

Development of process control and technical documentation for the construction of residential buildings and structures from monolithic reinforced concrete

Mukhammet Fahratov, *Pavel* Oleynik, and *Oleg* Kurenkov*

Moscow State University of Civil Engineering, 129377, Moscow, Russia

Abstract. One of the main tasks of the foreman at the construction site is the proper execution of technical and as-built documentation. As-built technical documentation is an integral part of construction production, which is necessary to confirm the quality and scope of work performed. In the event of accidents both during the construction of the facility and during its operation, as-built documentation is considered first to identify the reasons. It is also presented in the process of putting the object into operation. A foreman at a construction site needs to solve many problems: from ordering materials and controlling the production of construction and installation works to preparing as-built and reporting documentation for each completed stage of work. At the same time, as practice shows, a shortage of staffing to solve all the necessary tasks has been identified. In this regard, some companies resort to additional human resources for engineering and technical personnel from third parties. The task of the formation and functioning of the process of staffing mainly consists of creating a system for management regulation and providing this system with highly qualified professional personnel. This task is especially acute in the case of organizational coordination of construction management regulation. Based on this, there is a steady trend towards the growth of engineering corporations specializing in the complex provision of services for organizational coordination and management regulation. The selection of a professional construction organizer as an object of construction and investment activity imposes special requirements on the formation of an effective system of construction management regulation. The staffing level is expressed in accordance with the data on the composition of administrators, employees or the auxiliary personnel of a systematized configuration of management regulation with the number provided by the staffing table established in the process of organizational design or strategic planning process. The provisions considered in the paper make it possible to identify the actual availability of workers at all stages of management regulation, including the possibility of eliminating the shortage of engineering and technical personnel by rearranging company's own personnel, namely, to form a reserve for promotion, provide for retraining or additional training of the relevant groups of workers. In this

*Corresponding author: oleg9657425@mail.ru

case, the basis for the interaction of construction organizers and owners of labor resources is the process control and technical documentation.

1 Introduction

In recent years, the structure of using monolithic concrete in construction has fundamentally changed in Russia. Along with the use of prefabricated reinforced concrete structures, mainly in residential and civil construction, the share of monolithic construction has increased significantly. Monolithic concrete structures have significantly changed the architectural appearance of residential, business and administrative complexes, as well as sports facilities. The main advantage of monolithic buildings over all others is the absence of seams between various building structures. In monolithic buildings, there is a possibility of redevelopment of premises during operation without the risk of damaging the supporting structures, as well as the high quality of the surfaces of walls and ceilings, which reduces the amount of finishing work. As the main disadvantage, it can be noted that this construction method is very costly and time consuming, requires expensive equipment, a large number of highly qualified workers and engineers.

One of the basic rules for a foreman at a construction site is the proper execution of technical and as-built documentation. The foreman at the construction site is faced with many tasks: from ordering materials and monitoring the production of construction and installation works to preparing as-built and reporting documentation for each completed stage of work. In addition, he signs the as-built and geodetic schemes as a responsible person, thereby he confirms the geometric characteristics, the identified deviations of the erected structures and the amount of work performed. The foreman is primarily responsible for the quality of the work performed and for the identified structural deviations. As a rule, during the construction process, the labor costs of the engineering and technical personnel, including the foreman, increase in comparison with the labor costs included in the project. As practice shows, these labor costs increase due to an increase in the volume of work performed and calculations, as well as the coordination of additional work that was not included in the design and as-built documentation. At the same time, a shortage of staffing to solve all the necessary tasks has been identified. Therefore, some companies resort to additional human resources of engineering and technical personnel from third parties. The task of the formation and functioning of the process of staffing mainly consists of drawing up a system for management regulation and providing this complex with highly qualified professional personnel. This task is especially acute in the case of organizational coordination of construction management regulation.

2 Materials and methods

The composition and content of technical and as-built documentation mainly includes a textual part, which can be an explanatory note, prepared acts, documents confirming the quality of materials, products and equipment used, as well as a graphic part, which includes drawings or diagrams with all necessary information.

The mandatory technical documentation includes:

- construction organization project (COP);
- design and technological documentation (DTD);
- work production project (WPP).

The initial data for the development of COP are the feasibility study of construction, materials of engineering surveys, planning documents setting the construction time,

decisions on the use of materials and structures, as well as mechanization means, agreed by the general contractor and subcontractors, information on the conditions of delivery and transportation from supplier enterprises, space-planning and design solutions, information on the conditions for the provision of personnel for builders, data on the availability of a production base for the construction industry and other activities. COP, DTD and WPP are developed on the basis of a special section of the Terms of Reference for the design of a building (or a complex of buildings).

This section should include:

- calendar construction time;
- data on the number of cranes, technological transport and mechanization equipment available to the contractor (customer) and their technical characteristics;
- information on whether the contractor (customer) has a form workset or on the possibility of its manufacture (indicating the manufacturer);
- information on the provision of basic materials, semi-finished products and parts (including the possibility of using local materials and production wastes), as well as heat and electric energy for technological purposes.

The construction organization project for buildings from monolithic reinforced concrete includes:

- construction schedule;
- building master plan;
- a list of volumes of the main construction, installation and special works with the calculation of labor costs for concrete, reinforcement and formwork;
- labor demand schedule;
- schedule for the need for basic construction machines;
- terms of reference for the design of formwork (additional elements), tooling and auxiliary equipment (if necessary);
- an explanatory note containing, in particular: a description of the construction conditions;
- substantiation of the choice of the method of erection of buildings, indicating, if necessary, the method of performing concrete work in winter conditions and in conditions of dry and hot climates;
- instructions on the methods of instrumental control over the quality of the structure;
- safety measures and labor protection.

Design and technological documentation is developed on the basis of a terms of reference for the development of a building (complex) project and a construction organization project.

DTD includes: floor plans with a breakdown into work zones and an assembly diagram of the formwork placement. The diagrams indicate all the elements of the formwork and equipment (screeds, linings, scaffolds, stairs, elements forming openings, etc.), showing the installation sequence.

The work production project is developed on the basis of a construction organization project and design and technological documentation. The initial materials for the development of WPP are: a development task issued by a construction organization as a customer of a work production project; COP; required working documentation; terms of delivery of structures, finished products, materials and equipment, the use of construction machines and vehicles, provision of workers. The composition and level of detail of the materials developed in the work production project are established by the relevant contractor construction and installation company, based on the specifics and volume of work performed.

The work production project for buildings made of monolithic reinforced concrete includes:

- a work schedule for the facility or a comprehensive arrow diagram;
- building master plan;
- schedule of admission of building structures, products, materials, equipment to the facility;
- schedule of movement of workers and main construction machines at the facility;
- description of the way of performing work;
- flow charts for the performance of certain types of work;
- safety requirements;
- lists of technological inventory and assembly equipment, cargo slinging schemes;
- explanatory note (see COP);
- materials of DTD.

The composition of the WPP can be expanded or reduced in accordance with the terms of reference.

As-built technical documentation. As-built documentation is an integral part of construction production. It is necessary to confirm the quality and scope of work performed. In addition, this documentation is the basis for identifying the causes, in the event of an accident during the operation of the constructed facility. This documentation is presented during the commissioning of the facility to the relevant commissions (operating companies). In addition, it contains information to facilitate the further operation of the facility. It includes:

- the act of transferring the geodetic surveys to the customer;
- as-built schemes of the building foundation elevations;
- description of the method for transferring the geodetic control network to the mounting level and the as-built scheme;
- general work log, designer supervision log, log of receiving inspection of materials and equipment supplied to the construction site, as well as special logs of work production (concrete care log, welding log, earthwork log, concreting and pile driving log, waterproofing and anti-corrosion protection log, etc.);
- certificates of inspection of hidden works;
- certificates of inspection of critical structures;
- certificates of inspection of sections of engineering systems and networks;
- acts of acceptance of finished surfaces;
- documents confirming the quality of the materials, equipment and products used (certificates of conformity, quality certificates, declarations of conformity and other documents);
- acts of acceptance of subcontractors' work;
- working drawings with a stamp “approved for construction” and with added deviations from the project, agreed with the design company;
- laboratory and other tests reports;
- formwork kit passport (indicating turnover, data on production repairs, depreciation rate, manufacturer, certificates, etc.)

The set of as-built documentation includes acts (surveys of hidden works, surveys of critical structures, surveys of sections of engineering systems and networks, acceptance of finished surfaces) with corresponding annexes –as-built schemes, certificates and passports, acts and protocols of laboratory and other tests. The set also includes a general work log and all the necessary special work production logs described above, a list of which is provided by the general contractor or developer. In some cases, the set necessarily includes a photographic record of the work performed at the request of the General Contractor or

Customer. At the same time, the acts must reflect all the necessary information from a legal point of view, namely: the name and details of all participants in the construction, references to orders or powers of attorney of the responsible persons of the construction participants, details of all necessary documents attached to the acts, links to the design or working documentation corresponding to the work performed, references to the main regulatory documents according to which the work was performed, as well as the signatures of the responsible representatives, which legally confirm the fact of the work performed. As-built diagrams should reflect the actual positions of structures in space after performing construction and installation works (CIW). The as-built diagram records the actual horizontal and vertical deviations, the geometric dimensions of structures, their bindings to axes or other structural elements, and also indicates the amount of work performed and the materials used. Since the as-built documentation is directly related to the display of the quality of construction (reconstruction or overhaul) of the facility, for which the foreman is directly responsible, two blocks of factors affecting the quality can be distinguished: factors of direct impact and factors of indirect impact.

Factors of direct impact are those factors that primarily affect the quality and bearing capacity of the structures being built, these include: horizontal and vertical deviations of building structures; geometric characteristics of structures; quality of the building materials used; quality of work performed. Indirect factors are factors that do not affect the bearing capacity and performance of work, but only display the parameters of the work performed as an information block necessary for the further operation of the facility, which include: errors of the main indicators in the set of as-built documentation; not complete information about the performed work.

If we consider the quality of construction itself, then, first of all, it is necessary to pay attention to the factors of direct influence. Parameters related to these factors are displayed on as-built diagrams and drawings, laboratory test reports, certificates for materials and equipment. The main parameters were determined by studying as-built documentation and as-built geodetic diagrams.

The working day of a foreman or a work producer is often not limited to eight hours, although formally no one has the right to detain them. And when monolithic structures are poured, the sling works around the clock. During the daytime, the installation of formwork and the reinforcement of structures is underway. At night - filling the formwork with in-situ concrete. The work is carried out in two or even three shifts, i.e. around the clock.

There are many tasks that the foreman has to solve at the construction site. The duties of the foreman include control over the activities of the teams, ordering materials and construction equipment, and be responsible for safety and labor protection at the construction site. At the end of the working day, he draws up plans for the next day, during which he checks the quality of the assigned tasks, studies the project documentation, interacts with designers and subcontractors, and calculates the volume of performed work. It is also necessary to prepare as-built documentation and make reports. In addition, each completed stage of work must be presented to the technical supervision representative and the customer (developer).

As practice and theoretical research based on the collected statistical data on deviations made of monolithic building structures, including monolithic reinforced concrete walls, show, the deviations range from the minimum and permissible values (according to regulatory documents) to values that go beyond the limit tolerances. These deviations affect the structural scheme of the building, the distribution of loads on the supporting structures, the quality of construction and, in general, the operational reliability of the facility. To identify the degree of influence of deviations, it is necessary to determine the law of their distribution according to statistical data.

To determine the law of distribution of deviations of monolithic reinforced concrete walls along the axis with a standard tolerance of 15 mm (according to clause 5.12 of SP 70.13330.2012), it is necessary to transform statistical data into a variation series.

Let's consider statistical data on the change in the indicators of deviations of monolithic reinforced concrete columns along the axis in ascending order, forming a variation series:

$$P_1, P_2, P_3, \dots, P_m \quad (1)$$

where m – total number of statistics.

We transform the resulting simple variational series into a grouped one. A number of classes x are formed at regular intervals. Each class includes data for which P satisfies the inequality:

$$P_m - \frac{d}{2} < P < P_m + \frac{d}{2} \quad (2)$$

where P_m – mean value of an interval equal to the half-sum of its boundaries.

The initial data for calculating the distribution characteristics according to statistical data are presented in Table 1. The graphical interpretation of the frequency distribution of the deviation indicators is presented by the histogram in Figure 1. For the structures of monolithic reinforced concrete walls and columns, the algorithm for calculating the law of distribution of deviations, including the section thickness, is the same as for calculation of the distribution law for deviations of columns from the axis, based on empirical statistical data. This algorithm can be applied, since the graph and histogram constructed according to statistical data have at least 2 clearly expressed extremum points.

Table 1. Initial and auxiliary data for calculating the empirical characteristics of the distribution of wall deviations along the axis.

Interval P	Center of interval P_m	x	Absolute frequency, r		Σr	
			r	$r, \%$	r	$r, \%$
-1.5 - 0.5	-1	-3	0	0.0000	0	0.000
-0.5 - 0.5	0	-2.5	7	1.9663	7	1.966
0.5 - 1.5	1	-2	15	4.2135	22	6.180
1.5 - 2.5	2	-1.5	25	7.0225	47	13.202
2.5 - 3.5	3	-1	20	5.6180	67	18.820
3.5 - 4.5	4	-0.5	18	5.0562	85	23.877
4.5 - 5.5	5	0	22	6.1798	107	30.056
5.5 - 6.5	6	0.5	19	5.3371	126	35.393
6.5 - 7.5	7	1	20	5.6180	146	41.011
7.5 - 8.5	8	1.5	21	5.8989	167	46.910
8.5 - 9.5	9	2	19	5.3371	186	52.247
9.5 - 10.5	10	2.5	19	5.3371	205	57.585
10.5 - 11.5	11	3	14	3.9326	219	61.517
11.5 - 12.5	12	3.5	11	3.0899	230	64.607
12.5 - 13.5	13	4	9	2.5281	239	67.135
13.5 - 14.5	14	4.5	11	3.0899	250	70.225
14.5 - 15.5	15	5	16	4.4944	266	74.719
15.5 - 16.5	16	5.5	9	2.5281	275	77.248
16.5 - 17.5	17	6	8	2.2472	283	79.495
17.5 - 18.5	18	6.5	7	1.9663	290	81.461

18.5 - 19.5	19	7	6	1.6854	296	83.146
19.5 - 20.5	20	7.5	7	1.9663	303	85.113
20.5 - 21.5	21	8	3	0.8427	306	85.955
21.5 - 22.5	22	8.5	6	1.6854	312	87.641
22.5 - 23.5	23	9	1	0.2809	313	87.922
23.5 - 24.5	24	9.5	4	1.1236	317	89.045
24.5 - 25.5	25	10	5	1.4045	322	90.450
25.5 - 26.5	26	10.5	6	1.6854	328	92.135
26.5 - 27.5	27	11	2	0.5618	330	92.697
27.5 - 28.5	28	11.5	4	1.1236	334	93.821
28.5 - 29.5	29	12	4	1.1236	338	94.944
29.5 - 30.5	30	12.5	5	1.4045	343	96.349
30.5 - 31.5	31	13	4	1.1236	347	97.472
31.5 - 32.5	32	13.5	2	0.5618	349	98.034
32.5 - 33.5	33	14	1	0.2809	350	98.315
33.5 - 34.5	34	14.5	2	0.5618	352	98.877
34.5 - 35.5	35	15	3	0.8427	355	99.720
35.5 - 36.5	36	15.5	1	0.2809	356	100.000
36.5 - 37.5	37	16	0	0.0000	356	100.000

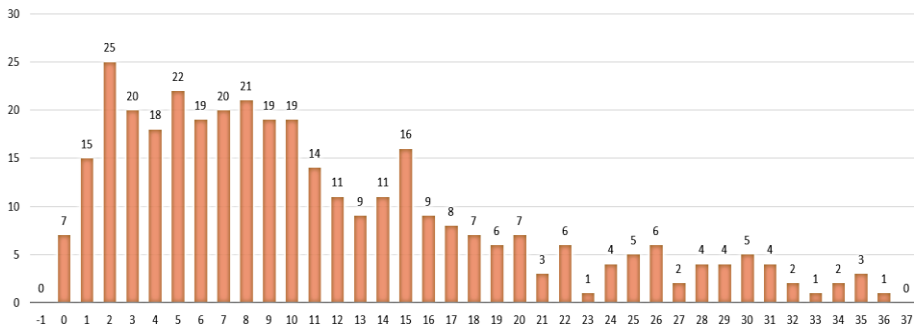


Fig. 1. Histogram of the empirical distribution of the frequencies of deviations of the walls from the design position along the axis with a standard limit tolerance of 15 mm. Abscissa - deviation values in mm., Ordinate - number of repetitions (frequency).

In the grouped variation series of deviations, the value of the abscissa (deviation value) equal to 5 mm is taken for the middle of the classes.

The constructed step curve increases from 0 to $n = 356$ and has jumps of $1/r$.

Table 2. Auxiliary data for calculating the empirical characteristics of the distribution of deviations

Center of interval P_m	x	Absolute frequency, r	xr	x^2	x^2r
-1	-3	0	0.000	9.000	0
0	-2.5	7	-17.500	6.250	43.75
1	-2	15	-30.000	4.000	60
2	-1.5	25	-37.500	2.250	56.25
3	-1	20	-20.000	1.000	20
4	-0.5	18	-9.000	0.250	4.5
5	0	22	0.000	0.000	0

6	0.5	19	9.500	0.250	4.75
7	1	20	20.000	1.000	20
8	1.5	21	31.500	2.250	47.25
9	2	19	38.000	4.000	76
10	2.5	19	47.500	6.250	118.75
11	3	14	42.000	9.000	126
12	3.5	11	38.500	12.250	134.75
13	4	9	36.000	16.000	144
14	4.5	11	49.500	20.250	222.75
15	5	16	80.000	25.000	400
16	5.5	9	49.500	30.250	272.25
17	6	8	48.000	36.000	288
18	6.5	7	45.500	42.250	295.75
19	7	6	42.000	49.000	294
20	7.5	7	52.500	56.250	393.75
21	8	3	24.000	64.000	192
22	8.5	6	51.000	72.250	433.5
23	9	1	9.000	81,000	81
24	9.5	4	38.000	90,250	361
25	10	5	50.000	100,000	500
26	10.5	6	63.000	110,250	661,5
27	11	2	22.000	121,000	242
28	11.5	4	46.000	132.250	529
29	12	4	48.000	144.000	576
30	12.5	5	62.500	156.250	781.25
31	13	4	52.000	169.000	676
32	13.5	2	27.000	182.250	364.5
33	14	1	14.000	196.000	196
34	14.5	2	29.000	210.250	420.5
35	15	3	45.000	225.000	675
36	15.5	1	15.500	240.250	240.25
37	16	0	0.000	256.000	0
		$\Sigma = 356$	$\Sigma = 1112$		$\Sigma = 9952.00$

In order to determine the empirical distribution, it is necessary to calculate the arithmetic mean. The arithmetic mean can be represented as the center of the grouping of a random variable:

$$\text{Par. m.} = \frac{\Sigma xr}{n} d + 5 = \frac{1112}{356} 2 + 5 = 11.247 \quad (3)$$

Deviations from the mean value ($P_m - P_{ar.m.}$) describe the spread of the original data around this value. The variance is calculated as:

$$\sigma^2 = \frac{d^2}{n} + \left(\Sigma x^2 r - \frac{(\Sigma xr)^2}{n} \right) = \frac{2^2}{356} + \left(9952 - \frac{1112^2}{356} \right) = 72.79 \quad (4)$$

In this case, the positive value of the square root of the variance characterizes the mean square (standard) deviation:

$$\sigma = \sqrt{\sigma^2} = \sqrt{72.79} = 8.532 \quad (5)$$

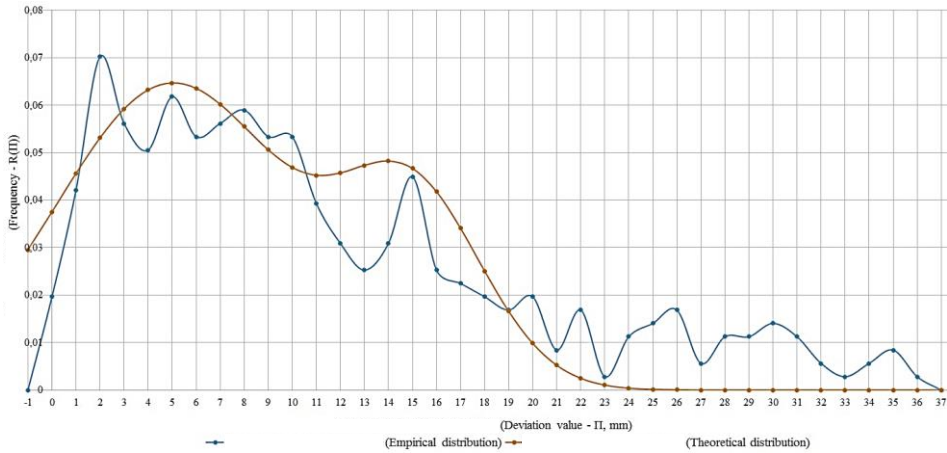


Fig. 2. Frequency histogram and non-uniform distribution curve of wall deviations from the design position along the axis

The revealed numerical characteristics of the empirical distribution of deviations make it possible to conclude that the distribution is non-uniform. The non-uniform distribution equation was found by fitting different normal distribution curves and has the form:

$$R_0(P) = A_1 e^{-B_1 (P-\mu_1)^2} + A_2 e^{-B_2 (P-\mu_2)^2} = 23e^{-0,022 (P-5)^2} + 14e^{-0,057 (P-15)^2} \quad (6)$$

where: A_1 and A_2 – the coefficients that are the extremum points of the curve function; B_1 and B_2 – coefficients calculated according to the formula: $B = 1/2\sigma^2$; μ_1 and μ_2 – deviation values corresponding to the extrema of functions.

The set of initial data is composed of two normal sets with parameters $\sigma_1 = 4.80$ and $\sigma_2 = 2.95$.

Table 3. Parameters of the theoretical distribution by empirical frequencies

P_m	Absolute frequency, r	r^t	P_m	Absolute frequency, r	r^t
1	2	3	1	2	3
-1	0	10.53	19	6	5.91
0	7	13.37	20	7	3.50
1	15	16.25	21	3	1.86
2	25	18.92	22	6	0.88
3	20	21.09	23	1	0.37
4	18	22.52	24	4	0.14
5	22	23.04	25	5	0.05
6	19	22.64	26	6	0.01
7	20	21.44	27	2	0.00
8	21	19.76	28	4	0.00
9	19	18.02	29	4	0.00
10	19	16.70	30	5	0.00
11	14	16.11	31	4	0.00
12	11	16.29	32	2	0.00
13	9	16.86	33	1	0.00
14	11	17.18	34	2	0.00

15	16	16.63	35	3	0.00
16	9	14.88	36	1	0.00
17	8	12.14	37	0	0.00
18	7	8.93			

In order to determine the density curve of a non-uniform distribution, it is necessary to divide the found function by the area enclosed between $R_o(P)$ and the abscissa axis. According to the histogram, the area corresponds to: $d\sum r = 356$. Consequently, the equation of the density curve of the inhomogeneous distribution and the cumulative distribution function of the deviation value will have the following form:

$$B(P) = 0.065 \int_0^P e^{-0.022 (P-5)^2} dP + 0.048 \int_0^P e^{-0.057 (P-15)^2} dP \quad (7)$$

Based on the graph in Figure 3, the resulting distribution of deviations is two-peaked, and the abscissas of the largest values are 5 and 14 mm. Thus, two parabolas corresponding to the components of the inhomogeneous distribution are observed.

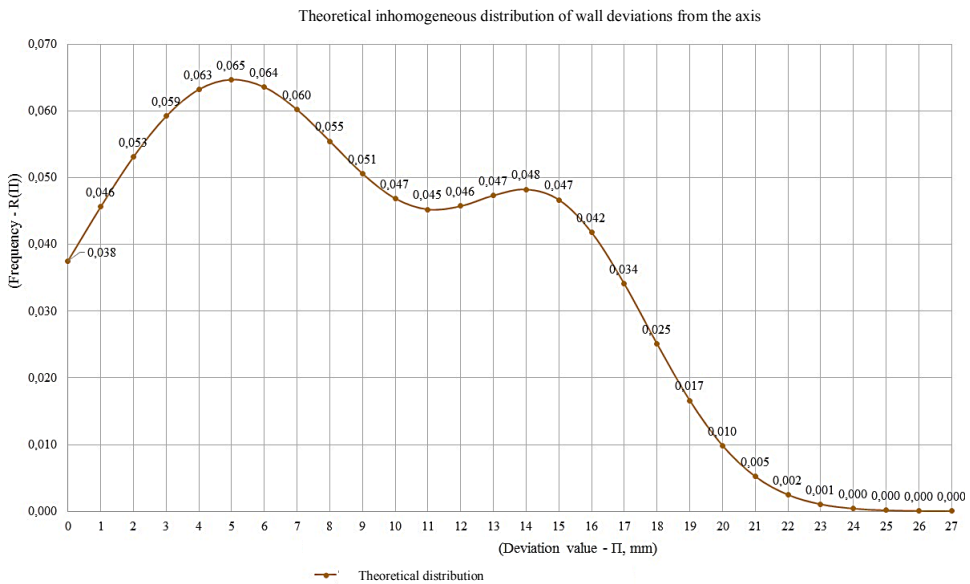


Fig. 3. Subdivision of a heterogeneous distribution

When arranging various monolithic reinforced concrete structures, the distribution laws, as a rule, are of a two-peaked nature. In this case under consideration, the extrema of the functions are within and on the border of the normative limit tolerances. This may indicate that in the design of as-built geodetic diagrams, the emphasis is on ensuring that the deviations do not go beyond the tolerances. In addition, given that a large proportion of deviations still go beyond the normative tolerances, special attention should be paid to them. These deviations are unacceptable according to the normative and technical documentation. In addition, a high value of deviations will affect the subsequent stages of the work production and the erection of overlying structures, which can lead to non-design distribution of loads. Responsibility for poorly performed work is borne by the producer of work, namely, the foreman.

To prevent the occurrence of non-standard deviations, it is necessary to identify the causes and develop a methodology for their prevention at subsequent stages of work. To achieve this goal, a multivariate correlation analysis was performed, based on the method of

expert assessments of all possible factors that may affect the occurrence of deviations. These factors are divided into corresponding groups, which are shown in Table 4.

Table 4. A group of factors affecting the occurrence of deviations in monolithic reinforced concrete load-bearing structures and their magnitude

No.	Group of factors	Factor
1	Technical and performance factors	Non-compliance of the supplied materials with the design characteristics;
2		Errors of measuring devices that control deviations of structures from design values;
3		Errors in binding to axes (geodetic alignment base) or existing structural elements;
4		The presence of deviations that go beyond the standard values, the base and underlying structures;
5		Lack of qualifications of construction personnel;
6		Incorrect installation of formwork panels (non-compliance with the required dimensions);
7		No required tightening of the formwork locks;
9		Inconsistency of the installation of embedded parts, their fixing to the values of the design and technical documentation;
11		Failure to comply with design dimensions, installation of formwork panels;
12		Failure to comply with the verticality of the formwork panels;
15		Installation of insufficiently rigid, deformable during concrete placement and insufficiently dense formwork;
16		Procedural and technological
18	Using a defective formwork system;	
19	Failure to take into account the influence of the existing deviations of the underlying structures;	
22	Violation of concreting technology;	
23	Violation of concrete care technology (temperature and humidity conditions);	
24	Unprofessional dismantling of the formwork (as a result, chips occur);	
27	The presence of an additional unaccounted load during the curing period of the concrete until the attainment of strength of at least 1.5 MPa.	
28	Violation of the operational control scheme by the engineering and technical personnel;	
32	Organizational and managerial factors	Lack of funding;
33		Lack of motivation;
34		Tight deadlines;
35		Negligence of construction personnel;
36		Irrational use of labor resources (intra-shift downtime, non-production costs);
39	Design and technolo-	The Developer does not have design solutions for specific sections of structures with a detailed study of units;

40	gical factors	Low quality of technological solutions;
41		Low quality of space-planning solutions;
42		Low quality of design solutions;
44		Lack of information in the design and technological documentation;
45		Poor quality of WPP development;
46		Incomplete display of information in design/working documentation (unprofessional design);
47	Information and technology factors	Incorrect execution of as-built documentation - errors in the display of deviation values;
48		The lack of all the necessary linear dimensions of the completed structures, including their binding to axes or other structural elements;
49		The absence of all the necessary height deviations of the previously executed structures.

According to the results of data processing and analysis of assessments of the considered factors, experts identified the most significant factors. These factors mostly include: Lack of qualifications of construction personnel; Incorrect installation of formwork panels (non-compliance with the required dimensions); Failure to comply with the verticality of the formwork panels; Non-professional formwork dismantling; Negligence of construction personnel; Failure to take into account the influence of existing deviations of the underlying structures. In this case, we can say that the qualifications of the personnel, as well as quality control of the work performed by the foreman, are the basis for preventing the occurrence of deviations in structures at the work performance stage.

3 Results and discussion

If we consider the aspect of the formation and preparation of as-built documentation, then the lack of motivation of contractors can be considered as a factor affecting the quality preparation of this documentation. This can be caused by a variety of reasons: lack of staff, time, budget, commitment, or simply underestimating the need despite a contractual requirement. If the importance of this type of documentation is underestimated, the work on its preparation and control is usually delegated to the least experienced engineer, trainee or junior employee - a technician. These people have little experience and are usually low paid. Based on practice, it can be concluded that the contractor has little incentive to distribute the line work of changing documents, which he widely distributes to foremen, masters, subcontractors, manufacturers and suppliers. Lack of funds is also an important factor. Collecting and analyzing information, collecting signed drawings and monthly reporting take up significant working time of the contractor's engineering staff. The contractor does not receive direct monetary compensation for his time and labor, since the task is considered auxiliary to the work and, therefore, must be compensated by the project overhead. Since there are no special conditions or prices prescribed in construction contracts, there are no financial incentives to perform the work on the formation and control of as-built documentation in the best quality. The only way that the construction work manager can ensure the proper maintenance and updating of as-built, reporting, and technical documentation is to periodically review the contractor's allowances and, if necessary, withhold payment for passing a certain stage or type of work. As practice shows, it is not unusual for a general contractor to perform less than fifty percent of the work with

his own efforts. In this case, the involvement of specialized contractors - intermediaries is practically necessary. The construction of a facility may require a variety of specialized work in which the general contractor must rely on specialized subcontractors at various stages of construction. It is understood that many parties are responsible for the execution of the work, and therefore for providing information for the preparation of documentation for the relevant work. The general contractor has to coordinate a huge amount of complex information, and this is a difficult task.

As the obtained heterogeneous distributions of deviations show, depending on the structural element and the values of the standard limit tolerances, the greatest distribution of values is concentrated within the tolerances, but at the same time a fairly large percentage of the values go beyond their limits. The resulting graphs indicate a two-vertex distribution, one vertex of which is within the normative tolerances, the second vertex is on the border and outside the tolerance values. These deviations have the greatest impact on the quality and safety of the erected building structures. The presence of deviations that go beyond the limit standard values indicate a faulty work. Also, the structures erected above will have their own deviations, which can lead to their total value, which will exceed not only the tolerance values, but also the distance between the bearing points of the bearing elements. Based on this, large values of deviations should be taken into account at subsequent stages of work production or be prevented. For this, it is necessary to attract the most qualified personnel and to tighten operational control during the construction of structural elements.

With regard to the activity in the management regulation of the personnel in housing construction, the task of forming or the functional structure of the process of providing personnel sources can be divided into two components:

1. Drawing up an expedient and rational system for management regulation (administrative and managerial personnel, engineering and technical personnel);
2. Provision of the construction and housing production complex with highly qualified and professional personnel of working specialties.

This task will be especially acute or indicate the need for adequate or early resolution within the framework of the construction and engineering scheme of organizational coordination of management regulation of construction.

In foreign practice, engineering has become an independent type of activity, directly related to the preparation of construction and industrial products or assuming:

- elaboration of issues related to the creation of industrial or housing and civil purposes, infrastructure schemes, including engineering communications of all types, primarily the provision of various engineering and consulting services on an economic basis;
- development on an economic basis of projects for the execution of construction and installation works, the construction or implementation of facilities, including the assessment of the technical or economic capabilities of the created facilities or objects, the design of equipment or provision of restrictions for its operation, the production of working drawings, prototypes, and the preparation of cost estimates, technical supervision of construction, assistance in technical and technological or organizational and economic issues of management regulation of production, training of the personnel, advice on the sale of equipment, optimization of technological processes, organizational coordination of product sales. In this regard, corporations specializing in the performance of the work approved above are called engineering firms, and the services provided by such corporations can be divided into two categories:

1. Consultations, surveys or reports carried out at the stages of theoretical study of the project, preparation of a feasibility study, including the implementation of an investment, construction and industrial project;
2. Services related to the direct implementation of a technical project or facility construction.

Nowadays, there seems to be a steady trend towards the growth of engineering corporations specializing in the complex provision of services, including services for organizational coordination or management regulation directly by the construction of the facility. At the same time, such corporations do not have their own resources for the purpose of providing contracting services, i.e. the performance of construction and installation or special works.

The selection of a professional construction organizer as an object of construction and investment activity makes special requirements for the formation of an effective systematized configuration of management regulation of construction both at the level of an economic facility (construction and engineering corporation - construction organizer, contracting corporation, etc.), or at the level of a construction facility. This is primarily caused by the complication of the construction process both in engineering and technical and organizational and managerial aspects. The basic element of a systematized configuration of management regulation is the administration personnel or employees who lead the work of the labor collective, determining the directions of the formation and optimization of the construction and industrial corporation, its divisions, including specific tasks for established periods, provide the necessary conditions for their implementation.

This element of the systematized configuration of management regulation is characterized by the human resources potential of the construction and housing complex, which includes:

- the need for specialists or leaders of an established profession or qualified configuration;
- provision of personnel for a systematized configuration of management regulation, i.e. the staffing as a whole or according to the main level indicators or links of the hardware complex of administrative regulation;
- placement of workers and employees in accordance with their qualifications or personal characteristics, i.e. high-quality staffing according to the correspondence of the level indicator or profile of education to the positions held;
- organization of the labor concept of employees of management regulation, including regulation of the activity of different groups of employees, rationing of the labor concept, provision of employees with the necessary technical means, organization of workplaces, etc.;
- organization of training, retraining or an increase in the qualification configuration of employees and administration personnel.
- stability of the staff (industrial or professional);
- intensity of promotion of administrators or workers in the enterprise.

The staffing level is expressed in accordance with the data on the composition of administrators, workers or an auxiliary personnel complex of a systematized configuration of management regulation with the number provided by the staffing table and established in the process of organizational design or a strategic planning process for the formation and optimization of a systematized configuration of management regulation.

The comparison made makes it possible to identify the real provision of workers at all stages of management regulation, including the possibility of eliminating the shortage of workers and employees by rearranging company's own personnel: to form a reserve for promotion, provide for retraining or additional training of the relevant groups of workers. This process is called outstaffing. As a business process, it is as follows: according to a civil law contract for the provision of personnel, the lessor undertakes to provide the lessee with workers of a certain profession and qualifications for a fee to use their labor in his production process. At the same time, an employment contract is concluded between the lessor and each employee, in which the lessor acts as the employer. The advantages of this service are: reduction in the number of employees allows reducing the direct costs of the

enterprise; acquisition of additional time for mastering and applying new methods of training and personnel management; a significant decrease in the legal difficulties associated with the payment of compensation in the event of dismissal of employees; the possibility of increasing staff salaries or benefits by optimizing management; reducing the administrative and financial burden while maintaining direct management of employees; the ability to check all new employees for professional and corporate compliance.

In addition, personnel leasing (outstaffing) of a corporation can use the system of benefits in its activity or involve former personnel of construction and industrial organizations. Thus, former employees also gain access to various types of insurance.

In the event that a construction corporation removes its labor resources, the format of work with a company that provides personnel leasing (outstaffing) services includes the following considered procedures.

After concluding an agreement for such services, a mandatory application to which are lists of former personnel with their personal data, a description of the functional basis, responsibility or compensation, these employees are formalized by transferring to personnel leasing (outstaffing) of the company, or an employment contract is concluded with each of them. After that, they are sent to work in a construction company. In the course of work, all current documents on management regulation of the former personnel are drawn up in personnel leasing (outstaffing) of the corporation. Every month it:

- compensates for the costs of the labor concept to each employee, including all bonuses or additional payments;
- fulfills obligations to the state established by Russian legislation (for example, to a pension fund);
- submits a report on the work done to the construction and housing company, on the basis of which an invoice is issued for the services of personnel leasing (outstaffing), which includes, in addition to the salary of the former employees, tax coverage, possible bonuses, or the actual payment for personnel leasing (outstaffing) services.

As noted above, the basis of interaction between the construction organizer or the owners of human resources is the organizational and technical documentation developed in a necessary way.

4 Conclusion

According to the federal law of the Russian Federation “Technical Regulations on the Safety of Buildings and Structures of July 2, 2013”, responsibility for construction lies with: the developer (technical customer), as well as the organization performing construction work at the facility and the relevant supervisory state authorities. The customer (developer) is responsible for the timely preparation for the operation and release of products of the commissioned facilities, for carrying out a comprehensive testing of equipment with the participation of design, construction and installation organizations, and, if necessary, equipment manufacturers, for setting up technological processes, commissioning of facilities on time. Thus, the customer bears full responsibility, which is not only administrative, but also criminal. The high quality of the constructed building is a factor in improving the standard of living, economic, social and environmental security. Responsibility increases sharply due to the provision of warranty obligations for the work performed throughout the entire operation of the construction facility, its reconstruction and overhaul, and, consequently, the time of the customer's work with the facility increases.

The quality of preparation of process control and design and technological documentation affects the quality of work performed for the construction of buildings and structures and the further process of operation. After conducting research and analysis, it is possible to identify how objectively the quality of the critical structures being built is

reflected. Often, in the process of building an object, the formed sets of structural and technological, as well as reporting documentation may not carry complete information about the work performed. That is, the documents that are necessary to reflect the important characteristics of structures are not indicated in full, which also increases the degree of error in displaying indicators. For example, when putting an object into operation, one of the main requirements is a correctly and fully completed executive documentation, and if it does not meet the requirements of the operating organizations, then the facility cannot be put into operation until it is corrected. As practice shows, it is this factor that is an obstacle to the timely completion of the project. The difficulty in correcting the documentation increases given the fact that some organizations that were engaged in construction and installation work by the time the facility was put into operation are disbanded or bankrupt. Based on this, the customer needs to resort to resources and help from other organizations to correct and restore as-built and technical documentation, thereby investing financial resources that are not taken into account when forming a project. In this regard, the use of the organizational model discussed in this paper with the use of outstaffing or personnel leasing is the most rational for the construction industry. Attracting administrative and engineering personnel from a third-party specialized organization using benefits allows optimizing the economic model of the enterprise, as well as reduce costs, and also improve quality control both in the formation of structural and technological documentation and in monitoring the implementation of each stage of construction and installation works. Outstaffing significantly reduces costs, minimizes the costs of a construction organization for non-core business processes. In addition, this procedure allows getting rid of the costs of financial and resource services for employees. Also, this organizational structure allows reducing the workload of the foreman or master of works by delegating the tasks assigned to them to the personnel provided under the lease agreement.

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