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Ecology-geophysical environment eexperimental studies of the coating based on polysiloxane for steel building structures

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The territories investigation of the regions endangered of fires caused of risk circumstances were carried out. The aspects of elaborated specimens heated in the experiment were presented. These leads to the elaboration of fireproof constructions on the territories' were the ecologically safe constructions are planned to be designed.

The ecology-geophysical experiment was carried out for the study of the environment in the aspect of linear expansion coefficient of high-temperature and fireproof coating based on polysiloxane and aluminum oxide for the steel building structures on the territories where the objects containing metallic ingredients in bridges, dams, highways, viaducts and other objects in the consequent geologically investigated territories.

According to the standardized method of fire protection treatment of building structures' general requirements and control methods, experimental studies were performed to determine the linear coefficient of swelling of high-temperature and fire-resistant coatings for steel building structures. Based on the conducted experimental studies, the indicator of fire protection efficiency was determined, in particular, the linear coefficient of swelling of the coating, which is 38. The dependence of the swelling thickness of the fireproof coating on the thickness of the applied layer was

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determined.

Introduction

The method of investigation of the ecology-geophysical endangered state of the environment was elaborated which involves both experimental field and laboratory investigations for the risk territories (*Starodub at al, 2022)*. Metallic constructions frequently have place on the geologically investigated territories. A geophysical experiment was carried out for the study of the environment in the aspect of linear expansion coefficient of high-temperature and fireproof coating based on polysiloxane and aluminum oxide for the steel building structures on the territories where the objects containing metallic ingredients are. Among them are bridges, dams, highways, viaducts and other objects on the consequent for further study of geologically investigated territories. Today, metal building structures are widely used in the construction of buildings and structures for various purposes, in reconstruction, re-equipment, etc. All construction products, in particular metal constructions, must comply with the technical regulation of construction products (*Resolution…,2006; Veselivskyy, Smolyak, 2021*). One of the important technical characteristics that must be monitored when using building structures is their fire resistance class, which must correspond to (*Pozhezhna bezpeka…,2016*) depending on the degree of fire resistance of the building or structure. Given that unprotected metal building structures have a small limit of fire resistance, which limits the scope of their application, the task of their fire protection remains relevant.

In works (*Shnal at al, 2021; Lavrenyuk, Mykhalichko at al, 2020; Tatsii, Pazen, at al, 2020; Ballo, Yakovchuk at al, 2023*), the authors consider various ways and methods of increasing the fire resistance limit of building structures (including metal ones). This contributes to a wider field of application of building structures, giving them various architectural forms and averting their destruction due to the influence of high temperatures, which occur during a fire. The main trends in the protection of metal building structures are fire-resistant treatment (painting/lacquering, plastering, cladding, wrapping).

The purpose of the work. Determination of the fire-resistant capacity of the developed high-temperature and fire-resistant coating based on polysiloxane and aluminium,

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titanium, chromium oxides for metal building structures (*Nyvliud, Smolyak, 2012*).

Method and Theory

The evaluation of the fire protection ability of the developed coating for steel structures based on polysiloxane and aluminum, titanium and chromium oxides was carried out according to the method (*Zakhyst vid pozhezhi…, 2010; Veselivskyy, Smolyak, 2022*).

The essence of the method of determining the linear swelling coefficient is to determine the ratio of the thickness of the fire-retardant material applied to the steel plate before and after exposure to a temperature of 340°C. The method is used for materials that are supplied with fixed dimensions (strips, rolls, plates, etc.). According to the results of tests using the method of determining the linear coefficient of swelling, the coefficient of swelling Kl on plates is calculated according to the formula

$$K_l = 0.5\ (h_{c1} / h_{p1} + h_{c2} / h_{p2}), \quad (1)$$

where h_{c1}, h_{c2} are the average values of the thickness of the swollen material layer on the first and second plates, mm; h_{p1}, h_{p2} - average values of the thickness of the initial layer of material on the first and second plates, mm.

Results

In order to study the fireproofing ability of the coating by the method of determining the linear coefficient of swelling, two steel square plates with a side of 50 mm and a thickness of 2 mm were made, on which a coating layer with an average thickness in the wet state of 0.8 and 1 mm was applied. After drying the average thickness of the dry layer was 0.53 and 0.68 mm on the 1st and 2nd plates, respectively.

Two samples of coated steel plates were placed in an electric furnace that was preheated for one hour to a temperature of 340 °C for 20 minutes.

30 minutes after the test and cooling of the tested coating sample, the average height of the swollen layer of material on each plate was determined with a caliper, measuring the height at five points: in the center of the plate and at the midpoints between the center and the corners of the plate. The height of the swollen layer was 22.5 mm and 23.2 mm on the 1st and 2nd plates, respectively, see Figure 1.

Using the results of experimental studies, authors

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calculate the linear coefficient of swelling of the coating: K_l = 0.5 (22.5 / 0.53 + 23.5 / 0.68) = 38.

Figure 1
Samples of coated steel plates after testing

The next stage of research is to determine the dependence of the swelling thickness of the fireproof coating on the thickness of the applied layer. This study of the fireproofing ability of the coating was carried out by the method of determining the linear coefficient of swelling, which is described above. The studied coating was applied to steel plates, according to the method [9], in groups. The thickness of the plate coating layer after drying was: group 1 (0.06 mm and 0.13 mm); group 2 (0.2 mm and 0.26 mm); group 3 (0.33 mm and 0.39 mm); group 4 (0.46 mm and 0.53 mm); group 5 (0.61 mm and 0.68 mm); group 6 (0.76 mm and 0.83 mm), group 7 (0.91 mm and 0.96 mm). After performing experiments and calculations according to formula (1), authors obtained linear coefficients of swelling of the coating for the studied groups. The summarized results are presented in the Table.

Table

Indicators	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Average thickness of the raw layer, mm	0.1/0.2	0.3/ 0.4	0.5/ 0.6	0.7/ 0.8	0.9/ 1.0	1.1/1.2	1.3/1.4
Average thickness of the dry layer, mm	0.06/ 0.13	0.2/ 0.26	0.33/ 0.39	0.46/ 0.53	0.61/0. 68	0.76/ 0.83	0.91/0.96
The average thickness of the swollen layer, mm	2.1/ 3.4	10.3/ 11.6	19.9/ 20.6	21.9/ 22.5	24.6/23 .2	19.3/ 17.5	17.0/15.7
Coefficient of linear swelling, mm	30.05	48.05	56.55	45.02	37.2	23.23	17.5

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Summarized results of experimental studies on the dependence of the swelling thickness of the fireproof coating on the thickness of the applied layer with the following parameters: The colour and appearance of the coating is white, matte surface. Cost to obtain a coating thickness of 1 mm – 1.65 kg/m^2 mm. Steel square plate side size – 50 mm. The thickness of the steel square plate – 2 mm

According to the obtained data, we construct the dependence of the thickness of the swelling of the fireproof coating on the thickness of the applied layer on Fig. 2:

As can be seen from the given dependence, swelling takes on the greatest value at a dry coating thickness of 0.6 mm, with an increase in application thickness, the swelling index decreases, and accordingly, the coefficient of linear swelling.

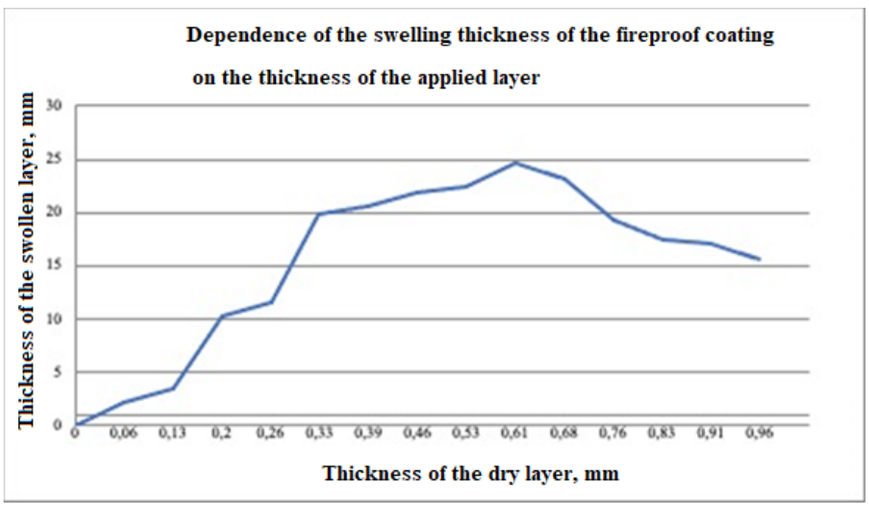

Figure 2

Dependence of the swelling thickness of the fireproof coating on the thickness of the applied layer

Conclusions

Based on the conducted experimental studies, the linear coefficient of swelling of the investigated coating was determined, which is 38. The dependence of the swelling thickness of the fire-resistant coating on the thickness of the applied layer was also determined. It was established that the swelling acquires the greatest value at a dry coating thickness of 0.6 mm, and with an increase or decrease in thickness application, the swelling index decreases, the integrity of the coating is violated, and, accordingly, the

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coefficient of linear swelling. Metallic constructions frequently have place on the geologically investigated territories. The geophysical environment experiment was carried out for the study of the environment in the aspect of linear expansion coefficient of high-temperature and fireproof coating based on polysiloxane and aluminum oxide for the metallic bearing constructions.

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