



## TECHNICAL AND ECONOMIC COMPARATIVE ANALYSIS OF THE USE OF MODERN MATERIALS IN THE TRAFFIC SECTION OF THE REINFORCED CONCRETE HIGHWAYS BRIDGE

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### ABSTRACT

*This article examines the causes of defects and damage that occur on the roadway of the bridge. A comparative technical and economic analysis of the method proposed by the authors for using modern materials in the design of the roadway of reinforced concrete road bridges is considered. Construction and material costs of existing and proposed roadway structures were calculated and compared.*

The bridge structure is a complex engineering object, and its reliability, strength and durability depend on the type of material used for it and the quality of construction works. If the listed parameters are not reflected in the structure, then the deterioration of the structure will accelerate, which in turn will lead to the acceleration of the operation and reconstruction process.

To date, as a result of the observations, it has become known that the bridge structures, in addition to preventing traffic jams, also create traffic jams. Due to this, as a result of the appearance of various defects and damages in the structures, they are operated every 3-5 years, as a result of the acceleration of the period of capital repair and reconstruction, the suspension of traffic on overpasses and bridges or the closure of these roads we can mention that processes are closed due to.

In order to prevent these situations, we believe that it is necessary to increase the service life of transport structures, for this, use modern technologies in bridge construction, take models from world bridge construction, and use new modern materials in their constructions.

### The main part.

Studies and researches show that most of the failures in bridges are observed in the intermediate device and carriageway. Below are the most common defects and damages in the construction in Figures 1 and 2.



**Figure 1. Defects and damage caused by moisture retention**



**Figure 2. Defects and damages caused by loads and structural wear and tear**

In this article, the technical and economic analysis of the construction of the roadway, which will be built on the basis of modern materials and technologies proposed by the authors to protect the structures of the bridge roadway from the above reasons or to prevent them, is considered.

### **Setting the issue**

- ☑ construction of the proposed carriageway;
- ☑ Feasibility analysis of existing and proposed constructions.

### **Proposed carriageway construction.**

The construction of the new carriageway is in accordance with all indicators

It consists of monolithic reinforced basalt-fibro concrete, which can fully meet the requirements stated in 2.05.03-12, combines leveling layer, waterproofing and protective layers in one construction.

Basalt-fibro concrete with waterproof properties has several advantages over the existing construction:

- *light compared to ordinary concrete;*
- *basalt fibers in the composition increase the compressive and bending strength of the structure;*
- *reduces material consumption in construction;*
- *reduces construction costs and labor.*

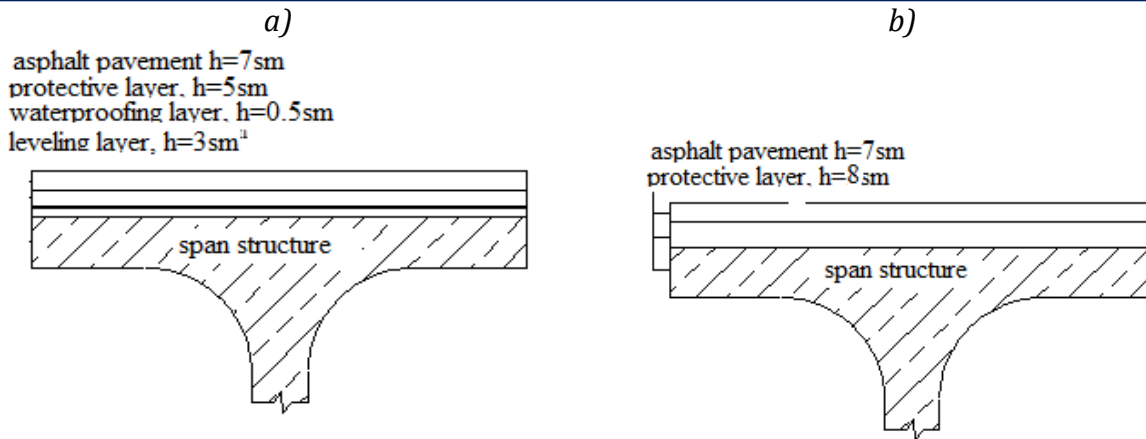
### **in relation to existing waterproofing material:**

- *less water seepage;*
- *long service life;*
- *reduces material consumption in construction;*
- *reduces construction costs and labor.*

### **Comparative feasibility analysis of existing and proposed structures.**

The selection of the main option of the facility will depend on the general combination of technical and economic indicators and requirements (economic, constructive, production, operational and architectural).

Below we will compare the existing and proposed constructions from a technical and economic point of view according to certain parameters. The construction of the road surface to be laid on the intermediate device is shown in Fig. 3. cited:



**Figure 3. Roadway constructions**

- a) existing roadway - leveling layer, waterproofing layer, protective layer, asphalt concrete coating;
- b) the proposed road section - leveling layer (includes leveling, protection, waterproofing layer), asphalt concrete coating.

This coating is laid directly on the head beam plate. The values of the calculated constant loads from the coating layers on the surface of 1 m<sup>2</sup> of the slab are presented in Table 1.

*Table 1*

existing roadway			the proposed road section		
Load type	$\gamma_f$	Estimated load, kPa	Load type	$\gamma_f$	Estimated load, kPa
Asphalt concrete (thickness $\delta = 7\text{sm}$ ; volume weight $g = 2.3 \text{ t/m}^3$ )	1,5	0,24	Asphaltobeton (thickness $\delta = 7 \text{ sm}$ ; volume weight $g = 2.3 \text{ t/m}^3$ )	1,5	0,24
Reinforced concrete protective layer (thickness $\delta = 4\text{sm}$ ; volumetric weight $g = 2.5 \text{ t/m}^3$ )	1,3	0,13	Reinforced non-waterproof basaltfibro concrete protective layer (thickness $\delta = 7 \text{ sm}$ ; volumetric weight		
Waterproofing (thickness					
$\delta = 1 \text{ sm}$ ; volumetric weight $g = 1.5 \text{ t/m}^3$ )	1,3	0,02			
		<b>0,47</b>			<b>0,46</b>



Based on the data in the above table, we can say that the impact of the load on the intermediate device from the calculated constant loads is less in the proposed structure compared to the existing structure.

Economic comparative analysis of existing and proposed constructions

In Table 2, we consider the example of a bridge of average length up to 50 meters on Class II roads. The gauge of the bridge is G-11.5, the scheme is 2x24 meters.

Table 2

existing roadway			the proposed road section		
Name of works		So'm	Name of works		So'm
Total work done		139563443,5	Total work done		95916478,5
Workers labor cost	Person-hour	8379794,4	Workers labor cost	Person-hour	1899156,4
Machine mechanisms	Machine-clock	2446754,2	Machine mechanisms	Machine-clock	1958797,2
Materials		128736894,9	Materials		92058524,9
Total materials		137748477,5	Total materials		98502621,6
Total eligible expenses		148575026,1	Total eligible expenses		102360575,2
Other expenses of the organization		35048848,7	Other expenses of the organization		24146859,7
<b>Total</b>		<b>183623874,8</b>	<b>Total</b>		<b>126507434,9</b>

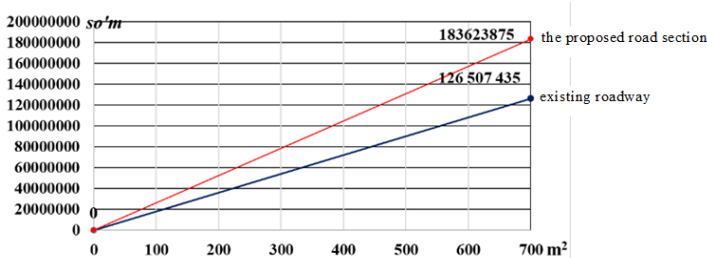


Figure 4. For constructions expenses incurred.

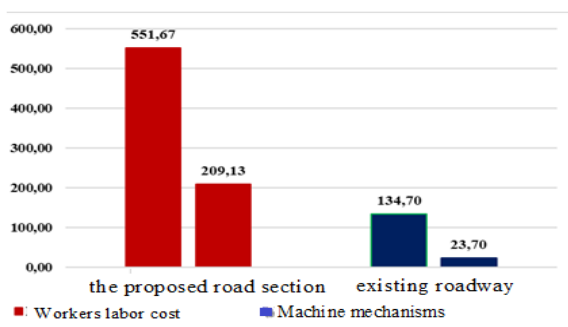


Figure 5. Cost of workers and machine mechanisms for constructions

From these tables and graphs, we can see that the proposed method is about 31% cheaper than the existing method, i.e. 57116439 soums.

In addition, we can see that labor costs of workers are saved by 75%, and labor costs of machines and mechanisms are saved by 87% compared to the existing method.

**Analysis of operating costs**



The results of the following inspections (observations) are taken into account when determining the operating costs of reinforced concrete bridges and overpasses: current and periodic; inspections and tests; special observation and inspections. The service life of the bridge and the period until the first repair are determined according to the Interstate standard GOST 33178-2014. [11].

According to GOST 33178-2014, the term of repair of the waterproofing layer is 10 years, and the term of replacement is 20 years. In practice, the repair period is 5 years, and the replacement period is 10 years.

Using the method developed in [11] for calculating (forecasting) the annual costs of operating bridges and overpasses, the formulas for calculating the costs for every 5 years of 50 years are given in Table 5.

Table 3

Operating expenses every 5 years

Years	Existing construction	Tproposed construction
0-5	$5E_A+E_D$	$5E_A+E_D$
6-10	$5E_A+E_D+E_A+E_W$	$5E_A+E_D+E_A$
11-15	$5E_A+E_D$	$5E_A+E_D$
16-20	$5E_A+E_C$	$5E_A+E_D+E_A$
21-25	$5E_A+E_D$	$5E_A+E_D$
26-30	$5E_A+E_D+E_A+E_W$	$5E_A+E_C$
31-35	$5E_A+E_D$	$5E_A+E_D$
36-40	$5E_A+E_C$	$5E_A+E_D+E_A$
41-45	$5E_A+E_D$	$5E_Y+E_D$
46-50	$E_R$	$E_R$

Here:

$E_A$ = Annual operating expenses;

$E_D$ = Costs incurred for replacement of deformation seams;

$E_A$ = Costs for replacing asphalt concrete pavement;

$E_W$ = Costs for replacing the waterproofing coating;

$E_C$ = Expenditures for capital repairs;

$E_R$ = Costs for reconstruction.

If we calculate according to this method, we can see that the costs associated with capital repair and replacement of the waterproofing layer will be saved in a new way. In addition, taking into account the monolithic form of the new style, it is possible to save labor costs.

### Conclusion.

The main defects and damages that appear in the intermediate device are caused by defects in the construction of the carriageway (failure of the waterproofing coating, long-term retention of moisture in the concrete).

Due to the lightness of basaltfibrobeton compared to conventional concrete, we can see that the stresses that occur as a result of constant loads on the slab of the carriageway are minimal in the new construction.



According to the project, 31% (57116439 soums) economic savings will be achieved in the new construction compared to the existing construction, 75% in the labor cost of the workers compared to the existing method, 87% in the labor cost of the machines-mechanisms.

By fully controlling the technology of construction work, using high-quality basalt-fibro concrete, it is possible to achieve the service of the construction of the road section built in a monolithic form for more than 30 years without requiring repair work. This significantly reduces the operating costs of the facility.

The construction proposed by this work cannot completely eliminate the defects that occur in some traffic sections, however, we believe that it is partially effective, both technically and economically, compared to the old method.

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