Improvement of the technology of cold reclamation of asphalt concrete in the asphalt plant and the possibility of its application in the republic of Iraq

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Abstract. This article presents the state of the highways in the Republic of Iraq and studying the possibility of using the regeneration technology of asphalt concrete as a base for road pavements strengthen. This technology has not yet used in Iraq. Therefore it proposed to use for the maintenance and reconstruction of roads the technology of cold regeneration of asphalt concrete in the asphalt plant, which ensures the improvement of the properties of asphalt granules due to its preliminary crushing, the introduction of cement additives as a mineral binder. Compositions of asphalt-granular-concrete mixtures have developed, and data from studies of the properties of asphalt-granular-concrete of various documents presented. The most common pavement defects in Iraq are plastic deformations, which are caused by a combination of high temperatures and low strength characteristics of asphalt concrete. Pregame compositions used to strengthen the construction of road pavements with increased strength and shear stability. A cost-effectiveness calculation of using the cold technique is also presented moreover compare the cost this application in Russia and Iraq also.

1. Introduction

Asphalt concrete mixtures is the main material used in repairing the pavement. This material is gradually increasing the price of it due to the increasing in the price of the resources, the transfer and the shipping costs etc.

Many studies and researches are working on reducing the time and the cost of the pavements repairing by studying different technologies based on the processing of old asphalt concrete, which are implemented both at asphalt concrete plants and directly on the road. Nowadays, these technologies are widely used around the World, where the volume of used old asphalt concrete is 20-30% of the total amount of produced asphalt concrete mixtures. Cold regeneration (CR) technology is the most economical maintenance technology which ensures restoring the original strength of the pavement.

Currently, Iraq and other middle east countries resorting to economic solutions in light of financial crises. Therefore, using cold regeneration (CR) technology assumed to be good Choice to improve the properties of old asphalt concrete, reduce the harmful effects of emissions on the environment and minimize the costs associated with the construction and reconstruction of highways [1].

The analysis of the weather and climatic conditions of Iraq showed that in the summer, the heating temperature of the asphalt concrete pavement reaches 70 °C [2,3]. That makes changes in the pavement structure and reducing the service life and causes an increase in the risk of the plastic deformation of the surface. The Figure below shows the main type of deformation occurs in the roads of the hot weather countries under a high traffic volume and heavy trucks, [4,5].
The proposed repair should be increasing structures of road pavements and increasing the strength and shear resistance of pavements in which we can get a smooth surface with a high rate of.

2. Materials and methods
In Russia, research in the field of asphalt concrete reuse was carried out by V.M. Goglidze, A.M. Aliev, B.A. Asmatulaev, G.S. Bahrach, J.I. Bilay, S.F. Balashov, E.B. Ilyev, N.V. Gladyshev, A.P. Lupanov, A.V. Rudensky, B.S. Gmyrya, V.F. Poloiko, G.N. Kiryukhin, V.V. Silkin et al. Despite a wide range of domestic studies, technologies for the regeneration of old asphalt concrete in Russia are still at the initial stage of development and have not received such widespread use as abroad, where the volume of use of this material is up to 20% of the total amount of asphalt concrete mixtures produced. In Iraq, these technologies are still practically not used.

A comparison between the CR of asphalt concrete pavements and the traditional repair methods has been made, and cold repair technique showed better results based on cost and time of maintenance. The analysis showed that for the conditions of Iraq, taking into account the main types of road damage, it is more convenient to use cold regeneration technology where this technique does not require additional equipment and can be implemented in a short time. In addition, carrying out work without heating the material leads to minimal damage to the environment and organometallic materials.

As a result of the cold processing of asphalt concrete, an asphalt-granule-concrete mixture (AGC-mixture) is formed, which has its own structural features.

Theoretical studies of the structure formation of asphalt concrete are devoted to the works of I.A. Ryb'sva, B.I. Ladygin, L.B. Gesenzvey, I. B. Gorelsheva, I.V. Koroleva, V.A. Zolotareva, G.K. Xunyi, A.V. Rudensky and others. The results of the reaches showing that the properties of asphalt concrete as a highly concentrated dispersed system are highly determined by the properties of the liquid phase, represented by bitumen.

Unlike hot a / b mixtures, where the dispersed medium is represented by bitumen, in the AGC-mixture, the dispersed phase is represented by cement paste.

Crystallization contacts, which are formed during hardening of cement, which are introduced together with water and form a strong framework or paste, play an important role in the structure formation of AGC (Figure. 2). The required amount of cement paste depends on the total surface of the granular and the thickness of the paste film, which also depends on the size of the granules.
The volume of cement paste for the AGC mixture can be calculated with the following expression [6]:

\[ P = \delta \sum \delta_i * S_i * P_i \]

Where:
- \( P \): Paste volume,
- \( \delta \): Density of cement paste kg/m³.
- \( \delta_i \): Thickness of the paste layer, m.
- \( S_i \): The specific surface area of the fraction, m²/kg.
- \( P_i \): the content of grains of the fraction, %.

To determine the value of \( S_i \), one can use the data of I.V. Koroleva [7] on the specific surface area of particles of different fractional composition. See figure 3.

![Figure 3: Dependence of the specific surface area of materials on the size of the fraction.](image)

The performed calculations showed that the volume of cement paste for the formation of a uniform technological layer in the AGC mixture is 0.05 kg / m³ or 100 kg / t. With a water-cement ratio \( w / c = 0.5 \), the cement content per 1 ton of granules is 0.03 kg or 3% of the mass of the granules.

### 3. Results and Discussion

Based on the results of the theoretical studies, the experimental work aimed at selecting the compositions of asphalt granular concrete with the highest density and strength characteristics with an optimal amount of cement.
The experimental works were performed in the laboratory of Dorexpert LLC. As a starting material, granules of old asphalt concrete was used, obtained as a result of milling of asphalt concrete pavements with a WR 2500 cutter from Wirtgen during repair work at facilities in Moscow. Granulometric curves are shown in Fig. 4.

![Figure 4. Aggregate composition of old asphalt concrete granules: 1-fraction 0/40; 2-fraction 5/20; 3-fraction 0/5.](image)

The work considered various options for the composition of AGC-mixtures based on granules of old asphalt concrete with the addition of cement in the range from 0.75 to 3%. Two types of granules were used to prepare AGC mixtures. Granules with a size of 0-40 mm (100%) obtained after milling without crushing and fractionation and granules with a size of 0-20 mm obtained after crushing, screening and mixing fractions of 5-20 mm and 0-5 mm, which ensured the production of denser AGC- mixtures. Table 1. illustrates the compositions of the mixtures.

| Materials | Comp. № 1 | Comp. № 2 | Comp. № 3 | Comp. № 4 | Comp. № 5 |
|-----------|-----------|-----------|-----------|-----------|-----------|
| A) Granules of old asphalt concrete (100% fraction 0-40 mm) | 100% | 97.75% | 95.5% | 93.25% | 91.0% |
| B) Granules of old asphalt concrete (60% fraction 5-20 mm and 40% fraction 0-5 mm) | | | | | |
| Cement M500 | - | 1.5% | 3% | 4.5% | 6% |
| Water | - | 0.75% | 1.5% | 2.25% | 3.0% |
| **Total:** | 100% | 100% | 100% | 100% | 100% |

The test results of the main indicators of the properties of AGC concrete from uncrushed and crushed granules at the age of 7 days are shown in Figures, 5,6,7 and 8.
Figure 5. Value of the flexural strength at a temperature of 20 °C after 7 days.
- No crushing; - After crushing and fractionation.

Figure 6. Swelling of samples at the age of 7 days.
- No crushing; - After crushing and fractionation.

The requirements of (STO NOSTROY 2.25.35-2011).

Figure 7. Comparison of the main indicators of the properties of AGC at 7 days: a- Residual porosity of samples; b- Water saturation of samples.
- No crushing; - After crushing and fractionation.
- . . The requirements of (STO NOSTROY 2.25.35-2011).

Summarizing the data obtained, we can conclude that, based on granules, it is possible to get mixtures for the construction of bases and lower layers of coatings, providing the required properties according to STO NOSTROY 2.25.35-2011 [9]. The properties of granular asphalt concrete can be modified by adding cement and aqueous Additives plasticizer through the grinding and the crushing the mixture to fractionated granules. Studies have shown that asphalt granule concrete at the age of 7 days using
fractionated granules of 0-5 and 5-20 mm has strength at different temperatures higher than granular asphalt concrete with granules 0-40 mm without crushing and screening.

Moreover, with similar values of the properties of the studied compositions of granular asphalt concrete, the highest strength at 20 and 50 °C, which characterizes its shear resistance, as shown by samples with the addition of cement. The use of AGC from crushed granules with the addition of 1.5-3% cement [8], in terms of its indicators, provides, and in terms of strength indicators, exceeds the requirements of GOST 9128-2013[10] for hot coarse-grained dense asphalt concrete.

From the given data, it follows that preliminary crushing and dosed granulate by fractions significantly increases the density of AGC. These reduce the water saturation and porosity of the samples. Crushing the granulate and increasing the amount of cement increases the flexural strength. However, increasing the cement is slightly decreasing the deformation due to an increase in the rigidity of the material. At the same time, the obtained values fit into the requirements of GOST 9128-2013 concerning coarse-grained asphalt concrete.

The use of fractionated granules significantly reduces the swelling rate. As for the indicator of water resistance and long-term water resistance, as can be seen from the data obtained, crushing and fractionation of the granules does not have a noticeable effect on this indicator.

The calculations help to assess the economic efficiency of the construction work using the cold regeneration technology in the asphalt plant for the conditions of Russia and Iraq. The following Figure 9 illustrates the analysis comparing the cost of coating (1m²) with a thickness of 10 cm from AGC mixtures for the conditions of Russia and Iraq.

The calculations showed that the most economical option is a technology that provides for the device of a coating or base from crushed granules with fractions of 0-20 mm with the addition of cement and a plasticizer. For a layer with a thickness of 10 cm, savings according to the selected option, in comparison with a hot coarse-grained mixture (type B), is 284 rubles. Per 1 m². For Moscow and USD 6.45 for Baghdad.

**4. Conclusion**

- An analysis of the climatic conditions of Iraq showed that the primary defects of the pavements are associated with the low strength of the pavement structures and insufficient shear stability of the pavements, which requires appropriate adjustments in terms of shear resistance requirements.
- Studied modern methods of road surface repair and various technologies for the regeneration of old asphalt concrete and studying the techniques of hot and cold rejuvenation. The results show that the
cold method with the preparation of mixtures in the manufacture is the most suitable for the conditions of Iraq.

- It is possible to modify the structure of AGC mixtures with adding a certain amount of cement and choosing the appropriate granular size in order getting the optimal AGC
- The experimental studies obtained shows the possibility of improvement in the properties of AGC by optimizing the granules composition of the granules and the selection of the optimal amount of cement.
- Economic calculations performed both for the conditions of the Russian Federation and for the conditions of Iraq have confirmed the effectiveness of the technology of cold processing of asphalt concrete with the addition of cement, Compared to a 10 cm thick hot asphalt concrete pavement, the savings for the selected option is 284 rubles. Per 1 m2. For Moscow and USD 6.45 for Baghdad.

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