Prediction and ensuring the reliability of buildings elements and structures of surface complex at reconstruction

Andreev B. M.

D.Sc. in engineering, professor,
Chair of construction geotechnologies,
Kryvyi Rih National University,
Ukraine
E-mail - andreyev_bn@mail.ru

Brovko D. V.

PhD in Technical Sciences,
Associate professor
Chair of construction geotechnologies,
Kryvyi Rih National University,
Ukraine
E-mail - dbymer@mail.ru

Khvorost V. V.

PhD in Technical Sciences,
Associate professor,
Chair of construction geotechnologies,
Kryvyi Rih National University,
Ukraine
E-mail-vasya_hvorost@mail.ru

Abstract
The concept of technical supervision of objects on mines surface and process safety as an integral part of industrial safety is presented. The basic terms and definitions of reliability are given, the main danger of the technical state of mining companies superstructures is shown. The main provisions of reliability theory are considered. The mathematical formulations used in evaluation and calculation of main properties and reliability parameters of technical objects are given. The analysis of stress-strain state of superstructures provided that they switch to lightweight walling is carried out.
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According to statistics, in about 70% the surface objects accidents with the failure of supporting structures are the result of human errors made during the design, construction and operation of buildings and structures. These errors form not only the object life, but also the amount of damages in case of its accident. Principal provisions to determine the residual life and establish the predictable life of buildings are represented in the methodology [4].

Evaluation of technical condition parameters and selection of criteria are carried out by the results of the analysis of technical documentation, diagnostic data, and expert investigation [5].

Prediction of residual life or determination of assigned life is made in accordance with the laws of change of parameters obtained in the analysis of damage mechanisms and by the results of functional indicators measurement [6]. One of decisions is made on the basis of results: to continue operation; to repair; to reconstruct; to change operation.

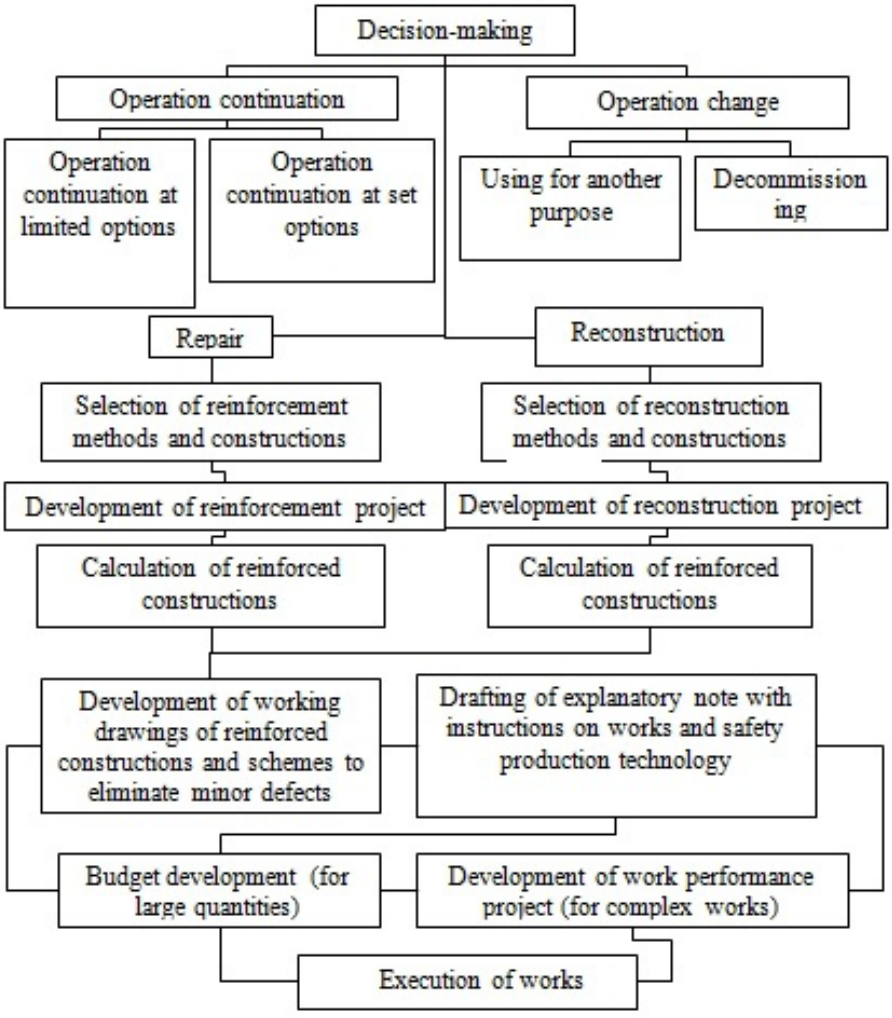

Figure 1. The main stages of decision-making and execution of works

General primary diagnostics is made at the first stage. The purpose of general primary diagnostics - is to obtain full data on technical condition of the object, investigated at the time of issue. The analysis of technical documentation, operating conditions is carried out, and the original determination of technical condition is made. The result of primary diagnostics is defective statement with technical state of constructions and conclusions about the need for full expert investigation. Further, if necessary, the complete expert investigation is carried out. The purpose is - to provide information about the object actual technical condition, damage presence in it and to determine the cause and mechanisms of their occurrence and development. Complete expert investigation comprises three main blocks: investigation of project correspondence; experimental studies; calculation on ultimate limit states. One of decisions is made on the basis of results: to continue operation; to repair; to reconstruct; to change operation.

The main stages of decision-making and execution of works are shown in structural diagram in Fig. 1.

With this technique, thanks to the studies and accumulated practical experience the promising area of galleries reconstruction technology development, which is to replace the old walling by modern lightweight materials is formed.

The most important dynamic characteristic of gallery superstruction is the frequency of its transverse vibrations.

The width of resonance zone (area $\theta_1' \div \theta_1''$ of lower frequency values of natural vertical superstructure oscillations) is:

$$\theta_1' = 0{,}9\ \theta_{1min} \div \theta_1'' = 1{,}1\ \theta_{1max};$$

where θ_{1min} and θ_{1max} – minimum and maximum value of the lowest natural frequency of superstructure vertical oscillations respectively.

Values θ_{1min} and θ_{1max} meet minimum and maximum mass of superstructure.

Substitution of walling reduces permanent loads on corresponding gallery elements, such as: floorings, coverage and walls. In order to see how the load changes will affect the strength and dynamic characteristics of gallery theoretical studies were carried out in several stages.

As a result of reinforced concrete structures replacement by reduced-weight the permanent load on walls decreased by 33.7%, which in turn led to a decrease in the weight of gallery chief beam by 8%. The rest of loads remained unchanged. When replacing flooring the permanent load decreases by 53.3%, the chief beam mass - by 16%. When the gallery coverage was changed, permanent load decreased by 14.93% and weight by 16.5%. At the final stage the replacement of all enclosure structure was held, which ultimately reduced the chief beam weight by 40.5%.

Hence, lightweight walling depending on their weight and hardness increase the amount of natural vertical oscillations by 5 ... 36%.

On the basis of conducted researches it follows that in galleries with chief beam length of 24 and 30 m systematic resonant oscillations are excluded even with complete replacement of walling. Dangerous is chief beam with length of 18 m, in which the resonant mode can be realized.

Further studies were conducted using the computer simulation of strength and dynamic characteristics of superstructures.

The calculation was performed using the design-computer complex SCAD. The results of the study determined that natural frequency of superstructure oscillations is inversely proportional to the mass of its elements and chief beam length.

Analysis of dynamic calculation showed that in the conditions of resonance the forces in elements grow by 30%. This can lead to emergency situation, so it is necessary to carry out validation calculations for strength, stability and durability.

Experimental studies of the superstructure dynamics were made on the existing conveyor gallery. Enclosure structures, floor slabs and gallery coverages before replacement were precast concrete slabs, walls made of reinforced concrete sandwich panels. Gallery is equipped with conveyor belt.

Comparative analysis of the results of theoretical calculations to determine the dynamic characteristics of gallery superstructure with the results of experimental studies of original structure indicates that: the experimental value of dynamic perturbation frequency from conveyor is slightly above the estimated $35.4 > 31.4\ sec^{-1}$; the average estimated frequency of dynamic perturbation from conveyor for F1 , F2, F3, F4 farms and floor beams and flooring misses the first resonance zone, which excludes the implementation of resonant mode.

Further experiments of farms vibration were carried out on superstructions of conveyor gallery with lightweight enclosure structures.

The analysis of amplitude spectra and vibration acceleration graphs shows that the vibrations in farms are generated at low frequencies (3-100 Hz) and the maximum vibration acceleration exceeds the permissible values by 10-15%.

According to the results of computer simulation the dependence of upper and lower borders of reso-

nance zone on combining static loads was derived. Thus, the less the static load is, the higher the values of resonance zones are.

As a result of studies a number of dependencies was obtained that make greatly simplified checking calculations at the stage of superstructures reconstruction design.

Conclusions and directions for further research.

1. The proposed methodology allows to carry out a more qualitative diagnostics and determination of technical condition and predictable life of surface objects and determination of necessary repair and restoration.

2. It was determined that the galleries with spans length of 24, 30 m the frequency of conveyor dynamic perturbation does not get into the resonance zone. Dangerous is the chief beam with length of 18 m, in which the resonance is realized with the complete replacement of walling.

3. It is proved that the ratio of stresses on dynamic and static loads, which takes into account the superstructure dynamic coefficient, is in the linear dependence on the ratio of maximum load combinations of this structure to minimum and should not exceed 1.7, which should be taken into account when calculating the forces in superstruction elements to determine its structural strength, stability and durability.

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