The substantiation of the influence of asphalt resin paraffin oil residue on the asphalt concrete technology

Kylyshbai Bisenov, Panabek Tanzharikov, Ulbossyn Sarabekova, Erden Kodar and Nurlan Abildaev

Korkyt Ata Kyrgyz University, Kyrgyz, 29A Aiteke Bi Street, Kazakhstan

E-mail: ulbolsyn.sar@mail.ru

Abstract. Based on scientific research and experimental tests, it has been proved that solid waste from oil fields in the Kyrgyz region based on asphalt resin paraffin sediment (ARPS) is close and binding in its chemical composition to the main component of the asphalt-concrete mixture of the road surface. And the most effective method of disposal and neutralization of oil waste was chosen. In this article, it is proposed to develop an asphalt-concrete technology based on asphalt-resinous paraffin deposits. The issue of increasing the reserves of raw materials for the production of durable asphalt concrete and reducing the amount of oil-containing waste in the fields due to the sale of solid oil-containing waste will be considered. Based on the study, the composition of asphalt-resinous paraffin deposits was analyzed by IR spectroscopy. The infrared (IR) absorption spectrum was captured in the IR-Fourier spectrometer. The results of the study showed the suitability of asphalt-resinous paraffin deposits for use as organic binders to dense asphalt concrete of type «B» grade III for IV-V road climatic zones recommended for applying top layers of coating on roads of technical category IV.

1. Introduction
Currently, the topical issue of interest to scientists in the field of construction is the decontamination of waste oil and its use in the production of construction materials as a source of renewable raw materials. The analysis of the literature has shown that one of the most widely used areas of oil waste is road construction. Oil sludge is used as an additive or as an additive in oil-soil, cement-soil, asphalt-concrete, aerated-concrete, sludge-concrete compositions, which improves the quality of concrete mixes by reducing strength, frost resistance, water resistance, water absorption, swelling and shrinkage.

Parallel use of waste oil in road construction is an expansion of the raw material base of soils, reduction of energy and labor costs, reduction of the road surface cost and simplification of the technological process [1].

Many scientists of the country have done a lot to improve the environmental situation and reduce their negative impact on the environment by using solid oil waste as a raw material. In particular: Academician K.A. Bisenov [2], professors P.A. Tanzharikov [3], A.A. Shomantaev, S.S. Uderbaev [4], R.A. Narmanova [5] and others. Their work is especially valuable not only in the Kyrgyz region, but in the whole territory of Kazakhstan in the development of oil production and industrial
waste as a source of renewable raw materials and the production of efficient building materials. It has been proved that the fields of high paraffin oil in Kyzylorda oblast can be used in road construction on the basis of scientific research and experimental tests [6].

The study selected the most efficient type of waste oil for disposal and neutralization. It was found that such wastes include asphalt-resin paraffin sediments. They are formed during the evaporation of pipes using special equipment for cleaning, dewaxing of process equipment (oil storage tanks, bullets, sewage wells) [7].

At present, the issue of disposal of asphalt-resin paraffin sediments and oil wastes remains unresolved. Therefore, one of the study tasks was to solve these problems, and it caused a special scientific research. The research program is based on the directions of this type waste utilization in the world professional practice and the effective implementation of promising technical solutions. The APRS from the Kumkol field was studied, which includes asphaltenes of 3...8%; resins 13...20%; oil 34...65%; mechanical additives 20...49%; water 1...5%.

Asphalt-resin paraffin sediments are close to bitumen, have a high deformation, soften when heated and completely dissolve in terms of composition and properties. These properties determine the areas of agricultural products use and the possibility of their use as a binder in the production of building materials [6-7]. The use of waste oil as a raw material is widely used in three industries. These are road construction, construction materials and fuel and energy. In table 1 show that the most profitable industry is the production of construction materials.

| Areas of application | Direction of application | The amount of waste, mass% | Source of waste | Technical result of use |
|----------------------|--------------------------|---------------------------|----------------|------------------------|
| Road construction    | Asphalt concrete         | 5-10                      | Paraffin sediment | Expansion of raw material construction |
|                      | Aerated concrete         | 1-2                       | Oil sludge      | Increasing mechanical stiffness |
|                      | Sludge concrete          | 80-90                     | Oil drilling sludge | Increase resistance to water and liquids |
|                      | Fuel oil floor           | 90-95                     | Technogenic oil sludge | - |
| Construction materials | Due to the soft roofing water-proofing material | 30-40 | Oil sludge | Reduce mixing time and temperature |
|                       | Roofing and water-proofing mastic Waterproofing mixture | 30-50 | Waste from spilled oil | Reduction of bitumen consumption |
|                       | As a lightening additive | 100                       | ARPS (asphalt resin paraffin sediment) | No preparation required |
|                       | Expanded clay            | 20-50                     | Oil sludge      | Reduction of material density |
|                       |                          | 5-15                      | Oil sludge      | Reducing the bulk density of the material and reducing fuel consumption |

2. Methods
The analysis of the asphalt-resin paraffin sediments (ARPS) formation was carried out, the composition and properties of paraffin and resin-asphaltenes were studied in order to discover the
meaning of the research topic. Heavy metals in asphalt-resin paraffin sediments were determined by X-ray fluorescence spectroscopy, and their composition was chromatographically analyzed by chromate-mass spectrometer.

A special group of oil wastes is asphalt-resin paraffin sediments, which are considered as the main object of study.

Asphalt-resin paraffin sediments (ARPSs) are formed during the injection of oil through pipelines, as a result of underground and overhaul of wells, cleaning of process equipment, evaporation of pump-compressor pipes using special dewaxing equipment. Asphalt-resin paraffin sediments are often dark-purple or dark-thick ointment-like masses with high viscosity.

Oil and gas fields as Kumkol, Aryskum, Kyzylkiya and Maibulak, located in the South Turgai depression, were selected as research objects. The oil from the above fields is a type of oil with high paraffin and complex parameters. Based on the characteristics of degassed oil, it was found that the freezing point and the high content of high molecular weight paraffin. The excitation range of these parameters is very large for the objects in the field and it will be very difficult to explain. It was not possible to relate these parameters to the location of the pipe in the hypsometric condition in the selected study material.

The average content of asphalt-resin paraffin sediments in oil recovery systems with wells is paraffin – 12-86%, resin - 0.8-20%, asphalten - 0.3-45%, oils 6.5-50% and inorganic impurities - 0 - 37%. Typical composition and physical and chemical properties of asphalt-resin paraffin oil residues from various fields are shown in Table 2.

**Table 2.** Composition and physical and chemical properties of asphalt-resin paraffin sediments in oils from various fields.

| Indicators | ARPS | Kumkol | Aryskum | Kyzylkiya | Maibulak |
|------------|------|--------|---------|-----------|----------|
| Group hydrocarbon content, mass% | | | | | |
| Hydrocarbons | | | | | |
| - paraffin-naphthenic (P) | 48,60 | 62,06 | 43,46 | 41,80 |
| - aromatic-monocyclic | 12,38 | 10,07 | 16,03 | 12,40 |
| - aromatic bicyclic | 11,07 | 10,37 | 10,04 | 6,70 |
| - aromatic polycyclic | 9,60 | 7,46 | 15,86 | 14,30 |
| Compound of hydrocarbons (M) | 81,65 | 89,96 | 85,39 | 75,20 |
| Resin (R) | 14,65 | 8,96 | 7,74 | 19,20 |
| Asphalteners (A) | 3,70 | 1,04 | 6,87 | 5,60 |
| The ratio of structural elements | | | | | |
| P / (R + A) ratio | 2,6 | 6,2 | 3,0 | 1,7 |
| A / (A + R) ratio | 0,20 | 0,10 | 0,47 | 0,23 |
| A / (M + R) ratio | 0,04 | 0,01 | 0,07 | 0,06 |
| Composition of mechanical impurities, mass% | 10,99 | 1,07 | 3,26 | 0,42 |
| Physical and mechanical properties | | | | | |
| Melting point, °C | 72,0 | 66,5 | 56,5 | - |
| Density 20°C, g / cm³ | 2,29 | 1,03 | 1,05 | 0,946 |
The composition and structure of oil from the Kumkol field were analyzed by IR (Infrared) spectroscopy. The absorption spectrum for the infrared (IR) region was recorded on an IR Prestige-21 IR Fourier spectrometer (Shimadzu, Japan) [8].

The composition of asphalt-resin paraffin sediments is determined by the IR spectrum, and the spectra of raw materials from relatively different deposits based on the analysis are shown in Figure 1 - 2.

**Figure 1.** Infrared spectrum of asphalt-resin paraffin deposits at the Kumkol field.

**Figure 2.** Infrared spectrum of asphalt-resin paraffin deposits at the Maibulak field.
Absorption spectra of asphalt-resin-paraffin sediments recorded in the IR spectrum show the structure of hydrocarbons in the methyl (2954-2852 cm\(^{-1}\)), methylene (1463-1377 cm\(^{-1}\)), and methyl (721 cm\(^{-1}\)) groups. The analysis shows that the composition of solid oil residues formed in the fields consists mainly of paraffinic hydrocarbons.

3. Results
The purpose of obtaining products in accordance with the standards of physical and mechanical nature, predetermined in the implementation of the ARPS based on the analysis of works on this topic in the literature and summarizing the results of research in this area. Comprehensive experimental and theoretical research to find a technology for the use of asphalt-paraffin resin sediments allows to consider this waste as a source of raw materials for road construction [6, 7]. The study revealed the need to add active substances such as lime and cement to improve the properties of oil waste used in road construction (viscosity of asphalt-resin paraffin sediments and the strength of oily soils). The mineral mixture heated to 140-160 °C is mixed with asphalt-resin paraffin sediment melted at a temperature of 80-95 °C, obtained in 10-15% by weight of the mineral component. The addition of agricultural products to the mineral mix in the ratio of 10-15% by weight is sufficient to obtain a quality asphalt concrete mix. It is not enough to get the ARPS below the specified weight ratio, and adding more than the specified limit will lead to a decrease in the quality of the mixture. In addition, the use of ARPS to replace commercial bitumen will significantly reduce the cost of asphalt concrete and improve the environment. The obtained asphalt concrete admixtures were tested by physical and mechanical methods in accordance with ST RK 1225-2003 and ST RK 1218-2003. The results are given in Table 3.

Table 3. Physical and mechanical properties of asphalt concrete based on asphalt-resin paraffin sediments.

| Samples # | Weight ratio,% | Compressive strength, mega Pascal (MPa) | Long-term water saturation coefficient | Water absorption coefficient | Medium density | Water resistance coefficient |
|-----------|----------------|------------------------------------------|--------------------------------------|-----------------------------|----------------|-----------------------------|
|           | Sample mineral admixture (gravel + sand) | ARPS Bitumen BND 60/90 | R\(_{20}\) | R\(_{50}\) | R\(_{0}\) | R\(_{5y}\) |                           |                           |                           |
| 1         | 92,0          | 8,0           | -              | 2,1  | 1,0  | 12,7 | 2,1 | 0,59 | 1,2 | 2,24 | 0,71 |
| 2         | 90            | 10,0          | -              | 2,5  | 1,1  | 12,5 | 2,4 | 0,65 | 1,5 | 2,25 | 0,72 |
| 3         | 88            | 12,0          | -              | 2,5  | 1,2  | 12,1 | 2,76 | 0,66 | 2,4 | 2,26 | 0,74 |
| 4         | 86            | 14            | -              | 2,58 | 1,2  | 12,3 | 2,6 | 0,66 | 3,5 | 2,27 | 0,73 |
| 5         | 84            | 16            | -              | 2,63 | 1,4  | 12,6 | 2,5 | 0,61 | 3,5 | 2,25 | 0,71 |
| 6         | 90            | 10            | 10             | 2,5  | 1,6  | 12,8 | 2,77 | 0,6  | 3,8 | 2,28 | 0,76 |

According to the requirements of ST RK 1225-2003, for type B, brand III, IV-V road-climatic zones:
- Not less than 2.0
- Not less than 1.1
- Not more than 13.0
- Not normalized
- Not less than 0.6
- 1.5 to 4.0
- Not normalized
- Not normalized
The results of the study showed that asphalt-paraffin resin residues can be used as organic binders for type III «B» type dense asphalt concrete for road climatic zones IV-V, which is recommended for use in the construction of the upper layers of pavement on roads of technical category IV.

Asphalt concrete mix obtained by mixing the mineral component with asphalt-resin paraffin deposits is not inferior to the mixture obtained when using commercial bitumen in terms of technical characteristics. At the same time, the replacement of scarce commercial bitumen with petroleum waste as ARPS, which significantly reduces the cost of commercial products, as well as simplifies the process of preparation of the mixture and prevents pollution of the environment with harmful substances released from oil [9-12].

During the study, the physical and mechanical properties were qualitative, the composition of the resulting mixture was as follows: gravel - 40 ... 50%, sand - 15 ... 20%, limestone - 10 ... 15%, ARPS - 20 ... 25%. These give new properties to the waterproof mixture.

Strengthening of oil paraffin soil by mixing with gravel showed that it increases the physical and mechanical properties of asphalt concrete mix and accelerates the formation of the mineral surface of the road. It was observed that the strength of asphalt-concrete mixtures made from oil wastes of oil companies with the addition of active substances (lime and cement) increases to 11%. They are temporary covering of highways; when lying frost-resistant layers in the construction of hard pavements; used in the construction of the lower layers of cement and asphalt pavements. If the residue consists mainly of pure paraffin sediment, it is very effective to use it instead of bitumen. Its quality is not inferior to bitumen, but it is 10-15 times cheaper [13-15].

It is proposed to use asphalt-resin paraffin sediments as a building material for the asphalt-concrete mixture to be laid on the road surface. Practical tests were carried out at the Asphalt Concrete Plant of Kyran LLP, and on the basis of the proposed technology in Kyzylorda, 100 m long and 5 cm thick asphalt concrete pavement was laid. The results of laboratory tests of strength and stability of asphalt concrete based on asphalt-resin paraffin sediments are given. Their resistances to moisture and frost, rheological properties, samples were made in the laboratory in special samples in order to test the physical and mechanical properties of asphalt concrete on the basis of asphalt-resin paraffin sediments.

Analysis of the diagram of the composition «mineral powder + amount of ARPS + mineral aggregate» in the system «Mineral aggregate + gravel + sand» led to the following conclusions: mineral aggregate is 80% of the total weight of asphalt concrete components, mineral powder 9.4-10.2% and production in the share of 8.6-10.2% of ARPS leads to high strength [16-19].

4. Discussion
The new scientifically based results of research for the development of asphalt concrete mixes, which provide an important environmental solution and expand the stock of road construction materials, and developments in the use of asphalt-resin paraffin sediments, are analyzed in this paper.

The main scientific and practical results are the analysis of the areas of use of oil wastes as a source of renewable raw materials showed that oil wastes, such as oil sludge and oil soils, are used mainly. In the Laboratory of Methods of Physical and Chemical Analysis of Engineering Profile at Korkyt Ata Kyzylorda University, functional groups of asphalt-resin paraffin oil residues were determined by IR spectrometer method. Chromatographic analysis of oil and asphalt-resin paraffin sediments was performed on Agilent 7890N / 5975 chromat-mass spectrometer.

The results of laboratory tests of strength and stability of asphalt concrete on the basis of asphalt-resin paraffin sediments have shown the physical and mechanical properties of asphalt concrete based on ARPS, its resistance to moisture and frost, rheological properties meet current standards.

Asphalt-concrete based on asphalt-resin paraffin sediments was introduced into production according to the results of research and experimental tests. This is confirmed by the act of commissioning at the asphalt plant of LLP «Kyran» in Kyzylorda region, Kazakhstan. The economic efficiency of the developed technology, based on the calculations, the environmental and economic efficiency of the production of asphalt concrete amounted to $ 3,000 per 1 km of road surface. In
addition, it was recommended for use in the educational process for engineering and environmental specialties and approved by the Act of introduction into the educational process.

References

[1] Tanzharikov P and Sarabekova U Zh 2014 Use of asphalt resinous paraffin deposits in the production of building materials Proceeding of International scientific conference on Current directions of fundamental and applied research North Charleston USA p 140

[2] Bisenov K A, Uderbayev S S and Saktaganova N A 2016 Optimization of the structure and process parameters of aerated concrete production with the use of oil sludge International Journal of Pharmacy and Technology 8 pp 17733-44

[3] Tanzharikov P, Ayfer Erken, Abilbek Zh, Sarabekova U Zh and Ermukhanova N 2018 The technology of preparation of the oil sludge pit with polymerorganic screen for oil waste ARPN Journal of Engineering and Applied Sciences 13 pp 4360-64

[4] Bissenov K A, Uderbayev S S and Saktaganova N A 2016 Physicochemical Analysis of Structure of Foamed Concrete with Addition of Oil Sludges Research Journal of Pharmaceutical Biological and Chemical Sciences 7 pp 1701-08

[5] Appazov N O, Seitzhanov S S, Zhunissov A T and Narmanova R A 2017 Synthesis of Cyclohexyl Isosulphate by Carbonylation of Isobutylene with Carbon Monoxide and Cyclohexanol in the Presence of Pd(PPh3) (4)-PPh3-TsOH and Its Antimicrobial Activity Russian Journal of Organic Chemistry 34 pp 1030-38

[6] Ruchnikova O I and others 2003 Recycling asphalt-resin-paraffin deposits in the manufacture of waterproof coating Oil Industry 3 pp 103-5

[7] Ruchnikova O I and others 2003 Environmentally safe disposal of solid oil waste. Protecting the Environment in Oil and Gas Industry 4 pp 29-32

[8] Nifonteev Y 2000 The scientific basis for the creation of resource-waste technologies of mining and processing coal Pechora Basin Abstract thesis Dr technical sciences Saint-Petersburg State horn Inst-T them G V Plekhanov p 40

[9] Tanzharikov P A, Sarabekova U Zh and Tanzharikova G P 2014 Evaluation of economic efficiency of oil waste recycling technology Science journal of Actual Problems of Economics 1 pp 340-46

[10] Ruchkinova O I and Weisman Y I 2003 Environmental security companies of oil-producing complex (oil waste management system) The journal Engineering ecology 2 pp 15-26

[11] Ruchkinova O I 2004 Environmental technologies a review of the major uses of oil waste as secondary raw material Ecological Engineering 2 pp 2-17

[12] Ryskaliev M Z, Zharylgapov S M, Saktaganova N A, Sarabekova U Zh and Yerimbetov K A 2019 Physico-mechanical properties of foam concrete with a keratin-based foaming agent International Journal of Engineering and Advanced Technology 8 pp 80-82

[13] Zhantokhov S K 2007 Reduction of anthropogenic impacts on the environment during infield collection and preparation of oil (for example deposit Kenkiyak): Autoreport of Candidate of Technical Sciences 25.00.36. -Almaty DGP "Institute of Mining by D A Kunaev" 22

[14] Abdibattaeva M M, Akhmedzhanoz T K and Zhubandykova Zh U 2007 Utilization of oily waste at deposit Kumkol Materials of the 9th International Scientific and Practical Conf (New Life Safety) -Almaty pp 4-7

[15] Bissenov K A, Uderbayev S S and Shalbolova U Z 2014 Environmental and economic efficiency of application of constructional insulating arbol from agricultural and industrial wastes Actual problem of economics 1 pp 304-11

[16] Candler J, Leuterman A 2008 Problems associated with the development of drilling fluids and waste management systems Oil and Gas Technologies 5 pp 32-36

[17] Adilova N B, Montayev S A, Montayeva A S, Shakeshev B T, Narikov K A, Taskaliev A T and Usenkulov Zh 2014 Modifying of ceramic mass by Kazakhstan bentonite for the purpose of improvement of structure and physic-mechanical properties of front wall ceramics Life Science Journal - Acta Zhengzhou University Overseas Edition pp 83-89
[18] Abilbek Z, Tanzharikov P, Tashimova A, Ermukhanova N and Zaurekul K 2019 Planning and mathematical processing of test results for obtaining organomineral and polymerorganic water proofing material *ARPN Journal of Engineering and Applied Sciences* **14** pp 4270-76

[19] Bishimbayev V K, Narmanova R A and Shalbolova U Zh 2017 Breakeven efficient production of cold hydraulic insulating mastic *Oil and gas* **1** pp 59-66