Experience in Repairing Highways Using Cold Regeneration Technology in the Altai Republic

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Abstract. Three main factors were taken into account cost, quality, and time when repairing the highway R-256 “Chuysky Trakt” in the Altai Republic. Repairs were carried out using various types of road constructions using cold recycling technology, implemented both at the near-road plant and directly on the road. The four types of structures are most common. The first type is asphalt and granulated concrete with a thickness of 20 cm using a mineral binder. The second one is asphalt-granulated concrete with a thickness of 15 cm using a combined binder. The third is with the use of wear layers of bitumen-mineral mixtures and leveling layers of asphalt concrete mixtures. The fourth - with the use of a combined binder and a layer of wear from the bituminomineral mixture with the use of polymer-bitumen binders. The use of cold regeneration technology of existing pavements allowed not only to restore their bearing capacity, but also to increase it by 50% to 56%, depending on the type of pavement design used.

1. Introduction

Over the past decade, significant changes have occurred in the road sector. One of the main documents that predetermined changes was Government Decree No 539, issued in 2007, which approved the rules for calculating the cash costs for the repair and maintenance of federal roads. They were valid until 2017, when Resolution No 658 was issued. It established the actual rules for calculating budget allocations for capital repairs, repairs and maintenance, and, moreover, it regulated new regulatory overhaul periods. They doubled: for repairs from 6 to 12 years, for major repairs - from 12 to 24 years.

In this situation the road community is faced with priorities such as providing the necessary time intervals between repairs and at the same time to keep within the established framework of budget allocations and to increase the proportion of the length of federal roads to 85% in accordance with regulatory requirements.

To put it another way, solving a problem should be based on three things: cost, quality, time. Achieving these goals is possible through the use of one or another modern high-performance technology. One of the most effective ways to reconstruction the base layers of existing road structures is the cold regeneration method.
Cold regeneration technology allows restoring the pavement carrying capacity by reusing materials from old layers of the road. The effectiveness of recycling is ensured by the possibility to regulate the properties of the asphalt-granular concrete mix by adding mineral materials and a binder. As the latter foamed bitumen, emulsion and cement in various combinations can be used. Cost reduction is achieved by minimizing the amount of new material used or rejecting it altogether and, as a result, reducing the costs of transportation and procurement.

Russian [1–4] and foreign [5–10] practice of use cold regeneration technology to repair asphalt pavements indicate the high efficiency of this technology. The roadbed layer rebuilt by regeneration to a predetermined thickness can be successfully used instead of the traditional practice of new layers of amplification construction or general reconstruction.

Numerous studies of the physicomechanical characteristics of asphalt-granulobentone mixture (hereinafter referred to as AGB-mixture) and asphalt-granulobeton obtained by cold regeneration [11–17] confirm their compliance with modern regulatory requirements. These requirements are governed by Decree of Rosavtodor No. 568-p of 06.26.2002 “Methodological recommendations for the recovery of asphalt concrete pavements and foundations of roads by means of cold regeneration” and ODM 218.2.022-2012 “Guidelines for the reuse of asphalt concrete in the construction (reconstruction) of automobile roads”. The experience of pavements cold regeneration in various regions of Russia is also presented in [18–20].

2. Materials and methods
The effectiveness of road repair is directly related to the balance of three components: cost, quality and deadlines. We will evaluate the effectiveness of road repair by cold regeneration using the practice of PKU "Uprdor" "Altai". The main scope of work on cold regeneration technology by the "Uprdor" "Altai" was carried out on the R-256 “Chuysky Trakt” road in the Altai Republic. In total for the period 2011–2018 288 km of roads were repaired by this method.

In recent years "Uprdor" “Altai” mastered three methods of cold regeneration. The first one is regeneration directly on the road using Wirtgen 2200CR recyclers with a capture width of 2.2 m and WR 2500S - 2.5 m as the leading machines. The second is using the AMMANN Goldmix 3600 continuous road processing plant. And finally the third using the Wirtgen WR 4200 machine. This type of recycling can be called combined. It is a synthesis of a cold milling cutter, a continuous plant and an asphalt paver.

The Wirtgen WR 4200 recycler operates in a variable width range from 2.7 m to 4.2 m. It is equipped with double shaft longitudinal stirrer, milling cutter with sliding milling drums, AB 500TV screed with pre-compaction functions. Mobile mixing unit WM 1000 is used for the dosed injection of mineral binder. It allows you to prepare a water-cement suspension in accordance with the specified proportions. All the above presented machines and plant are equipped with units for the dosage and supply of organic binders, including combined ones.

The most optimal for a particular object of construction method of production can be determined only after conducting a comprehensive analysis of technical and economic indicators of various methods of producing cold regeneration of pavement. Conditions on each particular road section are determinative not only in determining the method of production, but also in choosing the pavement construction.

The following factors influence the choice of the pavement structure option:
1. existing pavement design;
2. actual and future traffic intensity and composition of the traffic flow;
3. pavement condition;
4. road-climatic zone (the presence of areas with permafrost);
5. geometric parameters of the existing pavement;
6. temperature and time indicators of road exploitation;
7. physical properties of materials subject to regeneration.
When restoring base layers using cold regeneration technology the following most common designs can be distinguished. The first group is asphalt and granulated concrete with a thickness of 20 cm using mineral binder - Portland cement M400 in the amount from 4% to 5%.

The second is asphalt-granulated concrete with a thickness of 15 cm using a combined binder - Portland cement M400 in the amount of 3% and foamed bitumen - 2%. Traditionally arranged overlying layers are represented by the following combinations of materials:
- leveling: hot dense fine-grained asphalt concrete mix type B of brand II with thickness h ≥3.0 cm; hot porous fine-grained asphalt concrete mix grade II with a thickness h ≥3.0 cm; black crushed stone fraction 5-20 mm thickness 5-7 cm;
- top: hot dense fine-grained asphalt concrete mix type B of mark II with thickness of 3.0 cm; crushed stone-mastic asphalt concrete SMA 15 - 3.0 cm using polymer-bitumen binders based on block copolymers of type SBS brand PBB 90.

The third group of constructions is somewhat different from the ones given above. In this case wear layers from open bitumen-mineral mixtures are used and the leveling layers are represented by hot fine-grained dense multi-gravel asphalt concrete mixes type A grade II and A16BH with a thickness of 6 cm.

In the fourth case, on top of a 15 cm thick asphalt-granulated concrete layer using a combined binder — Portland cement grade M400 in an amount of 3% and foamed bitumen — 2% a wear layer 3.0 cm thick from a bitumen-mineral mixture of BMS 0/15 type was applied using polymer-bitumen binders based on block copolymers.

Variants of pavement designs with the use of base layers recovered by cold regeneration are shown in Figure 1.

**Figure 1.** Variants of pavement designs with the use of layers of bases restored by cold regeneration on the highway M 52 “Chuysky tract”: BMS - bitumen-mineral mixture, SMA - crushed stone-mastic asphalt concrete, BCS - black crushed stone, A16VN - asphalt concrete mixture for normal driving conditions, AGB - asphalt-granulo-concrete mixture.

In the presented designs the following materials and binders were used: bitumen-mineral mixture type II, black crushed stone - crushed stone of 5-20 mm fraction treated in a mixing plant with bitumen road oil viscous, a complex binder - (Fig. 1a, c); the mineral binder (cement) - (Fig. 1b).

The most important indicator of the operational reliability of roads is their bearing capacity which is characterized by the modulus of elasticity. The calculation of the elastic modulus of road structures which are presented in Fig. 1 showed the following results: for (a) - 362 MPa; (b) - 355 MPa; (c) - 369 MPa. Taking into account the fact that the calculated modulus of elasticity of existing structures was 236 MPa an increase in the carrying capacity of pavements as a result of the restoration of the base layers using the cold regeneration technology amounted to (a) - 53%; (b) - 50%; (c) - 56%.
When restoring road pavements using cold recycling technology in foreign practice, road pavement structures presented in Figure 2 are used.

Figure 2. A special case of pavement structures with the use of base layers, restored by cold regeneration in foreign practice: AC - wear layer, BSM - layer recovered by cold regeneration.

The structures shown in Figure 2 are designed for a standard equivalent axle load of 8.16 tons (ESAL): (a) – 10 000 000 is a country road, (b) – 30 000 000 is the federal highway, (c) – 100 000 000 - motorway.

3. Conclusion
The use of the cold regeneration technology for existing pavement structures layers with the help of special machines - recyclers makes it possible to ensure the carrying capacity of the repaired roads.

The analysis of the obtained results allows us to conclude that the strength of road structures is increased when applying the technology of restoring base layers using the cold regeneration technology.

The efficiency of repairing highways using cold regeneration technology makes it possible to use the material of the old layers, while the use of various binders — mineral binder, organic binder, and their combinations makes it possible to obtain new material with preassigned physical and mechanical properties.

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