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Research paper

Calculation of Organizational-Technological Tasks by Ensuring the Stability and Reliability; Erection of Multi-Storey Frame Buildings

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Abstract

In the article fundamentally new problems are considered - the calculation of organizational and technological tasks by ensuring the stability of multi-storey frame buildings. Multi-storey frame construction is a very complex spatial rod systems with inclusion of planar and volumetric elements from prefabricated and monolithic reinforced concrete or metal lattice systems in them and is used in almost all fields of the national economy.

Keywords: *building construction; frame; multi-storey; monolith; stability*

1 Introduction

One of the ways to improve the efficiency of construction is to increase the number of storeys of buildings, which is due to a number of objective reasons: a lack of convenient for the construction of urban areas, as well as the territories of industrial enterprises; increasing the capacity of enterprises and, as a consequence, the need to increase production facilities with limited opportunities; an integrated approach to solving urban problems, creating ensembles, bringing production closer to residential areas, and enhancing the architectural and artistic qualities of buildings and structures. The erection of high storeys in the new construction and reconstruction of enterprises in conditions of a shortage of land is very effective. As shown by technical and economic comparisons, the construction of high-rise buildings reduces the building area by 30-40%.
Increasing the height of buildings leads to the search for the most rational architectural and planning solutions and constructive solutions, as well as optimal organizational and technological solutions for their erection. All this puts the complex of difficult technical and economic tasks before the builders. Naturally, there is a need to create fundamentally new types of multi-storey buildings that have high operational and economic qualities: capital, reliability, high technology, aesthetics and architectural expressiveness.
The practice of multi-storey construction determined the main design schemes: with bearing walls, including the large-panel and skeleton. Recently in domestic and foreign construction preference is given to skeleton schemes. Their advantages: a clear system of loads, use of unified structural elements and high classes of concrete and steel, wide use of effective materials and a reduction in the mass of structures, creation of conditions for reliable control over the quality of construction and installation works, and the possibility of convenient layout of premises.

2 Overview of Problem

Multi-storey frame construction is a very complex spatial rod systems with the inclusion of planar and volumetric elements from prefabricated and monolithic reinforced concrete or metal lattice systems in them and is used in almost all fields of the national economy.
In multi-storey frame construction, as in construction in general, the issue of intensifying the organizational and technological process, accelerating scientific and technological progress and improving quality is acute.
When choosing the optimal solutions, in particular for the installation of building structures, where the main criteria are duration, labor intensity, unit cost, the organizational, technological and logistical issues of erection are mainly considered. However, as shown in the studies [2], such a choice without sufficient consideration of the static work of the load-bearing structural elements of the framework does not always guarantee the reliability and safety of the work, nor is it economically and technically justified.
The main factors that predetermine the reliability of the static work of the frame and the cost-effectiveness of solutions for its construction are the correct accounting, justification and ensuring the stability and geometric unchangeability of the building structures during installation, depending on the assembly sequence, the accuracy of fitting individual elements and the device connections and interfaces. Violation of these requirements causes additional stresses not being taken into account in the junction nodes and structural elements of the frame [3], which significantly reduces the strength and stability of its bearing elements and buildings as a whole, negatively affects their durability, and sometimes leads to severe accidents during operation or during installation.

As a rule, the practice of assembling building structures [4] calculation, justification and ensuring sustainability is a complex multifactorial task, the solution of which depends on the volume-planning, structural and organizational-technological factors. Their account for the optimal choice of solutions without use of modern computers is not possible. Use of a computer can be possible only if there is reliable mathematical support, i.e. when formalizing logical and analytical dependencies that describe the interrelationship of factors, would allow research to be performed reliably to ensure the installation stability, identify alternatives to decisions and evaluate their results, and determine the data necessary for its adoption, i.e. substantiation and construction of a logical-mathematical model of the technological process with regard to strength characteristics.

3 Calculations

The most objective, allowing to reflect the influence of all factors on the installation technology, can be considered a method based on the theory of random processes.

The condition of reliable static operation of the structural elements of the framework, which ensures its stability at a given time, can be represented in the following form

:

$$R \geq \sigma(y_м), \quad (1)$$

Here R – reduced strength characteristic of the structural element of the frame;

$\sigma(y_м)$ – The stress in this element, which is a function of the load on the structure (longitudinal force N, bending moment M, etc.).

If during a certain time of mounting Tм the probability of exceeding the voltage б (Ум) of the level q1 is greater than the predetermined stability q3 of the skeleton is ensured. This will be characterized by inequality:

$$\overset{\kappa}{\underset{i=1}{II}} q_{3i} \leq \overset{\kappa}{\underset{i=1}{II}} q_i\left[R \geq \sigma(y_м)\right], \quad (2)$$

here i – the index of the constructive element; k is the number of their constructive elements.

This value depends on the distribution parameters and the nature of the change in time $\sigma(y_м)$. To estimate the effect of the distribution parameters and the character of the time variation of the expression б (Ум), we consider the cases that are possible during installation.

1. The quantity R is strictly defined, $\sigma(y_м)$ does not change by time, $\sigma(y_м)$ = const. two correlations are possible: R$>\sigma(y_м)$, R$<\bar{\sigma}(y_м)$. By chosing the voltage б (Ум), which depends on the specific production conditions, but not more than the value of R, which is embedded in the architectural and constructive projects, it is possible with the probability equal to unity to state that the stability of the framework is ensured, and consequently, the reliability of the technological process subject to all other requirements.

2. The R-value is random, $\sigma(y_м)$ does not change by time, $\sigma(y_м)$ = const. Let R – be random with normal distribution law $f(R)$. Voltage in the structural elements of the frame will be constant. The probability of failure-free operation of such an element is determined by the distribution parameters R and б (Ум) (Figure 1) and is described by an analytic dependence.

$$\Phi = \Phi(\gamma_R) + 0{,}5, \quad (3)$$

Here $\Phi(\gamma_R)$ – Laplace distribution function; γ_R – safety characteristics of installation work:

$$\gamma R = [\,\bar{R} - \bar{\sigma}(y_м)\,]\;/\sqrt{D_R} \quad (4)$$

Here $\bar{\sigma}(y_м)$ - mathematical expectation in the load-bearing elements of the framework; D_R – dispersion of their resistance to brittle fracture.

Voltage in the structural element of the frame, which ensures its stability during installation.

$$\sigma = y_м / I, \quad (5)$$

Here I – the geometric characteristics of the element at the time of installation.

Taking into account the dependence (6.3.4)

$$I = (y_м / R)(1 - \gamma_R \nu) \quad (6)$$

Here ν – coefficient of variation of value $\bar{R}$; $\nu = \sqrt{D_R}\,/\,\bar{R}$.

We denote the second multiplier of (6) in terms of $K_p = 1/(1 - \gamma_R \nu)$. We represent the expression (6) in the form

$$I = y_м / \bar{R} K_p \quad (6.1)$$

The factor Kp included in the formula should always be greater than unit, take into account the heterogeneity of the properties of the structural material and its characteristics in particular of monolithic concrete or mortar when the prefabricated structures are reconsolidated during installation, which substantially improves the static work of the framework.

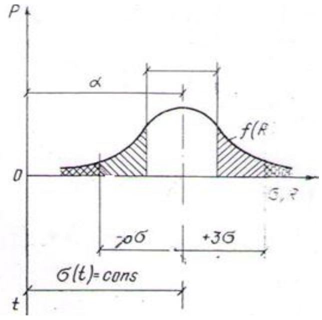

Fig. 1: Interpretation of a stable and unstable state of the frame system during installation

Consider the case when R is bounded from above by Rmax and from below by Rmin. Using the truncated law of the normal distribution, the distribution density of this quantity can be approximated by the analytic dependence

$$f(R) = \frac{d}{\sqrt{D_R 2\pi}} e^{(R-\bar{R})^2/(2D_R)} \quad (7)$$

Multiplier

$d = 2/[\Phi(R_{\max} - \bar{R})/D_R - \Phi(R_{\min} - \bar{R})/D_R]$ (8)

It is easy to see that for Rmax = (1 + 3v) R, Rmin = (1-3v) R, the value of d is practically equal to one, i.e. The truncation of the law of the normal distribution of R does not change the formulas obtained earlier.

The stability of the frame during installation largely depends on the sequence of installation of structural elements in the quality of installation. At present, the installation is carried out in three main schemes: horizontal, vertical and mixed. For multi-storey buildings in many cases the most rational scheme of construction is vertical.

The procedure for calculating the stability is checked by the appropriateness and conformity of technological and installation tolerances and permissible deviations in the design.

At the design stage, they do not usually have detailed information about the laws governing the distribution of dimensional deviations of products. There are several statistical methods that can serve as the basis for this task.

The definition of functionals and distribution functions by means of analytical methods presents certain difficulties. Therefore, we will solve the problem posed as follows:

1. On the basis of the selected criteria for collecting, we formulate probabilistic characteristics.
2. With the help of full-scale experiments or theoretical studies, we will clarify the nature and values of the probabilistic characteristics, corresponding to the requirements formulated above.
3. On the set of solutions (implementation of the model) we construct statistical estimates of the probabilistic characteristics of the system, i.e. functionals or distribution functions and their moments.

The method most appropriate to our conditions is based on the application of the Bayes probability theory. The basic principles of constructing the method of calculating stability on the basis of the Bayesian approach are formulated by Ove Dietlevsen (Denmark).

The meaning of the Bayesian theory is that by successive approximations one can obtain a reliable solution for incomplete or insufficient initial quantities.

Thus, it becomes possible to compensate to some extent for insufficient information about the laws of distribution of initial dimensional deviations. Of considerable importance for solving the problem of ensuring the required accuracy in such an approach is the fact that it is possible to combine in a rather wide range the previous experience with information on the parameters of analog production.

Correctly assigned tolerances should ensure the interchangeability of the components of the prefabricated structure, which is considered to be secured if the production tolerance is completely within the design tolerance zone.

Thus, when assigning tolerances, it must be ensured that the statistical distribution of dimensional deviations is such that the probability of obtaining sizes above and below the tolerance range would be relatively small.

Deviations of the sizes of the constituent links of the dimensional chain can be regarded as independently random variables. According to the theory of probability, random deviations of independent quantities sum up. The assembly complex will have a size that deviates by the amount:

$$\begin{aligned}&\sigma = \varepsilon_1\sigma_{1-1} + \varepsilon_2\sigma_{1-2} + \ldots + \\ &\varepsilon_1 n_1\sigma_1 n_1 + \varepsilon_{r-1}\sigma_{r-1} + \varepsilon_{r-2}\sigma_{r-2} + \ldots + \\ &+\varepsilon_{q1}\sigma_{q1} + \varepsilon_{q2}\sigma_{q2} + \ldots + \\ &\varepsilon_q n_q\sigma_q n_q = \sum_{i=1}^{q}\sum_{j=1}^{ni}\varepsilon_{ij}\sigma_{ij}\end{aligned} \tag{9}$$

In practice, the problem of determining standard Bayesian deviations, σ_{01}, σ_2, …, σ_{0q} is solved as in the case of physical standard deviations, σ_1, σ_2, …, σ_q by applying the following assumption.

Let’s suppose that $\mu_1 = 0$ and thus $\mu_{01} = \sigma_{01} = 0$; $\mu_2 = 0$ and so $\mu_{02} = \sigma_{02} = 0$; μ_3 и μ_4 – random variables.

μ_3 - normal with parameters (μ_{03}, σ_{03}),

μ_4 - normal with parameters (μ_{04}, σ_{04}).

Using (9), after substituting σ for L, we obtain the following conditional mean σ:

$$E\left[(\sigma)\mu_1,\ldots,\mu_q\right] = \varepsilon_1\mu_1 + \varepsilon_2\mu_2 + \ldots + \varepsilon_q\mu_q \tag{10}$$

From Proposition 3 we have the mean:

$$\begin{aligned}&E(\sigma) = E\left\lfloor E(\sigma)M_1,\ldots,M_q\right\rfloor = \\ &E(\varepsilon_1 M_1 + \ldots + \varepsilon_q M_q) = \varepsilon_2 M_{02} + \ldots\varepsilon_q M_{0q}\end{aligned} \tag{11}$$

This assumption means that the deviation from the mounting dimension σ given by the formula (10) has a mathematical expectation equal to:

$$\mu = \varepsilon_1\mu_{01} + \varepsilon_2\mu_{02} + \ldots + \varepsilon_q\mu_{0q} \tag{12}$$

Standard deviations σ of the sizes of all elements are equal to the expression:

$$\begin{aligned}&\sigma^2 = \varepsilon_1^2(\sigma_1^2 + \sigma_{01}^2) + \ldots + \varepsilon_q(\sigma_q^2 + \sigma_{0q}^2) \\ &+\lambda_1\sigma_1^2 + \ldots + \lambda_q\sigma_q^2\end{aligned} \tag{13}$$

Here, μ – mathematical expectation, in mm;

μ_{0q} – mathematical expectation with the serial number of the r distribution class in mm;

σ – standard deviation in mm;

σ_{0q} – standard deviations with the serial number in mm;

λ – coefficient characterizing the distribution of deviations of the r element

In the construction under consideration, the coefficients either can depend on one constant or from several random deviations. If we have only one product from each class, then all the values will be 0.

As the main characteristics of the calculation of organizational and technological support of stability, the factors that are equivalent in their importance are adopted, which ensure the installation without mounting, and the high output parameters of the product system (strength, sound insulation, air permeability, etc.).

4 Conclusion

The calculation of the organizational and technological sustainability should be carried out in the design of buildings, along with statistical, heat engineering and other calculations.

Conducted surveys to ensure the effectiveness of organizational and technological solutions of multi-storey frame buildings have not yet found their final implementation into practice.

References

[1] Gusakov A.A. Organizational and technological reliability of construction. M., 1998

[2] Torkatov V.N. Organizational and technological solutions in multi-storey frame construction. Kharkov, 1986

[3] Salahov M.A. Estimation of reliability and stability of skeletons of multi-storey buildings in the process of erection. International Conference. Baku, 2012

[4] Salahov M.A. Methods for calculating the collection and reliability of building structures. Monograph. Baku, 1998