THE RELEVANCE OF THE USE OF MONITORING SYSTEMS IN CONSTRUCTION

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I. INTRODUCTION

Modern construction in Uzbekistan is characterized by high rates and large volumes of erected buildings. The main distinguishing features of modern construction industry can be formulated as follows:

- improvement of methods for calculating building structures, both due to the development of computational methods and due to the extensive use of numerical models;
- non-standard design solutions, which sometimes can be described as bold, innovative, unique;
- The use of innovative technologies and materials.

These trends are a positive fact, but it is modern construction that is also characterized by an increase in the number of accidents. The use of complex mathematical models in conjunction with high-end computing technology has created the illusion of the ability to calculate any arbitrarily non-standard design with absolute, infallible accuracy. In reality, the controversy of the numerical model is supported by the highly controversial problems of a particular embodiment, in particular, the statistical variation of the characteristics of the material of the building structure, in particular the soils of the foundation. If for steel structures, the coefficient of variation in strength characteristics does not exceed 5%, then for concretes the normalized coefficient is already 13%, real - up to 20% and more, and for soils - not less than 20%. Attention should be paid to the fact that building materials combined in structures have different aging rates, thereby reducing the reliability of the assessment of the durability of the structure as a whole [1-3].

The entire list of problems caused by the discrepancy between the computational model and the real characteristics is superimposed on poor-quality construction work and constantly changing operational factors [8-9].

Thus, the current problem today is the development of various monitoring systems

Structures of buildings and structures, and their introduction into the practice of construction.

II. FIBER-OPTICAL MEASURING SYSTEMS: PROPERTIES, PRINCIPLES, APPLICATION

The current state of construction science and practice in the field of urban planning, the infrastructure of land transport communications, the construction of structures in earthquake-prone regions, the construction of nuclear power plants and other relevant applications requires the development of effective methods for continuous study of the state of the material of building structures and affecting loads. The development of civilization as a whole leads, on the one hand, to the creation of new methods for achieving greater reliability and safety, and, on the other hand, to the formation of conditions for an increased potential risk of man-made disasters. In this regard, monitoring systems are being developed based on smart technologies that are capable of organizing continuous autonomous diagnostics of any structures in real time.

Fiber optic sensors allow you to measure many physical parameters: deformation, pressure, temperature, distance, position in space, rotation speed, linear movement speed, acceleration, oscillations, mass, etc.

Fiber-optic measuring systems (FOMS) are a set of fiber-optical sensors (FOS), united in a single network of a topological configuration with a given polling algorithm, which can be divided into two broad classes depending on the role of the optical fiber (OF) which he plays in FOS:

1) OF the aircraft performs only the transit function of the medium – carrier for transmitting optical radiation to the sensitive element (SE) located in the measurement zone;

2) The aircraft is the medium – carrier for signal transmission and at the same time is a sensitive element of the FOS.

In the first case, the sensitive element of a FOS is an object that is foreign to the aircraft, and has the property of changing the characteristics of the light wave (amplitude, phase, polarization, wavelength, etc.) due to a change in the measured physical parameter. In this case, the sensitive element is in contact with a point of the medium, the parameters of which (or the parameters of a certain neighborhood of which) are monitored by the water-supply device. Therefore, for the organization of monitoring, distributed in a certain three-dimensional region of a continuous medium, the presence of several EOS is required. The number of measurement points can be defined as the product of the number of ESP, and the number of measuring channels of one ESP. The scheme of measuring systems of this type is shown in Fig. 1 [5-7].

In the second case, the fiber light guide in a certain sense and the object and subject of measurement simultaneously. It is assumed that there is a one-to-one correspondence between the state of the fiber section and the parameters of its environment. Measuring systems of this type use the properties of a fiber to transform the measured effects into the corresponding changes in the characteristics of a light wave propagating through the fiber. In this case, the optical scheme of the measuring system is greatly simplified and it becomes possible to carry out distributed monitoring of the state of the object along the fiber optic strip route. The corresponding simplified diagram of the measuring systems is presented in Fig. 2

In tab. 1 shows the most commonly used and recommended principles for converting the intensity of an optical signal into amplitude ESP. From consideration of this list, it can be seen that the most universal principles of operation of measuring transducers of VOD are the phenomena of reflection, interruption (quenching), and refraction of light.

III. FOREIGN EXPERIENCE OF MONITORING CONSTRUCTION STRUCTURES

To control the technical condition and promptly and accurately determine the coordinates of unexpectedly occurring major accidents, hazardous areas of natural environmental processes that can lead to such accidents, as well as tracking and predicting possible damage to various structures as a result of slow unidirectional geodynamic deformations The ground surface and climatic conditions are fiber-optic sensors.

Purposeful study of monitoring issues with the help of fiber-optical measuring systems, which are actively taking place abroad, determine the need for an analysis of European and American research in this direction. In the article “Experience gained from the use of fiber-optical sensors for monitoring civilian construction sites”, Smarted specialists describe the final results of the 9-year period. This work included the installation of WATU in building structures of the most common types, including bridges, tunnels, dams, piles, historical monuments, nuclear plants, etc. At the time of the analysis, about 1,300 WATU were installed in almost 70 different sites. Statistics show that it is possible to achieve sensor survivability up to 95–100% during installation and for a long service life of the object.

The main tasks solved by such monitoring methods are:

- identification of violations of the technical condition of the object: gaps, cracks, corrosion zones, damage to hydro- and thermal insulation, etc .;
- analysis of areas of influence on the construction of roads and railways;
- the study of active faults and modern movements of the earth's crust, as well as the stress – strain state of the environment around the sensor;
- mapping of soils, zones of waterlogging, flooded areas, areas of salinity, corrosive environments, freezing and thawing soils, etc.;
- study of modern exogenous processes (mudflows, landslides, landslides, etc.);
- ranking of areas according to the degree of danger, the allocation of areas for priority diagnostic studies.

For buildings such as bridges, tunnels, dams, high-rise buildings, nuclear power plants, the most important control parameters are:

- mechanical: displacements, deformations, forces, stresses, pressure, accelerations, vibrations;
- Chemical: pH, humidity, concentration of hazardous compounds;
- environmental parameters: air temperature, wind direction and speed, radiation, snow accumulation, precipitation, water level and flow velocity, pollution concentration.

European experts have focused on sensors monitoring the durability of civil buildings that have already reached the industrial level or at least are in the final stage of testing (Table 2).

IV. THEORETICAL AND PRACTICAL ASPECTS OF APPLICATION OF FIBER-OPTICAL SENSORS

The monitoring system of building structures, which can perform the functions of monitoring and diagnostics for elements of building structures of various designs: brickwork, monolithic and precast concrete, metal structures, was developed by the specialists of Monitoring Center. (Fig. 3-4).

The sequence of construction monitoring is as follows:

1. Analysis of the building project.
2. Numerical simulation:
- calculation of loads in the nodes of the supporting frame;
- identification of places requiring regular monitoring of movements (loads).
3. Installation of sensors, laying of transit cables, connection to the automatic control system.
4. Continuous / discrete polling of sensors and analysis of received information.
5. In the case of an alarm signal, analysis using numerical modeling and site surveys.
6. Development of recommendations for the elimination of the source of the alarm (destructive event)

In the general case, the control point provides for the installation of three displacement sensors oriented at measurements in the vertical and two planar dimensions perpendicular to the vertical (axes x, y, z.).

Temperature control points are installed on each side of the building. Sensitive elements are fixed in the front space (in the case of a ventilated facade) or mounted on the outer part of the facade.

Fiber optic cable, which is used as a distributed sensor, is laid in the base plate in a cross pattern and is attached to the fixture. Alternatively, it is possible to use a piecewise-distributed sensor circuit in the form of longitudinal and transverse segments of the fiber containing Bragg grating application areas.

After receiving the alarm, the operator reports this fact to the authorities responsible for the elimination of the destructive event. Next, the building is examined on the spot using additional measuring means, after which specialists in numerical modeling analyze the data obtained, selecting the option of structure deformation, at which such sensor readings occur. Comparison of the information of calculators and surveyors makes it possible to form a forecast and recommendations for the elimination of a destructive event.

Three fiber-optical strain sensors (developed by the Monitoring Center) were installed in pylons of the basement at a height of 120 cm from the floor (Fig. 5) according to the scheme shown in Fig. 8.

V. Helpful Hints

Table 1

Measured physical quantity	The principle of operation of the measuring transducer
pressure, force, vibration, acceleration, speed	reflection (including tunnel effect), interruption, light refraction, microbending and bending losses
displacement: linear and angular	reflection, absorption, light suppression
rotation frequency	reflection, interruption of light
fluid level	reflection, interruption, refraction of light, violation of the air defense condition
deformation, torque	microbending and bending losses
ash heat-resistant coating (HRC), the presence of flame	external radiation registration
temperature	reflection, light interruption, change in the intensity of body radiation, fluorescence, vibration of black body radiation, use of a semiconductor crystal as an attenuator

Table 2
Fiber optic measuring monitoring systems in Europe

Measurement method	Measured Parameters	Readiness degree	Firms actively operating in Europe	Approximate number of installed FOS
SOFO (Michelson Interferometer)	Moves	a commercial	SMARTEC, IMAC–EPFL	Over several thousand
Microstress method	Moves	Коммерческая	DehaCom	Hundreds of
Bragg gratings	Voltage, Temperature, (Displacement)	Test area	Stabilos project, LETI EMPA, Univ, Cantabria, Univ, Lipzig and many others.	Hundreds of
Fabry – Perot Interferometer	Moves	Test area	BAM	Dozens of
Raman scattering	Distributed temperature	a commercial	York Sensors, GESO	Dozens of
Бриллюеновское рассеяние	Распределенная температура и напряжение	Test area	MET–EPFL, Omniseus	Units

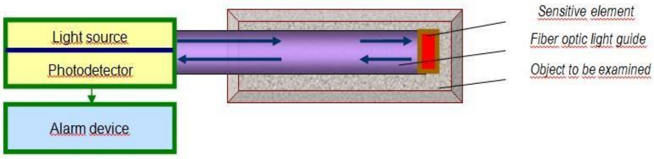

Fig. 1. Fiber optic measuring system of the first type: *1-sensitive element; 2 fiber optic light guide; 3-investigated object*

Fig. 3 Laboratory tests of a fiber-optic strain gauge embedded in a concrete cube 150 × 150 mm

Fig. 4. Fiber-optical amplitude-type strain sensor

Fig.5. Voltage control in a reinforced concrete pylon of the basement of a multi-storey building

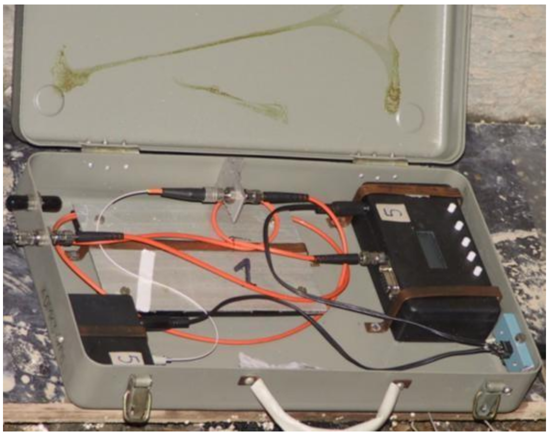

Fig.6. The working set of the electronic unit of the fiber-optical strain sensor: radiation source, optical power meter, digital indicator

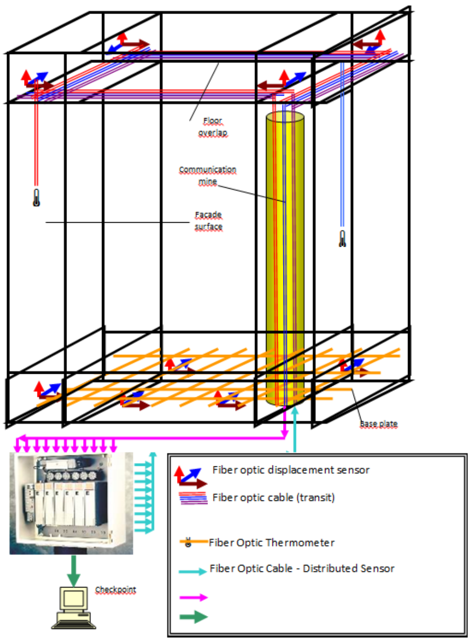

Fig. 7. Diagram of monitoring organization based on fiber-optic sensors for a residential building

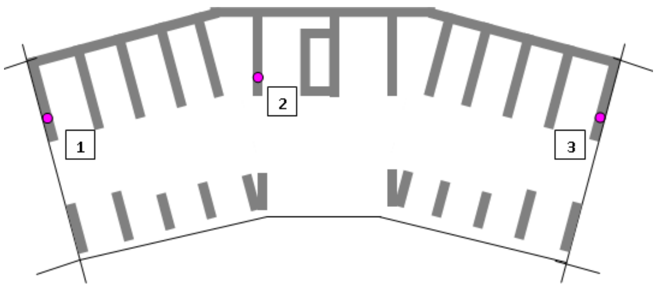

Fig.8. The installation diagram of the sensors in the pylons of the ground floor

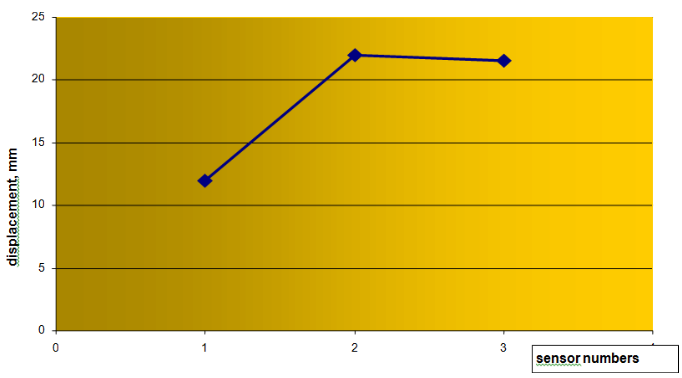

Fig. 10. Sediments of the foundation slab according to the results of leveling.

VI. CONCLUSION

Figures 9 demonstrate a satisfactory degree of coordination of the calculation with the monitoring data. In fig. 10 shows the values of the precipitation of the base plate according to the results of leveling. Plate sediments were recorded on September 8, i.e. 2 weeks earlier than the third monitoring data recording session, however, the correlation of the data (Fig. 9 and Fig. 10) is quite satisfactory. It should be borne in mind that on September 8 the degree of construction of the section "B" was estimated at 30–35%, and at the time of registration of the sensors on September 24 - 55– 60%. When taking into account these data, we can assume that the leveling data are quite consistent with the results of monitoring.

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