Development of Mathematical Model of High Rise Apartment Buildings Construction Complex Quality Index Assessment

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Abstract. A factor matrix was obtained and using regression equations the connection between the complex quality index and the values of the impact factors was determined. As a regression model, a linear regression quadratic and cubic models were used. It was determined that the most convenient form of noting a mathematical model while performing regression analysis calculations is an equation of a second-order polynomial. The research of the obtained mathematical model is made with the use of the methods of mathematical statistics - dispersion and correlation analyzes. It is proved that the mathematical model adequately describes the research process.

1. Introduction
In the development of the flow within the object or complex can be divided into three periods: An complex approach to the problem of improving the quality of construction of high-rise residential buildings allows us to take into account the various main factors affecting the quality of construction in general.

With the help of expert research, the most significant eight parameters were selected, which further on the basis of the intercorrelation matrix were combined into four groups $z_1, z_2, z_3$ и $z_4$:
- land plot development plan and being in compliance of project designs with requirements of Set of Rules, All union state standart and other normative-technical documents working at the moment of expertise conduction ($z_1$);
- technical conditions to all objects, designed fire-safety measurements ($z_2$);
- the usage of modern equipment with high-quality accuracy of conduction all operations and productivity, taking in account vertical transportation ($z_3$);
- presence of lifting devices, highly qualified specialists ($z_4$).

2. Analysis parametrical indicators
Further the authors obtained a factor matrix and using the regression equations they determined the connection between the complex quality indicator and the values of the impact factors

As a regression model, the authors used a linear, quadratic and cubic regression ones.

An necessary stage of the work is to estimate the values of the equation coefficients and check the adequacy of the regression equation.
On the basis of the conducted research, we conclude that the most convenient form of noting a mathematical model while performing regression analysis calculations is an equation of a second-order polynomial.

The regression equation in its final form:

\[
f(z_1, z_2, z_3, z_4) = 48.26 + 6.26z_1 + 15.91z_2 + 9.77z_3 + 1.23z_4 - 0.03Z_1^2 + 1.89Z_2^2 + 1.57Z_3^2 - 0.99Z_4^2 - 0.06Z_1Z_2 - 0.06Z_1Z_3 + 0.02Z_1Z_4 + 0.58Z_2Z_3 - 0.46Z_2Z_4 - 0.62Z_3Z_4
\]

Range of values of the received function:

- \( f_{\text{min}}(z_1, z_2, z_3, z_4) = 9 \)
- \( f_{\text{max}}(z_1, z_2, z_3, z_4) = 91.5 \)

The obtained second-order regression equation is a mathematical model of the process under study in this thesis.

Next, it is necessary to determine the adequacy of the equation for the description of the process, as well as to assess the significance of each coefficient in this equation. To solve this problem, we will use the methods of analysis of variance. The functional dependence of this regression equation is graphically shown in the figure.

*Figure 1. The Functional dependence of the regression equation.*

2.1. *Methods of correction production works schedule*

Investigation of obtained mathematical model performed with use of the methods of mathematical statistics - dispersion and correlation analyzes.

Dispersion analysis is used for impact estimation of each factor respond function.

Based on the obtained results we can conclude that the mathematical model adequately describes research process and its working tool for the research of a complex quality indicator of the high-rise residential buildings.

Based on the research we can conclude that all coefficients except \( z_1 \) are significant.

In further investigations, we study the behavior of complex quality indicator of high-rise apartment buildings in the indicators change of factors change.

The dependence analysis of the complex quality indicator from the investigated factors group was conducted in graphical form. For this purpose, a 3-dimensional surfaceplot of the obtained regression equation is graphed depending on different groups of factors.

Considering that the number of factors is 4, it will be most convenient to investigate the resulting surfaces by an alternate combination of two active factors, with a fixed position of the other two. In
our case, this will be a series of 6 graphic dependencies describing the alternating influence of two factors on the nature of the complex quality indicator change.

The resulting combination will be as follows:

\[ R_{qual} = f(z_1, z_2); \]
\[ R_{qual} = f(z_1, z_3); \]
\[ R_{qual} = f(z_1, z_4); \]
\[ R_{qual} = f(z_2, z_3); \]
\[ R_{qual} = f(z_2, z_4); \]
\[ R_{qual} = f(z_3, z_4). \]

In further studies, we calculate the weight of each factor to determine their significance in terms of the impact on the potential of the complex quality index, in the framework of an extended mathematical model.

To achieve these goals, we will use the principles of mathematical statistics – the method of variation series.

The arithmetic mean of the variation series is determined by the formula:

\[ \bar{u} = \frac{1}{m} + \sum_{i=1}^{m} y_i n_i, \]

where \( y_i \) - the number of points awarded \( i \)-th parameter; \( n_i \) - number of expert groups; \( m \) – the number of expert groups.

The sum of the arithmetic means of all parameters is found by the following formula

\[ U = \sum_{j=1}^{p} (u_j), \]

Where \( U \) is the sum of arithmetic mean variation series.

In the process of the third stage, we find the weight of each of the parameters:

\[ W_i = \frac{1}{m U}. \]

The results of the calculations allow to develop a discrete scale for assessing the potential of a complex indicator of the quality of multi-storey residential buildings, and then translate it into quality.

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