Increasing the technology of waterproofing from bentonite mortars for construction, reconstruction and overall repair of a building

Elena Korol, Rima Petrosyan and Nadezhda Smirnova

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

E-mail: KorolEA@mgsu.ru, PetrosyanRS@mgsu.ru, nadezhda-iva@mail.ru

Abstract. Subject: The article investigates the parameters of the technological processes of arranging underground injection waterproofing from bentonite solutions for construction, reconstruction, and overhaul of buildings in cramped conditions, taking into account the features of mechanization of work, the number and qualifications of workers. Based on the results of the timekeeping studies carried out in experimental conditions, the costs of working time for performing technological operations on the arrangement of underground waterproofing with an injection compound from bentonite solutions were determined. Considering the identified technological features, the number and qualifications of workers have been established during the work on the arrangement of injection waterproofing from bentonite solutions.

1. Purpose of the study
Experimental study of the parameters of technological processes of arranging underground injection waterproofing from bentonite solutions for construction, reconstruction, and overhaul of buildings in cramped conditions, taking into account the features of mechanization of work, the number and qualifications of workers.

2. Research methodology
The basement room of pavilion No. 53 "Mechanization, electrification and melioration", located on the territory of the landmark «VSKhV-VDNKh-VVC», was chosen as an experimental platform for experimental works on the installation of injection waterproofing from bentonite solutions.

During the experimental work on the arrangement of injection waterproofing at the experimental platform, the author investigated the indicators of the actual costs of working time to identify rational conditions to perform all the components of the technological process and establish technically justified norms of the time. As a method of studying the process of installing injection waterproofing from bentonite solutions, the method of timekeeping was adopted.

When carrying out timekeeping observations, the duration of each technological operation was measured using a stopwatch with an accuracy of 1 s. During the measurements, the name of the operations, the beginning and end of observations, and their duration were recorded. As a result, for each operation, multiple measurements of their duration were carried out and timekeeping series were compiled (table 1).
Table 1. Characteristics of the stability of timekeeping series.

| Name of technological processes and operations | Duration of technological operations, min | Ky | tcep | σ |
|-----------------------------------------------|------------------------------------------|----|------|---|
|                                               |                                            |    |      |   |
| 1. Preparation of the surface of insulated structures | 8 7 9 6 7 10 8 1,5 8 1,6 |    |      |   |
| 2. Drilling the holes in structures            | 90 88 89 88 91 92 88 1,0 90 1,8 |    |      |   |
| 3. Installation of injectors/packers in drilled holes | 13 15 16 13 16 15 16 1,2 15 1,4 |    |      |   |
| 4. Preparation of the injection composition | 10 11 10 12 11 12 10 1,2 11 1,1 |    |      |   |
| 5. Injection of the injection composition into the structure | 107 106 108 105 107 106 108 1,0 107 1,3 |    |      |   |
| 6. Removing injectors/packers from holes      | 15 14 16 15 16 15 14 1,1 15 0,9 |    |      |   |
| 7. Plugging (sealing) holes with a repair compound | 8 9 6 7 8 9 6 1,5 7 1,2 |    |      |   |
| 8. Technological break 16 hours               | 961 960 962 963 961 962 960 1,0 962 1,6 |    |      |   |
| 9. Cleaning the insulated surface from the solution | 13 15 14 15 13 13 15 1,2 14 1,0 |    |      |   |
| In total, duration of technological operations, min | 1225 1225 1230 1224 1230 1234 1225 - - - |    |      |   |

Review for row 1:

\[ KY = 1,5: 10 \leq \frac{121-10}{14}+0,9 \ (9 - 6), \ 10 = 10,63. \]

Review for row 7:

\[ KY = 1,5: 9 \leq \frac{111-9}{14}+0,9 \ (8 - 6), \ 9 = 9,09. \]

In total, the average duration of technological operations per 1 m²
(considering the technological break): 1228,0 min = 20,50 hours
(without considering the technological break): 266,0 min = 4,44 hours

In total, the average duration of technological operations per 15 m²
(considering the technological break): 18421,0 min = 307,00 hours
(without considering the technological break): 3994,0 min = 66,57 hours
3. Research results

Upon completion of the measurements, the obtained observational data were processed. From the timekeeping series, the values of time measurements, which sharply differed from the rest of the values of the measurements set, were excluded. After excluding defective measurements for each row, the scattering degree of the technological operation’s duration was determined through the stability factor of the timekeeping series, calculated by the formula

$$ K_y = \frac{t_{\text{max}}}{t_{\text{min}}} $$

(1),

where $t_{\text{max}}$, $t_{\text{min}}$—maximum and minimum measurement value in the timekeeping series, s.

Results of calculating the stability coefficient of the timekeeping series are shown in Table 1.

To assess the quality of the obtained timekeeping series, the fulfillment of this condition is Important

$$ K_y \leq K_{\text{n}} $$

(2),

where $K_{\text{n}}=1.3$ is the standard stability coefficient of the time series [2].

According to the results of the check, it was found that in two rows out of nine the stability condition (2) is violated and the rows need to be «cleaned». Incorrect measurement values were excluded from these rows, and a new value of the stability coefficient of the rows was determined. The correctness of excluding inaccurate measurements was determined based on the method of limit values according to the formulas

$$ a_{\text{max}} \leq a_{\text{cp}} + k \cdot (a_{\text{max}} - a_{\text{min}}); $$

(3),

$$ a_{\text{min}} \leq a_{\text{cp}} - k \cdot (a_{\text{max}} - a_{\text{min}}), $$

(4),

where $a_{\text{max}}$ is the maximum value in the checked row;

$a_{\text{min}}$ is the minimum value in the checked row;

$a_{\text{cp}}$ is the average value of the checked rows;

$k$ — coefficient, counting the number of observations and taken equal to 0.9 [2].

After eliminating incorrect measurements and re-evaluating the stability of the timekeeping series, the average duration of each operation of the technological process was calculated using the formula

$$ t_{\text{cp}} = \frac{\sum t_i}{n}, $$

(5),

where $\sum t_i$ is the total duration of all elements of the row;

$n$ - number of measurements in a row.

4. Analysis of the received data

Based on the results of the calculations, the duration of arranging injection waterproofing from bentonite solutions at the experimental site of work with an area of 15 m$^2$ was 66.75 hours. Based on the obtained data of time observations and analysis of the requirements given in the unified tariff and qualification reference book of jobs and professions [3], the author discovered the rational composition of the working section on the arrangement of injection waterproofing from bentonite solutions (table 2). Based on the set of working operations included in the technological process, as well as the characteristics of the developed technology, the following composition of the working section was selected: 4th-grade waterproofer (G4) — 1 person; 3rd-grade waterproofer (G3) — 1 person.
**Table 2.** Distribution of labor costs of workers by category for the arrangement of injection waterproofing from bentonite solutions.

(a)

| Name of technological processes and operations | Laboriousness, person - min | Laboriousness, person - hours | Including the division by category |
|-----------------------------------------------|----------------------------|-------------------------------|----------------------------------|
| 1. Preparation of the surface of insulated structures | 120 | 2,00 | 1,00 | 1,00 |
| 2. Drilling holes, not reaching the outer surface of the basement wall by 70-90 mm | 1350 | 22,50 | 11,25 | 11,25 |
| 3. Installation of packers for waterproofing mortar, not reaching the outer surface of the basement wall by 70-90 mm | 225 | 3,75 | 1,88 | 1,88 |

(b)

| | Laboriousness, person - min | Laboriousness, person - hours | Including the division by category |
|-----------------------------------------------|----------------------------|----------------------------------|
| 4. Preparation of injection solution | 165 | 2,75 | 1,38 | 1,38 |
| 5. Injection of the injection composition into the structure | 1605 | 26,75 | 26,75 | - |
| 6. Removing the injectors/packers and placing them on the next plot | 225 | 3,75 | 1,88 | 1,88 |
| 7. Plugging (sealing) holes with repair mortar | 105 | 1,75 | 0,88 | 0,88 |
| 8. Technological break around 16 hours | - | - | - | - |
| 9. Cleaning masonry from mortar | 210 | 3,50 | 1,75 | 1,75 |
| Total laboriousness, person - hours | 4005,00 | 66,75 | 46,75 | 20,00 |

5. Conclusion
Using the method of timekeeping observations at the experimental site, the actual costs of working time for the implementation of technological processes and procedures of arranging injection waterproofing from bentonite solutions were established, and the working processes that had a massive impact on the total duration of the waterproofing work were determined.

The technological features revealed during the process of arranging injection waterproofing from bentonite solutions in experimental conditions made it possible to establish the composition and
sequence of technological operations on the arrangement of injection waterproofing and to determine the numerical-qualification membership of the performers [4-15].

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