Evaluation method of technical condition façade systems

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Abstract. The technique of monitoring the conditions of a façade system as part of the scientific and technical support of construction. The building demands an increased level of responsibility. Façade systems "ZIAS-100.02" with cladding with fiber cement slabs and "ZIAS-100.02" with cladding with concrete slabs are used during the construction. Monitoring of the system is carried out in order to verify the compliance of the façade fencing with the requirements of design documentation, applicable standards and requirements, as well as to determine and evaluate the actual condition of the façade system. Selective tests of anchor dowels of sizes 10x135 and 10x100 mm used in hinged façade systems were completed as part of the monitoring. The tests were carried out after a visual inspection of the façade system structures. During the tests, the ONIKS-1.VD.050 material strength meter was used. Anchor dowels were pulled out from two types of walls. The first type of walls is made of foam concrete blocks, the second type of monolithic reinforced concrete. The results of tests for two types of walls are presented. A variant of processing the individual results of the breaking load values obtained during the testing of anchor dowels of the façade system is also shown.

1. Introduction
Special attention is paid to facilities with an increased level of responsibility in both industrial and civil engineering. It is at such facilities that the scientific and technical support of construction must be provided. This support is necessary in the design, installation and manufacture of structures. One of the most important tasks of scientific and technical support of construction is the organization of technical monitoring during the construction of building structures [1-5].

In this article, special attention is paid to monitoring the state of mounted hinged façade systems. In accordance with the design data, the purpose of the construction project is a multifunctional residential complex. The structural system of the building is column-wall (mixed). The complex consists of buildings in which residential buildings with public facilities, apartments and an underground parking lot are located. The maximum height of the object is 125.7 m from the level of land planning, which corresponds to 37 floors [6-15].

The purpose of scientific and technical support of construction is to verify the compliance of the façade system with the requirements of design documentation, the current standards and requirements...
of the manufacturer, as well as the determination and assessment of the actual technical condition of the facade system.

The ZIAS-100.02 hinged front systems with fiber cement cladding and the ZIAS-100.02 with concrete slab lining were used to install the facade of a multifunctional residential complex. The base for the facade system is made of two types: monolithic reinforced concrete structures and enclosing fillings between the supporting frame of foam concrete blocks [16-22].

2. Methods

Implementation of work on the scientific and technical support of construction was organized in several stages:

The development of a work program on scientific and technical support.

Checking the conformity of the designs of facade systems mounted in the periods established by the work program according to [23-27].

1. Monitoring of work on facade systems for control and conformity purposes.
2. During the monitoring, the following work was carried out:

3. Verification of materials and components of the facade system.
4. The study of the results of a technical examination of the base (wall) used for the facade system. The material of the walls was correlated with the requirements for the anchoring of the facade system according to the data received.
5. Verification of compliance with the technological sequence of work.
6. Checking anchor elements and deviations of the location of the supporting brackets.
7. Determination of the bearing capacity of anchor fasteners.

Determination of the bearing capacity of the anchor fastening was carried out directly at the construction site, after the construction of the building base and its design strength set. For a non-uniform building foundation, it was envisaged to install anchor fasteners in various types of areas separated by clear boundaries (heavy concrete, foam concrete block).

The tests were performed separately for each of the characteristic types of base sections (see Figure 1, 2). During the tests, the ONIKS-1.VD.050 material strength meter was used.

![Figure 1. Anchor pull from a monolithic reinforced concrete base.](image)

The device was mounted on a wall plug pre-mounted in the structure and then fixed tightly. Next, a uniform increase in load was performed at a constant speed, until the maximum load was reached. After which the maximum separation value was recorded.
The total number of tested anchorage for each homogeneous section of the base is 10 anchors. Each sample mounted for anchor testing was brought to failure with the construction of a graph of the dependence of deformation on load [28-30].

The single results of the breaking load values obtained during the tests were processed according to the following procedure:

1. The average load for all sections is determined:
   \[ N = \frac{1}{n} \sum_{i=1}^{n} N_i \]  
   (1)

2. The standard deviation of unit load values is determined:
   \[ S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (N_i - N)^2} \]  
   (2)

3. The coefficient of variation of the controlled batch is determined:
   \[ \nu = \frac{S}{N} \]  
   (3)

4. The calculated resistance of the anchor is found:
   \[ R = \frac{N(1-\nu)}{m} \]  
   (4)

3. Results and Discussion

Independent results were provided for each site. For convenience, the calculation results are summarized in the table. Table 1 presents the test results of facade anchors mounted in the walls of foam concrete blocks. During installation, FIKSAR DF-B 10x135 TD anchors were used.

Table 2 presents the test results of facade anchors mounted in monolithic reinforced concrete walls. During installation, FIKSAR DF-B 10x100 TD anchors were used.

The coefficient \( t \) corresponds to the lower limit of the bearing capacity of the anchor with a security of 0.95 at a level of confidence being 90%. Coefficient \( m \) is the material reliability coefficient characterizing the average ratio between the breaking load and the load corresponding to the end of the elastic deformation zone.

The values \( N + 3S \) and \( N-3S \) correspond to the upper and lower boundaries of the rejection of the obtained values.
Table 1. Test results for walls constructed of foam concrete blocks.

| No | $N_i$, kN | $n$, pcs. | $N_k$, kN | $S$, kN | $\sigma$,% | $(N+3S)$, kN | $(N-3S)$, kN | $t$, m | $R$, kN |
|----|-----------|----------|----------|--------|--------|-------------|-------------|------|--------|
| 1  | 4.48      |          |          |        |        |             |             |      |        |
| 2  | 3.57      |          |          |        |        |             |             |      |        |
| 3  | 3.67      |          |          |        |        |             |             |      |        |
| 4  | 5.35      |          |          |        |        |             |             |      |        |
| 5  | 5.47      | 10       | 4.37     | 0.70   | 16.1   | 6.47        | 2.27        | 2.568| 5      | 0.51   |
| 6  | 4.09      |          |          |        |        |             |             |      |        |
| 7  | 3.54      |          |          |        |        |             |             |      |        |
| 8  | 4.16      |          |          |        |        |             |             |      |        |
| 9  | 4.45      |          |          |        |        |             |             |      |        |
| 10 | 4.92      |          |          |        |        |             |             |      |        |

Table 2. Test results for walls constructed of monolithic reinforced concrete blocks.

| No | $N_i$, kN | $n$, pcs. | $N_k$, kN | $S$, kN | $\sigma$,% | $(N+3S)$, kN | $(N-3S)$, kN | $t$, m | $R$, kN |
|----|-----------|----------|----------|--------|--------|-------------|-------------|------|--------|
| 1  | 33.49     |          |          |        |        |             |             |      |        |
| 2  | 35.59     |          |          |        |        |             |             |      |        |
| 3  | 21.28     |          |          |        |        |             |             |      |        |
| 4  | 33.34     |          |          |        |        |             |             |      |        |
| 5  | 29.63     | 10       | 26.6     | 6      | 22.6   | 44.62       | 8.62        | 2.568| 5      | 2.24   |
| 6  | 21.09     |          |          |        |        |             |             |      |        |
| 7  | 23.72     |          |          |        |        |             |             |      |        |
| 8  | 21.43     |          |          |        |        |             |             |      |        |
| 9  | 19.68     |          |          |        |        |             |             |      |        |
| 10 | 26.98     |          |          |        |        |             |             |      |        |

4. Conclusion

The following conclusions can be drawn according to the results of the facade system monitoring:

1. When organizing monitoring as part of the scientific and technical support of construction, it is necessary to approve the work program, which will indicate the periods of inspection and testing of installed structures. These periods are recommended to be appointed in accordance with the schedule of works on the facade system at a particular construction site.

2. The results of the monitoring allow reporting at established intervals. This reporting allows one to assess the quality of the installation work carried out in established periods, to confirm that the installation is carried out in accordance with the requirements of the design and working documentation, and also to prevent the appearance of errors in the installation work at an early stage.

3. Based on the results of the selective control of the bearing capacity of the anchor dowels, it can be concluded if the mounted facade system as a whole is suitable. The obtained values can be compared with the technical characteristics of the anchors, as well as with the existing test results.

4. The suitability of the facade system for further operation must be evaluated comprehensively. It is necessary to take into account the results of a visual inspection of the system structures, as well as the results of instrumental control.

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