Selection of methods of inspection of building structures to prevent damage

V Ya Mishchenko¹, Yu D Sergeev¹, A Yu Sergeeva*, Yu V Myasischev¹ and R Yu Myasischev¹

¹Department of Technology, Organization of Construction, Examination and Management of the real estate, Voronezh State Technical University, 20-letia Oktjabrja str, 84, Voronezh, 394006, Russia

*E-mail: 933947@mail.ru

Abstract. This article discusses the mechanism studies of the functional provisions of the building construction, and identification of symptoms, in the case of which it's possible to forecast the appearance of accidents. The main purpose of this work is to find what kind of next examination should be performed otherwise, what sign that affects better than the others on the breakdown of the construction, you need to find to prevent its collapse and have time to take preventive measures to restore. In the work developed methods to determine the correct symptom, affecting more than any other on the disruption of the structure. An algorithm for the control of the system has been determined, Algorithm of monitoring when the life cycle of construction is maximum. It is proved that the issue of monitoring the priority or determination of the sign influencing the building breakdown can be defined by methods of nonlinear programming (parametric optimization). An algorithm which searches the main technical position of construction when the risk of disruption of the structure is minimal is developed.

1. Introduction

Violation of the building structures, leading to accidents, brings huge financial and property damage. Often predict the failure of the building structure is possible, in a timely manner after identifying signs of affecting her destruction. Therefore, it is required to develop an algorithm for checking the operation of the building structure, with the possibility of recreation, when the length of trouble-free operation becomes maximum [1-3].

The problem can be defined by methods of nonlinear programming (parametric optimization). To solve the formulated problem, the function of the reference point (the life cycle of the structure) $S$ - value as well as the property (for the construction structure) operating time without a fatal failure is recommended. It is assumed that the maximum value of this value – $S_{max}$ for any construction structure is achieved by absolutely accurate determination of its distinctive feature that affects its destruction $\gamma = \gamma$ (valid) and subsequent proactive methods of their regeneration [4, 5]. An analogy of the functional purpose of the reference point is $\Delta S$, and a similar goal of improvement is max $\Delta S$, where $\Delta S$ – an increase in $S$ as a result of the next survey. Effectively define both functions of the reference point $S$ and $\Delta S$. 
2. Calculation of the duration of the construction of structure without destruction

We calculate the function of the problem S [7, 9]. Perhaps three fundamental principles of calculation S. For a good example, imagine that there are three signs that affect the destruction of the building structure, their probabilities are \( d_1, d_2, d_3 \), and \( d_2 > d_1 \) and \( d_2 > d_3 \). We present conclusion \( A \) as the most probable sign of structural failure \( A = \gamma \{ \max (d_\gamma Y = 1, 2, 3, \ldots, n) \} \). In this example, \( A \) is a sign of failure № 2. Suppose there are three groups of building structures. The first - with a certain set of signs of destruction \( d_1 \), the second with a certain set of signs of destruction \( d_2 \), the third with a certain set of signs of destruction \( d_3 \). The first idea of calculus S is contained in the following. Suppose that all three groups of building structures are restored according to the definition of the degree of destruction \( A \). That is, it is possible to restore the building structure of group \( d_2 \), and it is impossible to group \( d_1 \) and \( d_3 \). The value of \( S \) for all types is different (the types are considered to consist of the same structures). \( S \) for all building structures as a result of the analysis \( a_0 \) is calculated as:

\[
S(a_0) = \sum_{\gamma} d_\gamma (a_0) S_{A, \gamma}
\]

Figure 1. The algorithm for calculating the life cycle of the structure on the principle of 1.
This is used in practice: the construction structure is restored by determining the degree of destruction, understood as the most likely sign of destruction (Figure 1).

The known methods of probability theory reflect the second principle under consideration [8]. So the systems consist of designs taken in free order. Relative number of constructions in groups $d_1$, $d_2$, $d_3$. The first group is restored from signs of destruction 1, the second - from signs of destruction 2, the third - from signs of destruction 3 (Figure 2).

![Figure 2. The algorithm for calculating the life cycle of the structure on the principle of 2.](image)

The third thesis is theoretical. For example, if the first type includes structures on the basis of destruction 1, the second - on the basis of destruction 2, then the third group will be construction structures on the basis of destruction 3 (Figure 3).

![Figure 3. The algorithm for calculating the life cycle of the structure on the principle of 3.](image)
All building structures, from which species are formed, contain completely identical features that affect the destruction of the structure. Therefore, to specifically form types, each with building constructions one characteristic, influencing the destruction, it is impossible. The third principle of restoration is that the building structures of each group is restored from the sign that destroys the structure that destroyed them, i.e. the restoration of building structures is carried out according to three estimates.

We use the calculus S when the constructions are reconstructed by the first principle. Let us use the matrix-column $B$ with elements $S_{\gamma, A}$. They show the format $S$ of the building structure (the age of the building structure, uneven sediment of the Foundation, the aggressiveness of the medium and other features) of the sign of destruction $\gamma (\gamma = 1,2,3,\ldots,n)$ at restoration, according to the conclusion $A$. Before the $m$-th test is carried out, conclusion $A$ is based on the characteristic that is most likely to subject the destruction of the structure $d_{\gamma_{\text{max}}} = \max\{d_{\gamma} | \gamma = 1,2,3,\ldots,n \}$, before the $m$-th test is performed:

$$S = \sum_\gamma d_{\gamma}^{\text{new}} S_{\gamma, A}. \quad (2)$$

In formula (2), probabilities are applied $d_{\gamma}^{\text{new}}$ not $d_{\gamma}$ since the distribution will be reliable $d_{\gamma}^{\text{new}}$. We can say that the building structures of the additional examination $a_{om}$ were reconstructed incorrectly - on the basis of determining the degree of deterioration of $A$. In the formula (2) $S$, it is calculated from the old definition of the degree of destruction $A$. That is, we assume that before determining the degree of destruction of the $m$-th survey, both the distribution of $d_{\gamma}$ and the restoration of the structure are, in General, incorrect. After the survey to determine the degree of destruction of $A_{\text{new}}$ will be considered a sign that allows the construction structure, which has the maximum probability:

$$\max \{d_{\gamma}^{\text{new}}(a_{om}), \gamma = 1,2,3,\ldots,n \}. \quad (3)$$

Value $S_{\text{new}}^{\text{new}}$ for examination $a_{om}$:

$$S_{m}^{\text{new}} = \sum_{c_{om}}^{c_{om_{\text{max}}}} Q_h(a_{om}) \sum_\gamma d_{\gamma}^{\text{new}}(a_{om}) S_{\gamma, A}, \quad (4)$$

where $S_{m}^{\text{new}}$ - the value of $S$ after its examination was carried out (after finding the $m$-th sign acting on the collapse of the structure).

Consider $S_{\gamma, A} -$ elements of the matrix $b$ column. Its numbering is more equal to the possible symptom of collapse - finding the level of destruction of $A_{\text{new}}$. The expression (4) means that $a_{om}$ passes discrete values from minimum to maximum (from $a_{om_{\text{min}}}$ to $a_{om_{\text{max}}}$).

For continuous signs affecting structural failure:

$$S_{m}^{\text{new}} = \int_{c_{om_{\text{min}}}^{c_{om_{\text{max}}}}} Q_m(a_{om}) \sum_\gamma d_{\gamma}^{\text{new}}(a_{om}) S_{\gamma, A_{\text{new}}} \, f(a_{om}). \quad (4a)$$

In the formula (4a) $d_{\gamma}$, $\gamma = 1,2,3,\ldots,n$ is better to show by vector $\vec{d}(a_{om})$.

In this vector, all coordinates are reset to zero, except for the largest coordinate, which is the conclusion.

This vector will be called $d_{\parallel}^{0}(a_{om})$. Then the expression (4a) will be represented as:

$$S_{m}^{\text{new}} = \int_{c_{om_{\text{min}}}^{c_{om_{\text{max}}}}} Q_m(a_{om}) \, B \times \vec{d}_{\parallel}^{0}(a_{om}) \cdot \vec{E} \, f(a_{om}), \quad (4b)$$

where $\vec{E}$ is a unit vector of dimension $n$.

By analogy, we rewrite the expression (4). Then according to the 3rd principle of the perfect reanimation of fix as:

$$S_{m}^{\text{new}} = \int_{c_{om_{\text{min}}}^{c_{om_{\text{max}}}}} Q_m(a_{om}) \, B^{d} \times \vec{d}(a_{om}) \cdot \vec{E} \, f(a_{om}), \quad (4c)$$
Where $B^d$ is the diagonal matrix obtained from matrix $B$ by zeroing nondiagonal elements (they have $j \neq \gamma$).

3. Determination of the necessary survey, in which the work of the building structure will have the maximum duration

After you define $S_{m_{\text{new}}}$ calculate the effectiveness of implementation of the conclusion of the $m$:

$$\Delta S(m) = S_{m_{\text{new}}} - S = f(m).$$  \hspace{1cm} (5)

After that, by analogy, calculations are carried out for absolutely all $k$ conclusions, features, information of instrumental and visual surveys. In the end, the sought trait (evaluation, instrumental or visual examination) $k$ is characterized by the number of trait acting on structural failure at which $\Delta S_m$ is maximal (Figure 4).

$$k = m \{ \max [\Delta S_m m = 1,2,3,\ldots,\delta] \}. \hspace{1cm} (6)$$

The number $k$ is obtained in the reconstruction of the building structure on the first principle.

The $k$ rating is recommended. After the calculation of this estimate $k$, there is its transition to the estimates of the already known $j$, $1 \leq j \leq b_{\text{new}}$, where $b_{\text{new}} = b + 1$. 

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**Figure 4.** The calculation algorithm in which the maximum life cycle of the structure.
4. Conclusion

Thus it is proved that the problem of priority of works on inspection of building structures for the prevention of destruction can be determined by methods of nonlinear programming. Methods for determining the characteristic that most affects the destruction of the structure have been developed. An algorithm for monitoring the system is determined, in which the maximum life cycle of the structure.

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