

**A. Tulebekova<sup>1</sup>, Zh. Kusbergenova<sup>1</sup>, A. Aldungarova<sup>2</sup>, A. Bakirbayeva<sup>2</sup>**<sup>1</sup>L.N. Gumilyov Eurasian National University, Astana, Kazakhstan<sup>2</sup>D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan

(E-mail: krasavka5@mail.ru)

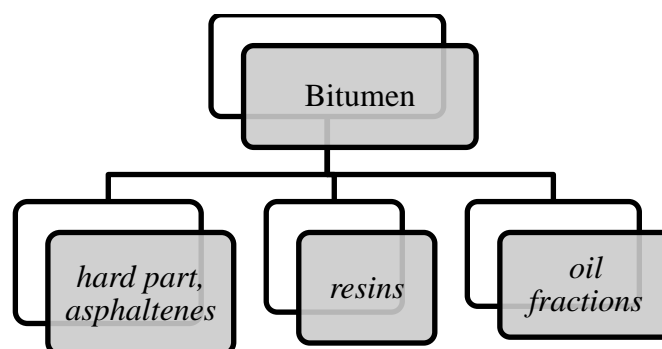
**Peculiarities of bitumen testing methods**

**Abstract.** Bitumen as a construction material is extremely widespread in hydraulic engineering and road construction. Bitumen has a wide variety of features and useful properties, which allowed it to reach a leading level among other binder building materials. The article presents the peculiarities of laboratory testing of bitumen. Step by step the technique of bitumen testing on the ring-ball device and on the ductilometer is disclosed. The importance of testing quality control is justified. The results obtained showed the absence of deviations from the normative values. And reliability and accuracy of the obtained results are reached due to the use of an analytical approach and taking into account the risks arising during the tests. The account of which is presented by means of the "bow-tie" methodology, the main advantages of the use of which are the analysis of the reasons for risk occurrence, and the determination of decisions on their elimination.

**Keywords:** bitumen, test, ductilometer, risk, reliability

DOI: [doi.org/10.32523/2616-7263-2022-141-4-47-54](https://doi.org/10.32523/2616-7263-2022-141-4-47-54)**Introduction**

Currently, there is an increase in requirements for the operational and transport characteristics of asphalt concrete pavement due to the annual increase in the number of motor vehicles in almost all regions of Kazakhstan. At the same time, the service life of road surfaces is affected by the quality of used bitumen, which is one of the important components of road pavement. The annual increase in road construction requires more bitumen and it is of high quality. But there are problems with the quality of bitumen sometimes. Bitumen is the product of the distillation of oil, and in recent years, the percentage of quality bitumen from tar is decreasing due to the increase in the depth of oil refining. Density is considered a distinctive property of bitumen, as it depends on the content of the components in the bitumen (Figure 1).



**Figure 1. Compounds that form bitumen**

For example, the build-up of aromatic structures increases the density of bitumen, while the build-up of saturated compounds, on the contrary, the density decreases[1].

Another important property of bitumen is the flash point [2]. Thus, the flash point of bitumen when heated determines the flammability of the bituminous mixture[3]. The ability of bitumen to resist

the movement of the dispersed medium under stress from the outside is its viscosity.

At the same time, other equally important factors of bitumen, which establish its marking, as well as the components are water resistance, water resistance, resistance to acid, alkali, salt, and gases, and the ability to dissolve in solvents.

Determination of these indicators is an important and responsible stage [4]. Therefore, a lot of research is devoted to improving the quality of bitumen [5]. Researchers from Drexel College, USA [6] note the possibility of adding the bacterium *Sporosarcina pasteurii*. The study [7] investigated the physical and mechanical properties of polymer asphalt concretes on bitumen-polymer binders modified with mixed thermoplastic elastomers. Thus, determining the initial properties of bitumen is an important part of the modification [8].

### Experimental materials and methods

Research to determine the softening temperature of bitumen is carried out on the device "Ring & ball"[9]. The test algorithm is shown in Figure 2.

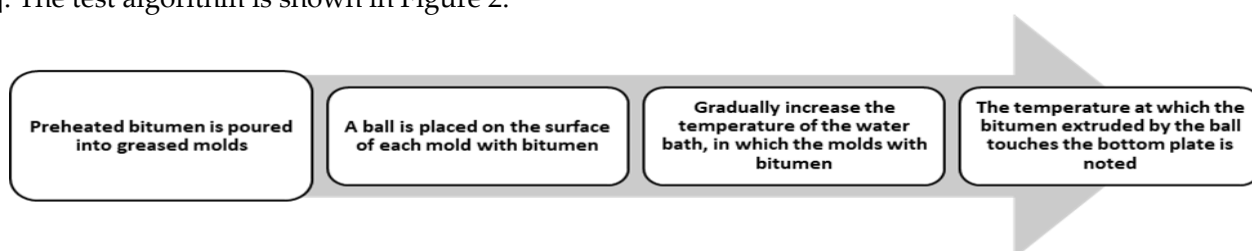


Figure 2. Stages of "Ring & ball" investigation

This study used road bitumen grade 70/100, which was preheated to a temperature of 25°C to be able to pour into the used containers of devices used in the study (Figure 3).



Figure 3. Forms for testing on the "Ring & Ball" device a) empty form; b) form with bitumen

Then, containers filled with bitumen were placed in a glass transparent cylinder with distilled water (Figure 4).



Figure 4. Bitumen testing process on the "Ring&Ball" device

Then the water in the cylinder is gradually heated, while increasing the temperature value at  $5^{\circ}\text{C}$  per minute, as a result, when the bitumen is heated to the softening temperature, the ball placed on the bitumen will fall, and contact the sensor installed at the bottom of the cylinder. Thus, the indicator of the softening temperature of bitumen is the value at which the ball placed on the bitumen reaches the bottom of the cylinder (Figure 5).

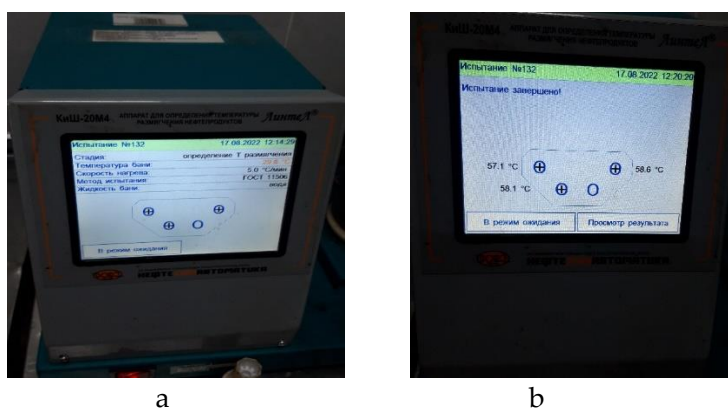


Figure 5. Readings of the instruments during the test a) data during the test; b) data at the end of the test

Tensile parameters of bitumen were determined using a ductilometer instrument [10]. The algorithm of the ductilometer test is shown in Figure 6.

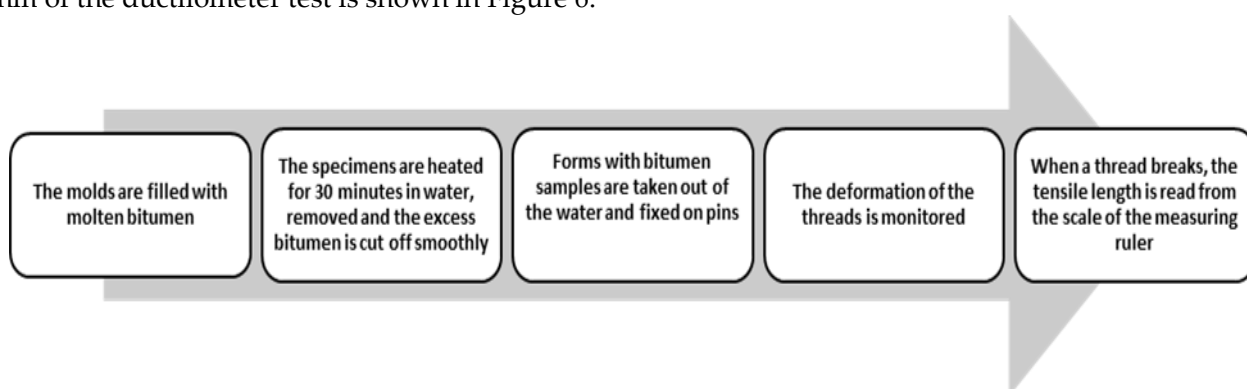


Figure 6. Stages of investigation tensile parameters of bitumen

During the test, the containers were pre-lubricated with Vaseline to facilitate the removal of bitumen residue after the test (Figure 7).

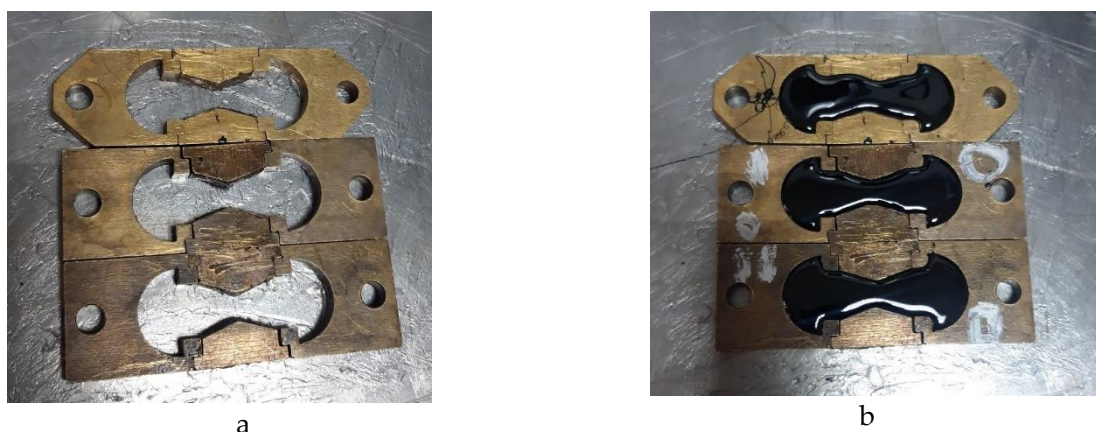
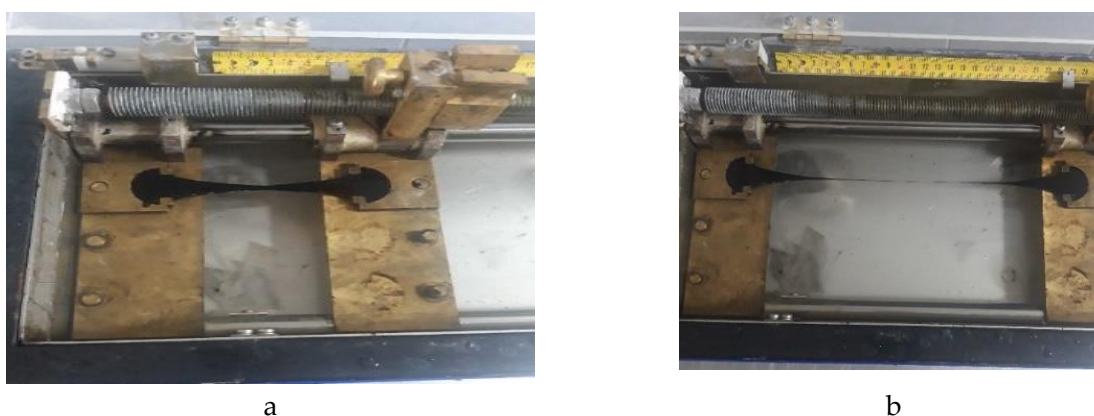


Figure 7. Photos of greased molds: a) before filling, b) filled with bitumen

These molds filled with bitumen were kept for 30 minutes at ambient temperature for the bitumen to cool down and come to its original state. Then the molds with the sample of tested bitumen were placed in water filled in a ductilometer and kept in water at 25°C for 30 minutes, then using a staple with a straight blade removed the excess top layer of bitumen protruding beyond the boundaries of the mold. The molds with the bitumen sample are attached to the ductilometer racks and the test begins (Figures 8-9).



Figure 8. Photo of forms with samples of bitumen in the water ductilometer



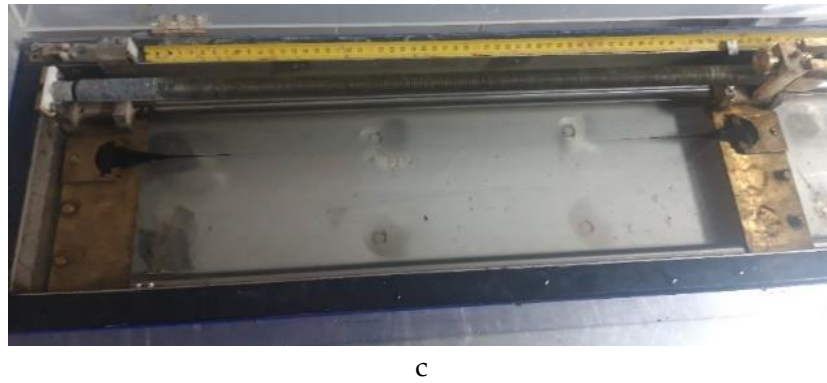


Figure 9. Tensile testing process in the ductilometer: a) stage 1; b) stage 2; c) stage 3

The bitumen sample was further aged in a heated and the ductility test was repeated (Figure 10).

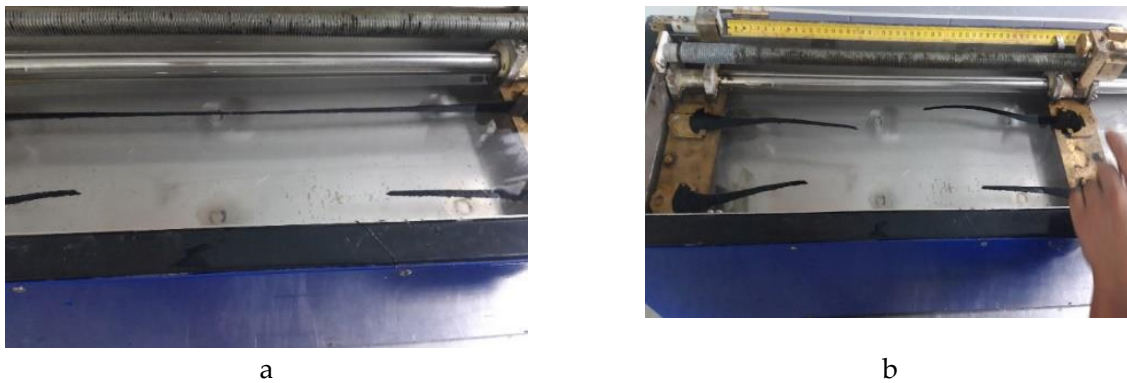


Figure 10. Tensile testing process further aged: a) stage 1; b) stage 2

### Results and Discussion

According to the research carried out in the laboratory, the softening temperature of bitumen was in the range from 57.1<sup>0</sup>C to 58.6<sup>0</sup>C. Table 1 shows the results of the "Ring&Ball" device and ductilometer tests.

Table 1 - Result of tests

Name of indicators, units of measurement	Standard	Standard norm	Test results
Softening temperature	ST RK 1227-2003 [9]	no more 43	45
Tensile strength at 25 no less	ST RK 1374-2005 [10]	no more 90	56

Since bitumen quality control is an integral part of testing to improve the quality of road construction materials, certain difficulties (events or conditions) arise during testing that tends to have a negative impact on achieving reliable test results.

When conducting tests using functional analysis of the "bow-tie" were identified the main risks [11], affecting the achievement of the goal of the research, as well as proposed ways to address the risks (Figure 11). And there are presented the ways of solving the emerging risks.

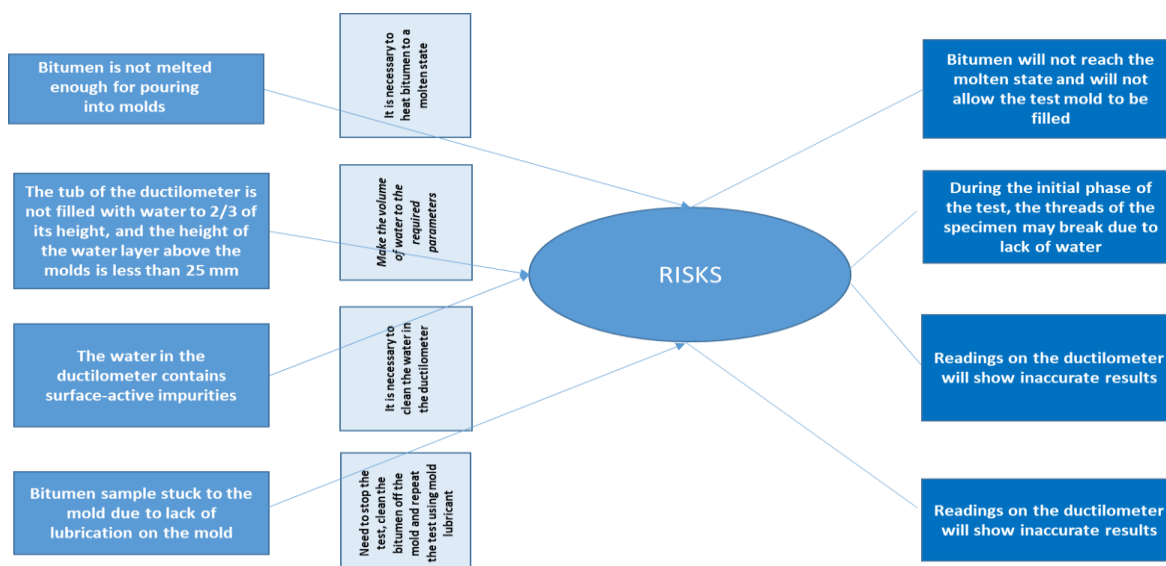


Figure 11. Risks of ductilometer testing

### Conclusion

The main purpose of assessing the quality of bitumen is to provide facilities for the construction, reconstruction, and repair of roads with high-quality bitumen, as well as the timely prevention of the use of the substandard product. Therefore, the fundamental factor is in the testing of bitumen guidance to the requirements of regulatory documentation.

The study also presents the risks that may arise in the process of determining the properties of bitumen. Knowing and understanding the importance of each stage of the experiment is the result of obtaining reliable data with low measurement error.

The results of tests on the extensibility of bitumen showed compliance with the normative indicators, which allowed evaluation of the resistance of the material to mechanical stress, and the ability to work in flexure and elasticity.

### References

1. The properties of asphaltic bitumen: with reference to its technical applications / J. Pfeiffer – 2013 – 300 p.
2. The Shell Bitumen Handbook / Robert N. Hunter, Andy Self and John Read 2015. – 761 p.
3. Polymer Modified Bitumen / Tony McNally 2011. – 424 p.
4. Investigation of the Effect of Adhesive Additive on the Plasticity of Road Bitumen and Physical-Mechanical Properties of the Road Concrete Mix / Mukhamatdinov I. I. // Chemistry for Sustainable Development. – 2021. – No. 1. DOI: 10.15372/CSD2021281
5. Practical experience with modified bitumen and bituminous binders / Z. Kusbergenova, A. Zhankina // Technobius. – 2022. – T. 2, № 1. – 3. 0013. DOI: 10.54355/tbus/2.1.2022.0013
6. Effect of Waste Polyethylene and Wax-Based Additives on Bitumen Performance / L. Desidery, M. Lanotte // Polymers. – 2021. – Vol. 13, No. 21. – P. 3733. DOI: 10.3390/polym13213733
7. Полимерасфальтобетоны с применением нефтяных дорожных битумов, модифицированных смесевыми термоэластопластами / Газинов К.И., Макаров Д.Б. – 2017. – № 1 (5).
8. FM analysis of aging properties of UV531/SBS modified bitumen / F. Zhengang, C. Fengjie, Y. Dongdong, L. Xinjun // IOP Conference Series: Materials Science and Engineering. – 2020. –

Vol. 758, No. 1. — P. 012068. DOI: 10.1088/1757-899X/758/1/012068

9. Bitumens and bituminous binders. Determination of the softening point by the ring and ball method / ST RK 1227-2003- 2003.
10. Bitumens and bituminous binders. Method for determining the extensibility/ ST RK 1374-2005-2005.
11. Risk assessment methods / GOST P ISO/IEK 31010-2011 — 2011.

**А. Тулебекова<sup>1\*</sup>, Ж. Кусбергенова<sup>1</sup>, А. Аддунгарова<sup>2</sup>, А. Бакирбаева<sup>2</sup>**

<sup>1</sup>Л. Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан

<sup>2</sup>Д.Серікбаев атындағы Шығыс Қазақстан техникалық университеті, Өскемен, Қазақстан

### Битумды сынаудың ерекшеліктері

**Андатпа.** Құрылыс материалдары ретінде битумдар гидротехникалық, жол құрылысында өте кең таралған. Битумдар басқа байланыстырушы құрылыс материалдарының арасында жетекші деңгейге шығуға мүмкіндік беретін ерекшеліктері мен пайдалы қасиеттерінің кең өзгеруіне ие. Мақалада битумды зертханалық сынаудың ерекшеліктері келтірілген. Битумды сақинада-шарикті құрылғыда және дуктилометрде сынау әдісі біртіндеп ашылады. Сынақтардың сапасын бақылаудың маңыздылығы негізделген. Алынған нәтижелер нормативтік мәндерден ауытқулардың жоқтығын көрсетті. Ал алынған нәтижелердің сенімділігі мен дәлдігіне аналитикалық тәсілді қолдану және сынақтар жүргізу кезінде туындайтын тәуекелдерді есепке алу есебінен қол жеткізіледі. Олардың есебі "галстук-бантик" әдісінің көмегімен ұсынылған, оны пайдаланудың негізгі артықшылықтары тәуекелдің себептерін талдау және оларды жою бойынша шешімдерді анықтау болып табылады.

**Түйінді сөздер:** битум, сынақ, иілгіштік өлшегіш, тәуекел, сенімділік.

**А. Тулебекова<sup>1\*</sup>, Ж. Кусбергенова<sup>1</sup>, А. Аддунгарова<sup>2</sup>, А. Бакирбаева<sup>2</sup>**

<sup>1</sup>Евразийский университет им. Л.Н.Гумилева, Астана, Казахстан

<sup>2</sup>Восточно-Казахстанский технический университет им. Д.Серикбаева

### Особенности методов испытания битума

**Аннотация.** Битумы как строительные материалы получили крайне широкое распространение в гидротехническом, дорожном строительстве. Битумы обладают широкой вариацией особенностей и полезных свойств, которые позволили ему выйти на ведущий уровень среди прочих связующих строительных материалов. В статье представлены особенности лабораторных испытаний битума. Шаг за шагом раскрывается методика испытаний битума на кольце-шариковом приборе и на дуктилометре. Обоснована важность контроля качества испытаний. Полученные результаты показали отсутствие отклонений от нормативных значений. А надежность и точность полученных результатов достигается за счет использования аналитического подхода и учета рисков, возникающих при проведении испытаний. Учет представлен с помощью методики «галстук-бабочка», основными преимуществами использования которой являются разбор причин возникновения риска и определение решений по их устранению.

**Ключевые слова:** битум, испытание, дуктилометр, риск, надежность.

### References

1. The properties of asphaltic bitumen: with reference to its technical applications / J.Pfeiffer – 2013— 300 p.
2. The Shell Bitumen Handbook / Robert N. Hunter, Andy Self and John Read 2015. — 761 p.
3. Polymer Modified Bitumen / Tony McNally 2011. — 424 p.
4. Investigation of the Effect of Adhesive Additive on the Plasticity of Road Bitumen and Physical-Mechanical Properties of the Road Concrete Mix / Mukhamatdinov I. I. // Chemistry for Sustainable Development. — 2021. — No. 1. DOI: 10.15372/CSD2021281
5. Practical experience with modified bitumen and bituminous binders / Z. Kusbergenova, A. Zhankina // Technobius. — 2022. — Т. 2, № 1. — 3. 0013. DOI: 10.54355/tbus/2.1.2022.0013
6. Effect of Waste Polyethylene and Wax-Based Additives on Bitumen Performance / L. Desidery, M. Lanotte // Polymers. — 2021. — Vol. 13, No. 21. — P. 3733. DOI: 10.3390/polym13213733
7. Полимерасфальтобетоны с применением нефтяных дорожных битумов, модифицированных смесевыми термоэластопластами / Газинов К.И., Макаров Д.Б. — 2017. — № 1 (5).
8. FM analysis of aging properties of UV531/SBS modified bitumen / F. Zhengang, C. Fengjie, Y. Dongdong, L. Xinjun // IOP Conference Series: Materials Science and Engineering. — 2020. — Vol. 758, No. 1. — P. 012068. DOI: 10.1088/1757-899X/758/1/012068
9. Bitumens and bituminous binders. Determination of the softening point by the ring and ball method / ST RK 1227-2003- 2003.
10. Bitumens and bituminous binders. Method for determining the extensibility/ ST RK 1374-2005-2005.
11. Risk assessment methods / GOST P ISO/IEK 31010-2011 — 2011.

**Information about authors:**

*Tulebekova A.* - Ph.D., Associate Professor in Department of Civil Engineering, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan.

*Kusbergenova Zh.* - Master Student in Department of Civil Engineering, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan.

*Aldungarova A.* - Ph.D., Associate Professor in School of Architecture and Construction, D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan.

*Bakirbayeva A.* – Master of Technical Sciences., Senior Lecturer in School of Architecture and Construction, D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan.

*Түлебекова Ә.С.* - «Құрылыс» кафедрасының доценті, Ph.D., Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан.

*Кусбергенова Ж.* - «Құрылыс» кафедрасының магистранты, Л. Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан.

*Алдунгарова Ә.Қ.* - Сәулет және құрылыс мектебінің доценті, Ph.D., Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті, Өскемен, Қазақстан.

*Бакирбаева А.А.* - Сәулет және құрылыс мектебінің оқытушы, магистр, Д. Серікбаев атындағы Шығыс Қазақстан техникалық университеті, Өскемен, Қазақстан.