is a change of the mechanism of their destruction from elastic-plastic to friable, i.e. "embrittlement" of coatings is observed. According to the linear mechanics of destruction a cracking fissuring of coatings happens, if

$$K_1 \geq K_{1c}$$

K_1 - coefficient of intensity of tensions,

K_{1c} - critical value of coefficient of intensity of tensions.

Considering that a main type of destruction of protective decorative coatings is cracking fissuring, it is of practical interest to estimate parameters of crack formation of coatings during an aging.

2 Experimental study

Determination of critical coefficient of intensity of tensions K_{1c} was carried out by us according to the technique [1] based on a ratio between the crack length, a print of an indentor of Vikkers and viscosity of destruction.

The critical coefficient of intensity of tensions was determined by a formula:

$$K_{1c}= 0,028\ Ha^{0,5}(E/H)^{0,5}\ (C/a)^{-1,5}$$

where N – hardness by Vikkers;

P - loading on indents;

C - semi-length of radial cracks

a - semi-length of print diagonal.

As colourful structures in work polyvinyl acetate cement PVAC and polymer limy paints were applied, and as a substrate - cement and sand solution. After curing the painted solution exemplars were subjected to alternate freezing and thawing, and also to humidification and a thermo aging. During tests with the help of Vikkers's indentor we measured a print diameter and length of radial cracks which are formed on both sides from a print. Hardness by Vikkers was calculated on a formula:

$$H=\frac{2P}{d^2}\sin\frac{\alpha}{2},$$

where d - diameter of a print;

α - angle at indentor top.

3 Results and discussion

Test results are provided in table 1.

Table 1: Parameters of a protective decorative coating

Type of coatings	Type of influence	Loading P, H	Hardness of coating H, Н/мм^2	The relation of crack semi-length C to the size of semi-diagonal of print	Coefficient of intensity of tension K_{1c}, МН/м$^{3/2}$

Table 1 (continued)

PVAC	After curing	47,39	61	1	0,06
	3 cycles of freezing thawing		137	1	0,075
	8 cycles of freezing thawing		164	1	0,078
	15 cycles of freezing thawing		179	1,2	0,088*
	Humidification 15 days		49	1	0,058
	Humidification 30 days		37	1	0,054
	Thermoaging 100h		85	1	0,065
	Thermoaging 200h		104	1	0,068
Polymer limy	After curing	47,39	27	1	0,044
	3 cycles of freezing thawing		45	1	0,05
	20 cycles of freezing thawing		70	1,54	0,069*
	Humidification 15 days		23	1	0,055
	Humidification 30 days		16	1	0,040
	Thermoaging 100h		55	1	0,053
	Thermoaging 200h		62	1	0,0546

Table 1 (continued)

PVAC (1% by weight asbestos cement)	After curing	47,39	44	1	0,055
	3 cycles of freezing thawing		130	1	0,073
	8 cycles of freezing thawing		130	1	0,073
	20 cycles of freezing thawing		133	1	0,074

* - critical coefficient of intensity of tensions

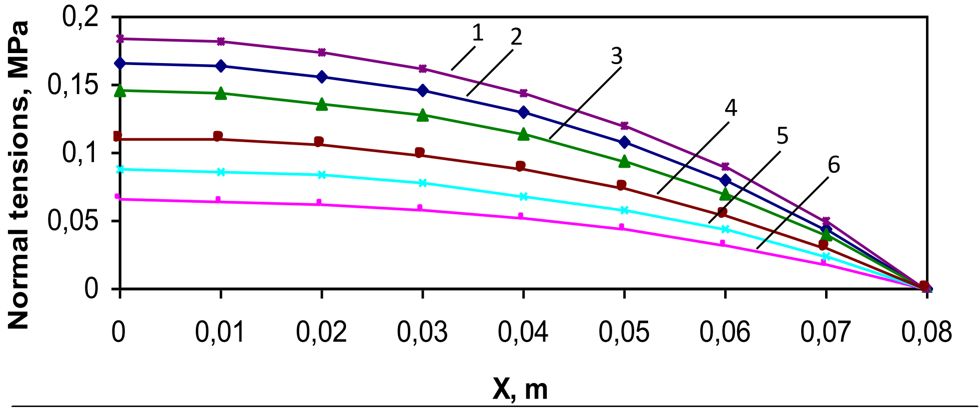
It was established that in PVAC and the polymer limy coatings on a solution substrate the "embrittlement" occurs after a particular duration of impact of alternate freezing and thawing. Cracks in coatings at cave-in of an indentor of Vikkers appear only after 15-20 testing cycles. Value of critical coefficient of intensity of tensions of PVAC coating is equal K_{1c}=0,088 MH/m$^{3/2}$, and for polymer limy coating K_{1c}=0,069 MH/m$^{3/2}$.

Introduction into a compounding of PVAC paint the fibrous micro excipient (asbestos) increases crack resistance of coatings. Thus even after 20 cycles of alternate freezing thawing the "embrittlement" of coating is not observed. The comparative analysis of data shows that at the same intensity of influences of the environment coatings with a fibrous micro excipient possess with smaller value of coefficient of intensity of tensions, after 8 cycles of alternate freezing thawing K_1(PVAC)=0,078 MH/m$^{3/2}$, and K_1(PVAC with 1% of asbestos) =0,073 MH/m$^{3/2}$.

Humidification of coatings leads to decrease of an elastic modulus and hardness of coatings that reduces a danger of crack formation at deformation of a wall construction. Humidification of coatings during 30 days does not cause crack fissuring of coatings. The coefficient of intensity of tensions of PVAC coating after curing is equal K_{1c}=0,06 MH/m$^{3/2}$, and after humidification K_{1c}=0,054 MH/m$^{3/2}$. Similar data are obtained and for the polymer limy coatings.

At studying a thermos aging it was recorded that the increase of time of thermos aging leads to natural increase of value of coefficient of intensity of tensions. For example, after a thermos aging of polymer limy coatings during 100 h increase of value of coefficient of intensity of tensions is observed from K_{1c}=0,044 MH/m$^{3/2}$ (after curing) to K_{1c}=0,053 MH/m$^{3/2}$, and after 200 h value makes K_{1c}=0,0546 MH/m$^{3/2}$.

Considering that properties of a protective decorative coatings are defined among other factors by properties of the painted construction and are heterogeneous on an extension, we follow-up carried out calculation of tensions arising in coatings as a result of influence of various factors according to a technique [2].



1-PVAC after thermoaging on heavy concrete
2-PVAC after curing
3-PVAC after thermoaging on hayditeconcrete
4-Polymerlimy after thermoaging on heavy concrete
5-Polymerlimy after thermoaging on hayditeconcrete
6-Polymerlimy after curing

Figure 1: Distribution of normal tensions on contact extent

As substrates we used the materials which are characterized by various value of coefficient of linear thermal expansion: heavy concrete, hayditeconcrete. Values of coefficient of linear thermal expansion for the considered materials are presented in table 2. The sizes of exemplars of a substrate make 4×4×16 cm. Results of calculation are presented in figure 1, 2.

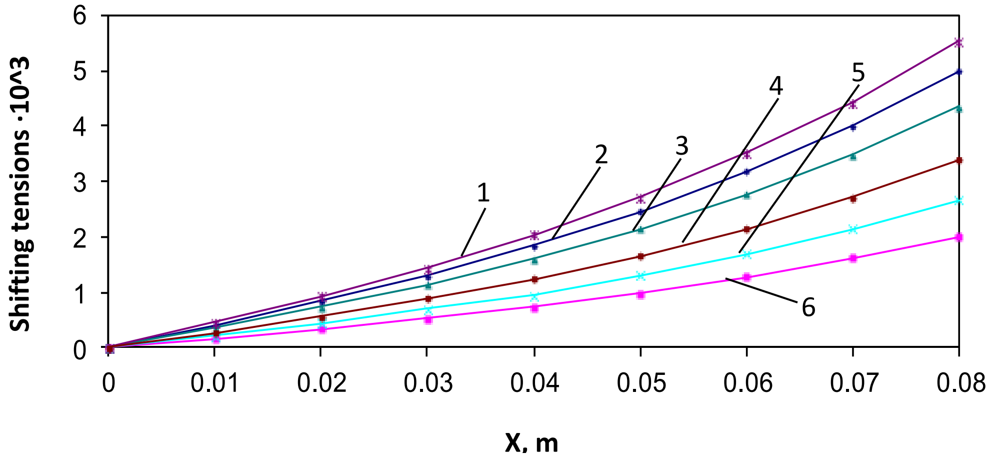
Table 1: Values of coefficients of a temperature linear dilatation

№	Name of material	Values coefficient of linear thermal expansion $\cdot 10^6$, 1/degree
1	PVAC coatring	8,43
2	Polymer limy coating	3,47
3	Hayditeconcrete of structure (on volume) 1:1,5:1,5	6,6
4	Heavy concrete	10

In figure 1 distribution of normal tensions depending on the extent of contact of coating with a substrate is presented. The received results testify that the greatest size of tension after curing is characteristic for PVAC coatings and makes σ =0,164 MPa. For the polymer limy coatings this value makes σ =0,066 MPa.

Subsequent after curing a temperature increase to 60°C leads to increase of value of size of normal tensions arising in coatings. So, for coating PVAC on a substrate from heavy concrete value of size of normal tensions makes σ =0,183 MPa, and for a polymer limy coating respectively σ =0,111 MPa.

In figure 2 distribution of the shifting tensions depending on the extent of contact of a coating with a substrate is presented. The received results testify that the greatest size of tension is observed in coatings on a substrate from heavy concrete. After curing of coatings value of the shifting tensions for PVAC coatings makes $\tau = 5 \cdot 10^{-3}$ MPa. For the polymer limy coatings this value makes $\tau = 2 \cdot 10^{-3}$ MPa.



1- PVAC after thermoaging on heavy concrete
2- PVAC after curing
3- PVAC after thermoaging on hayditeconcrete
4- Polymerlimy after thermoaging on heavy concrete
5- Polymerlimy after thermoaging on hayditeconcrete
6- Polymerlimy after curing

Figure 1: Distribution of the shifting tension on contact extent

After thermo saging there is an increase of value of size the shifting tensions. So, for PVAC coatings on a substrate from heavy concrete this value makes $\tau = 5{,}53 \cdot 10^{-3}$ MPa, and for polymer limy $\tau = 3{,}4 \cdot 10^{-3}$ MPa.

Proceeding from the aforesaid, it is possible to draw a conclusion that the assessment of crack resistance of a protective decorative coatings by Vikkers's method has to pass in two stages:

1) an assessment of crack resistance on average section as it is characterized by the greatest size of pulling tensions;

2) an assessment of crack resistance on extreme section as the shifting tensions increase with increase of extent of a finishing layer.

It will allow to approach to choice of materials research factors of increase of crack resistance of coatings more reasonably.

4 Conclusion

The conducted researches are justification for recommendations at developing of compounding of colourful structures, at carrying out of research works with use of technique of an assessment of crack resistance of coatings according to the offered scheme. It will allow to predict more reasonably firmness of coatings, and also to optimize finishing structures for the purpose of receiving coatings with a complex of the given properties.

References

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[2] V. G. Mikulski, V. V. Kozlov Bonding concrete. M: Stroyizdat. 1975. 236 p.

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