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**EXPERIENCE OF CONSTRUCTING THE ROADS  
WITH CEMENT CONCRETE COATINGS*****Annotation***

**Introduction.** Modern road constructions are based on two types of pavement: asphalt concrete and cement concrete. Theory and practice show that in any climatic conditions, any intensity and any composition of movement, cement concrete coatings are durable. At the same time, in developed countries, with an established developed network of roads and an efficient maintenance service, they maintain an approximate parity in the ratio between asphalt and cement concrete pavements in the total volume of roads under construction.

**Topic.** The technology of building roads using cement concrete coatings has been used in the world for several decades. It has found application in countries with a wide variety of climatic conditions. The average operation life of such roads is at least 20 years, with minimal repair and maintenance costs. A comparative analysis of the costs of materials during the construction of cement concrete and asphalt concrete pavements and taking into account the numerous overhauls of asphalt concrete pavement during its operation life shows that the cost for the concrete option is several times less than for the asphalt concrete option: 2 times for the overhaul period for asphalt concrete pavement 5 years and 3 times, with a three-year overhaul period. The high durability of cement concrete coatings is due to the peculiarity of cement concrete as a material. Strength and deformation properties of cement concrete, unlike asphalt concrete, practically do not depend on temperature and air humidity. Over time, over the operation life, the strength of cement concrete increases (on average, by 10 % – 20 %), despite the intense movement of vehicles and the aggressive effects of climatic factors. Accordingly, on cement concrete pavements, the formation of a rut because of surface deformations or wear is almost impossible, while rut is one of the most common defects in modern roads with asphalt pavement.

**Materials and methods.** In accordance with the approved strategic plans for the development of the road industry of the Republic of Kazakhstan, as well as taking into account international experience, over the past 15 years, 1,452 km of roads with cement concrete pavements have been built in the Republic.

**Results.** The result is the development of the construction of concrete roads, which, along with their positive properties, require new technological solutions to ensure the stability of coatings to the action of transport and weather and climate factors. As well as world experience in the construction of roads with cement concrete coatings, promises a great future of this direction development. Definitely the advantages of cement concrete coating are stable transport and operational performance and high durability.

**Key words:** automobile road, cement concrete coating, durability, operation life, traffic intensity, strength.

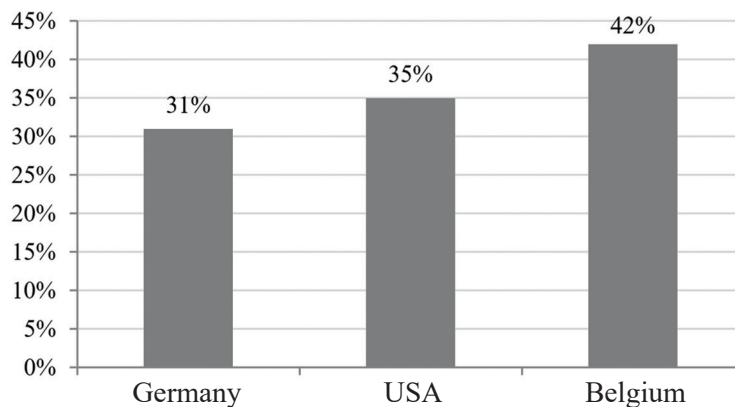
## Introduction

Modern designs of roads and their construction technology based on two alternative competing types of pavement, asphalt concrete and cement concrete. In this case, theory and practice clearly indicate that in any climate, at any rate and any part of the movement concrete slabs are the most durable. Thus, when the actual lifecycle in the US concrete covers, on average, 26 years, asphalt — 16 years, in Germany, respectively — 26 years and 18 years, [1] it means that abroad they apply the realistic achievable goal to provide term concrete covers lifecycle to 50 years and more. These types of coatings are also characterized by the kinetics of destruction: the intensity of the destruction of asphalt concrete coatings increases significantly after 5 years of operation, cement — after 20 years.

In developed countries, with the developed network of roads and their effective service content today in practice approximate parity ratio between asphalt and cement-concrete surfaces in overall road construction is applied [2].

## Construction experience

Cement for the construction of pavements is used in Austria, Germany and Belgium. In these countries, due to the active operation of the European Association of concrete roads, expressways develops construction of highways with concrete covers is developed and reaches 40 % (Figure 1).



*Figure 1* — Ratio cement concrete pavement of roads

Road construction technology with the use of concrete slabs has been used for several decades in the world. It has been applied in countries with different climatic conditions.

The first coating of Portland cement concrete were built in the UK (Edinburgh) in 1866, in USA first road with concrete coating was built in Bellefontaine 25 years later (1891). The massive construction of roads began exactly in this country. By 1912, there were 400 km of roads with concrete pavement in the US; by 1913 this figure had doubled. In 1914, there were already about 3 thousand km, and in 1951 — 140 thousand km.

In Europe, the construction of roads with hard coating began in the second half of the XIX century mainly in such countries as Scotland, France and Germany.

The average operation life of concrete coatings is at least 20 years, with minimal repair and maintenance costs. A comparison of the costs of materials in the construction of cement concrete and asphalt concrete pavements and taking into account the numerous overhauls of asphalt concrete

pavement during its service life shows that for the concrete concrete option the cost is several times less than for the asphalt concrete option: 2 times (with the overhaul period for asphalt concrete pavement 5 years) and 3 times (with a three-year overhaul period) [3].

The high durability of cement concrete coatings is due, first of all, to the peculiarity of cement concrete as a material. Strength and deformation properties of cement concrete, unlike asphalt concrete, practically do not depend on temperature and air humidity. Over time, over the service life, the strength of cement concrete increases (on average, by 10 % – 20 %), despite the intense movement of vehicles and the aggressive effects of climatic factors. Accordingly, on cement concrete pavements, the formation of a rut from plastic deformation or wear is practically excluded, while rut is one of the most common defects in modern roads with asphalt pavement.

Due to the distribution of the load from vehicles on the cement concrete slab, residual deformations and shear (shear) stresses in the underlying subgrade are significantly lower than in pavement structures with asphalt concrete pavement, which increases the durability of the entire pavement structure.

The texture of the surface of the cement concrete pavement and the artificial roughness created on the surface of the cement concrete pavement during the construction process provide a higher and more stable in time coefficient of adhesion to the car wheel and, accordingly, lower (approximately, 5 % – 10 %) fuel consumption [4].

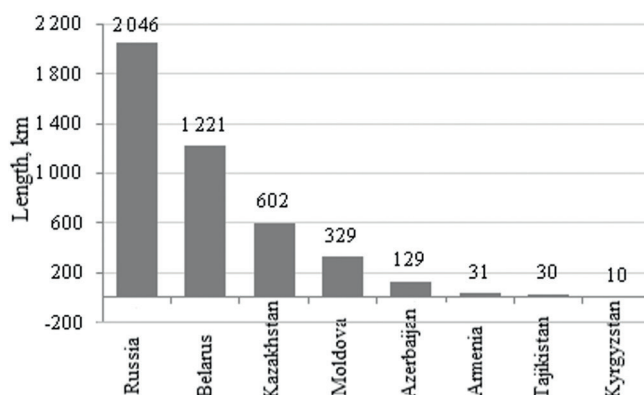
Speaking of cement-concrete coatings, their less maintainability is usually noted as a disadvantage. Indeed, when defects are detected, it is difficult to process the corresponding section of the cement concrete coating in comparison with the asphalt concrete [5].

However, modern technologies allow solving this problem [6].

The construction of concrete roads in the Soviet Union began in the early fifties of the last century using a domestic set of concrete-laying machines D-181, D-182 and D-195 on a rail track.

Since 1970, the USSR began the extensive construction of cement concrete pavements using equipment with sliding formwork. At that time, concrete-laying sets of high-performance Avtograd machines were purchased in the USA, which served as the basis for the production of domestic sets of machines under the brand DS-100 and DS 110 of the Bryansk Plant. It was during this period that roads with cement concrete coatings were built: Moscow – Volgograd, Omsk – Novosibirsk, Yekaterinburg – Chelyabinsk and others. The length of roads with cement concrete pavement then amounted to more than 10 thousand km.

The length of public roads with cement concrete pavement in the CIS countries is shown in Figure 2.



*Figure 2* — Public roads with cement concrete pavement in the CIS countries

Russia has accumulated a significant amount of theoretical and practical knowledge in the field of durable cement concrete coatings. Federal norms and rules have been developed for the design and construction of cement concrete coatings and foundations for various concreting technologies: in railforms, in sliding forms, by rolling by vibratory rollers and others. The actual service life of cement concrete coatings often exceeds the standard (20–25 years), reaching 30–40 or more years [7].

In the Russian Federation, the share of cement concrete roads is 3 %. As a rule, cement-concrete pavements were slabs 18–24 centimeters thick [8].

International experience in the construction of roads with cement concrete pavement has shown that its use in road construction provides significant savings. If the concrete road is well built, the first 10–12 years practically does not require any repairs, only routine maintenance.

The current ratio of the cost of building roads with cement concrete and asphalt concrete coatings is not stable, but is gradually changing in favor of cement concrete with increasing prices for oil products and lowering inflation. The cost of structures with cement concrete coatings is currently comparable to the cost of structures with asphalt concrete coatings. So, for example, the cost of 1 m<sup>2</sup> of coverage of a highway of the first technical category (MKAD-Kashira highway) with cement concrete coating is 1 352.13 rubles, and with asphalt concrete coating — 1 378.70 rubles. At the same time, the service life of cement concrete coatings is several times higher [9].

Considering the experience of Ukraine, it can be noted that a simplified design of pavement was adopted there: a draining and leveling sand layer 15 cm thick, a 12 cm thick crushed-sand mixture layer, 16 cm monolithic cement concrete. Ukrainian road workers calculated that the cost of repairing asphalt concrete is — 45.53 euros / m<sup>2</sup>, and cement concrete — 39.47 euros / m<sup>2</sup>. This allowed to reduce the cost of pavement and make it more economical in comparison with the design, which included asphalt concrete pavement.

At the same time, Ukraine uses two main methods of building concrete coatings: construction using special machines and equipment and construction using small-scale mechanization.

The latter is used in complex areas with rough terrain, if necessary, broadening of the existing coverage, etc. This technology was practiced in the construction of the Kiev – Chop road, and the reconstruction of the Kharkov – Simferopol road [10].

The Republic of Kazakhstan, the construction of roads with cement concrete coatings began in 2006. The first road with cement concrete pavement was “Astana – Schuchinsk” with parameters of technical category 1-A with 6-lane traffic at an estimated speed of 150 km per hour, a roadway width of 22.5 m, a length of 215 km, of which 96 km was a device for cement concrete coating according to German technology is provided [11].

The accumulated experience in the construction of the first autobahn laid the foundation for the implementation of the Western Europe – Western China international transit highway project (Figure 3), the length of which on the territory of Kazakhstan is 2,757 km, of which 994 km are cement-concrete coated [12].

In general, in Kazakhstan today, the network of republican roads is 24.4 thousand km, of which 94% are non-rigid type of coating and only 6% with cement concrete (Figure 4).

The first sections of cement-paved roads began to be commissioned for the first time since 2011, taking into account the 3–5-year warranty period. Over the past 8 years, the length of cement-paved roads has increased from 97 to 1 437 km, i.e. more than 15 times and continues to expand (Figure 5).



Figure 3 — Project «Western Europe – Western China»

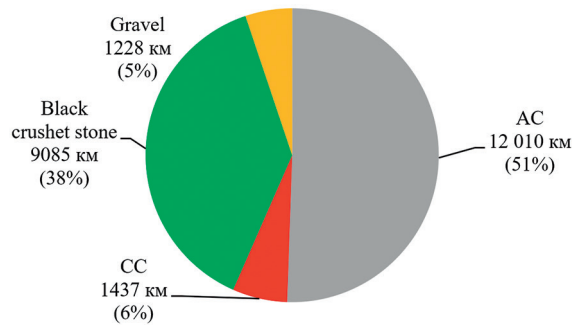


Figure 4 — Share of roads by coating types

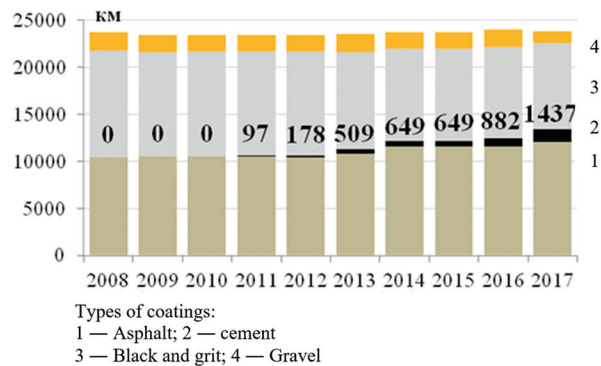


Figure 5 — Dynamics of the development of the republican road network by type of coverage from 2008 to 2017

Further development of the construction of roads with cement concrete coatings was received in the framework of the Center-South and Center-East projects.

## БУДІВНИЦТВО ТА ЦИВІЛЬНА ІНЖЕНЕРІЯ

The list of public roads with cement concrete coatings is given in table 1.

*Table 1*

### *List of highways with cement concrete coating of Kazakhstan*

№ a/d	Name of the road	Length, km	including:
			Cement concrete coating
<i>Akmola region</i>			
M-36	border of the Russian Federation (Ekaterinburg)-Almaty	469,0	71,0
A-1	Astana-Petropavlovsk	324,0	97,0
P-4	Astana Yereimentau-Shiderty	189,0	99,0
	<b>Total area:</b>	<b>2 285,5</b>	<b>267,0</b>
<i>Alma-Ata's region</i>			
	Almaty-Khorgos-Shelek	304,0	304,0
A-3	Almaty-Ust-Kamenogorsk	586,0	105,0
	<b>Total area:</b>	<b>2 821,9</b>	<b>409,0</b>
<i>Jambyl Region</i>			
A-2	Almaty-Tashkent-Termez	674,5	
	162-260 km, Bypass pass Kordai	80,0	69,5
	483-536 km, the new Bypass Taraz	65,1	7,7
	383-404 km, Bypass s.Kulan	20,0	20,0
	261,5- km 389,4; 404-483; 536-593	267,1	253,1
	<b>Total area:</b>	<b>1 237,2</b>	<b>350,3</b>
<i>West-Kazakhstan region</i>			
A-31	Chapaev-Zhalpaktal-Kaztalovka-oz. RF	213,0	18,0
P-44	Kaztalovka-Janibek-gr.RF	165,0	3,0
	<b>Total area:</b>	<b>1 393,0</b>	<b>21,0</b>
<i>Karaganda region</i>			
M-36	border of the Russian Federation (Ekaterinburg)-Almaty	637,6	65,6
	<b>Total area:</b>	<b>2 784,6</b>	<b>65,6</b>
<i>Turkestan</i>			
M-32	border of the Russian Federation (Samara) -Shymkent	201,0	141,9
M-39	Tashkent-Termez	24,1	24,1
A-2	Almaty-Korday-Merke-Tashkent-Termez	182,0	137,0
P-32	Northern bypass the city of Shymkent	36,5	36,5
	<b>Total area:</b>	<b>866,2</b>	<b>339,5</b>
	<b>Total in the country:</b>	<b>24 382,9</b>	<b>1 452,4</b>

### Conclusion

1. Increasing traffic loads on road surfaces and increasing traffic intensity contribute to the expansion of concrete road construction, which, along with their positive properties, require new technological solutions to ensure the stability of coatings to the effects of traffic and weather and climate factors.

2. The experience in the construction of roads with cement concrete coatings indicates the prospects for the development of this direction. Where the undoubted advantage of cement concrete are stable transport and operational performance and high durability.

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### ДОСВІД БУДІВНИЦТВА ДОРІГ З ЦЕМЕНТНОБЕТОННИМ ПОКРИТТЯМ

#### Анотація

**Вступ.** В основі сучасних дорожніх конструкцій лежать два види покриття: асфальтобетонне та цементобетонне. Теорія та практика свідчать, що за будь-яких кліматичних умов, будь-якої інтенсивності та будь-якого складу транспортного руху, цементно-бетонні покриття є більш довговічними. У той же час, у розвинених країнах, що мають розвинену мережу доріг та ефективну практику технічного обслуговування, підтримують приблизну рівність у співвідношенні між асфальтобетонним і цементобетонним покриттями в загальному обсязі доріг, що будуються.

**Тема.** Технологію будівництва доріг із використанням цементобетонних покриттів застосовують у світі вже кілька десятиліть. Вона знайшла застосування в країнах із найрізноманітнішими кліматичними умовами. Середній термін експлуатації таких доріг становить

не менше ніж 20 років за мінімальних витрат на ремонт та утримання. Порівняльний аналіз витрат на матеріали під час будівництва цементнобетонних та асфальтобетонних покриттів, а також із урахуванням численних капітальних ремонтів асфальтобетонного покриття протягом терміну його експлуатації показує, що витрати на будівництво бетонних покриттів — у кілька разів менше, ніж на асфальтобетонні покриття: 2 рази — на період капітального ремонту для асфальтобетонного покриття кожні 5 років і 3 рази, за трирічного періоду капітального ремонту. Висока міцність цементнобетонних покриттів обумовлена особливостями цементобетону як матеріалу. Характеристики міцності та деформаційні властивості цементобетону, на відміну від асфальтобетону, практично не залежать від температури та вологості повітря. З плином часу, протягом періоду експлуатації, міцність цементобетону зростає (в середньому на 10–20 %), незважаючи на інтенсивний рух транспортних засобів і агресивний вплив кліматичних факторів. Відповідно, на цементобетонних покриттях, колієутворення через деформації поверхні або знос — практично неможливі, в той час як колієутворення є одним із найбільш поширених дефектів на сучасних асфальтобетонних дорогах.

Матеріали та методи. Відповідно до затверджених стратегічних планів розвитку дорожньої галузі Республіки Казахстан, а також з урахуванням міжнародного досвіду, за останні 15 років у Республіці побудовано 1 452 км доріг з цементобетонним покриттям.

Результати. Результатом є розвиток будівництва цементобетонних доріг, які разом з позитивними якостями вимагають нових технологічних рішень для забезпечення стійкості покриттів до впливу транспортних і погодно-кліматичних факторів. Світовий досвід будівництва доріг із цементобетонними покриттями обіцяє велике майбутнє розвитку даного напрямку. Безумовно, перевагами цементобетонних покриттів є стабільні транспортні та експлуатаційні характеристики та висока довговічність.

**Ключові слова:** автомобільна дорога, цементнобетонне покриття, довговічність, термін експлуатації, інтенсивність руху, міцність.