Quality control of fireproof coatings for reinforced concrete structures

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Abstract. The article analyzes methods of quality inspection of fireproof coatings (work flow, measuring, laboratory, etc.). In modern construction there is a problem of lack of distinct monitoring for the fire protection testing. There is a description of this testing for reinforced concrete structures. The article shows the results of calculation quality control of hatches as an example of fireproof coating for reinforced concrete structures.

1. Introduction

Building structures are protected from thermal effect by using fireproof coatings. It is special material and structure processing for increasing its fire resistance and fire protection assurance of facility. Project and operation documentation contains the experimental and analytical basis for the design solutions on fire protection methods and means to ensure its ultimate value of fire resistance. The Russian and European methods for control tests of fire retardant coatings include document verification, visual inspection and monitoring with thermal analysis [1-4]. Safe building operation involves constant structural scrutiny. The analysis of quality control methods of fire retardant coatings established that there are no standards for quality control of fireproof coatings for reinforced concrete structures. The quality control for reinforced concrete structures is considered in detail.

Representatives of organizations, which make forensic enquiry and testing, conduct fire-protective work, can take part in monitoring. The safe building operation involves a constant examination of its technical condition. Each manufacturer regulates the quality control standards both in accordance with the requirements of regulatory documentation. Testing of fireproof coatings is conducted due to Russian National Standard [5-8]. Rules does not clearly describe the quality control of fire retardant coatings in concrete structures [9-16].

The rightly composed rules increase the quality of measures which are using to check the performance of fireproof coatings.

The purpose of this article is calculation of the number of holes for required quality of reinforced concrete structures. According to the aim, we have the following tasks:

1. To conduct an analysis of various methods of quality control of fireproof coatings;
2. To analyze the quality of concrete structures using the example.
2. Methods
There are no fire protection standards which take into the account the number of samples for testing. Because of absence of standards the operation documentation can be used as a recommendation for fire resistance testing.

Suppose reinforced concrete structures with fire protection as a special product. Then the fire protection becomes a product characteristic - thickness of the protective layer, which depends on required value of fire protection. The number of defects for this product characteristic, incorrect dimensions and shape of product and crack opening displacement can be selected.

Sample selection and its control are based on several normative documents. Sample selection is the control, which includes the testing of one or more specially chosen samples from the whole lot. Production lot should be manufactured due to standards. The products from different batches of raw materials or working conditions in sample selection are excluded. The samples should be equal; otherwise they should be divided in for making parts homogenous.

Manufacturer defines the acceptance quality level in the absence of standards:
- 4% - to control the accuracy of overall dimensions and shapes of products, the dimensions and shapes of its joints with other products, the thickness of the protective layer of structure;
- 10% - to control geometric parameters, which determine the quality of product.

Since the dimensions, which determine the quality of the surface of product, are high-quality reinforced concrete with fire protection we accept the value of acceptance level as 10%.

In case of one-stage control, when there are no defective items in indicator or its number is small, we can use the table 1.

| Table 1. One-stage control |
|---------------------------|
| Quantity, pcs. | Number of defects for the acceptance quality level, % |
| Lots of product to 25 | Samples | 4.0 | 10.0 |
| from 25 to 90 | 5 | 1 | 2 |
| 91 – 280 | 8 | 2 | 3 |
| 281 - 500 | 13 | 2 | 4 |
| 501 - 1200 | 20 | 3 | 6 |

In case of two-step indication, if quantity of defects in the first sample is less than or equal to acceptance level, the lot of products is taken for each indicator. We need the second sample if the defect quantity is greater than accepted value but smaller than the number of defects. If the total number of defects in two samples is less than or equal to the acceptance level for the second sample, the lot is accepted, alternatively not.

| Table 2. Two-stage control |
|---------------------------|
| Quantity, pcs. | Number of defects for the acceptance quality level, % |
| Lots of product To 25 | Samples (first second) | Ac | Re | Ac | Re |
| | 3 | Single-stage zone | 1 | 2 |
| From 26 to 90 | 5 | 0 | 2 | 0 | 3 |
| From 91 to 280 | 5 | 1 | 2 | 3 | 4 |
| From 281 to 500 | 8 | 0 | 2 | 1 | 4 |
| From 501 to 1200 | 13 | 1 | 2 | 4 | 5 |
| | 20 | 3 | 4 | 6 | 7 |
| | 20 | 4 | 5 | 8 | 9 |
Choosing the quantity of stages for the control depends on number of defects. To calculate the number of observation hatches in reinforced concrete structures we accept one-stage control as more simple way to control the quality of fire protection.

3. Results
As an example there is a high-rise multifunctional 70-storey (100-storey) building with reinforced concrete bearing structures with different fire resistance limits and loading conditions. The degree of fire resistance is taken as special - R240. The fireproof coating need in periodical inspection that is why we make calculation of value of necessary and sufficient number hatches in the node points of reinforced concrete structures in order to determine quality of coating.

There are the following numbers of node points of reinforced concrete structures:
• 1 type. The conjugation of the main beams with the core is in quantity of 1215 (1435) pieces (R240);
• 2 type. Attachment points of facade are in quantity of 2580 (2940) pieces (R120);
• 3 type. Attachment points of cantilever bars, which are fixed to the reinforced concrete core of the building, are in quantity of 1200 (1315) pieces (R150).

It is necessary to consider variants of joints and to divide into homogeneous lots, taking into account design features, loads, limits of fire resistance. Every type of fireproof construction is divided by floor due to the difference of loads on each floor: 18, 37, 18 (15, 30, 14) lots from each type.

We make one-step control according to Table 1. We make a selection of 5 pieces in each lot, which includes 18 points. For lots with 37 points - 8 pieces (Table 3). The number of windows should be equal to the number of selected pieces for each type of node.

Since the dimensions, which determine the quality of the surface of product, are high-quality reinforced concrete with fire protection we accept the value of acceptance level as 10%.

We determine the deviation from value in Table 1: for lots of nodes of types 1 and 3, the number is 2 pcs. For lots of second type of nodes - 3 pcs. (Table 3).

Then the control of samples for indicators is conducted according to fire-retardant coating quality control methods. The number of defects in each lot, which do not meet the specified fire protection quality requirements, is counted.

If the number of defects is less than value of deviation, the lot is accepted. Otherwise, there is carrying out of careful control of the fire-retardant coating.

Table 3. The acceptance level

| Node Type | Number of nodes, pcs. | Number of lots and size, pcs. | Samples, pcs. | The number of defects for the acceptance level, pcs. |
|-----------|-----------------------|-------------------------------|--------------|---------------------------------------------------|
| Acceptance level of defects: | | | 10% | |
| 1 type | 1215 | 70x18 | 5 | 2 |
| 2 type | 2580 | 70x37 | 8 | 3 |
| 3 type | 1200 | 70x18 | 5 | 2 |

The calculation shows that it is necessary to install hatches - 350, 560, 350 for reinforced concrete structures with different fire resistance limits, that is 5, 8, 5 on each floor, which corresponds to each type of nodes.

4. Conclusion
In modern building regulatory documents there is a lack of description of control methods for fire-retardant coating of load-bearing reinforced concrete structures. While studying the methods for testing fire retardant coatings, it is found that there are no well-defined inspection boundaries for concrete structures, despite the fact that they are fairly clearly described for wooden and metal structures. The calculation of the necessary and sufficient number of hatches for fire resistance control of load-bearing
reinforced concrete structures in case of various fire resistance limits and loading conditions of high-rise multifunctional 70-storey building is made.

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