UDC 625

DEVELOPMENT OF A METHODOLOGY FOR NON-DESTRUCTIVE MEASUREMENT OF SOIL ELASTICITY MODUL

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One of the main calculated characteristics in the design of road surfaces is the modulus of elasticity of road surface materials and paving soils. In this regard, it is necessary to determine the elasticity of each material, soil and take it into account during road construction. This contributes to the longer service life of road surfaces and lessening of road repairs. It is correct to constantly improve the properties of earthen coverings and foundations, maintain them at a stable level during application.

The main reasons for the unsuitability of road structures are insufficient load-bearing capacity of road surfaces and soil. The results of S. K. Iliopolov's research on highways and presented at the international scientific and practical conference "innovative technologies: ways to increase the time of intermediate repair of roads" (Madi, 04.02.2016) showed that residual deformations in the road surface layers were 30%, and in the roadbed and soil-70%.

In Germany, it is necessary to establish strict requirements for the soil and road surface of the land. For example, for any category of roads, the modulus of elasticity of the ground surface should be 45 MPA. In addition, the requirements for climatic conditions should be tightened. It is possible to increase the service life of road surfaces in the lower part of the road structure by increasing the hardness of the soil, reducing the thickness of the high road surfaces, which are considered quite expensive. In the work of A.M. Kulizhnikov, entitled" ways to increase the service life of intermediate road repairs", the value of the modulus of elasticity for each type of road climate zone is presented:

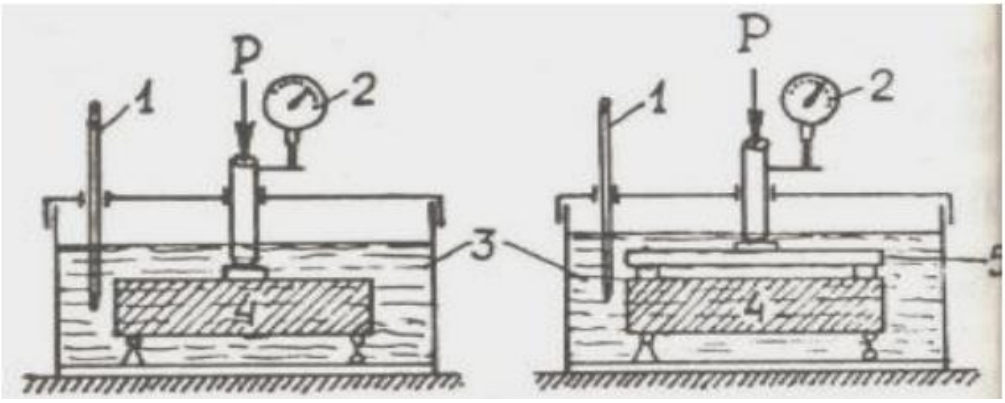
Road 1-climate zone-60 MPa;

Road 2 climate zone-50 MPA;

Line 3 climate zone -45 MPA [1].

The essence of the currently used test methods is to take samples(cores) from the existing road construction and test them. The disadvantage of this method is that the duration of the study, labor intensity, plus the test results do not provide information about the operational values of the modulus of elasticity of the road structure, which is used as the main accounting characteristic when designing measures for the repair and reconstruction of road clothing [2].

Stretching the impact of the Hammer allows you to determine the modulus of elasticity of asphalt concrete. Tensile resistance during stretching is a calculated indicator normalized by ODN 218.046-01. The scheme and structure used in this method are shown in Figure 1 [3].



A) B)

Figure 1. Scheme of tensile testing of asphalt concrete.

A) the assembled type of the device, B) determination of the elastic bend in the supports: 1-thermometer; 2-deformation indicator; 3-water bath; 4-sample; 5-device for determining the elastic bend.

Tensile resistance and relative deformation at bending are calculated using the following formulas [11]:

$$R_{изг} = \frac{3 \cdot P \cdot l}{2 \cdot b \cdot h^2}, E = \frac{6 \cdot f \cdot h}{l^2} \qquad (1)$$

Where P is the destructive force, kg; l is the distance between the supports; b, h is the width and height of the beams, cm; f is the deflection, cm.

Method of shock penetration sensing. In the Republic of Belarus, the IPM-1A installation is used [12], which implements the method of dynamic indexing with continuous recording of the impact process for operational control of the modulus of elasticity of asphalt concrete [3].

Device IPM-1A (Fig. 2), the main element of which is an indenter – 1, which produces a test shock on a controlled coating (sample); magneto indication sensor-2, an indenter acceleration mechanism-3; analog-to-digital signal conversion (ADP) device connected to a personal computer-4.using the method of Non-Destructive Testing, the device IPM-1a allows you to determine the physical and mechanical properties of the material being tested: hardness, hardness, according to GOST 22690-2015 dynamic modulus of strength, elasticity.

Figure 2. IPM-1A device and its structural diagram

Determination of the modulus of elasticity based on the deviation of the coating surface [4]. Methods of static loading with a car wheel (Benkelmann beam). This test method is used in Russia, Germany, the United States, and Vietnam. The advantage of the method is the simplicity of the

equipment used. The disadvantages are the duration of the study (1-1.5 hours per 1 km), depending on the weather conditions [4].

Figure 3. Benkelman's hammer

Taking into account the features, advantages and disadvantages of these methods, rapid methods for determining the modulus of elasticity of the Earth's surface are currently in great demand.

The instrument that has just entered the market is PDU-MG4. The main purpose of the device is to measure the modulus of elasticity of impact - materials. The characteristic is determined by the indirect method, direct measurement of the amplitude of movement of the load plate and the impact force acting on the stamp. The diagnostic process is carried out only on a flat horizontal surface.

The modulus of elasticity can be determined based on one-time measurement data or as a result of a series of tests. In the first case, it is necessary to ensure a complete (dense) placement of the plate on the surface of the material. To achieve this, all voids are filled with fine (one-dimensional) sand. With mass surveillance, this is not necessary. The accuracy of the characteristic value provides many tests included in the measurement series.

A special feature of the dynamic soil seal PDU-MG4 is the" impact " - a reliable design based on a pressure plate with a diameter of 0.3 m. The control of the mechanical part is carried out by a light portable remote control connected by a wire to the remote measuring module. Data processing, visualization and archiving of the received data are carried out by the electronics of the device [6].

PDU-MG4 is designed to monitor the quality of the base of road surfaces and soil density. The load, which is located on the guide bar weighing 10 kg, allows you to achieve a significant force pulse, providing an upper limit of measurement of 20 KN. At the same time, the error is 1% ± 20 N, the modulus of elasticity in the range of 5-370 MN/M2 is calculated automatically based on the value of the instantaneous linear deformation at the actual acting force (the upper limit of dimensions is 0.9 mm). The dimensions of the device are 0.3 x 1.3 meters, and the weight is 27 kg.

The device uses an indirect method for determining the modulus of elasticity. It is calculated using a formula that, in addition to the amplitude of movement and the diameter of the plate, includes the Poisson coefficient, the value of the contact voltage. All calculations are carried out by a microcontroller based on the parameters of the power effect falling on the electronic unit. A graphical display shows the values of the elastic modulus, load, and deformation.

With the help of a locking screw, the mechanism for fixing and releasing the movable load is installed at a certain height. After release, the cargo moves along the guide rail. The force of impact of the load on the furnace is regulated by the height of its installation.

The elastic elements of the tensometric sensor perceive the impact force and deform. The deformation is converted into an electrical signal proportional to the force of impact. The accelerometer mounted on the stamp generates an analog electrical signal using a digital integrator, which is proportional to the DD acceleration obtained when the load falls. Electrical signals enter

the electronic unit, where they are processed and converted. As a result, measurement data is output to the indicator [6].

Finally, using the PDU mg-4 device, it is possible to determine the modulus of elasticity of the ground surface, which affects the suitability of highways.

With the help of the device, it is possible to determine the modulus of elasticity of the earthen surface and compare it with regulatory technical documents without destroying the road surface.

Determination of the modulus of elasticity of the roadbed by the dynamic test method allows us to assess the uniformity of this indicator at the operational stage. Thus, the coefficient of change in the modulus of elasticity of the road surface can vary in the range of 12-50%, which indicates a significant heterogeneity of the road surface, which should be taken into account when planning repair activities.

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