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Case study

Analysis of the risk at the finishing of the building products and construction of paint compositions

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ABSTRACT

Information is provided on the application of risk management technology in the analysis of the quality of paint coatings of building products and structures. The methodology for estimating the value of the permissible risk is given.

1. Introduction

Practice shows, that the predicted lifetime of paint and varnish coatings of building products and structures is 5–6 years or more. But often the destruction of coatings is observed after 2–3 years of operation. In this regard, it is very important to develop methods to improve the quality of paint and varnish coatings. Previous research results have established a link between the durability of paint and varnish coatings and the quality of their appearance [1]. An analysis of domestic and foreign literature in the field of quality management shows that a number of questions on applying coatings to porous cement substrates have not yet been properly developed. Cement substrate is characterized by uneven distribution of pores along the of the surface, which undoubtedly influences the formation of the structure and properties of the coatings.

In order to ensure the quality of coatings, we propose an approach based on the inclusion of the stages of paint design and its application in the quality management process. Proceeding from the structural-probabilistic analysis, we consider the scheme for obtaining coatings:

paint → quality of the painted cement surface → coating.

To assess the reliability of the coating-substrate system, we propose to use the structural reliability scheme method, which allows us to assess the risk of a technical system. In accordance with GOST R 51901.1, risk analysis is an element of risk management, which includes actions to analyze, evaluate and reduce risk. The introduction of risk management will allow carrying out a risk assessment and will form the basis for developing requirements for the designation of admissible risks.

Standard GOST R 51901.4-2005 establishes general provisions for management of risk in the design, its subprocesses and the factors, that affect it. The method of the structural scheme of reliability is one of the methods often used in the analysis of risks of technical and technological systems [2,3]. General principles of risk assessment of technological systems are regulated by GOST R 51901-2002 “Reliability management. Risk analysis of technological systems”. The method allows to build models of technical and technological systems and to assess the probabilities of possible favorable and unfavorable events.

However, the analysis of scientific, technical and normative documentation shows that there is no information on the magnitude

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of the permissible risk for paint coatings operating in different climatic regions. In this regard, there is a need to create a database of acceptable risks of coatings.

2. The methodology of the research

The quantitative risk assessment is determined by the formula [3,4]

$$R = \sum_{i=1}^{n} r_i \tag{1}$$

Where ri is the risk corresponding to the *i* dangerous event

$$r_i = \frac{q_i h_i}{H \sum_{i=1}^{n} q_i} (i = 1, n), H = \max h_i \tag{2}$$

Where *q*i is the probability of an adverse event; *h*i is the consequence of the *i*-unfavorable event;

In general, the probability *q*i and consequences *h*i are functions of time, and, consequently, the risk depends on time.

The above calculations are applicable when the following conditions are met:

- Dangerous events are independent;
- a set of dangerous events describes quite fully possible situations;
- to each dangerous event there corresponds a consequence hi, which can be described as a damage.

The algorithm of risk assessment provides a comparison of the risk of the object R with the value of the permissible risk *R*o. The structural diagram of the reliability of protective and decorative coatings can be represented as a combination of three connected elements in series, which are the actual coating, contact layer and substrate (plaster) [5–7]. Thus, a quantitative risk assessment can be defined as

$$R = r_{coat} + r_{con.l} + r_{sub} \tag{3}$$

Since the failure of the technical system "coating-substrate" is due to the loss of the functional properties of paint coatings or the contact layer, the calculation of the risk of the technical system did not take into account the destruction of the substrate. Failure of coating occurs due to the loss of decorative and protective properties, and the failure of the contact layer – when the coating is peeled off. "Refusal" object (protective and decorative coating – substrate) occurs when any element fails, i.e. coating or contact layer, or at simultaneous failure. The probability of failure of an object on the time interval from 0 to t can be determined from expression [8].

$$Q(t) = 1 - \prod (1 - q(t)) \tag{4}$$

To determine the allowable value of *q*i for the coating and the contact layer, in assessing the consequences of adverse events, proceed from the cost of repairing previously painted surfaces in accordance with Ter 81-04-62-2001 for the Penza region. In accordance with the data given in TER 81-04-62–2001 "Painting work", the cost of repair painting works with water-dispersion paint amounts with clearing old paint to 10% – 1536.41 rubles (per 100 m^2), up to 35% – 1753.53 rubles, more 35% – 1913.48 rubles.

When calculating the allowable risk, *R*o was based on the following considerations. The service life of the protective and decorative coating with reliability α is 5 years (for example, water-dispersion acrylic paint). Therefore, the probability that the coating collapses is 1-α.

The reliability α of an object with a guaranteed service life should be different de-pending on its condition. It seems to us that if the reliability of the coating service life is α = 0.9, then is possible destruction up to 10% of the painted surface with a probability of 0.1. If the reliability is α = 0.95, then is possible destruction up to 35% of the painted surface with a probability of 0.05. If the reliability is α-0.99, then is possible destruction up to 35% of the painted surface with a probability of 0.01.

3. Research results

Proceeding from (4), were calculated the admissible probabilities of the destruction of the coating and the contact layer for

Table 1
Permissible fracture probability.

Condition the painted surfaces	Permissible fracture probability	
	coating	Contact layer
Destruction of up to 10% of the surface	0,068	0,032
Destruction of up to 35% of the surface	0,033	0,017
Destruction > 35% of the surface	0,0067	0,0033