

**AP14869145 “Development of an intelligent fiber-optic system for monitoring the geotechnical condition of mine workings of quarries and open-pit mines” – p.m. Neshina E.G.**

***Relevance:***

The relevance of the project is due to the importance of the issue of warning of sudden changes in parameters affecting the strength of the mine workings of quarries, surface mines and providing protection of personnel from sudden collapse. The paper proposes to increase the safety of work by using new achievements of science related to the use of fiber-optic technologies, namely fiber-optic sensor (FOS), included in the hardware and software complex.

***The project purpose:***

Project purpose: creation of an intelligent fiber-optic system for monitoring the geotechnical condition of mine workings of open pits and surface mines, operating in real time for timely notification of changes in geotechnical parameters leading to the collapse of the sides of the open pit and surface mine, which allows to increase the level of safety of mining operations and reduce the economic costs of liquidation of the consequences of the collapse.

***Expected and achieved results:***

Raising public awareness of developments in the field of fiber optic technology. The project will involve young researchers who will be able to develop this area in the future. Ensuring the safety of mining operations and reducing the cost of eliminating the consequences of cave-ins, reducing the cost of repeated work to strengthen the sides of quarries, open pit mines and restore the transportation communications of the quarry (open pit). The results of the project have a multiplier effect and can be adapted to control the geotechnical condition of mine workings of mines and mines, where similar problems with the collapse of workings and the creation of a threat to human safety. The refusal to use copper conductors will reduce the metal intensity of the system of monitoring the geotechnical condition of mine workings of quarries and mines and achieve resource savings. The results of the study are knowledge-intensive and will allow the introduction of digital technologies in the mining industry to replace outdated methods of monitoring the geotechnical condition of mine workings.

*For 2022*, theoretical studies were carried out to substantiate the mode of operation and determine the initial and boundary parameters and conditions of fiber-optic sensors, as well as the geotechnical condition monitoring system. The technical devices were evaluated in order to improve the efficiency of optical fiber. The degree of influence of optical signal propagation conditions on its power has been determined. It is determined that in laboratory conditions it is possible to use single-mode fiber-optic patch-cords with SC-type connectors as a communication line, in practice in quarry conditions it is necessary to use armored fiber-optic cable. The influence of various parameters has been investigated to develop the design of fiber optic sensor. The calculation of the electromagnetic wave intensity distribution is based on the fact that the process of signal passage in the space between fiber-optic elements inside the fistula is accompanied by attenuation of the electromagnetic wave amplitude due to its scattering in the air.

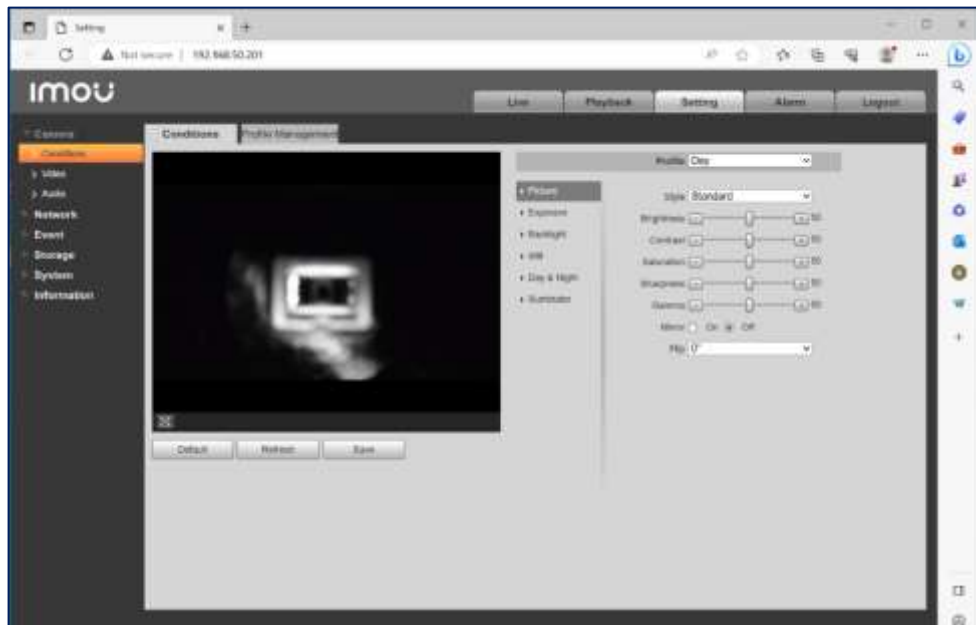
*In 2023*, research was carried out to create a laboratory sample of a fiber-optic sensor. Mathematical modeling of the processes of the system for monitoring the geotechnical condition of mine workings was carried out. The results were presented at the international conference and also published in the edition recommended by the SHEQAC (Proceedings of the University). Laboratory tests of the fiber optic sensor were carried out to determine the optimal parameters. The results of the experiments were processed using Wolfram|Alpha program. The hardware and software system of the monitoring system was developed. The sensor control code is able to read and analyze with the help of computer vision algorithms the information and produce numerical values depending on the changes in the parameters of the light spot. In case of changes in geotechnical parameters, the hardware-software complex after fixation of changes in the diffraction spot by the camera is able to assess the emergency situation and give a warning sound signal with simultaneous fixation of the triggering time and saving on the hard disk, as well as

with the possibility of transmitting information over the Internet and sending notifications to the messenger Telegram. The results of research were published in 5 articles, including 1 in a domestic edition recommended by SHEQAC, 4 in rating journals included in the Scopus database. 2 certificates of state registration of rights to the object (scientific work) of copyright, 1 patent were obtained. Contracts for the purchase of equipment necessary for the research have been concluded. Mathematical modeling of processes of the system of monitoring of geotechnical condition of mine workings was carried out. Hardware and software complex of the monitoring system was developed.

*In 2024*, the results of testing the laboratory sample of the intelligent fiber-optic system for monitoring the geotechnical state are published in the certificate of inclusion of information in the state register of rights to copyrighted objects by Neshina E.G. "Development of hardware and software complex for identification of displacement of quarry rocks", No. 42745 dated February 8, 2024. Also published 1 article in a peer-reviewed scientific publication indexed in Science Citation Index Expanded of Web of Science and (or) having a CiteScore percentile in Scopus database not less than 35: Y. Neshina, A. Mekekova, A. Mekova, A. Mekova, A. Neshina. Neshina, A. Mekhtiyev, V. Kalytka, N. Kaliaskarov, O. Galtseva, I. Kazambayev. Fiber-Optic System for Monitoring Pit Collapse Prevention. Appl. Sci. 2024, 14(11), 4678; <https://doi.org/10.3390/app14114678> (Scopus 75th percentile, WoS Q2). Contracts have been concluded for the purchase of equipment necessary for the study. Contracts have been concluded for the production of a prototype of an intelligent fiber-optic system for monitoring the geotechnical condition of mine workings of open pits and surface mines.



<b>Figure 1 - Sample system BSK-12U-44C-2023</b>	<b>Figure 2 – “Data processing unit”</b>	<b>Figure 3 – “Network Switching Unit”</b>
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**Figure 4 - Software Setup**



**Figure 5 - The process of conducting the experiment**

***List of publications:***

*For the year 2022:*

1. Neshina E.G., Mehtiev A.D., Kaliaskarov N.B., Yugai V.V., Alkina A.D. Geotechnical and optical monitoring of monitoring of the environment. Proceedings of the University, NPJSC " Abylkas Saginov Karaganda Technical University", №3, 2022. - C.347-352.
2. Alkina A.D., Neshina E.G., Brazhanova D.K., Bilichenko E.N. Investigation of additional losses in optical fibers under mechanical influence. Certificate of inclusion of information in the state register of rights to copyrighted objects No. 29392 dated 12.10.2022.

*For the year 2023:*

1. Mehtiev A.D., Kovtun A.A., Neshina E.G., Alkina A.D., Yugai V.V.. "Distributed fiber-optic system of perimeter security of various objects" // Proceedings of the University, No.1, 2023. - P.360-364
2. Neshina E.G., Mehtiev A.D., Alkina A.D., Bilichenko E.N., Malikov N.M. Fiber-optic system for the safety of mining operations at the open-pit mines. Certificate on entering

information into the state register of rights to objects protected by copyright #32036 from 26.01.2023. Y.G. Neshina, A.D. Mekhtiyev, V.V. Yugay, A.D. Alkina, P.Sh. Madi. Developing A Sensor For Controlling The Pit Wall Displacement. News Of The National Academy Of Sciences Of The Republic Of Kazakhstan. Series Of Geology And Technical Sciences, Almaty: ST «Aruna», Vol.2, No. 458, 2023. - Pp. 160-167. (Scopus 40 percentile)

3. Mekhtiyev A.D., Yurchenko A.V., Kalytka V.A., Neshina Y.G., Alkina A.D. and Madi P.Sh. Fiber-Optic Long-Base Deformometer for a System for Monitoring Rocks on the Sides of Quarries. Technical Physics Letters, Vol. 48, No. 15, 2022, pp. 30–32. (Scopus, Science Citation Index Expanded)

4. Neshina E.G., Mehtiev A.D., Kaliaskarov N.B., Bilichenko E.N., Alkina A.D., Malikov N.M. Fiber-optic sensor for control of stability of quarry sides. Patent for useful model No. 8004. Reg. application number 2023/0108.2, dated 03.02.2023.

5. Neshina Y.G., Mekhtiyev A.D., Alkina A.D., Dunayev P.A., Manbetova Z.D. Hardware-Software Complex For Identification Of Rock Displacement In Pits. NEWS of the National Academy of Sciences of the Republic of Kazakhstan SERIES OF GEOLOGY AND TECHNICAL SCIENCES ISSN 2224-5278. Volume 3, Number 459 (2023), 180–192 <https://doi.org/10.32014/2023.2518-170X.30> (Scopus 40 percentile)

6. Neshina E.G., Mehtiev A.D., Kaidanovich O.Yu. System of control of displacement of the rock massif of the roof of excavations. Certificate of information in the state register of rights to copyrighted objects No.33844 dated 27.03.2023.

7. Mekhtiyev A.D., Abdikashev Y.N., Neshina Y.G., Dunayev P.A., Manbetova Z.D. Monitoring the geotechnical condition of underground Minings using digital technologies. NEWS of the National Academy of Sciences of the Republic of Kazakhstan SERIES OF GEOLOGY AND TECHNICAL SCIENCES ISSN 2224-5278 Volume 1, Number 457 (2023), 166-176. <https://doi.org/10.32014/2023.2518-170X.267> (Scopus 40 percentile)

8. A. Mekhtiyev, Y. Neshina, A. Alkina, V. Yugai, V. Kalytka, Y. Sarsikeyev and L. Kirichenko. Developing an Intelligent Fiber-optic System for Monitoring Reinforced Concrete Foundation Structure Damage, Applied Sciences (Switzerland), Appl. Sci. 2023, 13(21), 11987; <https://doi.org/10.3390/app132111987> (Scopus, 62 percentile)

*for 2024:*

1. Neshina E.G. “Development of hardware and software complex for identification of displacement of quarry rocks”, No. 42745 dated February 8, 2024.

2. Y. Neshina, A. Mekhtiyev, V. Kalytka, N. Kaliaskarov, O. Galtseva, I. Kazambayev. Fiber-Optic System for Monitoring Pit Collapse Prevention. Appl. Sci. 2024, 14(11), 4678; <https://doi.org/10.3390/app14114678> (Scopus 75 percentile, WoS Q2).

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***Information for potential users:***

Kazakhstan has a developed mining industry and potential consumers can be about 80 large enterprises engaged in the extraction of various minerals. Since the proposed system solves an important problem of early diagnosis of collapse of mine workings and sides of pits and open-pit mines, it will allow potential consumers to significantly reduce material costs of accident elimination and avoid losses of technological equipment, as well as casualties among production personnel in case of sudden rock collapse in places of mining operations. The project will result in the development of a prototype fiber-optic system for monitoring the geotechnical condition of mine workings of quarries and open-pit mines and preparation of documentation.

***Scope:***

Enterprises engaged in the extraction of various minerals.

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