1. Introduction

In previous studies, predicted patterns of changes in the physical-mechanical properties of asphalt concrete containing mineral powders from the local mineral raw materials of Yakutia — natural zeolite and brown coal — have been obtained.

Road oil bitumen contains a large number of surface-active substances (asphaltenes, ketones, carboxylic, and asphaltogenic acids), which chemically interact with the surface of the mineral material and provide it with the presence of chemisorption bonds with the formation of water-insoluble compounds. Moreover, the active components penetrate through the pores and capillaries into the mineral material during the selective filtration and interact with the surface of the pores and capillaries [1-5].

It is known that mineral powders for asphalt concrete should have high porosity, which defines their acceptable adsorption properties concerning most of the bulk bitumen. In the adsorption layers of bitumen, the asphaltene concentration increases on the surface of the mineral powder particles. With the optimum ratio of bitumen – mineral powder, the viscosity of bitumen intensifies and the degree of its structuring increases: the concentration of asphaltenes increases due to the depletion of the adsorption layers of bitumen with resins and oils. Most of the resin are accumulated in the surface micropores of the mineral powder, whereas part of the oils penetrates deep into the material due to selective diffusion. Owing to the presence of chemisorption processes on the surface of grains of
mineral powders during their interaction with bitumen, asphalt concrete containing natural zeolite and brown coal has improved indicators of water resistance (accelerated method) and water saturation [6-9].

2. Research objects and objectives
The most intense destruction of asphalt concrete surface of roads occurs during prolonged wetting, as well as in spring and autumn, which are characterized by frequent freeze-thaw temperature differences. Such damage, as a rule, manifests itself in the form of the formation of a large number of scattered corrugations due to the flaking of mineral particles from the pavement. The reason for such defects lies in insufficient water and frost resistance of asphalt concrete [10].

One of the main factors for extending the service life of road pavement is the use of asphalt concrete with satisfactory resistance to atmospheric corrosion. The key indicators characterizing the corrosion resistance of asphalt concrete are the indicators of long-term water saturation of asphalt concrete samples and their frost resistance, that is, the parameters, which characterize the operation of asphalt concrete pavement in the most unfavorable climatic conditions – autumn-spring period.

The weakening of structural bonds at the boundary of the “binder – mineral material” phase interface occurs due to the presence of water in the pores of the asphalt concrete. The peeling of bitumen films from the surface of the stone material is observed under the action of water. As a result, various coating defects develop beginning from a network of cracks to the spalling of asphalt concrete particles from the pavement [11-13]. Therefore, asphalt concrete must have high water resistance and frost resistance in the upper layers of the pavement.

3. Assessment of the corrosion resistance of asphalt concrete
According to the mix design of the asphalt concrete composition [14], cylindrical samples were manufactured, for which the water resistance during long-term water saturation (Figure 1) and frost resistance (Figure 2) were determined.

The cylinders of asphalt concrete, tested for prolonged water saturation, meet the requirements of GOST 9128-2013 [15] (Figure 1). Asphalt concrete with mineral powders from local mineral raw materials are characterized by higher water resistance compared to asphalt concrete with traditional mineral powder. It indicates higher adhesion at the “binder – mineral filler” phase interface. Enhancing the adhesion is possible due to the best indicators of the structuring ability of the suggested mineral powders [16].

![Figure 1. Water resistance of asphalt concrete samples after 15 days of water saturation](image-url)
1 - Asphalt concrete with limestone MP; 2 - Asphalt concrete with MP from natural zeolite; 3 - Asphalt concrete with MP from natural zeolite (activated); 4 - Asphalt concrete with MP from brown coal; 5 - Asphalt concrete with MP from brown coal (activated).

Water that accumulates in the pores of asphalt concrete is one of the major causes of its destruction at low temperatures. In addition to the above-described peeling of bitumen films from the surface of stone material, water-saturated road surfaces undergo alternating freezing and thawing in the spring-autumn period. The upper layers of the structure are most often exposed to the moisture and cycles of crossing the 0°C. Water can penetrate the asphalt concrete surface from three sides: from above due to precipitation – rain and snow, from the sides, when road shoulders are saturated with melt and surface water, and from below, when groundwater is lifted. Owing to the expanding effect of water during freezing and the fragility of bitumen films at low temperatures, stresses arising in the pore walls cause microcracking. Thawing of asphalt concrete leads to the filling of freshly formed microcracks with an additional volume of water. Consequently, during the next freezing, defects develop further, and the entire road structure weakens: the stability of the roadway and base deteriorates, its strength decreases, and the ability to absorb and redistribute loads from the passing vehicular transport decreases. Such defects as peeling, flaking, corrugations, and cracks can appear on the road, and with a decrease in strength and weakening of the entire structure of the pavement, a tracing rut with a crack network can occur. It should be noted that the deformation and destruction of the pavement are facilitated not only by the humidity and aggressiveness of the environment but by the moistening duration of the entire mass of asphalt concrete as well. Herewith, the resistance to humidification (water resistance) of the asphalt concrete pavement depends on the quality of its compaction and the strength of the bonds of the organic binder with mineral materials through structured bitumen films. Therefore, it is necessary to increase the water resistance of bitumen films to reduce the negative impact of water. The denser the asphalt is, the higher is its corrosion resistance to moisture. The density of the asphalt concrete depends on the porosity of its mineral part, the amount of moisture, and the level of compaction. The destruction of the asphalt concrete coatings is especially intensive during prolonged wetting, as well as during thaws, which were preceded by a significant number of freeze-thaw temperature fluctuations [11-13, 17-20].

The frost resistance index of asphalt concrete samples was determined according to GOST 12801-98. The method consists in assessing the loss of compressive strength of pre-saturated samples after exposure to a specified number of freeze–thaw cycles. One cycle includes the freezing of samples at a temperature of -18±2°C for at least four hours followed by thawing in water with a temperature of 18±2°C [18].

![Figure 2. Frost resistance of asphalt concrete samples](image)

*Figure 2.* Frost resistance of asphalt concrete samples

Note: Sample numbers correspond to Figure 1.
Asphalt concrete with mineral powders from zeolite and brown coal has improved indicators of frost resistance compared to asphalt concrete on limestone mineral powder. Thus, the loss of compressive strength of asphalt concrete samples after 50 freeze-thaw cycles amounted: 26.24% and 29.81% (in dispersed and activated states) for samples with zeolite in their composition, 13.75% and 16.26% (in dispersed and activated states) for samples with brown coal as mineral powder. The loss of compressive strength of asphalt concrete samples with limestone mineral powder after 50 cycles was 36%.

4. Conclusion
According to the obtained data on the study of asphalt concrete on water and frost resistance, the corrosion resistance of the investigated asphalt concrete of the optimal composition increases with the complete replacement of limestone mineral powder with mineral powders from natural zeolite and brown coal. The ongoing chemisorption processes on the surface of the mineral powder grains can improve adhesion at "mineral material – binder” phase interface during their interaction with bitumen. Therefore, asphalt concrete containing mineral powders from local raw materials has increased corrosion resistance compared to traditional asphalt concrete. Thus, we can conclude that asphalt concrete pavements using mineral powders from natural zeolite and brown coal will have increased durability.

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