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TECHNICAL SCIENCES

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INSTRUMENTS AND METHODS FOR CONTROLLING THE PARAMETERS OF ASPHALT CONCRETE SURFACES

Аннотация

This paper presents an overview of asphalt pavement inspection techniques and methods. The principle of destructive pavement inspection is described and the advantages and disadvantages are described. The device of georadar method of georadiolocation and back-scattered radiation in quality control of asphalt concrete pavement is described.

Ключевые слова: неразрушающий контроль, асфальтобетонное покрытие, программно-аппаратный комплекс, обратнорассеянное излучение, радиационный метод, георадар, точность.
Keywords: non-destructive testing, asphalt pavement, hardware-software system, backscatter radiation, radiation method, GPR, accuracy.

Controlling the quality of asphalt pavements is an essential task for the smooth functioning of all areas of society. The condition of the roadbed directly affects the standard and quality of life of citizens. This task in our country is regulated by GOSTs and carried out by state road corporations (Rosavtodor and regional operators).

Monitoring the condition of road surfaces is an extensive complex of works that can be divided into 2 components:

- Examination of the structural layers of the soil. This phase of the work is of paramount importance both in the design of new highways and in the revision of existing highways. It is necessary to understand the distinction between foundation soil and structural layers of embankment or excavation. In the first case, the layers formed by geological processes in the road construction area are studied. The second consists of layers of various inert materials (sand, sand and gravel mixtures, crushed stone etc.) that are placed before the road surface.
- Inspection of the roadbed. This includes inspection of the supporting elements of the roadway - bituminous concrete layer, concrete pavement (including slabs), crushed stone, sand and gravel layer, etc, as well as surface treatment.

Roadway quality control techniques are divided into destructive and non-destructive. Both methods are used in Russia:

- destructive methods are represented by core sampling from roads. This method is effective for detailed and complete examination of asphalt concrete samples in laboratory conditions. Its advantages are: the possibility of complete analysis of physical, mechanical and chemical properties, but it has significant drawbacks in terms of examining only a small section of the road and in terms of damage to the asphalt concrete surface, which can worsen the overall condition of the road surface.
- Non-destructive testing is carried out using different methods of measurement: GPR, radiation, ultrasound and others and video methods using pattern recognition technology have now also started to appear (to evaluate the surface condition of the road).

The inspection of supporting structures is carried out regularly, especially on federal roads. In recent years, destructive inspection methods have been used most frequently for this purpose - drilling followed by removal of cores in certain sections of the asphalt pavement.

Based on the information obtained, a decision is made on additional protective devices or other works capable of preventing the spreading of detected defects and mass destruction of the pavement in good time.

Just as important is the study of the subgrade, since subsidence or embankment washout can have even more devastating consequences. And it is precisely this work that was always the most difficult, as the investigation of the underlying layers of the embankment (excavation) required expensive and time-consuming work. Moreover, drilling in individual areas cannot always give an indication of existing reconsolidations, karst cavities, abrupt rise of the water table and seasonal drift of clay and spilled soils, which may be sporadically deposited in different volumes. In areas with severe hydrological and climatic conditions the roads therefore have a much shorter lifespan and parts of them often deteriorate.

To cope with these problems engineers and builders needed high-performance non-destructive testing methods for asphalt pavements, the first of which was seismic testing.

Seismic surveys are based on the properties of elastic waves, first applying overpressure to the ground by hitting it with a small charge or using a special vibratory hammer. A seismic probe then records the reflected wave and draws conclusions about the geology of the site based on the strength of the wave and the timing of its propagation. This method is very productive, but gives relatively general information, and also cannot be used in small populated areas, as vehicles, factories and other infrastructure cause strong interference.

Electrical prospecting was then developed, based on measuring the electrical resistance of various rocks. It is very effective in detecting groundwater, but of little use in studying coastal layers. In addition, hidden objects and utilities create a lot of interference, which greatly reduces the detection efficiency.

The most modern and efficient method is considered to be georadiolocation. It is based on the study of electrical properties of various media - their electrical conductivity and dielectric permittivity. The instrument used is GPR, which is a special complex equipped with antenna units (receiving and transmitting), as well as control, monitoring and recording equipment.

This method is based on the principle of radar - radar that penetrates the ground emits short electromagnetic pulses downwards, after which they propagate in the carrier and are reflected off their borders. These are then captured by receiving antennas and converted into a digital signal by the control unit. This signal is then sent to a data logger (essentially an embedded or attached computer), processed, and from this data a radiogram - a three-dimensional or two-dimensional image of the captured area - is created.

The radiogram can be displayed in either three-dimensional or cross-sectional form. Based on this information it is possible to:

- construct cross-sections which will show structural and deeper layers as well as defective spaces (cavities, decompaction, swelling and rising groundwater areas) with a high degree of accuracy;
- construct maps of buried networks and utilities;
- determine the thickness, position and displacement of embankment and road base layers.

Based on the information obtained, potentially dangerous sections and significant road defects in individual sections can be quickly identified.

Significant damage with costly repairs can be avoided if these problems are corrected in good time. The results of the ground investigation are very precise and provide an excellent overview of both the base course and the structural layers. With this information drilling and other expensive works can be minimised.

The GPR method is characterised by its low cost, high accuracy and efficiency. With additional equipment such as a rangefinder and a motion sensor, GPR can be mounted on a vehicle and linked to a benchmark or other reference point. During the initial survey, which is carried out before road design begins, the sensing system can locate karst cavities, underground tanks, wells, pits and pipelines. By including work to extract them in the design plan, problem areas can be avoided in the future.

Modern GPRs are equipped with an interchangeable or adjustable antenna unit that can be used to thoroughly survey the top layers or explore to depths of 20 metres or more. The GPR can be moved by hand or by vehicle. The unit can be connected to the vehicle's odometer for accurate trace measurement; depending on the scanning mode and antenna selected, speeds can sometimes be between 20 and 70 km/h.

Radiation-based quality control methods make it possible to determine not only the density but also the bitumen mass fraction in asphalt concrete. The control of bitumen content in asphalt pavements is a very demanding task. So the bitumen mass fraction decreasing in asphalt concrete mixture by 1 % from the optimum one bring to decrease of asphalt concrete surface performance at repeated loadings on 20-40 %. The increasing of bitumen mass fraction decreases the shear stability and there is a risk of rutting at total thickness of asphalt concrete surface and foundation more than 15 cm.

Radioisotope surface moisture meter (RSMM-1) is also applicable for determination of bitumen mass fraction in asphalt-concrete structural layer. In this mode of operation fast neutrons with chemically bound hydrogen in bitumen are slowed down. The control procedure remains the same as for measuring the moisture content of the subgrade. The bitumen content of the asphalt concrete is determined from the measurement results using a graduation chart.

The instruments described above are used extensively in the metallurgical and mining industries.

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О РЕЗУЛЬТАТАХ СТАНОВЛЕНИЯ ЭКСПЕРИМЕНТАЛЬНОГО МЕТОДА ИССЛЕДОВАНИЯ ДИНАМИЧЕСКИХ СВОЙСТВ ЭКРАНОПЛАНОВ «ИРКУТСКОЙ ШКОЛЫ ЭКРАНОПЛАНОСТРОЕНИЯ»

Аннотация

Развитию научной школы экранопланостроения в Иркутском государственном техническом университете доктором техн. наук, профессором А.Н. Панченковым способствовало наличие вблизи озера Байкал и Иркутского водохранилища. Под его руководством была создана методология проведения экспериментов по определению динамических свойств экранопланов методом буксировки, а также самоходных и пилотируемых моделей. В статье рассмотрены основные результаты становления экспериментального метода исследования динамических свойств экранопланов «Иркутской школы экранопланостроения»- метода буксировки моделей.

Ключевые слова: экраноплан, аэродинамическая компоновка, переходные процессы, экспериментальные исследования, метод буксировки моделей, динамические свойства.
Keywords: ekranoplan, aerodynamic layout, transients, experimental studies, model towing method, dynamic properties.

Специфика околоэкранного полета экраноплана, заключающаяся в том, что неровности экрана формируют дополнительные возмущения [1], периодического или импульсного характера, требует решения особого класса динамических задач, включающих в свой состав разнообразные исследования колебаний экранопланов. Необычайно широкий диапазон режимов движения экранопланов усложняет экспериментальное исследование из-за принципиально различных законов изменения действующих на них сил и законов подобия явлений. Еще более сложны для изучения переходные процессы при изменении режимов движения. В соответствии с указанными режимами весьма разнообразны и методы экспериментального исследования характеристик данных аппаратов. На сегодняшний день существует несколько методов, как определения аэродинамических характеристик экранопланов, так и исследования их динамики. Это испытания моделей в гидроканалах и аэродинамических трубах, катапультируемых и буксируемых, кордовых и радиоуправляемых самоходных и пилотируемых моделей, натурные испытания построенных аппаратов. По мнению ряда зарубежных специалистов Х. Вейлаида, А. Липпиша только применение моделей различного масштаба от продуваемых в аэротрубах до многотонных самоходных пилотируемых обеспечивает получение необходимых данных для достаточно надежного представления об ожидаемых качествах экраноплана. Опять же наиболее полные исследования динамики и стабилизации экраноплана на всех режимах движения, от режима плавания до режима околоэкранного полета можно провести только с помощью буксировки модели экраноплана в гидроканале.

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