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VEHICLE BRIDGE DEFORMATION PREDICTION DEVICES

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Abstract:
Nowadays, big cities cannot be imagined without bridges. These engineering and technical structures not only make our life easier by reducing the distance between separate objects, but are also the decoration and identity symbol of many megacities. However, modern bridges experience huge loads and stresses every day due to various factors (traffic load, climatic conditions, seismic conditions, etc.) that contribute to their deformation.

Keywords
Bridges, ZETSENSOR, seismometer, synchronization module, navigation, Spectrum

Introduction

In this regard, it is necessary to constantly monitor the structure, measure its dynamic characteristics and determine the remaining service life, in order to increase the safety of the use of bridges and reduce large-scale construction costs, take measures to eliminate defects in time. allows access.

Figure 1. Mobile bridge monitoring system

The mobile bridge monitoring system based on ZETSENSOR digital sensors allows comprehensive diagnostics of load-bearing structures, including (Fig. 1):
- Monitoring the stress-strain state (SSS) of load-bearing structures of bridges;
- monitoring and evaluation of acceleration and vibrations;
- calculation and control of basic modes and maximum vibration amplitudes of structures.

Advanced mobile bridge monitoring system

The mobile bridge monitoring system is a set of digital sensors installed directly on the measuring object and an autonomous digital recorder in a portable box.

The basic system package includes:

• digital three-component accelerometer ZET 7152-N, which records linear acceleration, vibration acceleration, vibration speed and change of vibration location of structures;

• digital three-component seismometer ZET 7156, which provides registration and control of periods of natural vibration frequencies of bridge structures and corresponding logarithmic reductions;

• ZET 7110-DS digital strain gauges in the amount of 3 units for monitoring the stress-deformation state of load-bearing structures; mounted directly on the bridge supports and connected to the system recorder;

• stand-alone tape recorder (ZET 7176 interface converter, designed for remote connection of tape recorders to a personal computer via an Ethernet network; ZET 7173 autonomous recorder, for recording registered signals when working in stand-alone mode, as well as data backup; ZET 7175 synchronization module allows to synchronize data from digital sensors based on the signals of navigation satellites, rechargeable battery that provides autonomous operation of the tape recorder for up to 10 hours).

With the simultaneous use of 3-4 recorders, it is possible to create distributed systems for data collection and monitoring of load-bearing structures of bridges. Data collection systems allow you to get timely information about the current state of structures and make a decision on the need to change the operating mode or carry out repairs. These preventive measures allow you to save money without resorting to capital reconstruction. Specialized software provides visualization of the received data on the operator's screen. The data can be displayed graphically or numerically depending on the client's requirements. The standard display software provided with the mobile bridge monitoring system is a multi-channel measurement system. According to the wishes of customers, the software part can be supplemented with ZETLAB programs or SCADA system ZETVIEW to develop your own convenient interface.

The principle of operation of the mobile system

In the example of processing the results of ZET 7156 seismometers

The principle of working with a mobile monitoring system can be divided into three main stages:

• preparing the system for measurements;
• carrying out a cycle of measurements;
• processing recorded data and obtaining results.

Preparation

Preparation for work consists of initial configuration and adjustment of devices that are part of the mobile system.

To do this, you need to connect the sensors included in the kit to the mobile recorder via a cable, and the recorder to a personal computer via a USB interface. The computer must have Windows operating system installed and ZETLAB software installed and running. Devices are configured in the "Device Manager" program in the "Service" menu of the ZETLAB panel according to the user manual of the device:

• ZET 7110-DS
• ZET 7152-N
• ZET 7156
• ZET 7154

After completing the installation, you need to make sure that the built-in batteries of the recorder are charged. If necessary, it is also necessary to charge the installed batteries.

Taking measurements

Measurements at the test facility are carried out in the following sequence:

• Installation of ZET 7156 seismometers at control points (on the metal magnetic surface of the test facility or on a pre-prepared platform installed on the monitoring facility) on special magnetic supports that direct the "X" measurement axis in the desired direction.
• Connect the ZET 7156 seismometer to the recorder and switch the recorder to recording mode using the "Power" button.
• Turn off alarm recording when finished.
• If necessary, place the seismometer in the required places and make a series of similar measurements.

Processing and retrieval of results

The processing of the recorded signals is carried out on a personal computer with the ZETLAB software installed, and the ZETKEY digital key with the appropriate firmware must be installed in the USB port of the personal computer. After connecting the recorder to a personal computer, the "Select files to be converted..." program will automatically start on the computer. This program is designed to copy and change files from the internal memory of the tape recorder to the computer. After you finish copying the signals from the recorder to the computer, you need to open the "Signal Playback" program from the "Registration" menu of the ZETLAB panel and select the desired directory with the recorded signals. Monitoring results are processed in the "Fundamental Tone" program. The object of experimental monitoring was a car-pedestrian bridge crossing railway tracks. During the monitoring, two load-bearing structure monitoring sets were installed on the bridge. The first set is installed in the middle of the bridge, and the second is installed under the bridge. Seismometers are attached to the bridge structure using metal platforms mounted on the bridge's concrete foundation. The seismometer is attached to the metal platform using magnetic supports attached to the base of the sensor. The orientation of the sensors is chosen in such a way that the Z-axis is directed vertically along the bridge. First, for this you need to determine the natural frequency of the bridge, in the "Settings" tab of the "Fundamental Tone" program, the expected limits of the natural frequency range along the three axes are selected for each measurement point.

After collecting the measurements, the calculated spectra along the three measurement axes are displayed in the "Spectrum" tab. Based on the obtained spectra, the natural frequency range of the bridge should be determined. Later on. You need to change the values of the limit of the natural frequency range along the three measurement axes according to the ranges selected in the "Settings" tab. After collecting the measurements, the Spectrum tab displays the spectra for the three measurement axes. On the right side of the spectra, there are calculated values of the period and frequency of natural oscillations, as well as logarithmic reduction indicators on three measurement axes. ZET 7110 DS digital small strain sensor (with integrated strain gauge) is designed for tension testing of concrete structures and is used in monitoring systems for SMIC engineering structures. These sensors can be used in stationary and mobile SMIK systems.

Figure 2. ZET 7110 DS digital small strain sensor.

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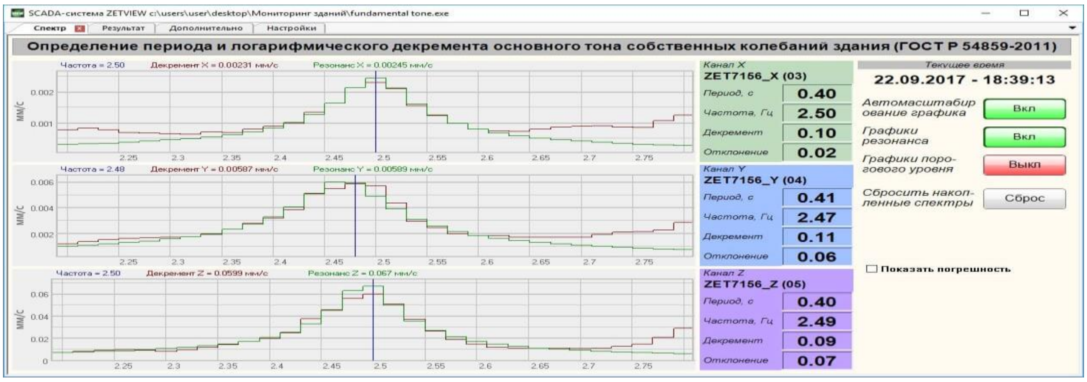

Figure 3: Graph of load bearing of the bridge.

During the recording of the dynamic parameters of the structure, the bridge was subjected to various loads (Fig. 2):
- dynamic movement of vehicles along the bridge;
- movement of high-speed electric trains under the bridge;
- stop large vehicles on the bridge;
- lack of vehicles on the bridge.

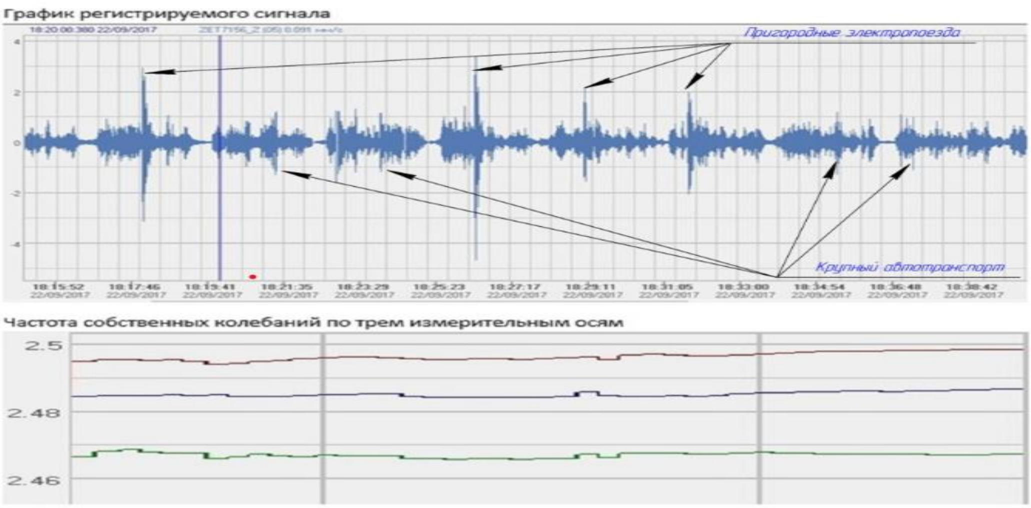

Figure 4. Below are the transient performance of the loads to which the bridge is subjected and the corresponding value of attenuation reduction.

If we analyze the graphs, it is clear that despite the different levels of loads on the structure, the value of the drop has changed slightly. At the same time, the location did not affect the quality of the measurements. This experiment shows that regardless of the choice of location of the equipment (the only condition is that the measuring device must be placed directly on the structure being observed), the natural frequency of the structure's vibrations and the value of the logarithmic decrease with the help of a single algorithm integrated into the ZETLAB program have the required accuracy. The stiffness and strength of the structure is determined by the natural vibrations of the system. The lower the value of the logarithmic damping decrement, the higher the power of the dynamic system. Attenuating reduction of mechanical vibrations allows a generalized assessment of the state of the entire structure.

CONCLUSION

Currently, the next task in this direction is to further automate measurements and reduce the time for processing the received data using computer technologies. Experimental studies are important for evaluating the dynamic properties of intermediate devices of car bridges and for developing theoretical calculations. Many centuries of practical construction experience, the absence or presence of accidents and accidents have allowed us to choose the most reasonable constructions. Unsuccessful solutions that could not stand the test of time were discarded, and on the contrary, the most modern designs and structures were preserved. We need and need to use devices that prevent vehicle bridges from decompression. It is necessary to teach the principle of operation and operation of new technologies. It is necessary and necessary for us to study the training of personnel and foreign experience and develop measures to implement them in our country.

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