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Determination of the effectiveness of the production process of winter concreting based on field studies

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Abstract. This article considers the process of formation of the term "winter concreting production potential". Approaches to the formation and use of the term "potential" in the scientific environment are analyzed. Goals and objectives are formulated, and the methodology for collecting and processing data on the results of field studies is created. A quantitative indicator for assessing the effectiveness of organizational and technical decisions, as well as the measurement scale to translate the qualitative assessment of each factor into a quantitative one was introduced. Developed a tool to regulate the management of data collection at the sites for further processing in the form of a map of management of data collection at the sites. Also, a questionnaire was made, filled in during the data collection process for further processing. In order to process the data obtained during field studies, a Construction Site Analysis Questionnaire was developed. The results of the field studies of 152 objects are presented. The basis for the mathematical apparatus characterizing the value of "production potential of winter concreting" was prepared.

1 Introduction

Currently, the actual task in the field of winter concreting is the development of comprehensive and methodological foundations of the organization of production processes, which will increase the effectiveness of the organization of construction of residential buildings made of monolithic reinforced concrete. Organizational and technological design does not solve this problem today. The adoption of correct organizational and technical solutions at each stage of work production plays an important role. [1,2] Earlier researches set the task of in-depth and more detailed consideration of organizational approaches connected with production of concrete works in winter period. [3-8] In order to solve this problem there were determined factors which influence productivity of production of concrete works in winter period and the most significant of them were revealed in order to create united complex mechanism which could increase

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productivity of organization of construction of residential monolithic buildings in winter period. [9-11]

Earlier studies on the study and analysis of the term "organizational and technological potential", allow us to conclude that its formation was based on the method of expert evaluations, due to the impossibility of conducting a large number of experiments. [12-14]

The method of expert evaluations was used not only in forming the list of parameters affecting the final indicator of potential, but also in determining their significance and developing a mathematical model. [15-20] This approach is widespread and quite successful, but it has shortcomings. [21-26] Experts are not always able to reliably characterize and take into account all the real conditions at the construction site, especially when performing concrete work in the winter period, since at an average daily temperature of less than +5 degrees there are many unforeseen situations that negatively affect the quality of the final product. In view of this, an expert survey will not be able to fully reflect, much less evaluate, all possible combinations of organizational, technical, managerial, technological solutions and contingencies. That is why it was decided to collect and use statistical data obtained on the building site itself in order to create a data set able to assess the real situation at the site qualitatively. And then to offer measures to improve the effectiveness of the organization of the erection of residential high-rise buildings of monolithic reinforced concrete structures in the winter period.

In this regard, there was a need to resort to full-scale research. Under the full-scale research is understood the collection of actual data from the relevant documents on both the implemented projects on the erection of monolithic reinforced concrete structures of residential high-rise buildings in the winter period, and in the process of construction.

Before starting the research, it is necessary to clearly formulate goals and objectives, as well as to create a methodology for the collection and processing of data on the results of field studies. For statistical research it is necessary to describe in detail and rank the factors influencing the quality of the final product, as well as the criterion which characterizes the effectiveness of the organizational and technical solutions taken during the construction of monolithic reinforced concrete in the winter period. In-situ research can be divided into stages, including:

1 - development of the draft program and methodology of the study;
2 - preparation of the study;
3 - carrying out the study;
4 - processing of the obtained data and drawing up a report.

2 Methods

In order to simplify the solution of the tasks we took as a basis the following technological stages of the device of monolithic reinforced concrete structures in the construction of residential multi-storey buildings: arrangement of the building foundation; erection of monolithic structures of the building aboveground part; erection of structures of the building underground part. And so in order to assess the performance of the organization in terms of duration it is necessary to introduce an indicator that could assess the level of productivity of all technological stages of the construction of monolithic reinforced concrete structures. Since the task was to assess the performance of the erection of monolithic reinforced concrete structures in winter conditions, the evaluation criterion was chosen as the term of erection of monolithic reinforced concrete structures of the typical floor.

Due to the fact that the studied construction objects have differences among themselves, the value of the term of erection of monolithic reinforced concrete structures of one storey varies among themselves. This value can vary from 6 days to 15 days or more. Therefore, to evaluate the performance it is necessary to determine a single parameter for all objects. We need an effective tool which could show the limits of possibilities of organizational and technical solutions for production of concrete works in the winter period. In order to create such a tool, we apply the previously introduced notion of "production potential of winter concreting" which shows the ratio of the planned term of erection of a typical storey to the actual term. Since, as a rule, an appropriate unit of measurement is used for determining the range of design values, and since the design values taken as 100 percent, percent should be taken as a unit of measurement of the indicator "production potential of concrete works in winter period" as well. This approach will provide a basis for quantitative and qualitative assessment of the "winter concreting production potential".

$$P_{cwc} = \frac{T_p}{T_f} * 100\% \qquad (1)$$

Where P_{cwc} is the production potential of winter concreting, T_p is the planned period of installation of monolithic reinforced concrete structures of the typical floor, T_f is the actual period of installation of monolithic reinforced concrete structures of the typical floor.

When assessing the performance of monolithic reinforced concrete structures in the construction of residential buildings and structures in winter, there can be problems related to the fact that the performance can be characterized by different parameters. The solution to the problem is to take into account the whole list of properties. But in this case there is an incompatibility of some values, determined by different types of scales. The solution to this problem lies in the transition from one scale of measurement to another. In this case it is necessary to keep the meaning of criteria and purposes of their use.

Let "P" be the value of the performance of monolithic reinforced concrete works, which should be evaluated; x = {x_1, x_2, ..., x_n} - the set of factors describing and affecting the performance indicator. The task is to find the value of the criterion "P" depending on this or that combination of values of the factors "x".

As stated earlier, due to the fact that the factors are measured on different quantitative and qualitative scales, it is necessary to bring them to a single scale of measurement with preservation of the meaning and purpose of the factors [27].

Therefore, a measurement scale was introduced in the form of scores from 1 to 3 , which will characterize the degree of compliance with the concepts of "excellent," "good," and "unsatisfactory." The value "unsatisfactory" is assigned when the assessed indicator violates normative or regulatory standards, does not meet the requirements prescribed in the organizational and technological documentation. The value "good" is assigned when the assessed indicator is in an incomplete stage. The value "excellent" is assigned when the assessed indicator does not violate the regulatory or legal norms, meets the requirements prescribed in the organizational and technological documentation. [27-29] As a result, the assessment of potential will be represented not by a set of qualitative judgments, but by a set of numerical assessments. This will allow the use of a unified numerical scale, and will make it possible to use the values obtained in the same calculations.

The use of a scale with unified boundaries and explanations of the assignment of assessments solves the problem of bringing qualitative and quantitative assessments into a single measurement plane. The results of the analysis are summarized in a common table, which indicates organizational and technical factors and levels of the possible state of these values.

In order to develop the program and methods of research of organizational and technical solutions during the production of concrete works in the winter period, the detailed analysis of the following documents was carried out - the organizational and technological documentation, the list of engineering and technical personnel and responsible persons;

production documentation; executive technical documentation; design and estimate documentation.

The last step in preparation for the study is to create a tool that will regulate the management of data collection at the sites for further processing. To solve this problem, a map of data collection management by objects (Table 1) and a step-by-step algorithm of data collection and processing were made.

Table 1. Control map of data collection by objects.

Process designation and name	**Data collection management**
Process Status	1. Preparatory stage 2. Basic stage 3. Final stage
Process designation	Collection of statistical data.
Process manager	Responsible manager.
Process Participants	Master, foreman, project manager.
Process components (main activities)	-procedure of technical assignment -process of data collection -analysis and study -structuring and assembling in a database
Process documentation	normative documents (GOST, codes of practice), organizational and technological documentation (construction organization project, works execution project, technological catalog, defectoscopy)
Process Inputs	Process Suppliers
Process charts, journals, graphs	Planning the progress of facility construction.
Process outputs	Processes-consumers
Actual floor erection rate, deviations, defects, strength, ambient temperature, temperature of concrete mix during curing.	Monitoring of construction and assembly works on site.
Control actions	Distribution of responsibility and authority of the process participants; Monitoring the process; Implementation of corrective and preventive actions Performance analysis of the process; Actions to improve the process
Resources required	Production facilities (office); Design and working documentation, normative and technical documentation; Office equipment, means of communication.
Controlled process parameters	Compliance with the work schedule
Methods for measuring process parameters	Control over the results of already built objects; Control over the results of the objects under construction; Filling out questionnaire data; Processing of results.

Since it was necessary in addition to assessing the actual and projected rate of erection of monolithic reinforced concrete structures of one floor, to determine the value of variation of each factor in the object under study, a questionnaire was compiled. (Table 2)

Table 2. Construction site analysis questionnaire.

Name of the object: (indicate address; representative of the customer, representative of the builder and representative of the person carrying out the construction, who carried out the work subject to certification)

<table>
<tr><td colspan="3">Responsible executor: full name, contact details.</td></tr>
<tr><td colspan="2">Rate of erection of monolithic structures of the standard floor as per design.</td><td>The value is set using organizational and technological documentation.</td></tr>
<tr><td colspan="2">Rate of monolithic structures of typical floor as per design.</td><td>The value is set using the production documentation.</td></tr>
<tr><td colspan="2">Average daily ambient temperature during the erection of the floor monolithic structures.</td><td>The value is set according to the concrete work log.</td></tr>
<tr><td>№</td><td>Name of factors</td><td>Estimated score</td></tr>
<tr><td>1</td><td>Quality of organizational and technological documentation</td><td>-</td></tr>
<tr><td>2</td><td>Methods of accelerated concrete hardening</td><td>-</td></tr>
<tr><td>3</td><td>Use of methods of non-destructive control of concrete strength.</td><td>-</td></tr>
<tr><td>4</td><td>Qualification of employees and engineers.</td><td>-</td></tr>
<tr><td>5</td><td>Timeliness and accuracy of implementation of measures to protect the concrete laid in the construction.</td><td>-</td></tr>
<tr><td>6</td><td>Ambient temperature during the production of concrete works.</td><td>-</td></tr>
</table>

In order to obtain data, it was necessary to study design, production and organizational and technological documentation. It was necessary to study the projects of the works on monolithic reinforced concrete structures arrangement, regulations on winter concreting at the object, concrete works logs, general works log, defectoscopy of monolithic structures of the erected floor, protocols of concrete compressive strength 7 and 28 days, prescriptions of the technical customer, to determine timeliness and accuracy of the measures to protect the concrete laid in the structure, acts, protocols, schedules of previously revealed block schemes and draw up in accordance with the table 3. X_i - coded value of the i factor, Z_i - estimated score of the i factor.

Table 3. Coded factor values.

No.	Factor name	Coded value (Xi)	Evaluation score (Zi)
1	Quality of organizational and technological documentation	X_1	1.Satisfactory 2. good; 3. excellent.
2	Methods of accelerated concrete hardening	X_2	1.Satisfactory 2. good; 3. excellent.
3	Use of methods of non-destructive control of concrete strength.	X_3	1.Satisfactory 2. good; 3. excellent.
4	Qualification of employees and engineers.	X_4	1.Satisfactory 2. good; 3. excellent.
5	Timeliness and accuracy of implementation of measures to protect the concrete laid in the construction.	X_5	1.Satisfactory 2. good; 3. excellent.
6	Ambient temperature during the production of concrete works.	X_6	1.Satisfactory 2. good; 3. excellent.

The information was collected during the visit to the construction site in person. The results of the analysis of design, production and organizational and technological documentation, as well as information from the questionnaires were summarized in Table 4. The process of collecting and analyzing data on the constructed objects was carried out in a different way. The responsible person provided copies of the necessary documentation for the study and a completed questionnaire (Table 2).

3 Results

After obtaining all the necessary information on the objects, in order to process it further, it was necessary to bring it into the following form (Table 4)

Table 4 Construction site analysis questionnaire.

No.	X_1	X_2	X_3	X_4	X_5	X_6	t fact, days	t plan, days	Y
1	Z1(x1)	Z1(x2)	Z1(x3)	Z1(x4)	Z1(x5)	Z1(x6)	T1f	T1p	$\frac{T1p}{T1f}$
2	Z2(x1)	Z2(x2)	Z2(x3)	Z2(x4)	Z2(x5)	Z2(x6)	T2f	T2p	$\frac{T2p}{T2f}$
3	Z3(x1)	Z3(x2)	Z3(x3)	Z3(x4)	Z3(x5)	Z3(x6)	T3f	T3p	$\frac{T3p}{T3f}$
i	Zi(x1)	Zi(x2)	Zi(x3)	Zi(x4)	Zi(x5)	Zi(x6)	Tif	Tip	$\frac{Tip}{Tif}$
n	Zn(x1)	Zn(x2)	Zn(x3)	Zn(x4)	Zn(x5)	Zn(x6)	Tnf	Tnp	$\frac{Tnp}{Tnf}$

Where,
- X_i - name of the factor;
- Z_i – estimated score of the factor;
- Zi(Xi) – estimated score of factor Xi;
- $T_{iф}$ - actual value of the term of erection of the typical floor of monolithic reinforced concrete structures in winter;
- $T_{iп}$ - design value of the period of erection of the typical floor of monolithic reinforced concrete structures in winter;
- Y – level of productivity of erection of the typical floor of monolithic reinforced concrete structures in winter.

Table 5. Results of the analysis of the construction site.

№	X_1	X_2	X_3	X_4	X_5	X_6	t fact, days	t plan, days	Y
1	2	2	2	2	2	2	9.5	9	94.73
2	2	2	2	2	3	2	10.2	10	98.03
3	1	2	1	2	1	2	11.8	9	76.27
n	Zn(x1)	Zn(x2)	Zn(x3)	Zn(x4)	Zn(x5)	Zn(x6)	Tnf	Tnp	$\frac{Tip}{Tif}$
150	2	3	2	2	3	3	12	13	108.33
151	3	3	3	3	3	3	8.4	10	119.04
152	2	3	2	1	3	1	11.2	11	98.21

4 Conclusions

The data obtained as a result of field studies will be processed for further formation of a mathematical apparatus capable of evaluating the potential of organizational and technical solutions in the production of concrete works at average daily ambient temperatures below +5 degrees.

The mathematical apparatus will allow to determine the dependence of the terms of erection of a typical storey on the accepted organizational and technical factors.

Reference

1. Aidarov, S., Tošić, N., & de la Fuente, A. A limit state design approach for hybrid reinforced concrete column-supported flat slabs. Structural Concrete, **23(6)**, 3444-3464. https://doi.org/10.1002/suco.202100785, (2022).
2. Aidarov, S., Nadaždi, A., Pugach, E., Tošić, N., & de la Fuente, A. Journal of Building Engineering, **51**, 104205, (2022), https://doi.org/10.1016/j.jobe.2022.104205
3. A. Lapidus, *Vestnik MGSU,* **1**, 175-180 (2014)
4. A. Khubaev, T. Bidov, Science and business: Development ways, **4(82)**, 101-103 (2018)
5. A. Lapidus, T. Bidov, A. Khubaev, MATEC web of conferences, **V. No. 00094**, DOI: 13.1051/matecconf/201711700094 (2017)
6. A. Lapidus, A. Khubaev and T. Bidov., MATEC Web of Conference, **V. № 05014**, DOI: 17.1051/matecconf/201825105014 (2018)
7. A. Lapidus, A. Khubaev and T. Bidov., E3S Web of Conference 97, FORM 2019 DOI: 10.1051/e3sconf/20199706037 (2019)
8. A. Lapidus, A. Khubaev and T. Bidov., IOP Conf. Series: Materials Science and Engineering 869,V. №072033, DOI:10.1088/1757-899X/869/7/072033/, (2020)
9. A. Lapidus, A. Khubaev, Science and business: Development ways, **11(77)**, 7-11 (2017)
10. A. Khubaev, Science prospects, **4 (103)**, 57-61 (2018)
11. A. Khubaev, T. Bidov , Izvestiya TULGUU, 2, p 466-471, 2022
12. Lapidus A.A., Govorukha P.A., *International Journal of Applied Engineering Research*, **Vol. 10**. **№ 20**. p.40946-40949 (2015)
13. Govorukha P., *Scientific review*, **13**, 11-16 (2017)
14. A. Lapidus, T. Bidov, *International Journal of Applied Engineering Research*, **Volume 11**, 8, 5972-5974 (2016).
15. R. Fatullaev, Components *of Scientific and Technological Progress*, **3 (33)**, 17-22 (2017)
16. Feldman A., *Science and business: Development ways*, **12(78)**, 24-27 (2017)
17. Govorukha P., *Science and business: Development ways*, **3(81),** 85-88 (2018)
18. *R. Fatullaev,* Science and business: Development ways, **9(75)**, 34-40 (2017)
19. D.Topchiy, *Technology and organization of construction production*, **3(8)**, 40-42.(2014)
20. Lapidus, A. Makarov, *Bulletin of Moscow State University of Civil Engineering*, **8**, 150-160 (2015)
21. D.Topchiy, *Technology and organization of construction production*, **4**, 34-41.(2014)
22. T. Bidov, Scientific review, **13**, pp. 54-57 (2017)
23. A. Lapidus, I. Abramov, Science and Business: Development ways, **10** (2017)
24. A. Lapidus, K. Tolstova, Industrial and civil engineering, **5,** 68-71 (2016)

25. Fatullaev, R., Bidov, T. XV International Scientific Conference "INTERAGROMASH 2022". INTERAGROMASH 2022. Lecture Notes in Networks and Systems, **vol 575**. https://doi.org/10.1007/978-3-031-21219-2_15, (2023)
26. Fatullaev, R., Bidov, T, Networked Control Systems for Connected and Automated Vehicles. NN 2022. Lecture Notes in Networks and Systems, **vol 510**. Springer, Cham. https://doi.org/10.1007/978-3-031-11051-1_125, (2023)
27. Fatullaev, R, V. Gergaulova, S. Aydarov, E3S Web of Conferences, Chelyabinsk, 17–19 февраля 2021 года. – Chelyabinsk, 2021. – P. 09022. DOI:10.1051/e3sconf/202125809022.
28. A.A. Lapidus, I.V. Shesterikova, Mathematical model for assessment the potential of the high-rise apartment buildings complex quality index, E3S Web of Conferences 91, 02025 (2019) TPACEE-2018 doi.org/10.1051/e3sconf /20199102025 TPACEE-2018
29. V.V. Efimov, Statistical methods in quality management (UlSTU, Ulyanovsk, 2003)